CHARACTERIZATION AND REGENERATION OF CARBONACEOUS SUBSTRATE PRODUCED FROM BIOTIC PRECURSORS AND ITS USE FOR THE WASTE WATER TREATMENT

By

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IT IS RECOMMENDED THAT THIS THESIS PREPARED BY MR. SULTAN ALAM ENTITLED **"CHARACTERIZATION AND REGENERATION OF CARBONACEOUS SUBSTRATE PRODUCED FROM BIOTIC PRECURSORS AND ITS USE FOR THE WASTE WATER TREATMENT"** BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PHYSICAL CHEMISTRY.

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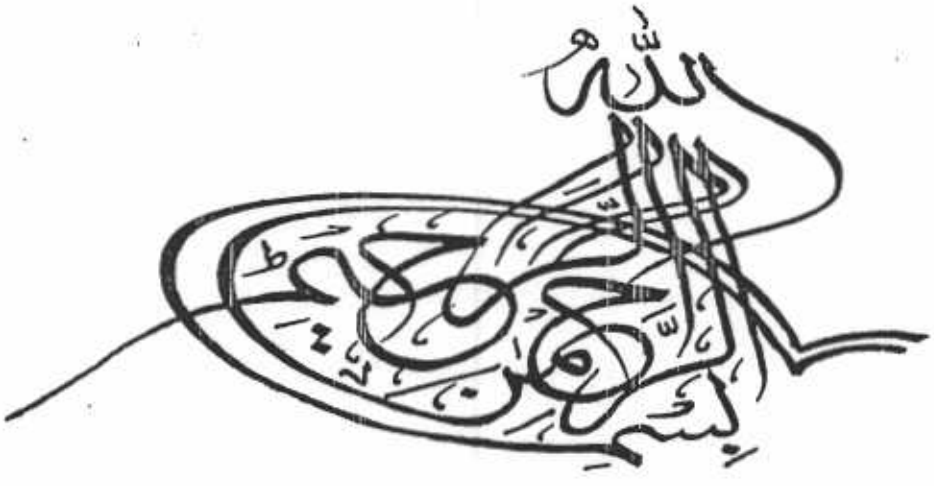
To

MY FATHER

SULTAN MEHMOOD KAKAKHEL (LATE)

(May Allah Bless Him)

SULTAN ALAM


بسم الله الرحمن الرحيم

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SULTAN ALAM

Nomenclature

D_o	=	Initial concentration of dye.(t = 0)
D_e	=	Equilibrium concentration of dye (t = t)
PT	=	*Paulownia tomentosa*
PC	=	*Populus caspica*
CC	=	*Corn cobs*
AA	=	*Ailanthus altissima*
SO	=	*Salvadora oleoides*
AB	=	Animal bones
Reg.	=	Regenerated
FTIR	=	Fourier transform infrared
XRD	=	X-rays diffraction
SEM	=	Scanning electron microscope
EDS	=	Energy dispersive spectrum
Θ	=	Burn-off weight
μm	=	Micrometer
M	=	Mol/L
BET	=	Brunauer-Emmett-Teller
P/P_o	=	Relative pressure
BJH	=	Barrett, Joyner and Holenda
DR	=	Dubinin-Redushkovich
LSA	=	Langmuir surface area
CPS	=	Counts per second
IR	=	Infrared
D_Φ	=	Amount of dye adsorbed
AB1	=	Acid blue 1
BBR	=	Brilliant blue R
AY29	=	Acid yellow 29
AY34	=	Acid yellow 34
AO7	=	Acid orange 7
AO10	=	Acid orange 10
PET	=	Polyethylene
Q	=	Flow rate
w.r.t	=	With respect to
N	=	Avogadro's number
γ	=	Gamma
k_{ad}	=	Rate constant

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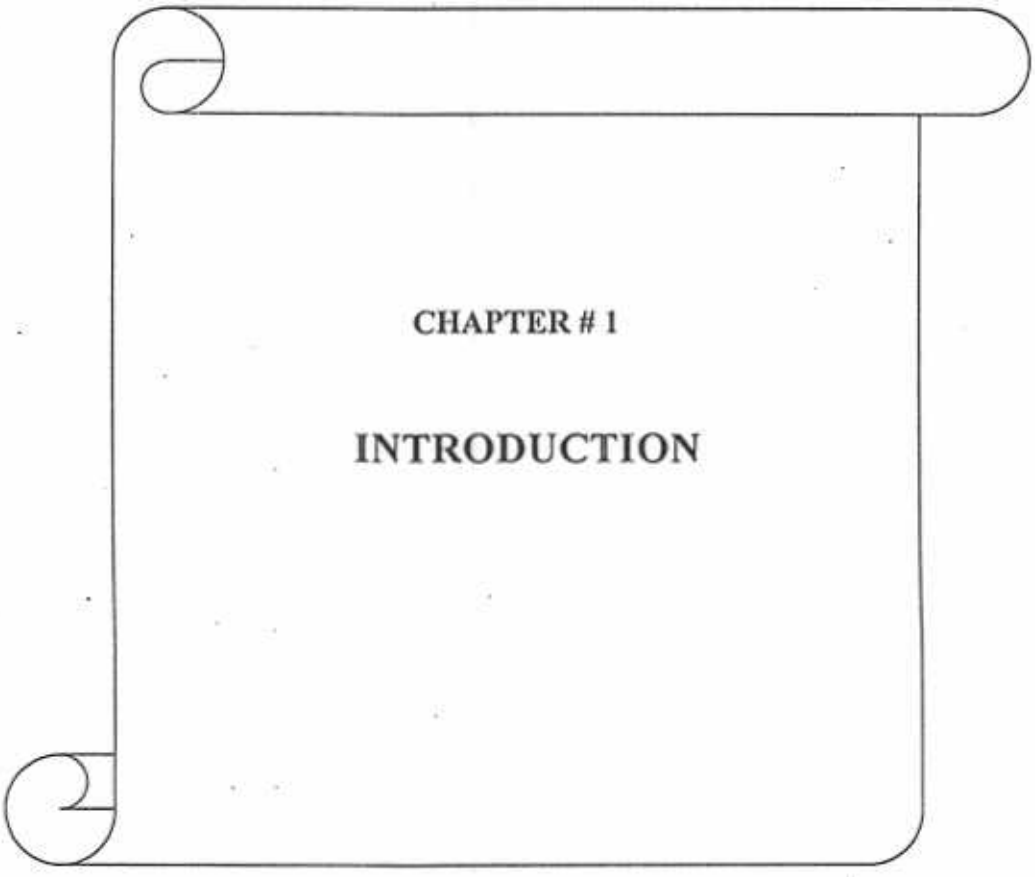
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ABSTRACT

Low cost agricultural waste material (*Corncobs-CC*) and fast growing wood (*Paulownia tomentosa-PT, Populus caspica-PC, Ailanthus altissima-AA, Salvadora oleoides-SO*) and animal bones were utilized for the preparation of activated carbon. Industrial spent carbon was also regenerated. The carbon samples were activated chemically and by thermal means (400-1000°C). The samples were characterized by pH, moisture content, ash content, bulk density, surface area (BET, DR, BJH, Langmuir) with pore volume, FTIR, XRD, SEM and EDS. The BET (m^2g^{-1}) surface area analysis of the carbon samples activated at 800 °C showed that SO has greatest surface area of 587 m^2g^{-1}. The surface area of other carbon samples activated at 800 °C was found in the sequence: 418 for SO > 412 for CC > 398.29 for PC > 387 for AA > 219 for PT > 140.23 for ABC. DR method was used for the determination of micropore volume ($cm^3.g^{-1}$) using **NOWWin2** computer software. For the 800 °C activated carbon samples the pore volume was in the sequence: 0.23 for PC > 0.220 for SO, RG > 0.21 for CC > 0.20 for AA, 0.11 for PT > 0.100 for ABC. FTIR analysis showed that the carbon surface carried the oxygen containing functional groups, which disappeared at high activation temperatures. The XRD analysis using **ORIGIN-50** computer software showed that carbon, hydrogen, nitrogen, oxygen, boron, chromium, fluorine, nitrogen and molybdenum were present in the carbon samples. The EDS analysis showed high carbon contents in the sample activated at high temperature as compared to Raw and 400 °C activated samples while the contents of oxygen was found to decrease with the increase in activation temperature. Other elements like sulfur, potassium, chlorine, silica, iron, magnesium, copper, phosphorus, sodium, calcium, aluminum and molybdenum were found in trace amounts. The rate of adsorption of dyes on the carbon samples was high in the initial fifteen seconds and then declined due to its diffusion in to the micropores. From the first order kinetics the rate constants were determined which were found to be high at high temperatures of adsorption /sample activation. The high activation energy of the dye adsorption on the Raw and 400 °C activated carbon samples was due to the presence of polar functional groups at the pore openings that blocked the entrance of the dye molecules, thus raising the energy barrier. Negative values of entropy of activation ($\Delta S^{\#}$) of the dyes adsorption

reflected the affinity of the dye molecules towards the carbon surface which were found to decrease with the increase in adsorption temperature. The dye molecules thus have acquired a more stable oriented position on the surfaces at high temperature of adsorption/ sample activation. The linear plots of Bangham and intraparticle diffusion models showed that the adsorption of dye on the carbon surface is a diffusion controlled process. The Freundlich, Langmuir and DR models were used to estimate the adsorption parameters. The best fit of the isotherms, found from the correlation coefficients (r^2) were in the sequence: DR > Langmuir > Freundlich. Distribution coefficients of the dyes on the surfaces of carbon activated at different temperatures were found to be in the sequence: $D_{e1000\,^{\circ}C} > D_{e\,900\,^{\circ}C} > D_{e\,800\,^{\circ}C} > D_{e\,600\,^{\circ}C} > D_{e\,400\,^{\circ}C} > D_{e\,Raw}$. The industrial waste water was treated by column adsorption. Thomas model was used to derive the adsorption capacity (mol g^{-1}) of the carbon samples for the dye and also for Ni^{+2}, Cu^{+2} and Zn^{+2} adsorption from the industrial waste water.



CHAPTER # 1

INTRODUCTION

1. INTRODUCTION

There exist increasing demands for the availability of adsorbents that are cost effective and efficient remover of water contaminants. Despite significant research in the production of activated carbon for dye adsorption, there prevails a clear knowledge gap about the dyes in aqueous solution and mechanism of their adsorption on activated carbon [1]. There is also inadequate understanding of the role of dye structure and the physical and chemical characteristics of activated carbon in the adsorption. With the growth of industrialization and urbanization, the treatment of the bulk waste water is a challenge. Pakistan has agricultural based economy and textile, leather and tanning industries are its back bone. Dyes when present even in very small quantities (< 1ppm) in the water bodies make it unacceptable for use [2]. Dyes (Triphenylmethane and azo) are mutagenic and carcinogenic and can cause sever damage to humans causing by dysfunction of kidneys, reproductive system, liver, brain and central nervous system. Dyes are recalcitrant organic molecules that are resistant to aerobic digestion and are stable to light, heat and oxidizing agents [3-8].

Although adsorbents are used abundantly throughout the water and wastewater treatment industries. The use of activated carbon remains expensive process. Most of the commercial systems currently use activated carbon as adsorbent to remove dyes from the wastewater because of its excellent adsorption ability [9-11]. Activated carbon adsorption has been cited by U.S. environmental protection agency (EPA) as one of the best available control technologies [12].

Over the recent years there has been a considerable research on the low cost alternative materials for the production of activated carbon. Agricultural waste such as waste wood, coconut shell, apricot stones, corncobs, bamboo, plum kernels etc were used for this purpose [13-36]. Agricultural waste wood materials and animal bones waste are cheaply and

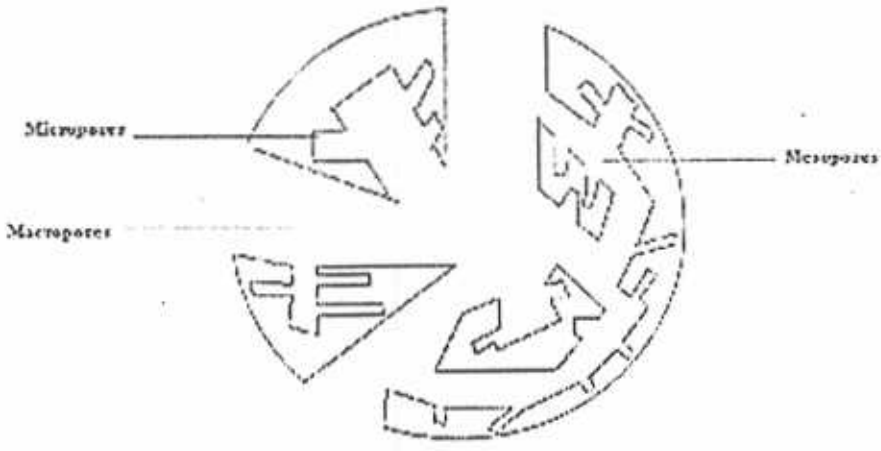
widely available in Pakistan. Converting these materials into value added product and study its use for the decontamination of water bodies is an interesting area to be explored in this investigation.

Various wastewater treatment technologies which are based on the processes of coagulation, flocculation, biodegradation, adsorption, membrane separations, ion-exchange, oxidation, oxidation, selective bio-adsorbents and biomass are in use [37-44]. All of them have advantages and drawbacks. Because of the high cost and disposal problems, many of the conventional methods for treating dye wastewater have not been applied at large scale in the textile and paper industries. There is no single process capable of adequate treatment, mainly due to the complex nature of the effluents [45, 46]. In practice, a combination of different processes is often used to achieve the desired water quality. Research has been continuously conducted in the areas of using different methods of treatment in order to improve the biodegradation of dyestuffs and minimize the sludge production [46]. Among the methods used, adsorption is a well known equilibrium separation process that effectively decontaminates water [47]. Adsorption has been found to be superior to other techniques for water re-use in terms of initial cost, flexibility and simplicity of design, ease of operation and insensitivity to toxic pollutants and also it result in the formation of harmful substances.

Amongst all the adsorbent materials proposed, activated carbon is the most popular for the removal of pollutants from wastewater [48]. The effectiveness of adsorption on commercial activated carbons (CAC) for removal of a wide variety of dyes from wastewaters has made it an ideal alternative to other expensive treatment options [49]. This capacity is mainly due to their structural characteristics. Their porous texture gives them a large surface area, and their chemical nature which can be easily modified by chemical treatment leading to increase their adsorption properties [50-61].

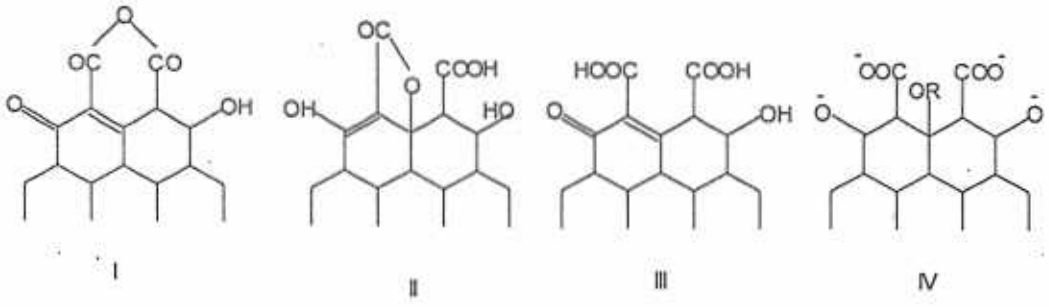
Agricultural and wood by-products are lignocellulosic and carbonaceous in nature and may offer an inexpensive and renewable additional source for the production of activated carbon. These waste materials have little or no economic value and often present a disposal problem. The raw material is carbonized to obtain the char or carbonaceous material, which is activated to yield the highly porous final product. Typically, surface areas ranging from 300- 1400m^2/g are obtained for the activated material [62]. Chemical activation proceeds under conditions that prevent the deposition of hydrocarbons on the surface. The raw material is mixed with the chemical agent, dried and calcined at temperatures up to 900 °C. Other methods are also used such as mixing of the carbonaceous materials or chars with potassium hydroxide as activating chemical, treatment of char with sulphur vapor at elevated temperatures and subsequent desulphurization with hydrogen and activation in an inert atmosphere under reduced pressure without the use of any chemical activation agent. Activated carbon particles have micropores (< 20), mesopores (20 - 500) and macropores (>500). The macropores provide a passageway to the particle's interior and to the micropores but do not contribute substantially to the particle surface area. The micropores, on the other hand, are responsible for the large surface area of activated carbon particles and are created during the activation process [63]. It is in the micro pores that adsorption largely takes place. Tsai et al. [64] prepared activated carbon from agricultural by-product and the pore structure was examined by using the scanning electron microscopy (SEM). They concluded that the shape and size of these pores vary from surface to surface and are different from each other. PastorVillegas [65] investigated the pore structure of activated carbons prepared from different precursors and characterized by mercury porosimetry and scanning electron microscopy. They reported that the pore volumes (micro, meso and macro) increase up with the increase in activation temperature, and that two main parameters are relevant to the

performance of the activated carbon namely the surface area and the pore volume or structure. The pore volume limits the size of the molecules that can be adsorbed whilst the surface area limits the amount of material which can be adsorbed, assuming a suitable molecular size. Other factors such as surface chemistry (heteroatom content), surface charge can also affect the adsorption capacity. Guo et al [25] showed that the amount of adsorption does not always increase with surface area. Besides the physical structure, the adsorption capacity is strongly influenced by the chemical nature of the surface i.e. acid-base character and also on the accessibility of the adsorbate molecules to the inner surface of the adsorbent, which depends on their size. The specific mechanisms by which the adsorption of dyes from aqueous solution on the adsorbents are still not clear because adsorption is a complicated process that depend on several electrostatic and non-electrostatic (hydrophobic) interactions.



Diagrammatic representation of pores in the carbon particle

The carbon atoms located at the surface and edges of carbon crystallites have residual valencies which make them to act as active sites. These sites show a strong tendency to chemisorb elements like oxygen, nitrogen, hydrogen, chlorine, bromine, iodine and sulfur and give rise to non-stoichimetric stable surface compounds which may be called surface complexes. Among these surface complexes, surface oxygen complexes such as carboxyls, phenols, lactones, aldehydes, ketones, quinines, hydroquinones, anhydrides or ether structures are the most common and most important [66]. It has been shown that the carbon activated at high temperature remove these complexes and drive off them in the form of CO, CO_2 and H_2O. Petrov [67] characterized the carbon and found oxygen-containing groups of acidic character (carboxyl groups, carboxyl groups in lactones-like binding, phenolic hydroxyl and carbonyl groups). Boem [68] characterized the surface groups of carbon and determined the mode of attachment with the carbon surface (I, II, III, IV). Vicente Gómez-Serrano [69] and Strelko [70] found phenolic hydroxyl, quinonic, carboxylic acid, and ether on the surface of carbon (Fig. 1.1).



I II III IV

Figure 1.1: Proposed functional groups on the surface of carbon.

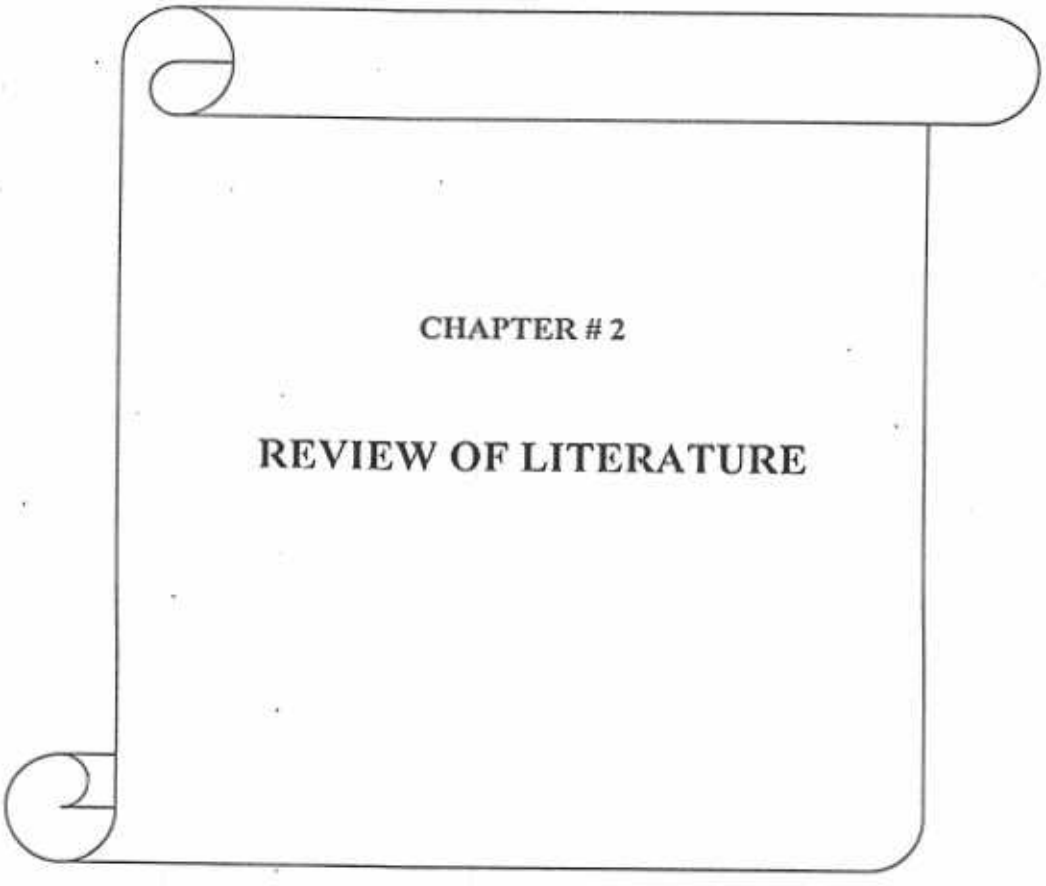
1.1. Goals of the study

Investigation of the adsorption of organic compounds from (wastewater) aqueous solutions on low cost activated carbon obtained from plant materials (including agricultural waste) and animal bones .Investigation and modeling of the kinetics and of the thermodynamics of the adsorption process.

The present study was carried with the steps.

1. To prepare carbon from different local agricultural, fast growing low cost wood wastes and the bones.
2. To activate the prepared carbon by chemical and thermal treatment.
3. To regenerate the industrial spent carbon.
4. To characterize the prepared and regenerated carbon by determination of pH, bulk density, particle size, ash contents, moisture and surface area (BET, BJH, Langmuir and DR) and pore size distribution (DR).
5. To investigate the effect of degassing temperature on the surface properties of the prepared activated and the regenerated carbons.
6. To characterize the surface of prepared and regenerated carbons for the presence of surface functional groups, using the FTIR technique.
7. To elucidate the surface morphology of the samples by using scanning electron microscopy (SEM).
8. To know the presence of inorganic contents on the surface of carbon by energy dispersive spectrophotometry (EDS).
9. To investigate the organic and in organic phases present on the surface of carbon by x-rays diffraction (XRD).

10. To study the adsorption efficiency of the samples by using dyes (acid blue 1, brilliant blue R, acid yellow 29, acid yellow 34, acid orange 7 and acid orange 10) as adsorbate which includes, equilibrium and the kinetics.
11. To calculate the thermodynamic parameters such as change in activation energy ($\Delta E^{\#}$), change in enthalpy of activation ($\Delta H^{\#}$), change in entropy of activation ($\Delta S^{\#}$) and Gibbs free energy (ΔG^{o}) for the adsorption of dyes.
12. To determine the mechanism of adsorption of dyes by applying different kinetic models like first order, Bangham and parabolic diffusion.
13. To study the dyes equilibrium adsorption by applying different available adsorption models such as Freundlich, Langmuir and DR.
14. To study the adsorption of acid blue 1 and industrial waste water treatment, by using break through technique (column method).
15. To verify the Thomas kinetic model for the column adsorption of adsorbate from aqueous solution.



CHAPTER # 2

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

A number of different low cost wood and agricultural waste materials have been utilized for the production of activated carbon. Different techniques have been used for its preparation. It is important to establish relation between characteristics of the activated carbon and its adsorption behavior which depend on the nature of adsorbate, adsorbent (precursor material) and the experimental conditions. Following is the update survey of literature on the production, characterization and adsorption properties of the activated carbon produced from the low cost wood, agricultural waste materials, spent carbon and bones.

ElHendawy [71] and Tsai [72] *et al.* prepared activated carbon from corncobs (an agricultural waste) at low (500 °C) and high (700 °C) carbonization temperature. The results show that the low carbonization temperature (500 °C) yields a poor porosity while high carbonization temperature (700 °C) enhanced the porosity. The activated carbons proved highly porous and rich in mesopores, and showed high adsorption capacity for methylene blue and Pb^{2+} ions. The samples were characterized by thermo gravimetric (TG) and scanning electron microscopy (SEM). Chang [73] *et al* also prepared activated carbon from corncob and activated by a chemical method and also thermally at 1073 and 1173 K. The experimental results revealed that the BET surface area, pore volume, and average pore diameter of the resulting activated carbon generally increases with the increase of activation temperatures. Cao *et al* [74] prepared activated carbon from corncobs by chemical (KOH) and thermal activation (450 °C and 850 °C). The results showed that carbonization temperature (78% micropores), activation time and KOH ratio highly influenced the surface area (2700 m^2/g) of the activated carbon.

Gupta *et al* [75] prepared activated carbon from bagasse fly ash and utilized it for adsorption (both kinetic and equilibrium) of Rhodamine B and methylene blue. From the kinetic data the mechanism of adsorption was derived and the equilibrium data was analyzed by Langmuir and Freundlich models. Thermodynamic parameters were calculated from the adsorption data.

Ahmedna *et al* [76] used the rice straw, rice hulls, sugarcane bagasse and pecan shells for the preparation of activated carbon by physical and chemical activation. Carbons were characterized by bulk density, ash contents, pH and surface area. The activated carbon samples were then used for color removal from aqueous solutions. Bagasse activated carbon showed a better potential than other carbon samples for the decolorization of solutions. Valix *et al* [77] also prepared activated carbons from bagasse precursor by heating at 160 °C and 900 °C. The surface areas of the samples were found to be 614 to 1433 $m^2 g^{-1}$ with pore volume of 0.45 to 1.2 nm. The activated carbon samples were then used for the adsorption of acid blue dye from which it was concluded that the adsorption of acid dye enhanced on carbon, exhibiting alkaline or positively charged surfaces.

Daud *et al* [78] studied the preparation of activated carbon from palm shell and activated at 500, 800 and 900 °C. During activation it was noted that a small amount of mesopores were developed in the initial stage but burn-off increased, a rapid development in mesopores was observed. At 900 °C activation temperature a significant amount of mesoropores were developed. Guo and Lua [79] prepared activated carbon from palm stones and studied the effects of carbonization temperature on the textural and chemical properties of activated carbons. At high activation temperature porous structure was developed, however at high temperature the pore narrowing also occurred. They found that the temperature has a insignificant effect on the inorganic components of the carbons, but the organic surface

functional groups were removed significantly. Ashri *et al* [80] also prepared the activated carbon from palm shell and then investigated the effect of activation temperature (500 - 900°C) on pore development in the carbon samples. The study showed that activated carbon prepared at high temperature had a significant amount of micropores. No clear pattern was demonstrated on the effects of carbonization temperature on the development of mesopore and macropores.

Yalcin et *al* [81] prepared activated carbons from the rice husk and characterized by density, elemental analysis, surface area and porosity. The results showed that the surface area was 480 m^2g^{-1}, pore diameter was 0.0044 μm and pore volume was 1.3652 $cm^3\ g^{-1}$. Guo [82] *et al* also prepared the active carbon with a high specific surface area (more than 3000 m^2/g) from rice husks by using potassium hydroxide (KOH) as activating agent. The effects of preparation parameters on the properties of the active carbon were also studied.

Alaya *et al* [83] studied the production of activated carbons from date palm wastes (branches, leaves and date pits) at 600-700 °C. The products were characterized by N_2 (77 K) adsorption for evaluating their surface area and pore volume. They concluded from their study that carbonization at 700 °C resulted into low surface area carbon having poor adsorption properties. They compared the porosity of the activated carbon with that produced from rice husks and barbecue and found that the later developed porosity to a lower extent, due to the inherent ash content.

Quan *et al* [84] investigated the regeneration of three granular activated carbons (GACs) exhausted with acid orange 7. The three carbons were made from coconut shells, almond nucleus and coal. The dye adsorption process was carried out in a continuous-flow adsorption column. After adsorption, the dye-saturated carbon was dried at 120 °C and then regenerated in a quartz reactor by 2450 MHz microwave (MW) irradiation at 850 W for 5 min. The

efficacy of this procedure was analyzed by determining the rates and amounts of dye adsorbed in successive adsorption–MW regeneration cycles. Effects of this regeneration on the structural properties, surface chemistry and the dye adsorption capacities of carbon samples were examined. It was found that after several adsorption–MW regeneration cycles, the adsorption rates and capacities of carbons could maintain relatively at high levels, even higher than those of virgin carbons as indicated by the dye breakthrough curves and adsorption isotherms. The improvement of carbon adsorption properties resulted from the modification of pore size distribution and surface chemistry by MW irradiation.

Rahman *et al* [85] investigated the adsorption of malachite green on activated carbon derived from rice husks by chemical and thermal treatment. They showed that the optimum carbonization temperature was 500°C. The adsorption studies were conducted with respect to contact time, concentration and adsorbent dosage of the samples. Both Langmuir and Freundlich models were found fit to describe the adsorption behavior.

Hu [86] *et al* prepared a mesoporous carbon from coconut shells, presented a cost effective method for the production of carbons with high mesopore content. The mesoporosity was substantiated by the absorption capacity for phenol, methylene blue, and erythrosine red.

Hu and Srinivasan [87] used the coconut shells and palm seeds for the preparation of activated carbons. The samples were chemically and thermally activated. They demonstrated that the thermal treatment influenced the surface area and porosity (micropores and mesopores) of the samples. The adsorption capacities of the mesoporous activated carbons were much higher than those of microporous carbons for larger adsorbate.

Hu and Srinivasan [88] prepared a high-surface-area activated carbon from the coconut shell by using KOH as a chemical activating agent. The KOH-to-shell ratio and activation

temperature were used for the condition optimization. The surface area, (2451 m^2/g) and pore volume (1.21 cm^3/g) of the carbons were determined by BET nitrogen adsorption. They concluded that the carbon treatment at 600 °C favored the product with good yield and high surface area.

Macedo *et al* [89] prepared activated carbon from coconut coir dust and used it for the adsorption of methylene blue (MB) and remazol yellow (RY) from aqueous solutions. First order, second-order and intraparticle diffusion models were applied to the kinetic adsorption data. The results for both dyes suggested that the adsorption of MB and RY was a diffusion controlled process. Kunwar et al [90] prepared activated carbon from coconut shell fibers which was then utilized for the removal of *methylene blue* and *methyl orange* from wastewater. The results indicated that the Freundlich model fitted best to the adsorption data as compared to the Langmuir model. Kinetic studies followed the first order rate equation. It was concluded that the methyl orange adsorption occurred through film diffusion both at low and higher concentrations while methylene blue adsorption occured through film diffusion at low concentration and partial diffusion at high concentration.

Tay *et al* [91] prepared activated carbon from sewage sludge using coconut husks as an additive. The preparation conditions involved the heating temperature, dwell time, heating rate and coconut husk to sewage sludge mixing ratio. Surface area, pore size distribution and the production yield of the final products were determined and compared. Experimental results revealed that heating temperature had a considerable impact on the surface area and pore size distribution whereas dwell time and heating rate performed comparatively insignificantly. The increasing mixing ratio of coconut husk to sewage sludge increased the microporosity of the final product. The surface area was determined by BET nitrogen

adsorption. Heating temperature of 500 °C and mixing ratio (1:4) of coconut husk to sewage sludge were found to be most cost effective.

Senthilkumaar *et al* [92] prepared the activated carbon from coconut tree carbon and Jute fiber and then studied the adsorption of reactive red dye (RR) on the prepared carbon sample. Adsorption studies were carried out at different initial dye concentrations, initial solution pH and adsorbent doses. Adsorption kinetics followed the pseudo-second order and diffusion models. The adsorption isotherm data also fitted well to Langmuir equation and the adsorption capacity were found to be 181.9 and 200 mg/g.

Evans *et al* [93] studied the preparation of activated carbon from macadamia nut shells. Initially the precursors were subjected to elevated temperatures (400-900 °C). Pore size distribution studies (micropore volumes exceeding 1.0 cm^3 g^{-1}) were also carried out for 750 and 800 °C activated samples. A high yield of microporous carbon was obtained at 540 °C activation temperature.

Ahmadpour and Do [94] prepared different activated carbons from Macadamia nutshell by chemical activation with potassium hydroxide and zinc chloride. The influence of process variables on the carbons pore structure was studied in order to optimize the conditions. The most important parameter in chemical activation with both chemical agents was found to be the impregnation ratio. Carbonization temperature was the second important variable which had significant effect on pore volume.

Toles *et al* [95] carbonized the nutshells into activated carbon. For oxidation the prepared carbon was treated with acid solutions. The oxidized carbon surface was characterized for surface functional groups like carbonyl, phenols, lactones and carboxyl by different techniques. The results showed that acid treatment has introduced a sufficient

amount of surface functional groups into the carbon surface. The effect of functional groups on the uptake of copper was also investigated in the study.

Lua *et al* [96] prepared activated carbons from pistachio-nut shells by thermal activation under nitrogen flow and under vacuum. It was found that under vacuum conditions, the characteristics of the activated carbons were better than those under nitrogen atmosphere. The activation temperature and the activation hold time were found to be important parameters that influence the characteristics of the activated carbon. Activation temperature 400 °C and 1 hour hold time were found as optimum condition for the production of high surface area and micropore volume. The BET surface areas of the carbons activated under nitrogen atmosphere and vacuum conditions were 1635.37 and 1647.16 m^2 / g, respectively. Fourier transform infrared (FTIR) spectra were used to detect the changes in the surface functional groups of the samples.

Guzel and Uzun [97] prepared activated carbons from sour cherry pits and was chemically activated. From the surface area studied it was found that four hours activation time was suitable for the production of porous structure. The prepared activated carbon was then utilized for the adsorption studies of p-nitrophenol, methylene blue, orange-II and victoria blue from aqueous solution at 298 K. They found a greater removal efficiency of the prepared activated carbon.

Mishera [98] prepared activated carbon from cherry pits and then used it for the removal of color and other organic compounds from industrial effluents. The same carbon was also used in column and concluded that the removal efficiency of the prepared carbon was more in columns.

Mohamed *et al* [99] used sawdust as a source material for the preparation of activated carbons by acid solution activation. Textural properties of these carbons were determined by

nitrogen adsorption at 77K. The nitrogen adsorption isotherms were interpreted by BET equation. The nature of carbon surface functionalities were determined by FTIR spectroscopy and the results showed that the carbon surface acquired acidic character with carboxylic, lactonic and phenolic groups. The removal of contaminants from aqueous solution at 298K on these carbons samples was also investigated. The equilibrium data was fitted well by the Langmuir isotherm.

Ismadji *et al* [100] prepare activated carbon from teak sawdust by vacuum pyrolysis. The effects of process variables such as temperature and activation time on the pore structure of activated carbons were investigated. High surface area (1150 m^2/g) and pore volume (0.43 cm^3/g) were obtained from the conditions applied for the preparation of activated carbon.

Girgis *et al* [101] prepared the activated carbon from cotton stalks at 383 K and 773 K. High adsorbing carbons with well developed mesoporosity were obtained. Porosity was determined by analysis of N_2 (77 K) adsorption isotherms.

Santhy and Selvapathy [102] studied the removal efficiency of reactive dyes on activated carbon prepared from coir pith. Batch experiments showed that the adsorption of dyes increased with an increase in contact time and carbon dose. Adsorption of dyes was found to follow the Freundlich model. Lagergren rate constants of the dyes were found to be in the range of 1.77×10^{-2}–2.69×10^{-2} min^{-1}.

Kavitha and Namasivayam [103] studied the kinetics of methylene blue on coir pith carbon prepared from coconut husk. The adsorption studies were carried out with respect to agitation time, dye concentration, adsorbent dose, pH and adsorption temperature. Lagergren first-order, second-order, intra particle diffusion and Bangham models were used to fit the experimental kinetics data. Equilibrium data was analyzed by Langmuir, Freundlich and DR

isotherms. The equilibrium time was found to be 30 and 60 min for 10 and 20 mg/L and 100 min for 30, 40 mg/L dye concentrations, respectively. The change in entropy and heat of adsorption of coir pith carbon was estimated as 117.20 J/mol/K and 30.88 kJ/mol respectively. The high negative value of change in Gibbs free energy showed a feasible and spontaneous adsorption of methylene blue on coir pith carbon.

Sudaryanto *et al* [104] prepared a high surface area activated carbon from cassava peel (agricultural waste) by chemical and thermal activation. The preparation process consist of potassium hydroxide impregnation followed by carbonization at 450–750 °C for 1–3 h. Results revealed that the activation time have no significant effect on the pore structure of activated carbon, however, the pore characteristic of carbon changes significantly with carbonization temperature. The maximum surface area and pore volume were obtained at impregnation ratio of 5:2 and carbonization temperature of 750 °C.

Olivares-Marín *et al* [105] used cherry stones (CS) as a precursor for the preparation of activated carbon by chemical and thermal means. Information on the surface functional groups and structures of the carbons were provided by FT-IR spectroscopy. The BET surface area of the prepared carbon was 1971 $m^2 g^{-1}$. The effect of carbonization temperature on the porous structure of activated carbon showed that the surface area increases with the carbonization temperature.

Martínez *et al* [106] prepare activated carbon from agricultural wastes such as olive stone, acorn, pecan, walnut shells, and stone fruits by treatment with 50 and 75% (w/w) of KOH. The two types of activated carbons obtained were characterized by scanning electron microscopy (SEM). Good quality carbons were obtained with 75% KOH in both the cases. The adsorption of iodine was carried out for the determination of its adsorptive capacity. olive pits carbon was found with greater adsorption capacity as compared to other samples.

The walnut shells activated carbon was found to be more macrocroporous structure than olive pits.

Sanchez *et al* [107] prepared activated carbon from the wood of *Quercus agrifolia* and walnut shells and activated at three different activation temperatures. The samples were characterized (micro and mesoporosity) by nitrogen adsorption. It was concluded that the initial properties of precursors have strongly influenced the activation process under similar experimental condition.

Badie *et al* [108] used the dried peanut hulls to get activated carbon by chemical (KOH) and thermal activation. Products were characterized by the N_2 at 77 K and methylene blue (MB) adsorption. Simple carbonization at 700 – 900 °C showed high surface area and greater removal of MB. On the other hand the sample activated with KOH resulted into low surface area, greater mesoporosity but poor removal efficiency of MB.

Gómez-Serrano *et al* [109] used chestnut wood as a precursor for the production of activated carbon at 300 - 600 °C. The products obtained were characterized by N_2 adsorption at −196 °C and found microporous carbon. Results showed that the surface area (S_{BET}) and micropore volume (V_{mi}) increased with the increase of activation temperature (600 °C).

Erdogan *et al* [110] prepared activated carbon from waste apricot and activated by chemical and thermal methods (400–900 °C) under the N_2 atmosphere. The maximum surface area (1214 m^2/g) and micropore volume (0.355 cm^3/g) were obtained at 900 °C. The resulted activated carbons were then used for removal of Ni^{+2} ions from aqueous solution with respect to temperature and different concentrations. Adsorption parameters were determined by using Langmuir model. The results indicated that the effective uptake of Ni^{+2} was obtained by activating the carbon at 900 °C.

Kobya *et al* [111] prepared activated carbon from apricot stones and activated at 200 °C for 24 h. The activated carbon was then used for the removal of Ni^{+2} and Cu^{+2} from aqueous solutions. Batch adsorption experiments were conducted and the adsorption capacities were obtained in the order of $Ni^{+2} > Cu^{+2}$.

Corcho-Corral *et al* [112] utilized the low-cost agricultural waste (*Vitis vinifera*) for the preparation of activated carbon by chemical (H_3PO_4) and thermal (350-550 °C) treatment under the N_2 atmosphere. The carbon surface was characterized by FT-IR spectroscopy. Better developments of surface area and microporosity were obtained at 200 and 450 °C.

Zhang *et al* [113] convert agricultural and forest residues (oak wood waste, corn hulls, and corn stover) into activated carbons. Microporous activated carbons were produced by physical activation with CO_2 as the activation agent, specifically the effects of activation temperature and duration were explored. The resultant activated carbons were characterized by measuring their porosities and pore size distribution. The activated carbons produced had BET surface areas ranging from 400 to 1000 m^2/g, and ratios of micropore volume to total pore volume ranging from 0.38 to 0.66. The pore size distribution was narrow and peaked approximately at a pore diameter of 0.5 nm. Both the surface area and nature of porosity were significantly affected by the conditions of activation, the extent of which was dependent on the nature of the precursors. In general, the higher the activation temperature, the greater was the surface area and micropore volumes of the resultant activated carbon. For oak, longer the duration of activation, greater was the adsorption capacity, whereas for corn hulls and corn stover the duration of activation had negative effect on the adsorption capacity.

DelosReyes *et al* [114] obtained activated carbons from Chilean Native agricultural and forest residues through a thermal process. The products obtained had different surface areas

with low ash-content. The FTIR spectrum showed that the surface of the carbons contain oxygen groups.

Başar [115] prepared the microporous and mesoporous activated carbon (WA11Zn5) from waste apricot. The BET surface area was 1060 m^2/g with 36% micropores, 74% mesopores and 19% micropore volumes. The ability of WA11Zn5 to remove three dyes, methylene blue (MB), malachite green (MG), and crystal violet (CV), from effluent solutions was also investigated. The adsorption capacity of WA11Zn5 for different dyes was found to be in the following sequence; malachite green > methylene blue > crystal violet. Equilibrium data was analyzed by the Langmuir, Freundlich and Dubinin–Redushkevich (DR) equations.

Haimour and Emeish [116] utilized the datestone wastes for the production of activated carbon by chemical and thermal means. The effects of the activation time, activation temperature, impregnation ratio, and particle size on the yield and the adsorptive capacity towards iodine were also studied. It was found that with the increase in activation temperature the adsorption capacity of the carbon was increased.

Girgis and ElHendawy [117] used date pits as low cost agricultural by-product for the production of porous carbon. The raw material was carbonized at 300, 500 or 700 °C and surface characteristics of the products were determined by the adsorption of N_2 (77 K), iodine, phenol, and methylene blue. They found that the carbon carbonized at 300 °C was less porous, which was attributed to the contribution of the unsaturated chemical bonds initiated in the partially decomposed material. Carbons obtained at 500 and 700 °C had excellent porosity.

DiazTeran *et al* [118] prepared activated carbons from *Esparto grass* (*Stipa tenacissima*) by chemical (KOH) and heating techniques. The samples were characterized by different methods including surface area by BET, micropores by DR method, the pore size distribution

by DFT. The results suggested that the fundamental factor over adsorption was the development of porosity in carbons activated at high ratios of KOH impregnation.

Kailappan *et al* [119] produced activated carbon from *prosopis* (*Prosopis juliflora*) by chemical and thermal activation. The process variables were: activation temperature, and activation duration of heating at 600°C. The activated carbon yielded was 56.9%. The adsorption capacity of the prepared activated carbon was determined by methylene blue adsorption.

Gurses *et.al* [120] develop activated carbon from *Rosa canina* sp. seeds, characterized and then used for the removal of methylene blue from aqueous solutions. Adsorption studies were carried out at 20 °C and various initial dye concentrations (20, 40, 60, 80, and 100 mg/L) for different periods (15, 30, 60, and 120 min). The adsorption isotherm obtained for methylene blue was typically S-shaped. The shape of isotherm was believed to reflect three distinct modes of adsorption. Region 1 represents the adsorption of methylene blue mainly by ion exchange. Region 2 by polarizations of π-electrons established at cyclic parts of the previously adsorbed methylene blue molecules. Region 3, the slope of the isotherm was reduced, because adsorption then must overcome electrostatic repulsion between oncoming ions and the similarly charged solid. Adsorption in this fashion is usually complete when the surface is covered with a monolayer of methylene blue. The adsorptive characteristics of the produced active carbon were determined by porosity and BET surface area (799.2 $m^2 g^{-1}$). Structural analyses were performed by SEM–EDS techniques.

Khezami *et al* [121] prepare activated carbons from wood and its basic component like cellulose, lignin and xylan (hemicelluloses). Activation was done by simple pyrolysis under N_2 and the thermal treatment of the material impregnated with KOH (KOH-activation). The surface area was determined by BET method. The sample was used for the adsorption of

methylene blue from aqueous phase. It was shown that the Langmuir and Freundlich isotherms satisfactorily fit to the adsorption data.

Karthikeyan *et al* [122] prepared activated carbon from the wood of *Hevea Brasilinesis*. The carbon samples were then utilized for the adsorption of Cr^{+4} from aqueous solution. The effects of parameters like contact time, initial concentration and temperature were studied on the adsorption study. Increase in adsorption capacity with increase in temperature showed endothermic nature of adsorption. Thermodynamic parameters like standard Gibb's free energy ($\Delta G°$), standard enthalpy ($\Delta H°$) and standard entropy ($\Delta S°$) were evaluated. Adsorption kinetics of Cr^{+4} was analyzed by pseudo first-order and pseudo second-order models. Pseudo second-order model was found to explain the kinetics of Cr^{+4} adsorption most effectively. Intraparticle diffusion studies at different temperatures showed that the mechanism of adsorption was mainly dependent on diffusion. The rate of intraparticle diffusion, film diffusion coefficient and pore diffusion coefficient at various temperatures were also evaluated. The Langmuir and Freundlich isotherm were used to describe the adsorption equilibrium data. Langmuir isotherm showed a better fit than Freundlich isotherm in the temperature range studied.

Wu and Tseng [123] studied the preparation of activated carbon by using *fir* wood and carbonized for 1.5 h at 750 °C and then soaked in a KOH solution. During the last hour CO_2 was poured in for further activation for 0, 15, 30, and 60 min, respectively. Carbonaceous adsorbents with controllable surface area and pore structure were chemically activated (KOH). The pore properties, including BET surface area, pore volume, pore size distribution, and pore diameter of activated carbons were characterized by the *t*-plot method based on N_2 adsorption isotherms. *Fir* wood carbon activated with CO_2 gasification from 0 to 60 min exhibited a BET surface area ranging from 1371 to 2821 $m^2 g^{-1}$, with pore volume

significantly increased from 0.81 to 1.73 $m^2 g^{-1}$. Scanning electron microscopic (SEM) results showed that the surfaces have honeycomb like holes. The adsorption of methylene blue, basic brown 1, acid blue 74, *p*-nitrophenol, *p*-chlorophenol, *p*-cresol, and phenol from water on the carbons were carried out. Adsorption kinetics was in good agreement with the Elovich equation, and all equilibrium isotherms were in agreement with the Langmuir equation. These results were used to compare the Elovich parameter ($1/b$) and the adsorption quantity of the unit area (q_{mon}/S_p) of activated carbons with different CO_2 gasification durations. This work facilitated the preparation of activated carbon by effectively controlling pore structures and the adsorption performance of the activated carbon on adsorbates of different molecular forms.

Krzesińska *et al* [124] studied the preparation of activated carbon using perennial plants bamboo (*Bambusa vulgaris*) yucca (*Yucca flaccida*) by highly controlled carbonization process at 550 - 950 °C in the presence of nitrogen atmosphere. They found that at higher carbonization temperature the dimensional shrinkage and orderness in structure was greater. The samples were characterized by density, pore size distribution and surface morphology using the scanning electron microscopy.

Brown *et al* [125] produce carbon from the wood of pitch pine at 30 - 1000 °C. The chars were then characterized using density and surface area. From the comparison of these key parameters it was clearly demonstrated that good quality of carbon can be produced at maximum temperatures of 500–600 °C.

Ravikumar *et al* [126] studied the decolorization of Reactive red 3GL and Acid brown 29 from aqueous solution by adsorption technique using a hybrid adsorbent that was prepared by a mixture of carbon and flyash at 1:1 ratio. The effect of pH, temperature, particle size and time on the dye adsorption was investigated and optimized using response

surface methodology. The optimum pH, temperature, particle size and time were found to be 10.8, 59.25 °C, 0.0525 mm and 395 min, respectively, for reactive red 3GL and those for acid brown 29 were 1.4, 27.5 °C, 0.0515 mm and 285 min, respectively. Complete removal (100%) was observed for both the dyes using the hybrid adsorbent

Palit and Moulik [127] investigated the adsorption behavior of dyes on carbon surface. The results showed that the dyes does not adsorbed on the negatively charged surface. The results were analyzed in the light of Freundlich and Langmuir isotherms and the related thermodynamics parameters were evaluated.

Choy *at al* [128] studied the adsorption of three acidic dyes, Acid Blue 80 (AB80), Acid Red 114 (AR114), and Acid Yellow 117 (AY117) onto activated carbon, Filtrasorb 400. Three single-component and three binary, AB80 + AR114, AB80 + AY117, and AR114 + AY117, isotherms were determined. Four models for predicting the multi-component equilibrium sorption isotherms have been compared in order to determine the best; fit model to predict or correlate binary adsorption data. These were an extended Langmuir isotherm, a simplified model based on single-component equilibrium factors, a modified extended Langmuir isotherm with a constant interaction factor, and a modified extended Langmuir isotherm incorporating a surface coverage dependent interaction factor.

Wu *et al* [129] studied the regeneration of spent carbon from mono-sodium glutamate factory using radiation and acid-alkali chemical cleaning method. Results showed that the activated carbon saturated with pollutants could be washed away easily by flushing with chemical solution prior to irradiation.

Martin *et al* [130] produced carbon from surplus sewage sludge and then activated at 700 °C. The activated carbon produced was mainly mesoporous in nature, with a surface area of 253m^2/g and an average pore diameter of 2.3 nm. The adsorption performance of the

prepared activated carbon was checked by the adsorption of three anionic dyes in solution (CI Acid Brown 283, CI Direct Red 89 and CI Direct Black 168). The effect of molecular size of the dye on the adsorption behavior has also been discussed.

Al-degs *et al* [131] investigated the effect of carbon surface chemistry on the removal of reactive dyes from textile effluent. The removal efficiency of activated carbon towards three highly used reactive dyes (remazol reactive yellow, remazol reactive black and remazol reactive red) in the textile industry was investigated. The adsorption capacity data showed high removal ability for the three reactive dyes. The high adsorption capacity of the activated carbon was attributed to the net positive surface charge during the adsorption process, surface acidity, surface basicity, H^+ and OH^- adsorption capacities.

Chen and Changqing [132] have studied the adsorption behavior of dyes such as *crystal violet*, *bromophenol blue* and *erichrome blue black R*, from aqueous solution on various activated carbon fibers. They also studied the effect of temperature, surface area and pore size on dyes adsorption.

Moreira *et al* [133] studied the removal of dyes by using high ash char. Thermodynamics and kinetics of reactive dyes was taken into consideration. Equilibrium data were obtained using the static method with controlled agitation at temperature in the range of $30^{O}C$ to $60^{O}C$. Langmuir isotherm model was used to describe the equilibrium of adsorption and the equilibrium parameters, R_L in the range of 0 to 1 indicate favorable adsorption. The kinetic data at $30^{O}C$ to $60^{O}C$ were presented for controlled agitation at 50 rpm and constant temperature with dye concentration in the range of 10 ppm to 50 ppm. Results indicated the diffusion controlled the adsorption rate.

Mesko *et al* [134] worked out isotherms for the adsorption of basic dyes from aqueous solutions on different adsorbents. The equilibrium of adsorption of two basic dyes, *MS-300*

and *MG 400*, on activated carbon was studied at 20, 40 and 60^{O}C. The experimental equilibrium data was fitted by the Langmuir, Freundlich, Langmuir–Freundlich and Redlich Peterson models. Freundlich isotherm has shown best agreement with the equilibrium data for all dye carbon systems. Temperature slightly increased the adsorption capacity.

Tanthapanichakoon *et al* [135] carried out the liquid-phase adsorption-desorption process and ethanol regeneration efficiency of an activated carbon prepared from waste tires. Adsorption experiments revealed that the prepared activated carbon possessed a larger adsorption capacity for two reactive dyes, black 5 and red 31. It was ascertained that the prepared activated carbon exhibited less irreversible adsorption of dyes. The ethanol regeneration efficiency of the prepared activated carbon saturated with dyes was higher than the commercial activated carbon. Due to the superior liquid-phase adsorption-desorption characteristics as well as higher ethanol regeneration efficiency, the prepared activated carbon could be used for wastewater treatment, especially for adsorbing bulky adsorbates.

Albanis *et al* [136] investigated the removal of dyes from aqueous solution by adsorption column techniques. The logarithmic form of Freundlich equation was applied and was found in high linearity. The constant "K" was found to increase with affinity between adsorbent surface and adsorbate concentration.

Wilson *et al* [137] used bone charcoal for the decontamination of polluted water. The charcoal was used in batch and column experiments designed to investigate the sorption of two cationic metals Cu and Zn. The data from batch experiments fitted the Langmuir isotherm and so the theoretical maximum binding capacities were obtained. These values were compared with experimental values derived from the column experiments. The mechanisms involved in the immobilization were also investigated.

Choy *et al* [138] studied the adsorption of copper, cadmium, and zinc, onto bone char in terms of equilibrium and rate studies. Maximum sorption capacities for the metals found from the Langmuir isotherm were 0.477, 0.709, and 0.505 mmol g^{-1} bone char for cadmium, copper, and zinc ions, respectively. The kinetic experimental data was used to analyze the effect of external film boundary layer and intraparticle mass transfer resistance on the sorption process and its significance. Four methods for determining the external film transport coefficient were developed and tested; three utilized experimental data to obtain the coefficient and the fourth method was completely empirical. The three experimentally based models gave similar results and consequently similar values of the deviation error values, whereas the error values for the empirical correlation were greater than these three values. The results demonstrated that the methods for determining the film coefficient could be integrated into more complex diffusion-transport model such as film–intraparticle diffusion.

Zhou *et al* [139] described electrochemical process for the regeneration of activated carbon loaded with *p*-nitrophenol. The regeneration parameters such as current density, liquid flow rate, NaCl concentration and regeneration time were systematically investigated. Under the optimum conditions, the regeneration efficiency of AC was reached to 90% in 1.5 h, and no significant declination was observed after five-time continuous adsorption–regeneration cycles. It was confirmed that the adsorption of organic pollutants had occurred in the micropore of activated carbon. The regeneration was mainly due to the decomposition of organics by the attack of active species such as hydroxyl radicals that were generated by electrochemical oxidation. The time-space production for activated carbon regeneration was greatly improved in the investigated modified process. Then it was concluded that the regeneration process has much more potentially cost-effective for the application.

Brown *et al* [140] studied the removal of crystal violet dye solution using a non-porous, electrically conducting carbon-based adsorbent. The adsorption process was very quick (88% of equilibrium capacity was achieved within 2 min) and the adsorptive capacity of the adsorbent was very low (2 mg g^{-1}). This was due to its low surface area. The loaded carbon-based adsorbent was regenerated with respect to current density, treatment time, concentration and thickness of the adsorbent bed. Multiple adsorption and regeneration cycles indicated that there was little or no loss in adsorbent capacity on regeneration.

Sabio *et al* [141] studied the thermal regeneration of carbon, saturated with *p*-nitrophenol. Three thermal regeneration methods were tested: (1) pyrolysis, (2) pyrolyis-gasification and (3) direct gasification with air and CO_2. The results showed that the pyrolysis treatment does not completely eliminate the contaminant from the carbon and the recovery of the initial adsorption properties was low. CO_2-gasification yielded to a complete regeneration as compared to pyrolysis-gasification and direct gasification. The air-gasification produced lower regeneration properties, although direct air-gasification was 87% recovery. The results suggested that thermal regeneration could be carried out in a single step, simplifying the process and reducing the operation cost. Moreover, CO_2 was found to recover the initial carbon more than air.

Tamon *et al* [142] studied the solvent (ethanol) regeneration of spent activated carbon loaded with organic compounds, and the industrial wastewater. High regeneration efficiency was achieved except for aromatic compounds substituted by electron-donating groups. Efficient regeneration was carried out using an electron-donating solvent such as N,N-dimethylformamide, where ethanol regeneration was not effective. The solvent regeneration of carbon loaded with phenol was studied using fixed-bed runs. It was found that ethanol and toluene showed high regeneration efficiency. The column desorption of phenol was

simulated and gave good agreement with observed results. The regeneration efficiency of ethanol and toluene was 80% after five regeneration cycles.

Ania et *al* [143] studied the regeneration of activated carbon previously exhausted with phenol. For this purpose two experimental devices were used: a single mode microwave device operating at 2450 MHz and a conventional electric furnace. By employing microwave energy, the regeneration time was considerably shortened compared to conventional thermal heating. Moreover, microwave heating preserved the porous structure of the regenerated activated carbon more efficiently than treatment in a conventional device. In both cases successive regeneration cycles reduced the microporosity of the activated carbons. However, conventional heating shifted the micropore size distribution to pores of narrower sizes. The BET surface areas were also reduced significantly over the regeneration cycles. A loss of the adsorptive capacity of the carbon material was observed after six adsorption–desorption cycle in both systems. The phenol adsorption capacities decreased to a greater extent in the samples regenerated in the electric furnace.

Shende *et al* [144] studied the wet oxidative regeneration (WOR) of spent powdered activated carbon (PAC) and granular activated carbon (GAC) loaded with the reactive dyes, namely chemictive brilliant blue R and cibacron turquoise blue G. A slurry (10% w/v) of spent carbon in distilled water was oxidized by wet oxidation in the temperature range of 150 - 250 °C using oxygen partial pressures between 0.69 - 1.38 MPa in autoclave. The percent regeneration was determined from a ratio of Xe(RC)/Xe(VC), where (Xe(RC) was the equilibrium adsorption capacity of regenerated carbon and Xe(VC) was the equilibrium adsorption capacity of virgin carbon) from the initial adsorption period of 3 h. It was observed that the regeneration mainly occurred due to the oxidation of the adsorbates taking place on the surface of carbon. It was possible to regenerate the spent GAC and PAC to the

extent of more than 98% (approximately X(RC)/X(VC) > 0.98) by wet oxidation. After four consecutive cycles of adsorption and regeneration using the same stocks of GAC, carbon weight loss observed at 200 °C was about 40%. SEM studies of the regenerated carbon showed widening of the pores and loss of structure between the adjacent pores. PAC was found to be more suitable as compared with GAC for the adsorption and wet oxidative regeneration processes to treat the aqueous solution containing lower concentration of unhydrolyzed reactive dye.

Bagreev *et al* [145] studied the thermal regeneration of spent coconut shell-based activated carbon exhausted with hydrogen sulfide adsorbent in three successive adsorption/thermal regeneration cycles. The regeneration of exhausted carbon was done by heating the samples at 300°C. The observed changes in the capacity were linked to changes in surface chemistry and porosity. Heating in air atmosphere resulted in the removal of sulfur dioxide and oxidation of elemental sulfur to sulfur oxides. All sulfur from small pores was removed and the pore structure was 100% regenerated. The results showed that the capacity of the carbons to adsorb hydrogen sulfide could be regenerated to at least 30% of its initial value.

Huling *et al* [146] chemically regenerated the spent activated carbon by using Fenton mechanism pre-loaded with methyl tert-butyl ether (MTBE). Two successive regeneration cycles were performed involving iterative adsorption and oxidation processes: MTBE was adsorbed, oxidized, re-adsorbed, oxidized and finally re-adsorbed. Oxidant solutions comprised of hydrogen peroxide (H_2O_2) (1.7–2.0%) and $FeSO_4 \cdot 7H_2O$ (3 g/L) (pH 2.5) were re-circulated through the carbon column (30% bed expansion). The regeneration efficiency after two full cycles of treatment was calculated to be 91%. The regenerative cost of H_2O_2 cycle was also calculated. There was no loss of sorptive capacity. Small reductions in carbon

surface area and pore volume were detected. The lack of carbon deterioration under aggressive oxidative conditions was attributed to the oxidation of the target contaminants relative to the oxidation of carbon surfaces.

Brown *et al* [147] demonstrated the removal of atrazine using a novel carbon-based adsorbent to below 1.0 $\mu g\ l^{-1}$ and its subsequent electrochemical regeneration in a simple electrochemical cell. Effective electrochemical regeneration was achieved with a treatment time (20 min) over a number of adsorption/regeneration cycles. The results suggested that electrochemical modification of the particulate surface on electrochemical regeneration resulted in adsorptive capacities three times greater than originally achieved.

Ania *et al* [148] studied the regeneration of activated carbons used for the decontamination of water and wastewater polluted with organic compounds related to the pharmaceutical industry. The thermal heating of exhausted activated carbons was performed in a quartz reactor. The influence of the pyrolysis of saturated activated carbons on their adsorptive capacities and porous structure was evaluated. Textural characterization of the samples was carried out by helium density, N_2 and CO_2 adsorption isotherms, at −196 and 0 °C, respectively. Consecutive cycles of pyrolysis of activated carbons exhausted with phenol and salicylic acid generated a widening of the microporosity, and a decrease in the apparent BET surface areas. The adsorptive capacities for phenol retention after a series of adsorption/pyrolysis cycles were found to decrease drastically. In contrast, consecutive cycles gave higher salicylic acid adsorptive capacities, as compared to phenol. These results provided evidence of the different adsorption mechanisms of pollutants used for adsorption.

Misra *et al* [149] regenerated the granular activated carbon (GAC) loaded with trinitrotoluene (TNT) and nitrobenzene (NB) in the presence of nitrogen, oxygen, air, steam and an air-steam mixture, at varying temperatures and for different time intervals for

regeneration. The air-steam mixture proved to be the best regenerating media for the explosive-loaded GACs. The regeneration of the activated carbon was found to be above 85% for TNT and above 90% for NB loaded carbons.

Walker *et al* [150] studied the removal of acid dyes, Tectilon blue 4R, Tectilon red 2B and Tectilon orange 3G, from single component solution by adsorption on activated carbon and bone char. Results from these experiments were successfully modelled using Langmuir and Freundlich isotherm analyses. Nitrogen adsorption analysis was also undertaken and indicated that the activated carbon had a much higher specific surface than the bone char. Calculations involving the pore size distribution data indicated that only 14% of the total specific surface of the activated carbon is available for adsorption due to the high molecular area and aggregation of the dye.

Choy and McKay [151] studied the sorption of cadmium, copper and zinc from aqueous solutions onto bone char in single and binary multi-component systems. Equilibrium experimental studies were performed to determine the sorption capacity of bone char for each metal ion. The isotherm results were analyzed using single and multi-component equilibrium models. The rate of sorption of the metal ions onto bone char were studied using an agitated batch adsorber. The results of the equilibrium and rate studies were presented and discussed. A series of fixed bed column studies were performed and analyzed using a diffusion mass transport model. The experimental results showed a displacement effect for the binary metal ion breakthrough curves.

Ko *et al* [152] studied the sorption of copper and cadmium ions onto bone char in single component systems using fixed-bed column adsorber. The effects of solution flow rate, initial metal ion concentration and bone char particle size were investigated. A film-pore diffusion model was developed for the prediction of fixed-bed breakthrough curves. Further analyses

were carried out for the investigation of influence of the external mass transfer coefficient (film resistance), the effective diffusion coefficient (pore diffusion) and the solid phase loading capacity. It was found that film diffusional resistance was low and the Biot numbers were relatively high. Furthermore, constant effective pore diffusivity was not sufficient to correlate the breakthrough curves accurately and a variable dependent effective diffusivity was required. Therefore it was suggested as a surface diffusion.

Cheung *et al* [153] carried out the adsorption of cadmium ions onto bone char using a batch adsorber. The experimental data was analyzed by four sorption kinetic models, the pseudo-first order, the Ritchie second order, the modified second order and the Elovich equations, to determine the best-fit equation for the sorption of metal ions onto bone char. The best-fit equation was identified using the sum of the errors squared (*SSE*). Finally, equilibrium studies were used to evaluate the sorption capacity of bone char for cadmium ions and experimental results showed this to be 0.57 $mmol\,g^{-1}$ at an equilibrium solution concentration of 3.0 $mmol\,dm^{-3}$. Since the sorption capacity was relatively high, bone char can be considered as a suitable sorbent for the adsorption of cadmium in wastewater treatment systems.

Ko *et al* [154] studied the sorption of copper and cadmium ions in a fixed-bed column with different feed concentrations, flow rates and adsorbent particle sizes (bone char). Pilot-plant experimental studies were performed and two simplified design models, namely, the BDST model and EBRT analysis were used for the data analysis. New correlations, incorporating a time-dependent term were developed to compensate for the time required for the bed to achieve equilibrium sorption capacity. Finally, predictions of the operating lines on the EBRT plots were correlated for the two metal ion sorption systems used.

Ravikumar *et al* [155] carried out the decolorization of Reactive red 3GL and Acid brown 29 from aqueous solution by the adsorption technique on hybrid adsorbent of carbon and flyash (1:1) with respect to pH, temperature, particle size and time The optimum pH, temperature, particle size and time were found to be 10.8, 59.25 °C, 0.0525 mm, and 395 min, respectively, for reactive red 3GL and those for acid brown 29 were 1.4, 27.5 °C, 0.0515 mm and 285 min, respectively. Complete removal (100%) was observed for both the dyes using the hybrid adsorbent.

Malkoc *et al* [156] studied the adsorption efficiency of waste of a tea factory from nickel containing aqueous solutions was investigated. All experiments were conducted in fixed-bed columns. Experiments were carried out as a function of liquid flow rate (5–20 mL/min), initial Ni^{+2} concentration (50–200 mg/L), bed height (10–30 cm), pH of feed solution (2.0–5.0) and particle size (0.15–0.25 to 1.0–3.0 mm) of adsorbent. The total adsorbed quantities, equilibrium uptakes and total removal percents of Ni^{+2} related to the effluent volumes were determined by evaluating the breakthrough curves obtained at different flow rates, different inlet Ni^{+2} concentrations, different pH values, different bed height and different particle size for waste tea. The longest breakthrough time and maximum of Ni^{+2} adsorption was obtained at pH 4.0. Decrease in the particle size from 1.0–3.0 to 0.15–0.25 *mm* resulted in significant increase in the treated volume, breakthrough time and bed capacity. The results show that the column performed well at lowest flow rate. Also, column bed capacity and exhaustion time increased with increasing bed height. When the initial Ni^{+2} concentrations were increased from 50 to 200 mg/L, the corresponding adsorption bed capacity appeared to increase from 7.31 to 11.17 mg/g. The bed depth service time (BDST) model and the Thomas model were used to analyze the experimental data and the model parameters were evaluated. Good agreement of the experimental breakthrough curves with the model predictions was observed.

Summary of review of literature: This dissertation present a novel data about the characterization and regeneration of carbonization substrate produce from biotic precursors and its use for the wastewater treatment. The innovative element of the present work is given below.

1. The activated carbon was prepared at 300 °C to 1000 °C carbonization temperature from such type of precursors which were not reported earlier i.e. *Paulownia tomentosa, Populus caspica, Ailanthus altissima and Salvadora oleoides*.
2. The BET surface areas of the prepared carbons were determined and then reported.
3. The nature of carbon surface functionalities were determined by FTIR spectroscopy and the results showed that the carbon surface acquired acidic character with carboxylic, ether etc groups. The effect of activation temperature on the surface functional groups was also studied. Such trend neither reported by earlier investigator.
4. In XRD the phases on the surface of carbon were determined which were not reported earlier.
5. In EDS the % atomic carbon were determined in different activated carbon samples which reveal that with the increase in activation temperature the carbon contents increases while oxygen contents decreases which is totally new.
6. The prepared activated carbon samples were then used for removal of dyes i.e. acid blue 1, Brilliant blue R, acid yellow 29, acid yellow 34, acid orange 7 and acid orange 10 for the present study and was used for the first time and not reported earlier.
7. Adsorption kinetics studies were carried out at 10 °C and 45 °C and various initial dye concentrations for different periods (in seconds) were used which are totally innovative.
8. Different kinetic equations such as first order, Bangham and parabolic diffusion law for the derivation of various kinetics constants. Thermodynamic parameters like standard Gibb's free energy ($\Delta G°$), standard enthalpy ($\Delta H°$) and standard entropy ($\Delta S°$) were evaluated from the innovative data.
9. Equilibrium data was analyzed by Freundlich, Langmuir and DR isotherms.
10. The spent carbon collected from the ***FUJI Corn complex Nowshera*** was regenerated and then the adsorption properties were investigated which was not regenerated earlier.

CHAPTER # 3

MATERIAL AND METHODS

3. MATERIAL AND METHODS

3.1. Adsorbent

3.1.1. Preparation of carbon

The source materials used were of the wood of plants are given in table 3.4 and Animal bones were collected and heated continuously for 8 hours on a flame burner in a specially designed iron container with an outlet for the emission of volatile matter. Carbon obtained (about half of the mass of wood used) was cooled in the container and ground with the help of pestle and mortar and screened with US standards mesh 150-180 μ m. It was then treated with 0.5 M aqueous solution of KOH for 24 hours with occasional stirring. The mixture was then filtered and washed with double distilled water for the complete removal of basicity. The carbon was then leached with standard 0.2N nitric acid and hydrochloric acid solutions in the ratio of 1:1, prepared from concentrated nitric acid and hydrochloric acid (70% and 36%, Merck respectively) and allowed to stand for 24 hours at room temperature with regular mixing. It was then filtered and washed with double distilled water until free from Cl^- and NO_3^- ions. The carbon thus obtained was then air-dried in an oven at 105 ± 2°C. This treated carbon was then extracted with n-hexane for two hours in a soxhlet extractor and allowed to dry for 8 hours in a vacuum oven. The sample was then degassed by placing in silica (SiO_2) tubes and heated at 400 and 800 °C in a tube furnace (FS. 215 Gallenkamp England) with a vacuum facility. The samples thus obtained were allowed to cool and stored under nitrogen atmosphere. The schematic diagram of the preparation of activated carbon is given in Fig. 3.7.

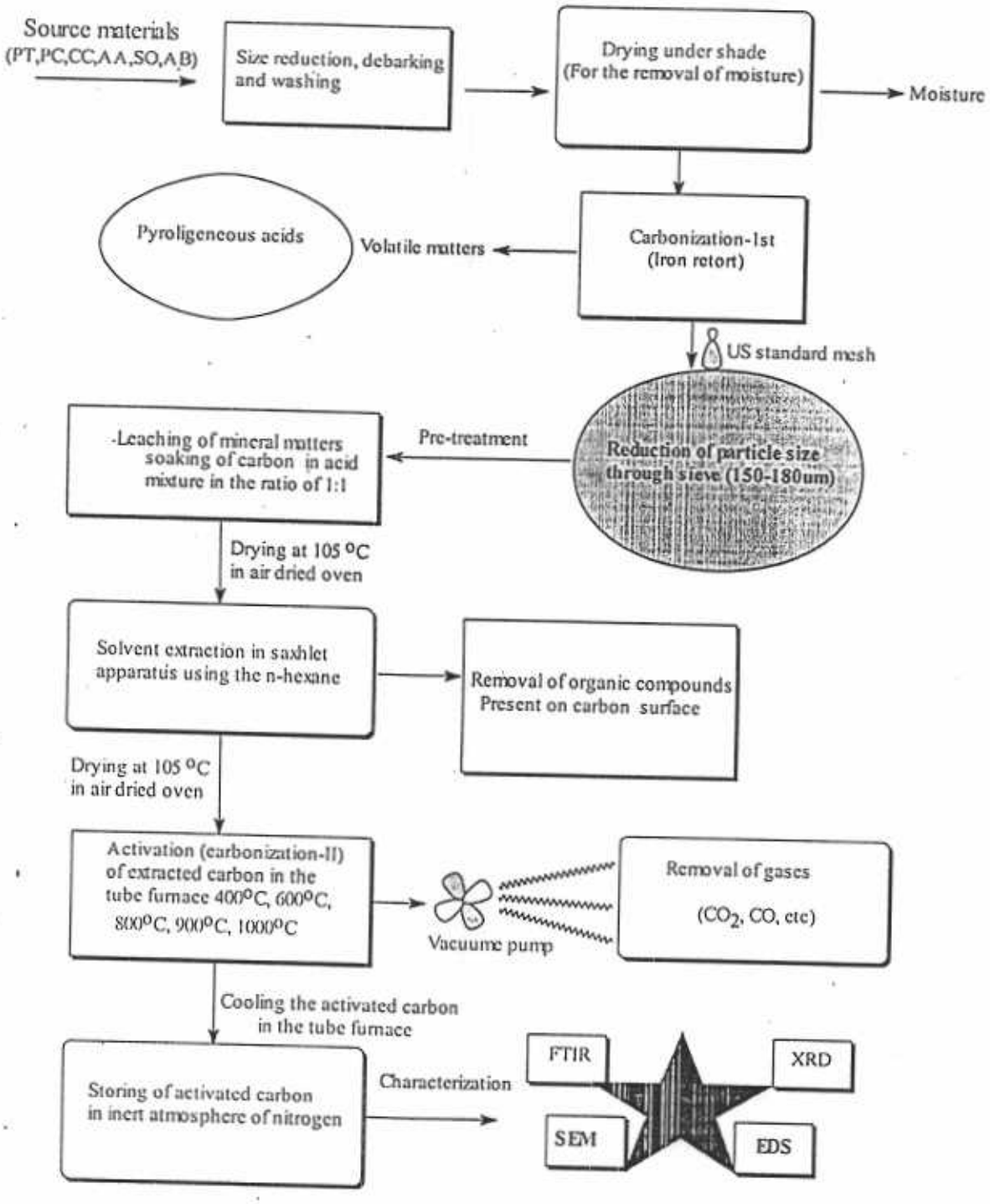


Figure-3.7: Preparation of activated carbon from source materials

3.1.2. Regeneration of spent carbon

Spent carbon in slurry form collected from Fuji corn complex was soaked in double distilled water for 24 hours and then dried at 100 °C ± 1 °C in an oven. The carbon when cooled, was ground with the help of pestle and mortar and screened with US standards mesh 150-180 *μm*. The meshed carbon was then treated with standard 0.2N nitric acid and hydrochloric acid solutions in the ratio of 1:1, prepared from concentrated nitric acid and hydrochloric acid (70% and 36%, Merck respectively) and allowed to stand for 24 hours at room temperature with regular mixing. It was then filtered and washed with double distilled water until free from Cl^- and NO_3^- ions. The carbon thus obtained was air-dried in an oven at 105 ± 2°C. This treated carbon was then extracted with n-hexane for two hours in a soxhlet extractor and allowed to dry for 8 hours in a vacuum oven. The sample was then subjected to thermal treatment by taking it in a silica tube opened at both ends, and placed in a tube furnace (FS. 215 Gallenkamp England) at 300 – 1000 °C, such that at the one end air was introduced at low pressure for oxidation and at the other end the combustible matter was emitted. The carbon was then allowed to cool and then transferred to a degassing silica tube having one end closed and the other attached to a vacuum. The degassing was done at 300 - 1000 °C in a tube furnace for one hour. The activated carbon samples were stored under nitrogen atmosphere. The regeneration layout is given in Figure-3.8 and 3.9.

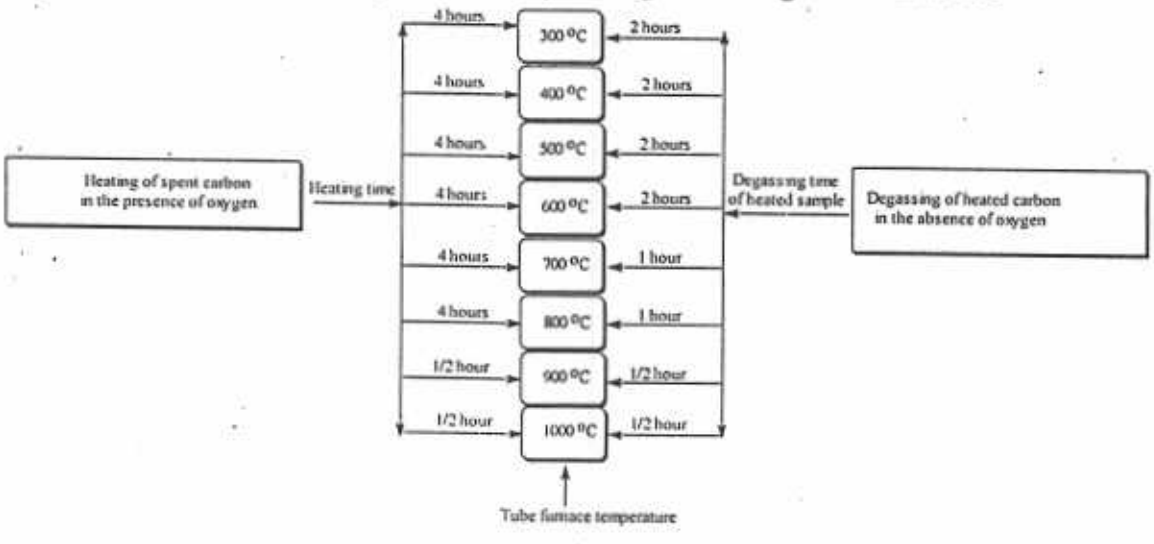


Figure-3.8: Thermal regeneration of spent carbon

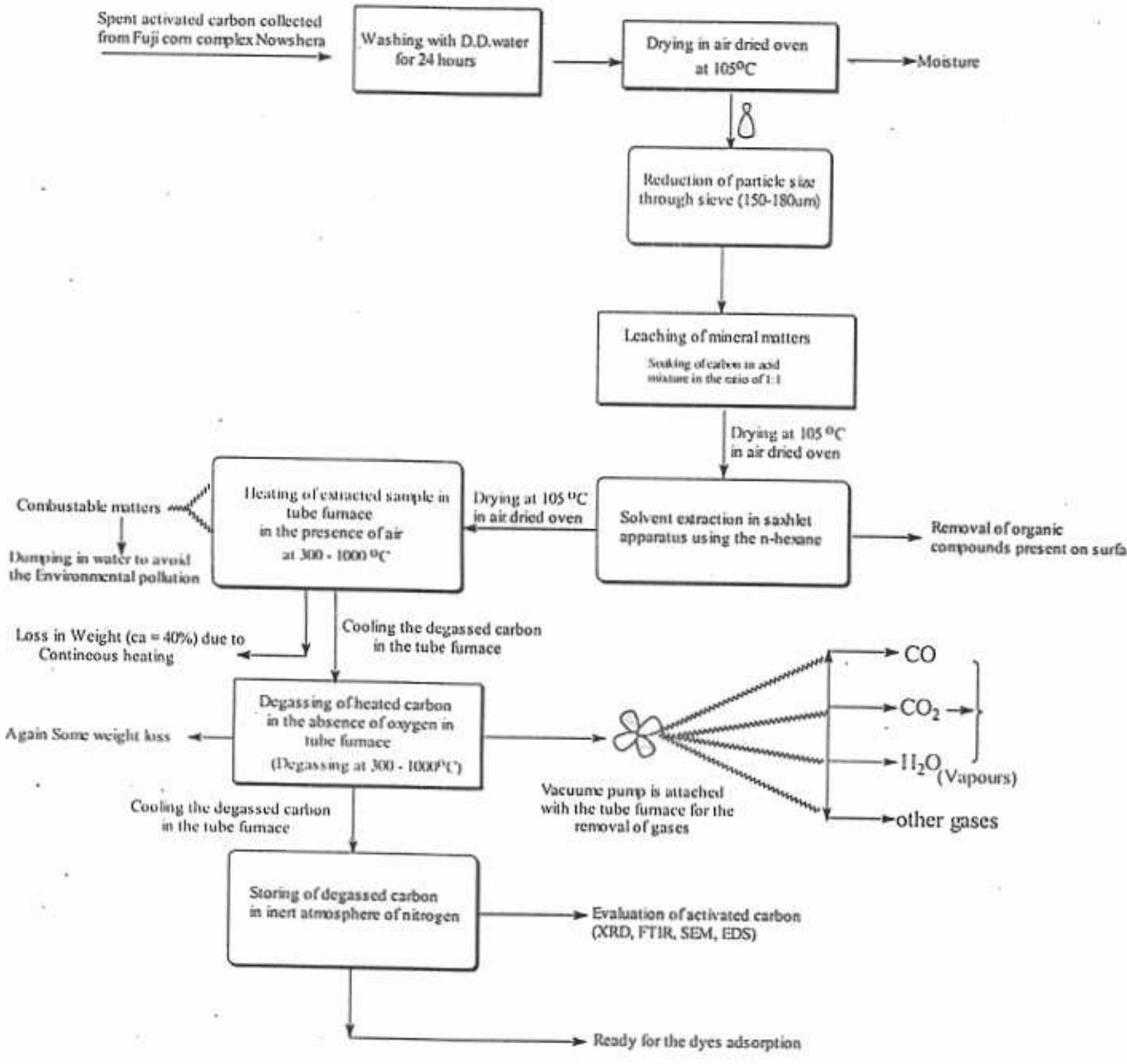


Figure-3. 9: Schematic representation for the regeneration of spent carbon

3.1.3 Characterization of adsorbent [158]

3.1.3.1 pH

One gram of the activated carbon sample was taken in a 100 cm^3 beaker and added 50 cm^3 of freshly boiled and cooled to 20°C CO_2 free double distilled water. The suspension was uniformly mixed and pH of the suspension was measured by pH meter with combined glass electrode.

3.1.3.2. Moisture contents

One gram of carbon sample was taken in a china dish and covered with a watch glass and then heated in a vacuum oven at 105 ± 2°C for two hours. The china dish having the carbon contents was cooled in a desicator and weighed. The procedure was repeated three times for the same samples until a constant equilibrium weight was attained. The percent weight loss was then calculated as percent free moisture.

$$\text{Moisture (\%)} = \frac{\text{Weight loss during heating}}{\text{weight of sample}} \times 100 \qquad (1)$$

3.1.3.3. Ash contents

One gram of carbon sample was taken in a porcelain crucible and ignited at 600 °C in a Muffle furnace with the door partially open, to provide good circulation of air until the carbon has been completely burned. After ignition the crucible was allowed to cool in the furnace and then transferred to a desiccator. Weight of the cooled crucible was then determined. The procedure was repeated (mostly three times) until a constant equilibrium weight was obtained. The percent weight loss was then calculated.

$$\text{Ash content (\%)} = \frac{\text{weight of ash}}{\text{weight of sample}} \cdot 100 \qquad (2)$$

3.1.3.4. Bulk density

250 cm^3 graduated cylinder containing water and one gram of carbon sample was weighed. The cylinder and the contents were avoided from any agitation before weighing. The apparent density was calculated by dividing the weight of the carbon in gram by the volume of sample in cm^3.

3.1.3.5. Surface area

BET-N_2 adsorption experiments were carried out manometrically at -196 °C using Quantachrome NOVA 2200 surface area and pore size analyzer. Surface area was obtained by applying the standard BET equation to the adsorption data in the relative pressure (P/P_o) range: 0.05 - 0.85. The values of 0.81 g cm^{-3} and 16.2×10^{-20} m^2 were used for the density of liquid nitrogen and the molecular area of adsorbate nitrogen at -196 °C, respectively. The pore size distribution was determined by DR method using the NovaWin2 data analysis software [159].

3.1.3.6. X-rays diffraction (XRD)

X-ray diffractometer (Rigaku) was used to record X-rays intensities scattered from the examined carbon samples. Cu K_α radiation (35 KV, 20 mA) was used as an X-ray source. Samples were packed into a rectangular cavity in an aluminum holder and scanned in a step-scan mode (0.05°/step) over the angular range of 7-30° (2θ). The observed intensity curve was obtained in arbitrary unit (CPS). The sample spectra were analyzed with the help of origin 50 XRD computer soft ware.

3.1.3.7. FTIR

Transmission infrared spectra of the carbon samples were obtained by using 8201PC Shimadzu Fourier Transform Infrared Spectrophotometer along with FTCOM-1 computer control disc unit. The alkali halide (KBr) pellet technique was used. Potassium bromide (Spectrosol BDH), was well dried and stored in a vacuum desiccator before use. The sample was ground and vacuum dried (110°C and 10 torr). Various ratios of carbon and potassium bromide were tried, until spectrum with an acceptable resolution was obtained. The test showed that the ratio of carbon to potassium bromide was best at 1:1 (w:w). In the procedure the carbon sample of approximately 3-5 mg was correctly weighed and then mixed with potassium bromide. This mixture was finely pulverized in porcelain container after which the pellet of weighing 70±2 mg was hard-pressed in a 13 mm die for 4-5 minutes under a load of 10 tons. The resulting pellet was 0.5mm thick. Since potassium bromide is hygroscopic, the pellet was dried in a vacuum oven (110°C, 10 torr). It was found that drying the pellet for 12 hours removed all detectable traces of water. The pellet was dried overnight and kept in a vacuum desicator to keep away from any moisture absorption. The IR absorption bands of the samples were obtained in the region of 500-4500 cm^{-1}.

3.1.3.8. SEM

Scanning electron micrographs of the samples were obtained by mounting the sample on aluminum discs (1 cm × 0.25 cm) and by using scanning electron microscope (SEM-Model-JSM-5910, Japan JEOL) with energy dispersive spectrum (EDS -INCA 200 Oxford Instruments) for elemental analysis.

3.2. Adsorbate

3.2.1. Dyes

The adsorbates used were triphenylmethane and azo dyes, supplied by *Sigma-Aldrich (Milwaukee, USA)*. The stock solutions of the dyes were prepared from which the standard working solutions were prepared in doubly distilled water. The chemical structure and trade name used of each dye is shown below (A-F).

A. Acid blue 1

Catalogue No.	=	19, 821,
Dye contents	=	50%,
Formula weight	=	566.68
$\lambda_{max.}$	=	635nm
.pKa	=	1.995×10^{-8}

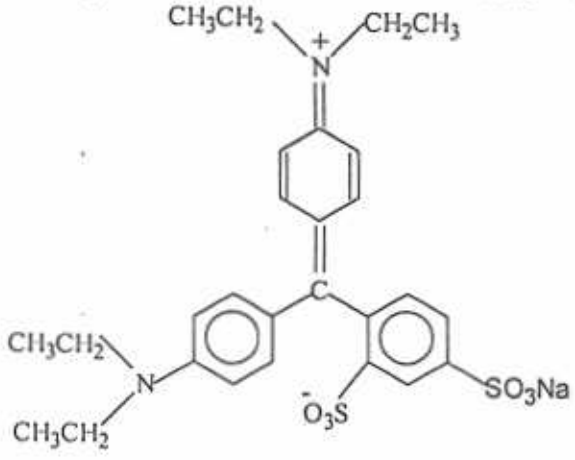


Figure-3.1: Chemical structure of acid blue 1

B. Brilliant blue R

Catalogue No.	=	37,920
Dye contents	=	50%,
Formula weight	=	825.99
$\lambda_{max.}$	=	588 *nm*
pKa	=	7.94×10^{-7}

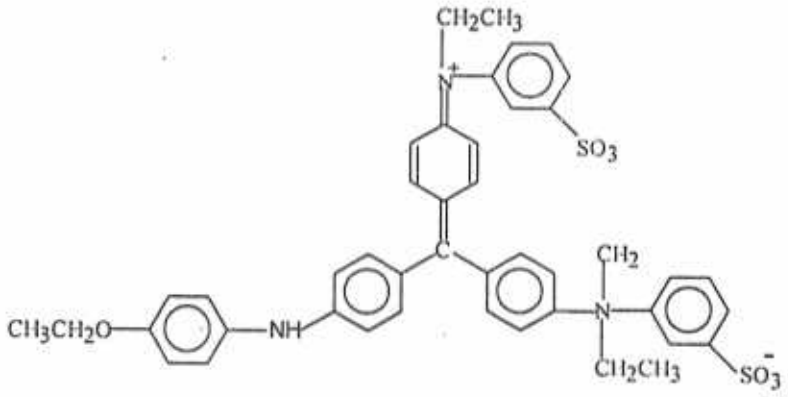


Figure-3.2. Chemical structure of Brilliant blue R

C. Acid yellow 29

Catalogue No.	=	21.036-6
Dye contents	=	60%
Formula weight	=	569.98
λ_{max}	=	409 *nm*
pKa	=	2.82×10^{-7}

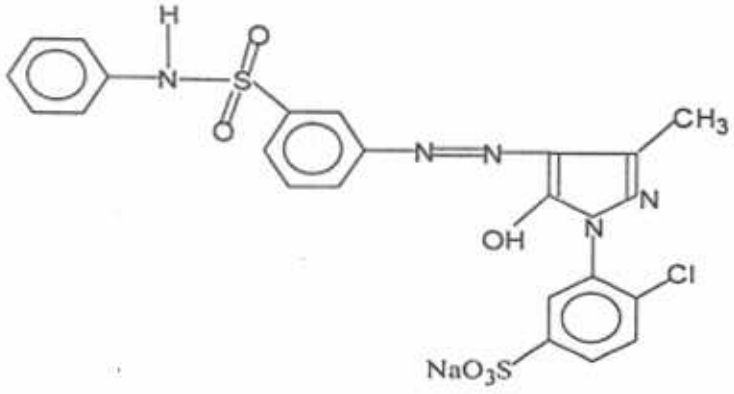


Figure-3.3: Chemical structure of acid yellow 29

D. Acid yellow 34

Catalogue No.	=	20, 200-2
Dye contents	=	75%,
Formula weight	=	414.81
λ_{max}	=	408 *nm*
pKa	=	5.01×10^{-8}

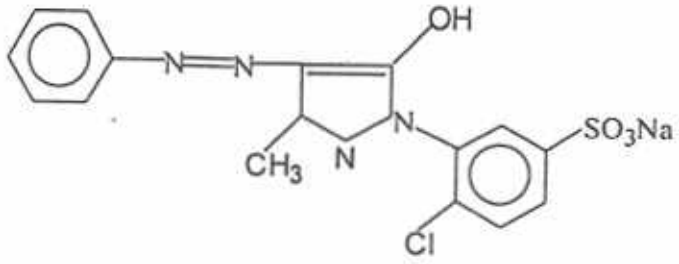


Figure-3.4: Chemical structure of acid yellow 34

E. Acid orange 7

Catalogue No.	=	19, 523-5
Dye contents	=	90%,
Formula weight	=	350.33
λ_{max}	=	483 *nm*
pKa	=	7.94×10^{-9}

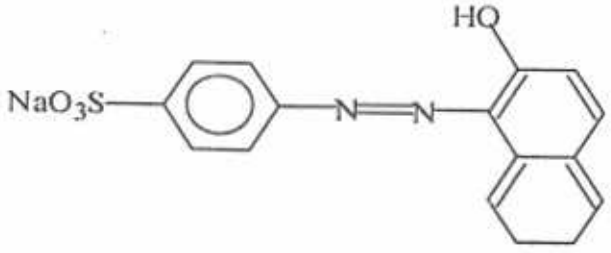


Figure-3.5: Chemical structure of acid orange 7

F. Acid blue orange 10

Catalogue No.	=	86, 128-6
Dye contents	=	90%,
Formula weight	=	452.38
λ_{max}	=	475 *nm*
pKa	=	5.62×10^{-7}

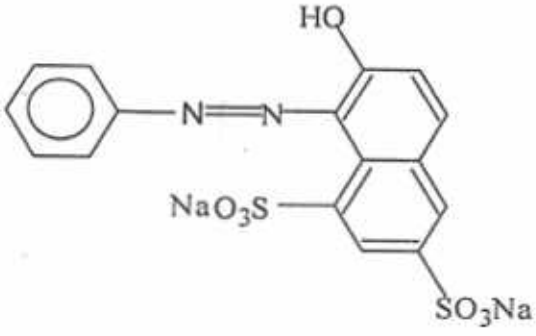


Figure-3.6: Chemical structure of acid orange 10

3.3. Adsorption studies

3.3.1. Equilibrium time

0.2g of carbon sample was taken in a series of seven reagent bottles and 20cm^3 of dye solution was added to each. Two different initial concentration of the dye were taken for each carbon sample (Table 3.1). The contents of the bottles were shaken in thermostated water bath shakers at 25°C (Gallenkamp Brit. Pat. No. 882942) for different time period of 0.5, 1, 2, 4, 6 and 8 hour using. The pH was noted before and after the shaking period with pH meter. The slurry in each flask was filtered through ordinary filter paper, discarding the first 5 cm^3 portion of the filtrate. The clear filtrate was then analyzed for the residual concentration of dye contents by uv-visible spectrophotometer. Blank determinations were performed under similar experimental conditions. The amount of dye adsorbed (D_Φ, $mol.g^{-1}$) was calculated [160].

$$D_\phi = \frac{D_\circ - D_\sigma}{W} V \qquad (3)$$

Where D_o and D_σ are the concentration of dye in solution (mol.dm-3) at t=0 and t=t respectively, V is the volume of solution and W is the weight of carbon.

Table 3.1 Initial concentration of dyes for the equilibrium time on carbon samples

Carbon sample	Initial concentration of the dyes ($mol.dm^{-3} \times 10^{-5}$)											
	Acid blue 1		Brilliant blue R		Acid yellow 34		Acid yellow 29		Acid orange 7		Acid orange 10	
Paulownia tomentosa (PT)	3.000	6.000	2.000	4.000	3.000	6.000	4.000	8.000	2.000	4.000	2.000	4.000
Populas caspica (PC)	3.000	6.000	2.000	4.000	3.000	6.000	4.000	8.000	2.000	4.000	2.000	4.000
Corn cobs (CC)	3.000	6.000	2.000	4.000	3.000	6.000	4.000	8.000	2.000	4.000	2.000	4.000
Allanthus altissima(AA)	3.000	6.000	2.000	4.000	4.000	8.000	4.000	8.000	2.000	4.000	2.000	4.000
Salvadora oleoides (SO)	4.500	9.000	12.25	24.50	15.00	30.00	20.00	40.00	20.00	40.00	10.00	20.00
Animal bones (ABC)	4.500	9.000	10.00	20.00	20.00	40.00	20.00	40.00	20.00	40.00	20.00	40.00
Regenerated (RG)	4.500	9.000	8.250	16.50	30.00	60.00	20.00	40.00	20.00	40.00	20.00	40.00

3.3.2. Kinetic study

0.2g carbon sample was taken in syringe fitted with 0.2μm filter paper adopter (Hamilton CO.; Reno Nevada) and 20cm^3 of dye solution of initial concentration as shown in Table 3.3 was added to the syringe. The contents of the syringe were shaken at 10°C and 45°C for the duration of 5, 10, 15, 20, 25 and 30 seconds respectively. The slurry was filtered through the same syringe. pH was noted before and after filtration with pH meter. The clear filtrate was then analyzed for the residual concentration of dye contents by uv-visible spectrophotometer. The amount of dye adsorbed (D_Φ. $mol.g^{-1}$) was then calculated.

Table 3.2 Initial concentration of dyes for the adsorption kinetics on carbon samples

Carbon sample	Initial concentration of the dyes ($mol.dm^{-3} \times 10^{-5}$)					
	Acid blue 1	Brilliant blue R	Acid yellow 34	Acid yellow 29	Acid orange 7	Acid orange 10
Paulownia tomentosa (PT)	2.000	3.000	3.000	3.000	3.000	2.000
Populas caspica (PC)	2.000	3.000	3.000	3.000	3.000	2.000
Corn cobs (CC)	2.000	3.000	3.000	3.000	3.000	2.000
Ailanthus altissima(AA)	2.000	3.000	3.000	3.000	3.000	2.000
Salvadora oleoides (SO)	1.100	7.200	10.00	8.000	8.200	4.800
Animal bones (ABC)	3.160	7.200	10.00	20.00	10.00	6.000
Regenerated (RG)	1.550	6.500	8.000	26.00	18.00	4.800

3.3.3. Adsorption Isotherm

20cm^3 of dye solution of different concentration (Table 3.3) were taken in a series of reagent bottles each containing 0.2g of carbon. The bottles were then shaken in thermostated water bath shaker 10 °C and 45 °C for 2 hour equilibrium time. The slurries were then filtered through ordinary filter paper by discarding the first 5 cm^3 portion of the filtrate. The filtrate was then analyzed for the dye concentration using uv-vis. spectrophotometer.

Table 3.3 Initial concentration of dyes for adsorption isotherm on carbon samples

Carbon sample	Initial concentration of dyes ($mol.dm^{-3}$)					
	Acid blue 1	Brilliant blue R	Acid yellow 34	Acid yellow 29	Acid orange 7	Acid orange 10
Paulownia tomentosa (PT)	$3.0 - 23 \times 10^{-6}$	$1.00\text{-}4.5\times10^{-5}$	$1.0 - 4.1\times10^{-4}$	$1.0 - 4.6\times10^{-4}$	$1.0 - 4.6\times10^{-4}$	$1.0 - 4.6\times10^{-4}$
Populas caspica (PC)	$3.0 - 23 \times 10^{-6}$	$1.00\text{-}4.5\times10^{-5}$	$1.0 - 4.1\times10^{-4}$	$1.0 - 4.6\times10^{-4}$	$1.0 - 4.6\times10^{-4}$	$1.0 - 4.6\times10^{-4}$
Corn cobs (CC)	$3.0 - 23 \times 10^{-6}$	$1.00\text{-}4.5\times10^{-5}$	$1.0 - 4.1\times10^{-4}$	$1.0 - 4.6\times10^{-4}$	$1.0 - 4.6\times10^{-4}$	$1.0 - 4.6\times10^{-4}$
Ailanthus altissima(AA)	$3.0 - 23 \times 10^{-6}$	$1.00\text{-}4.5\times10^{-5}$	$1.0 - 4.1\times10^{-4}$	$1.0 - 4.6\times10^{-4}$	$1.0 - 4.6\times10^{-4}$	$1.0 - 4.6\times10^{-4}$
Salvadora oleoides (SO)	$1.0 - 10\times 10^{-5}$	$24 - 52 \times10^{-5}$	$16 - 56\times10^{-5}$	$8.0 - 26 \times10^{-5}$	$6 - 27 \times10^{-5}$	$3 - 17 \times10^{-5}$
Animal bones (ABC)	$4.0 - 18\times 10^{-5}$	$5 - 26 \times 10^{-5}$	$10 - 100\times10^{-5}$	$32 - 60 \times10^{-5}$	$10 - 100\times10^{-5}$	$5 - 40 \times10^{-5}$
Regenerated (RG)	$1.0 - 24\times 10^{-5}$	$11\text{-}34 \times 10^{-5}$	$50 - 120\times10^{-5}$	$32 - 68 \times10^{-5}$	$10 - 70 \times10^{-5}$	$5 - 40 \times10^{-5}$

3.3.4. Waste water treatment (column study)

Continuous adsorption experiments were performed by using a column packed with the activated carbon. Glass columns with a glass disc having pores of 5mm diameter, fixed at the bottom of each for supporting the ordinary filter paper, were designed. The column was used for removal of dye in solution and the heavy metals from the industrial effluents of Omar glass industry in Peshawar.

The wastewater sample was collected from Omar glass industry in clean polyethylene bottle. The wastewater sample was first filtered for the removal of the suspended particles through ordinary filter paper by discarding the first 5ml. The filtrate was adjusted to pH 5.5 by the drop wise addition of 0.01M $HCl:HNO_3$ (1:1) solution, and analyzed for Ni^{+2}, Zn^{+2} and Cu^{+2} by atomic absorption spectrometry. The working solution of acid blue 1 (1.0×10^{-5} $mol.dm^3$) was prepared from the stock solution. One of the column was packed with 4g of carbon activated at 400 ^{0}C and the other with carbon activated at 800 °C. Dye solution and the industrial waste water was passed through the columns at the flow rate of 5ml min^{-1}. The outflow samples were then collected after each 5 minutes up to 90 minutes total time, and analyzed for their residual concentration of the metal ions.

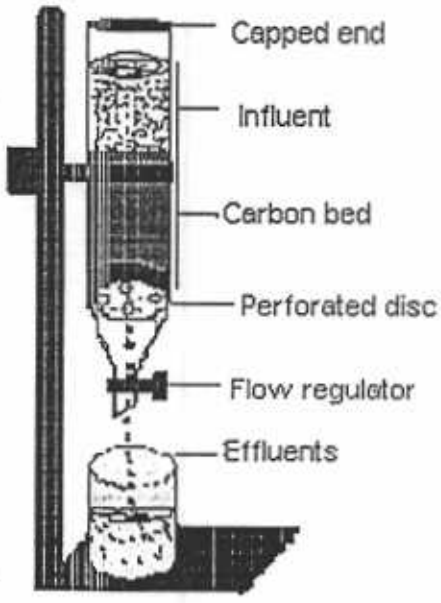


Figure-1.1: Diagramatic representation of column study

3.4. Reagents

The following reagents of analytical grades were used in the study.

- Hydrochloric acid (36%) — Merck
- Nitric acid (70%) — Merck
- Potassium hydroxide — Merck
- n-hexane — Merck
- Dyes — Sigma Aldrich

Table 3.4 Plants used as wood source for the preparation of activated carbon

Botanical name of plants	Class	Order	Family	Collection Locations
Populus Caspica	*Dicotylidenae*	*Salicales*	*Salicaceae*	Swat
Paulownia Tomentosa	*Dicotylidenae*	*Tubiflovae*	*Scrophulariaceae*	PFI
Salvadora Oleoides	*Dicotylidenae*	*Oleales*	*Salvadoraceae*	Peshawar
Ailanthus Altissima	*Dicotylidenae*	*Rutales*	*Simaroubaceae*	Swat
Corn cobs (agro waste)	*Monocotylidenae*	*Graminales*	*Poaceae*	Swat

CHAPTER # 4

RESULTS AND DISCUSSION

Table 4.1 Some characteristics of carbon samples

Carbon sample		pH of the carbon slurry	Ash contents (%)	Moisture content (%)	Bulk density (kg/m³)
PAULOWNIA TOMENTOSA	Raw	9.30	9.89	1.20	260
	400 °C	9.53	5.32	0.90	245
	800 °C	9.90	5.00	0.30	220
POPULUS CASPICA	Raw	8.80	4.520	1.60	330
	400 °C	9.90	4.00	0.900	312
	800 °C	10.00	4.00	0.600	280
CORNCOBS	Raw	9.00	9.46	2.20	320
	400 °C	9.82	9.00	1.90	275
	800 °C	9.99	8.79	0.05	252
AILANTHUS ALTISSIMA	Raw	8.950	6.30	1.50	210
	400 °C	8.850	5.020	0.600	195
	800 °C	9.990	3.000	0.4200	165
SALVADORA OLEOIDES	Raw	8.10000	68.4000	0.90000	270.500
	400 °C	7.9500	64.100	0.5000	262.00
	600 °C	8.7000	58.000	0.3300	255.80
	800 °C	11.300	51.100	0.1500	246.00
	900 °C	11.450	47.300	0.0500	238.50
	1000 °C	11.490	46.300	0.0010	232.50
REGENERATED	400 °C	6.390	50.100	10.000	242.00
	600 °C	6.950	38.000	0.8000	220.0
	800 °C	7.300	31.100	0.2500	206.00
	900 °C	7.690	27.000	0.0800	200.50
	1000 °C	7.530	25.00	0.010	195.00
ANIMAL BONES CHARCOAL	600 °C	9.7000	12.400	1.5000	465.00
	700 °C	9.1000	11.100	1.2000	400.00
	800 °C	9.5000	10.000	0.6000	385.00
	900 °C	10.390	8.700	0.5000	360.00
	1000 °C	10.630	6.9000	0.4000	340.00

Table 4.2 Surface area and pore size distribution of carbon samples

Carbon sample	Raw/ Degassing	Surface area (m^2/g)				Pore size distribution				
		Methods				BJH method		DR method		
		BET (MP)	BJH	LSA	DR	Pore volume (cc/g)	pore diameter (Å)	Micropore volume (cc/g)	Average Pore width (Å)	Ads. Energy (kJ/mol
Paulownia tomentosa (PT)	Raw	79.810	97.85	334.9	85.06	0.05	23.95	0.030	113.37	2.290
	400 °C	165.80	107.3	252.57	241.38	0.05	13.96	0.090	52.36	4.960
	800 °C	219.98	224.89	346.38	311.22	0.100	13.68	0.110	65.29	3.980
Populus caspica (PC)	Raw	37.830	38.20	127.63	41.84	0.010	10.88	0.010	110.23	2.360
	400 °C	360.84	152.35	546.88	528.74	0.040	7.160	0.190	50.090	5.190
	800 °C	398.29	261.76	688.70	644.68	0.130	14.190	0.230	52.590	4.940
Corncobs (CC)	Raw	68.809	38.09	142.30	41.87	0.010	10.88	0.010	111.74	2.330
	400 °C	140.41	80.24	210.14	200.63	0.020	6.720	0.070	50.090	5.190
	800 °C	412.38	302.67	615.81	592.33	0.130	13.30	0.210	48.690	5.340
Ailanthus altissima (AA)	Raw	74.153	50.270	111.49	42.700	0.020	21.360	0.020	107.97	2.410
	400 °C	337.16	247.87	516.64	490.90	0.110	13.740	0.170	54.990	4.730
	800 °C	387.28	200.24	577.85	559.69	0.05	6.7600	0.200	47.670	5.450
Salvadora oleoides (SO)	Raw	2.190	0.580	3.180	3.190	0.000	13.480	0.000	20.760	12.520
	400 °C	38.690	45.510	149.69	41.970	0.020	21.500	0.010	112.360	2.3100
	500 °C	162.75	109.19	244.37	236.59	0.050	13.660	0.080	48.700	5.3400
	600 °C	279.17	145.49	424.58	412.31	0.070	14.410	0.150	49.220	5.2800
	700 °C	312.06	216.48	482.94	457.66	0.100	14.090	0.160	57.000	4.5600
	800 °C	426.49	274.64	654.95	624.30	0.130	14.210	0.220	55.460	4.690
	900 °C	431.71	281.67	646.93	627.37	0.120	13.660	0.220	48.660	5.340
	1000 °C	587.84	452.06	897.55	848.12	0.210	13.520	0.300	54.460	4.770

Table 4.3 Surface area and pore size distribution of carbon samples

Carbon sample	Degassing	Surface area (m^2/g)				Pore size distribution				
		Methods				BJH method		DR method		
		BET	BJH	LSA	DR	pore volume (cc/g)	pore diameter (Å)	Micropore volume (cc/g)	Average Pore width (Å)	Ads. Energy (kJ/mol)
Animal bones charcoal (ABC)	600 °C	38.82	40.97	135.09	131.32	0.020	13.970	0.050	42.210	6.160
	700 °C	122.98	138.78	235.42	203.60	0.070	14.010	0.070	72.500	3.590
	800 °C	140.23	244.25	300.02	276.13	0.040	18.64	0.100	82.04	2.430
	900 °C	180.85	250.23	142.81	134.88	0.030	21.42	0.050	55.130	4.720
	1000 °C	280.03	360.45	400.23	398.35	0.050	21.37	0.070	60.250	4.310
Regenerated (RG)	Spent	40.190	44.73	88.32	50.21	0.010	9.0200	0.020	99.080	2.620
	400 °C	94.480	102.60	157.43	134.23	0.050	13.880	0.050	76.810	3.380
	500 °C	131.45	151.81	208.23	184.84	0.070	13.380	0.070	68.500	3.790
	600 °C	174.24	163.18	276.69	252.77	0.08	13.990	0.090	66.470	3.910
	700 °C	321.80	231.18	491.14	463.37	0.050	13.7700	0.160	55.460	4.690
	800 °C	343.25	318.87	682.00	612.16	0.170	13.670	0.220	55.570	4.680
	900 °C	397.18	319.84	606.05	572.94	0.140	13.860	0.200	54.770	4.750
	1000 °C	418.10	281.53	638.76	600.60	0.070	6.740	0.210	55.690	4.670
Commercial China GA carbon		560.44	426.86	838.77	806.19	0.190	13.540	0.290	51.020	5.100
Data reduction parameters		Analysis gas = Nitrogen, Molecular Wt = 28.013, Cross section = 16.200 *Å/mol*, Liquid Density = 0.808 *g/cc*, Surface tension = 8.850 *erg/cm²*, Eff. Mol. Diameter (D) = 3.5400 Å, Eff. Cell stem Diameter (d) = 4.00 *mm*, Po override = 760.0 *mmHg*, Bath Temp = 74K, Press tolerance = 0.100/0.100 (ads/des), Equi. time = 60/60 *sec* (ads/des).								

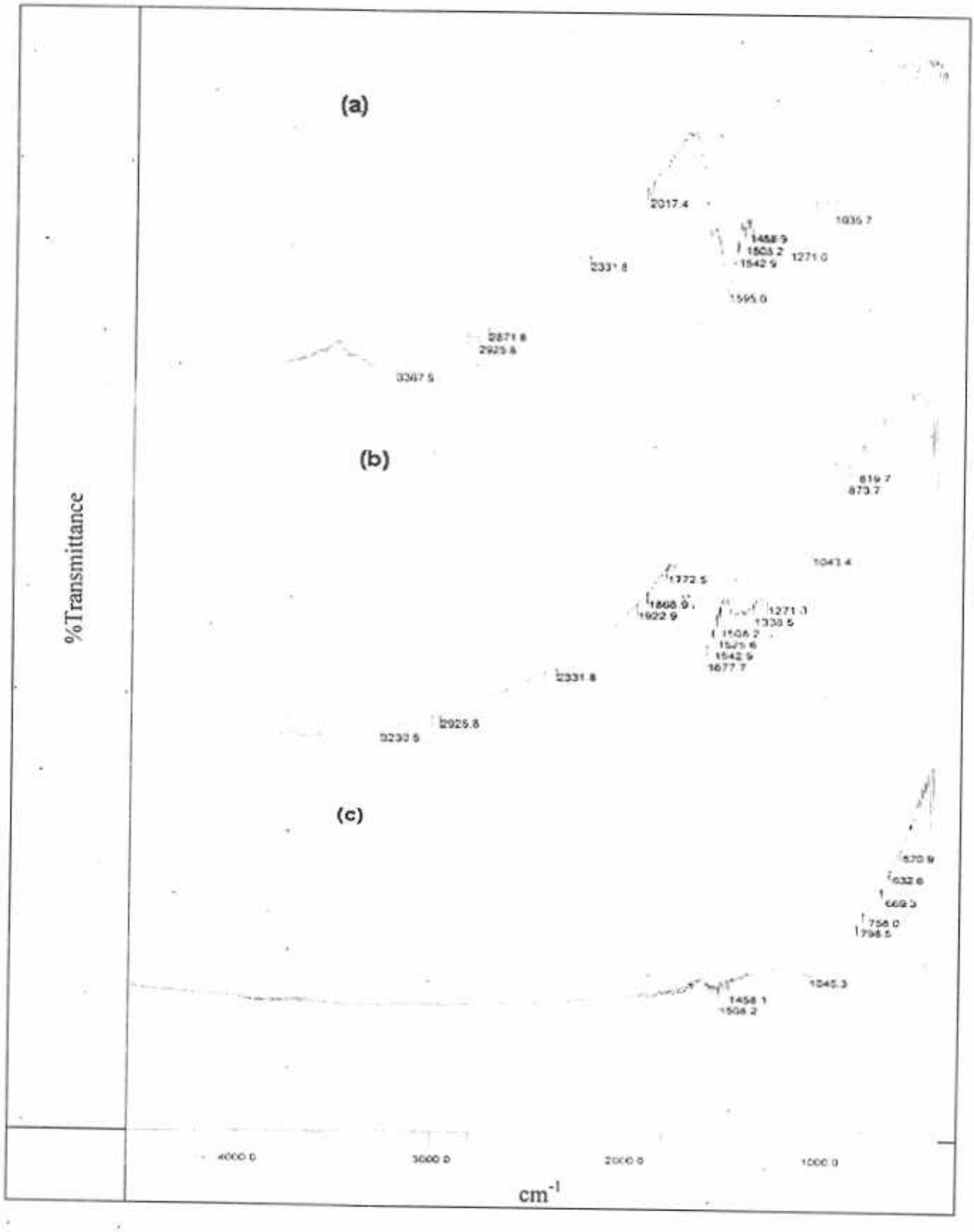


Figure 4.1 FTIR spectra of *Paulownia tomentosa* (PT) carbon samples (a) Raw, (b) 400 °C, (c) 800 °C

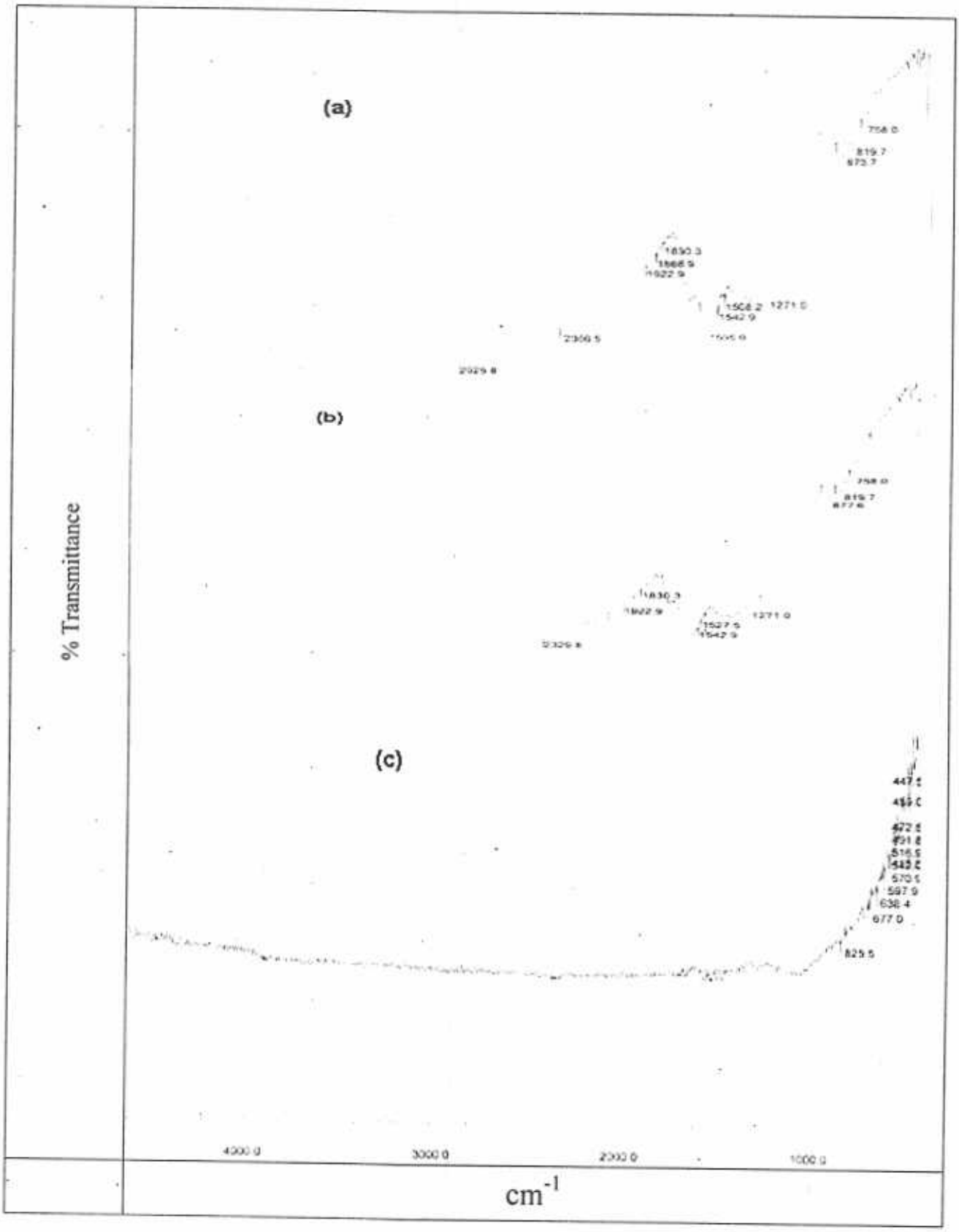


Figure 4.2 FTIR spectra of *Populus caspica* (PC) carbon samples (a) Raw (b) 400 °C (c) 800 °C

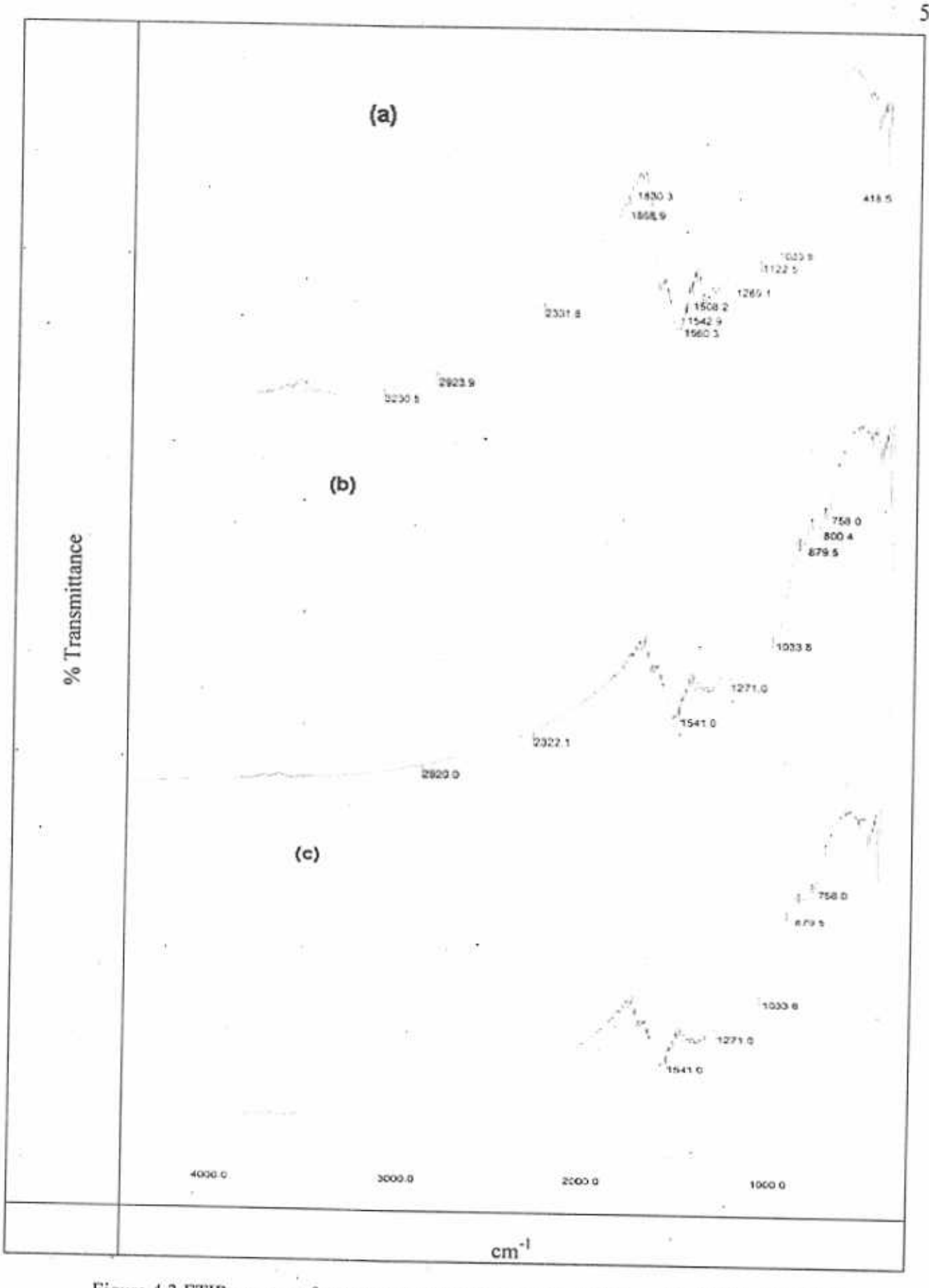


Figure 4.3 FTIR spectra of corncobs (CC) carbon samples (a) Raw, (b) 400 °C, (c) 800 °C

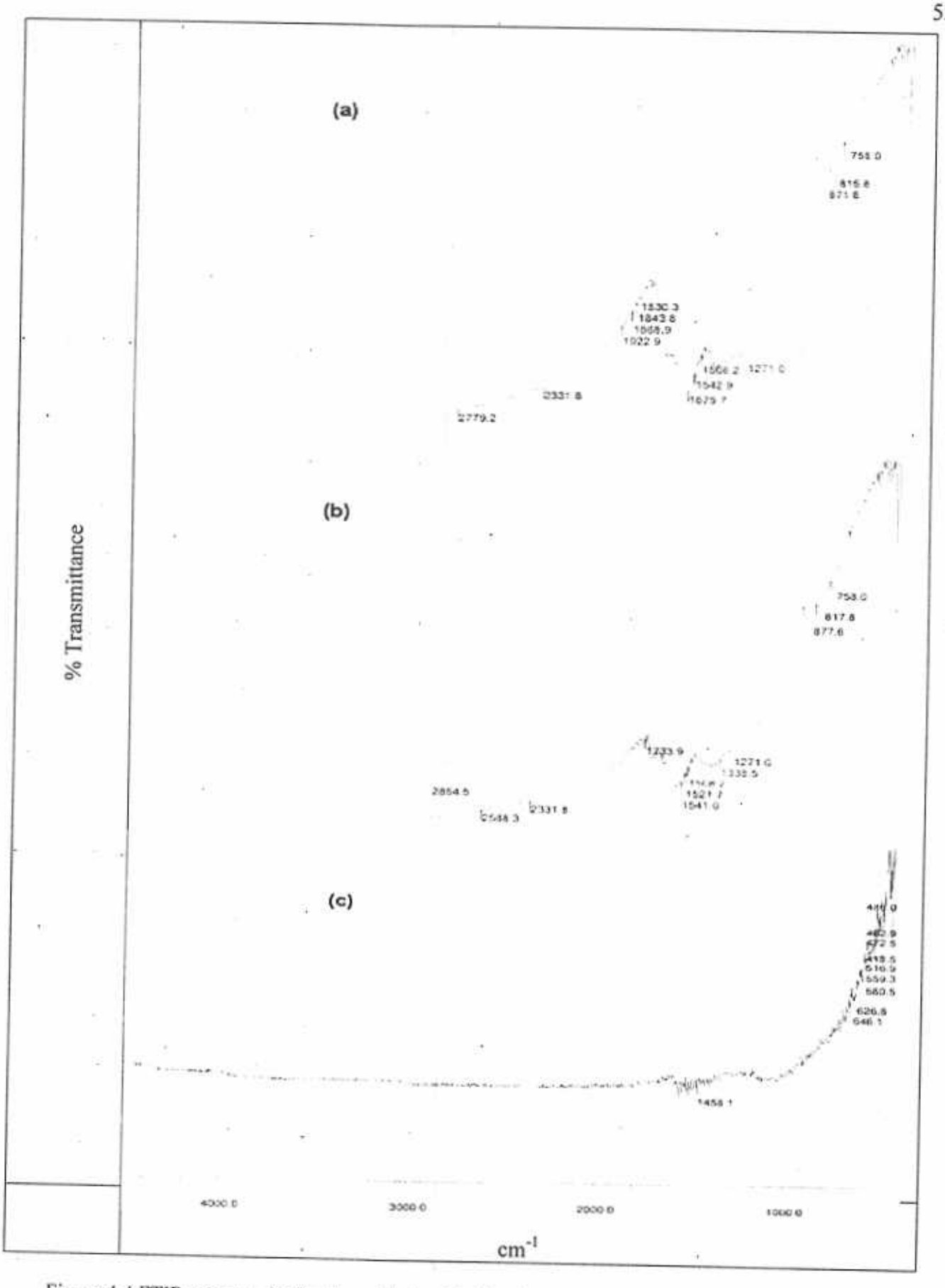
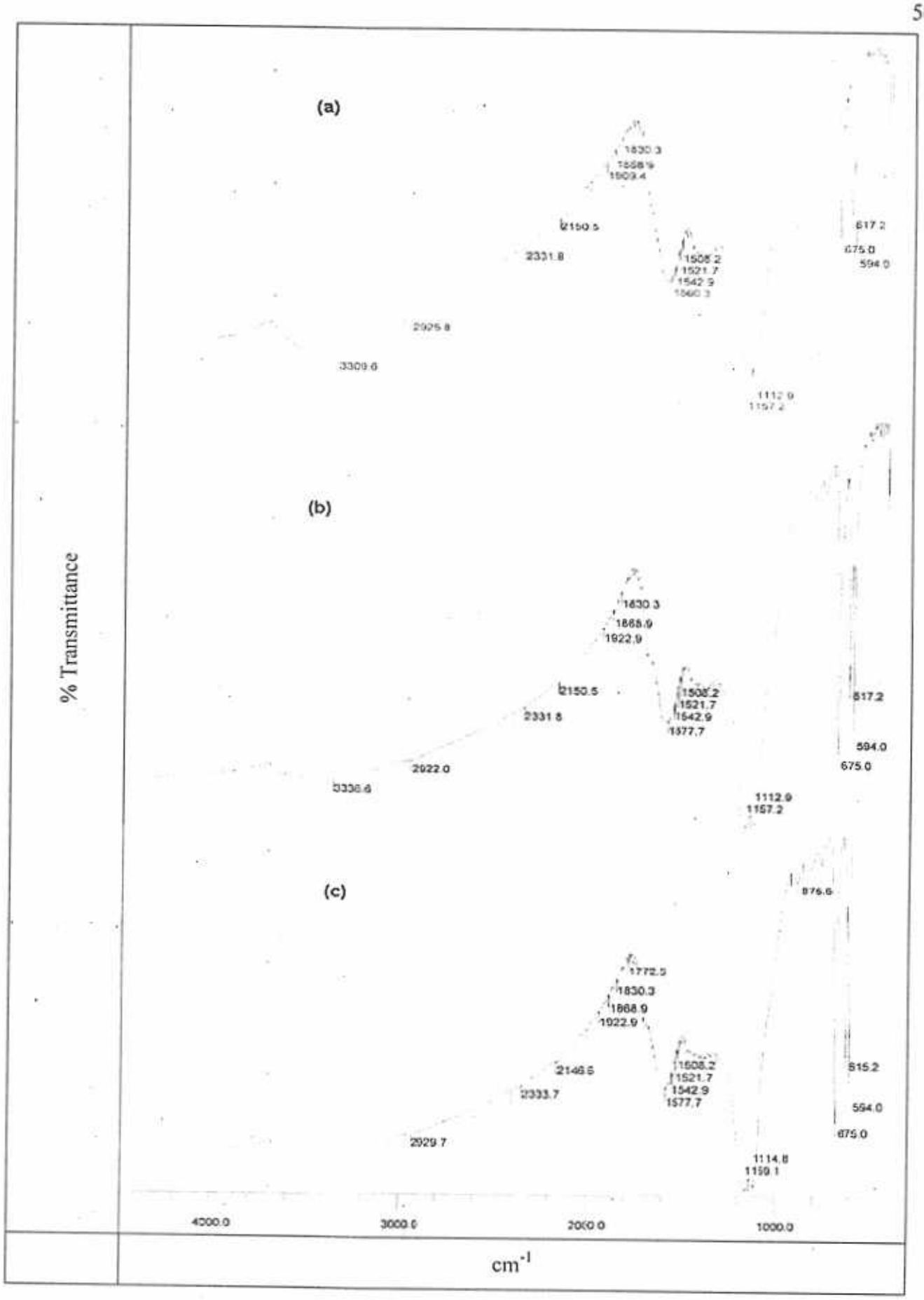
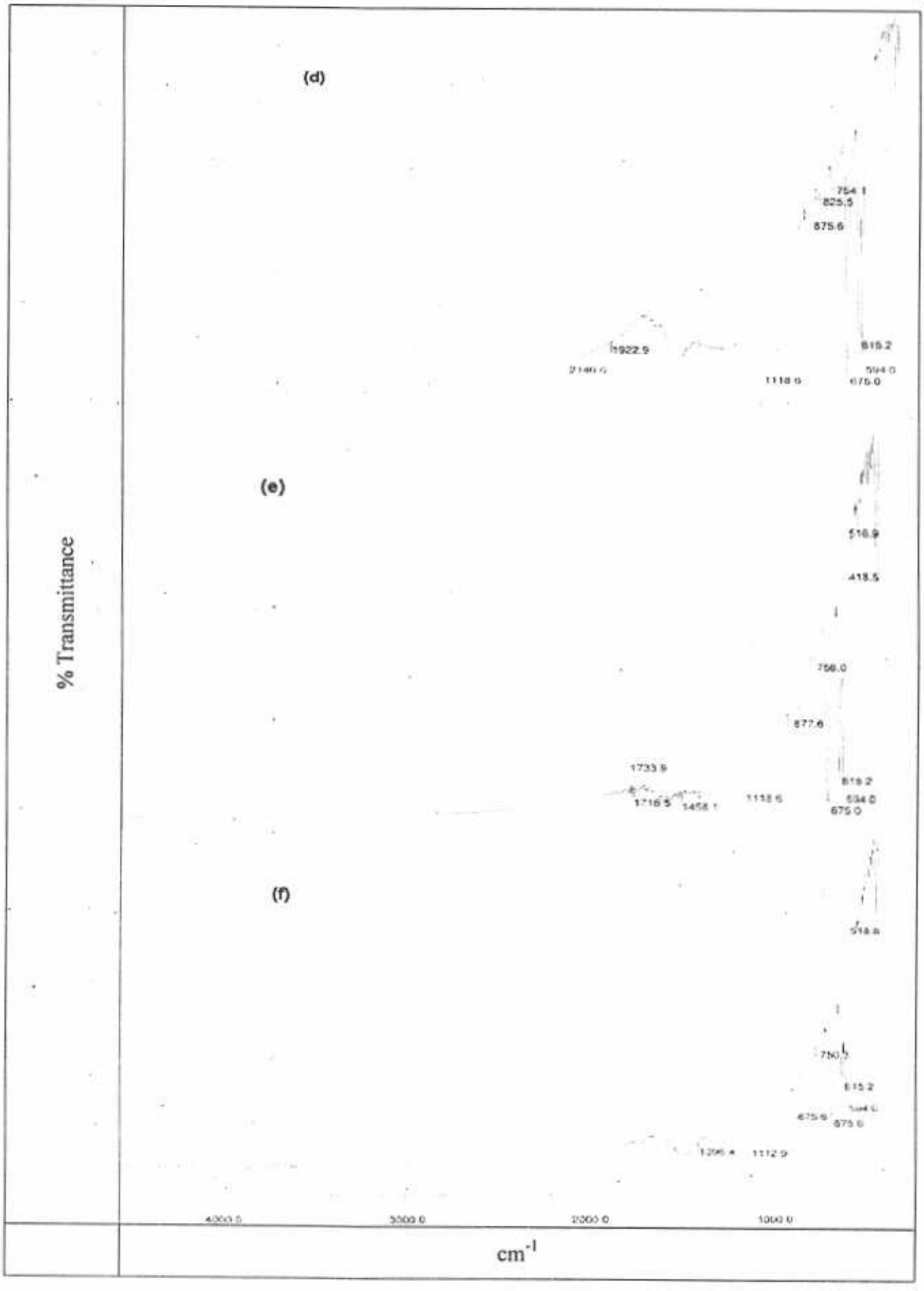


Figure 4.4 FTIR spectra of *Ailanthus altissima* (AA) carbon samples (a) Raw, (b) 400 °C, (c) 800 °C.


% Transmittance
(a)
1630.3
1868.9
1909.4
2150.5
2331.8
1508.2
1521.7
1542.9
1560.3
617.2
675.0
594.0
2925.8
3309.6
1112.9
1157.2
(b)
1630.3
1868.9
1922.9
2150.5
2331.8
1508.2
1521.7
1542.9
1577.7
617.2
594.0
675.0
2922.0
3336.6
1112.9
1157.2
(c)
876.6
1772.5
1830.3
1868.9
1922.9
2146.6
2333.7
1508.2
1521.7
1542.9
1577.7
615.2
594.0
675.0
2929.7
1114.8
1159.1
4000.0
3000.0
2000.0
1000.0
cm-1


(d)
754.1
825.5
875.6
1922.9
819.2
2146.6
1118.6
594.0
675.0
(e)
516.9
418.5
756.0
877.6
1733.9
819.2
1716.5
1458.1
1118.6
594.0
675.0
(f)
516.6
750.3
819.2
675.6
675.0
1206.4
1112.9
4000.0
3000.0
2000.0
1000.0
% Transmittance
cm-1

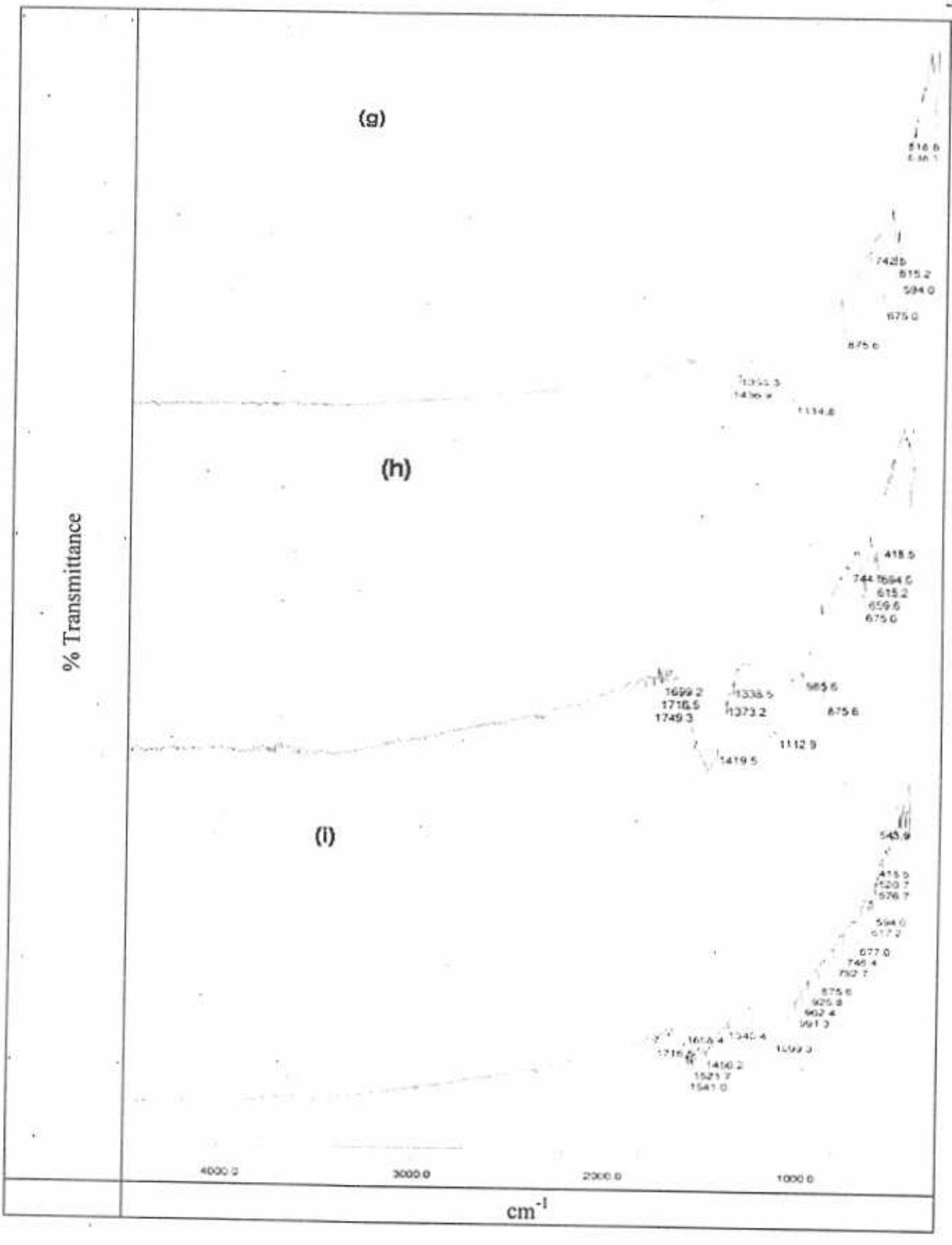
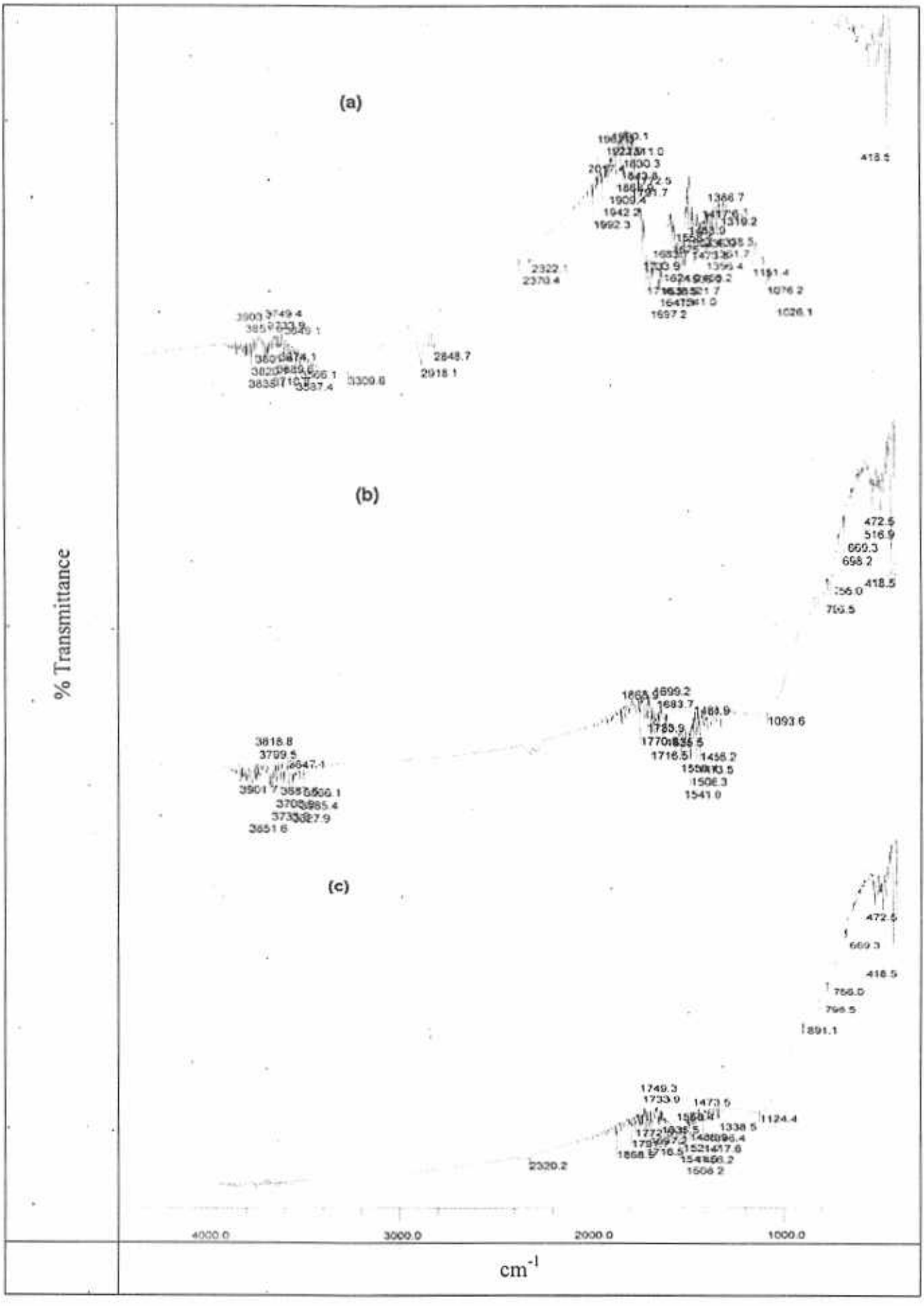


Figure 4.5 FTIR spectra of *Salvadora oleoides* (SO) carbon samples
(a) Raw, (b) 300 °C, (c).400 °C, (d) 500 °C, (e) 600 °C, (f) 700 °C, (g) 800 °C, (h) 900 °C, (i) 1000 °C


(a)
(b)
(c)
% Transmittance
4000.0
3000.0
2000.0
1000.0
cm-1

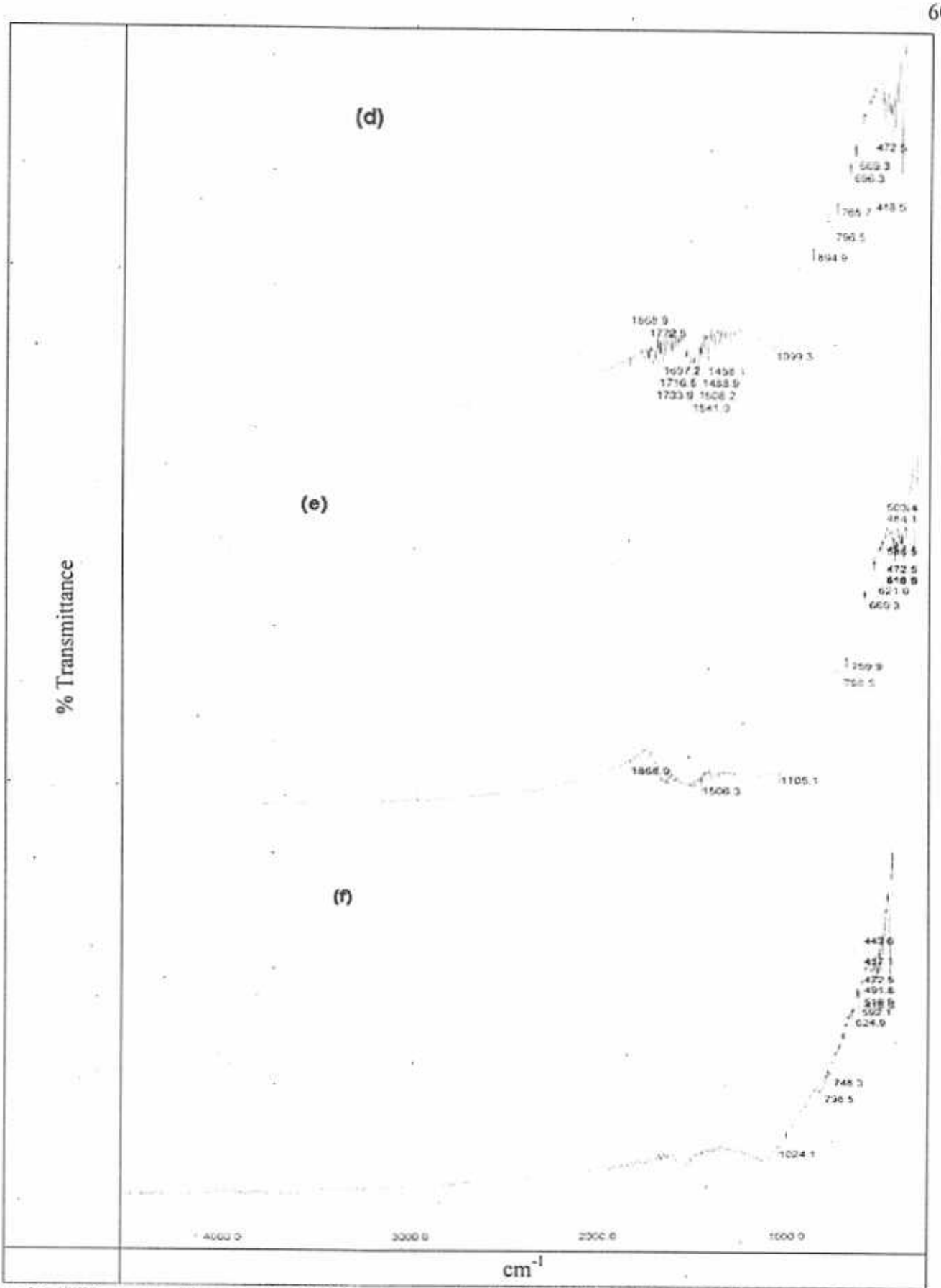
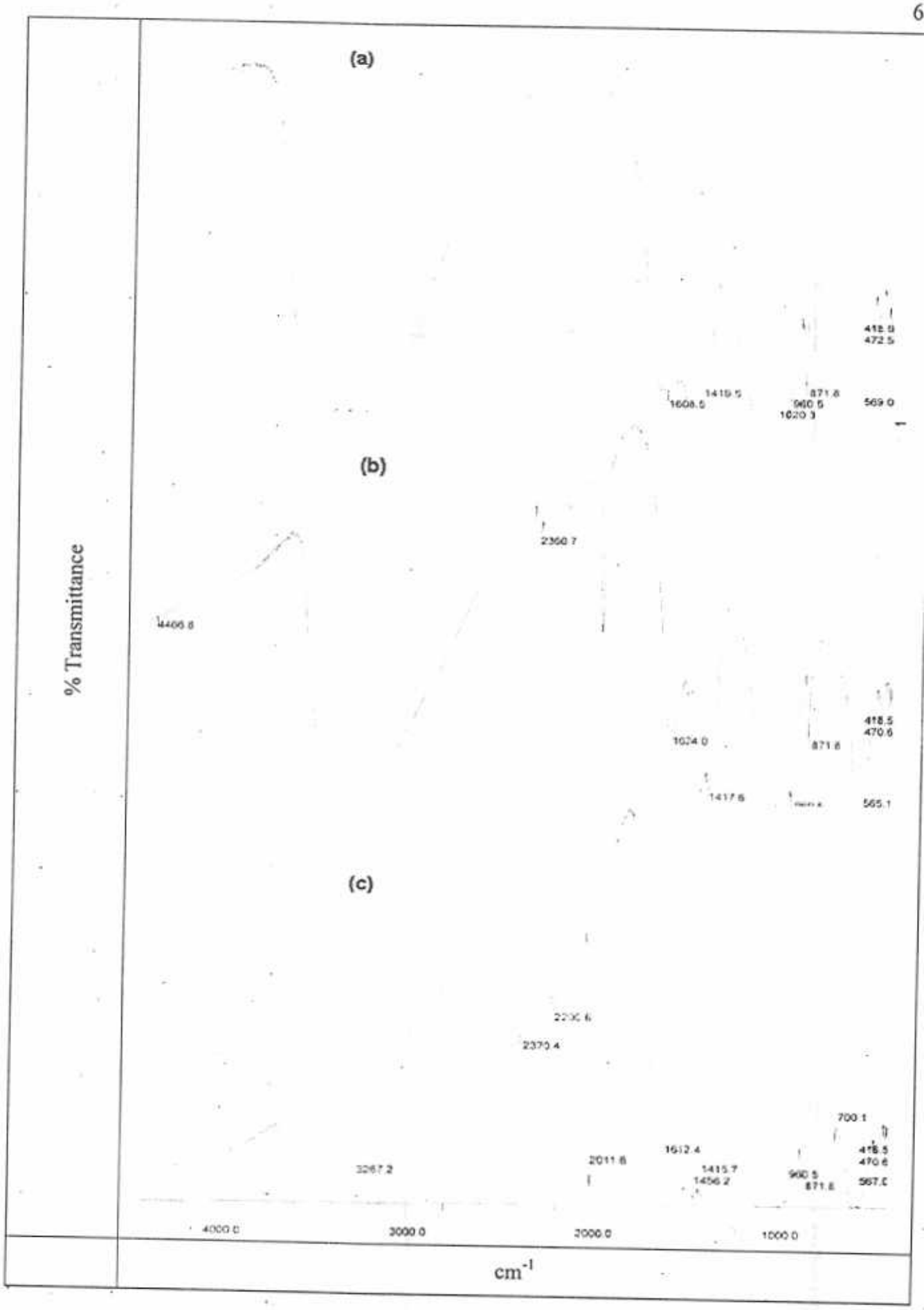


Figure 4.6 FTIR spectra of regenerated (RG) carbon samples (a) Spent (b) 400 °C (c) 500 °C (d) 600 °C (e) 700 °C (f) 800 °C


(a)
418.9
472.5
1608.5
1419.5
871.8
960.5
1020.3
569.0
(b)
2360.7
4406.8
418.5
470.6
1024.0
871.8
1417.8
565.1
(c)
2370.4
700.1
418.5
470.6
1612.4
3267.2
2011.8
1415.7
1456.2
960.5
871.8
567.0
4000.0
3000.0
2000.0
1000.0
% Transmittance
cm-1

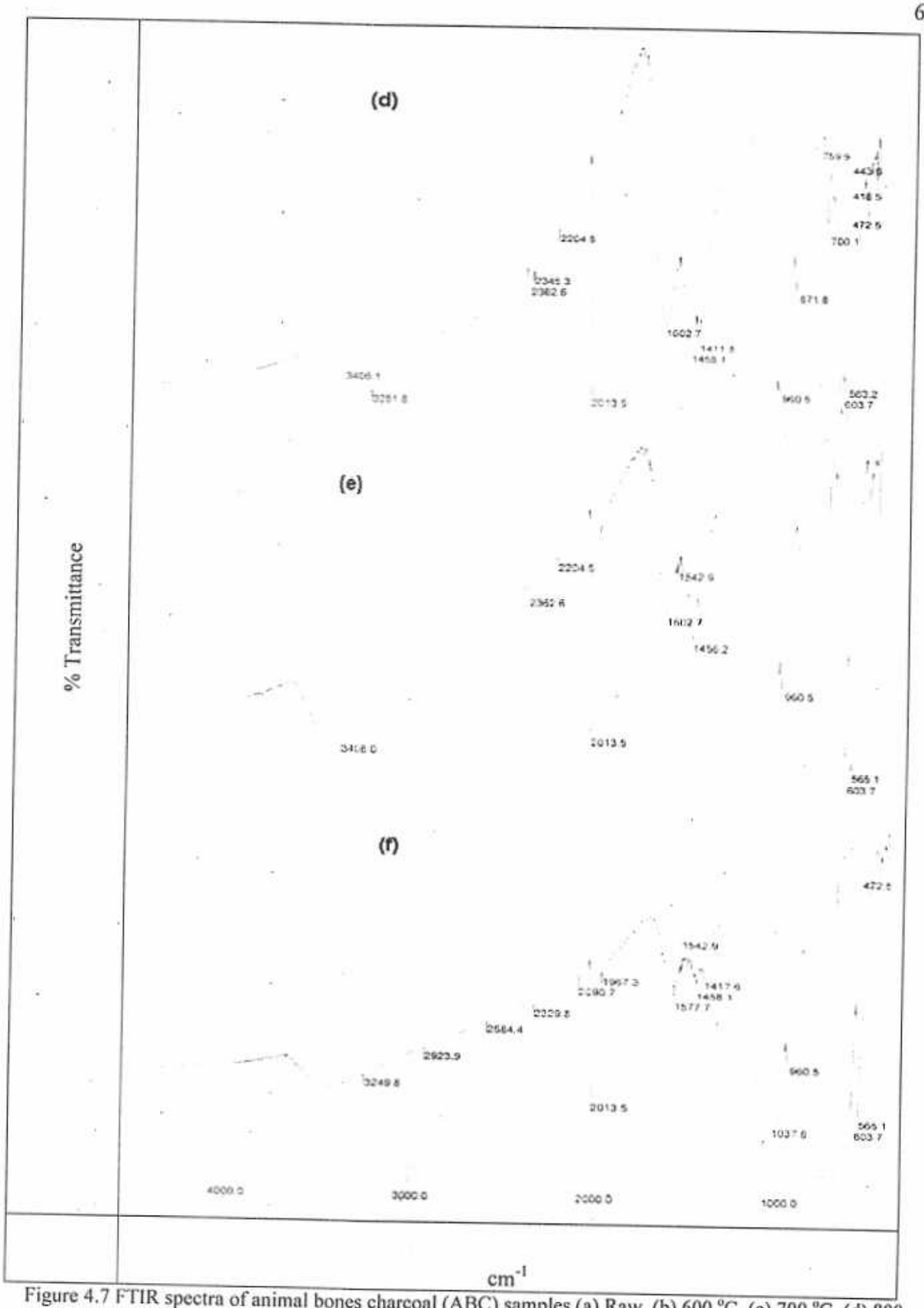


Figure 4.7 FTIR spectra of animal bones charcoal (ABC) samples (a) Raw, (b) 600 °C, (c) 700 °C, (d) 800 °C, (e) 900 °C, (f) 1000 °C.

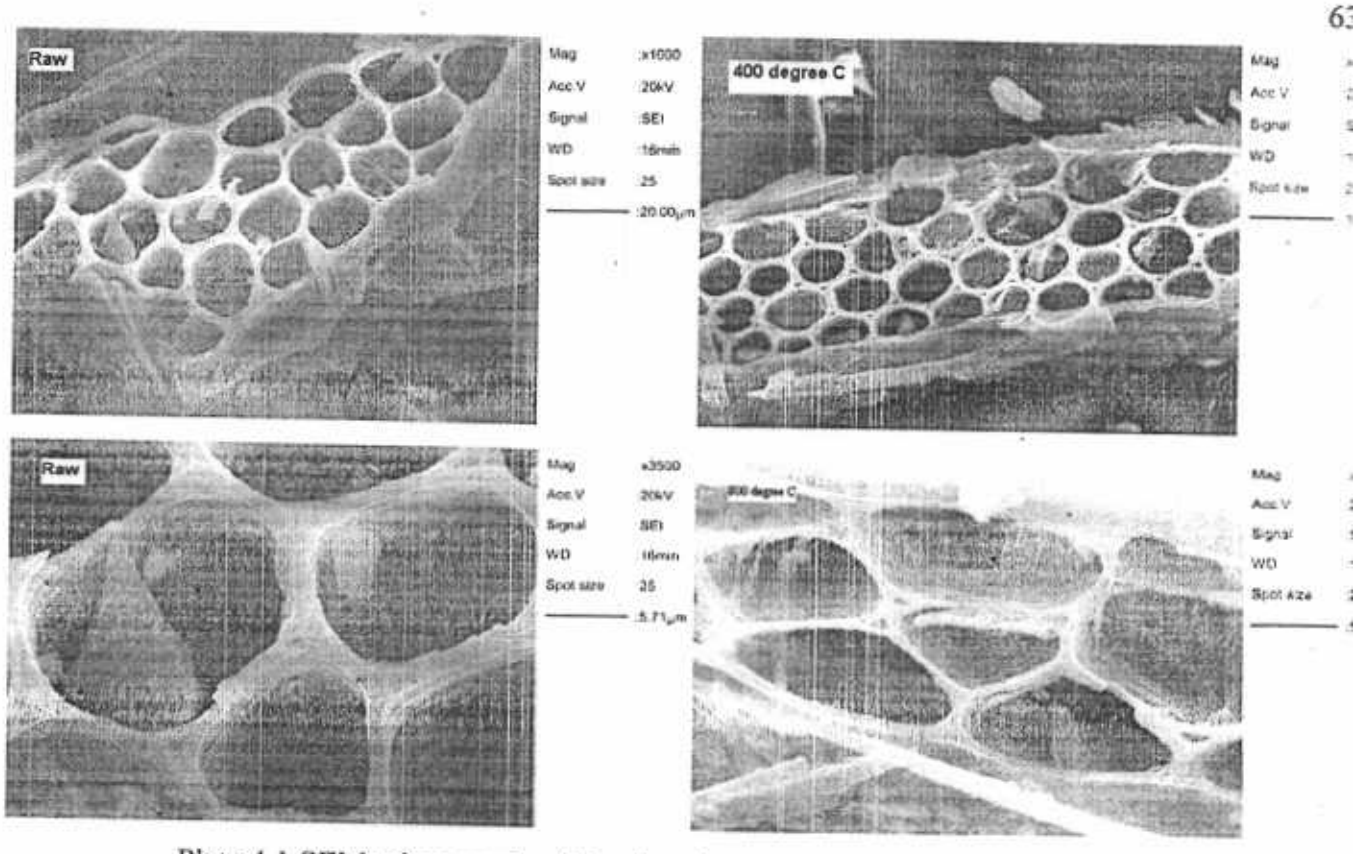


Plate 4.1 SEM micrographs of *Paulownia tomentosa* (PT) activated carbon

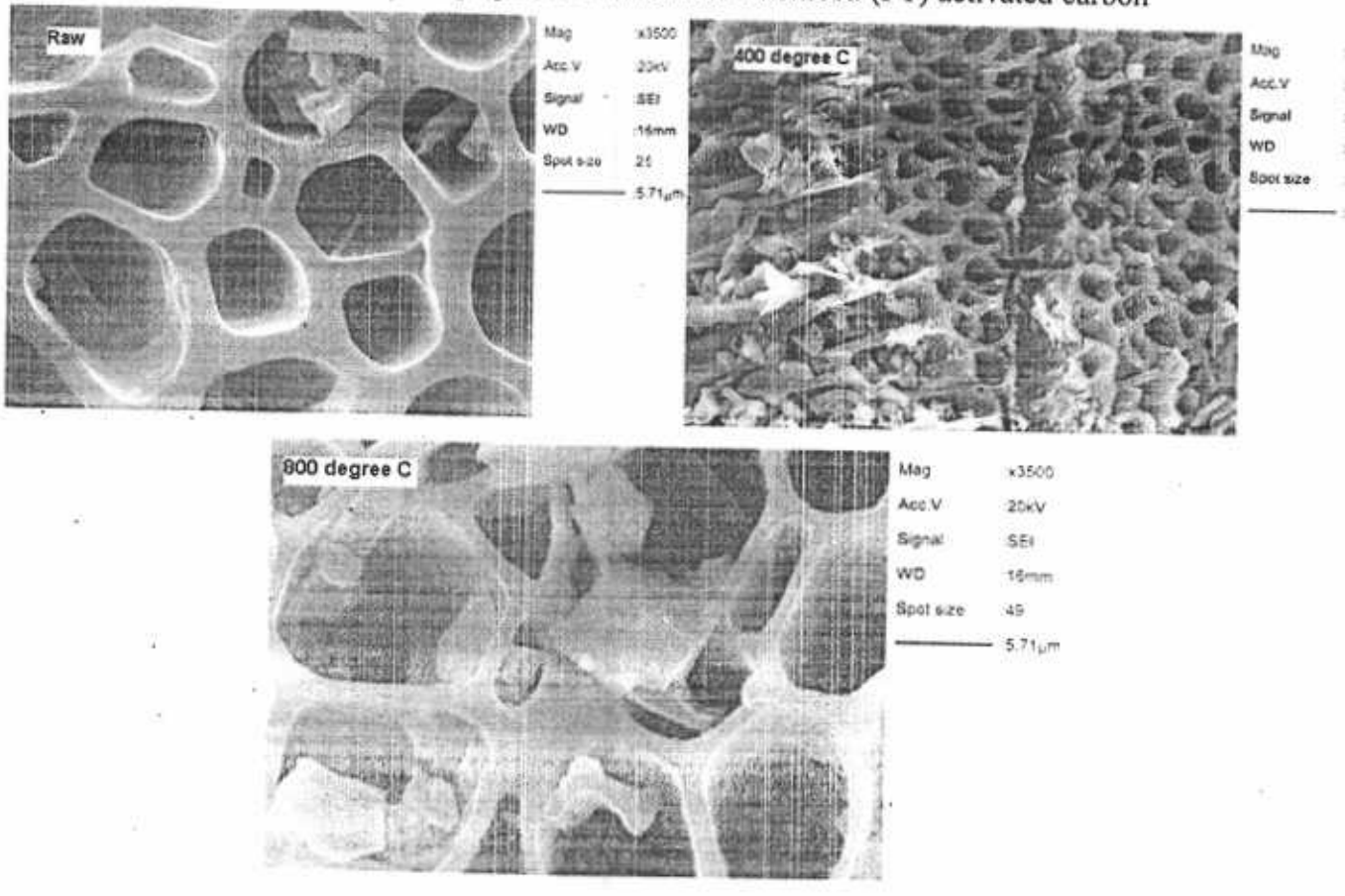


Plate 4.2 SEM micrographs of *Populus caspica* (PC) carbon samples

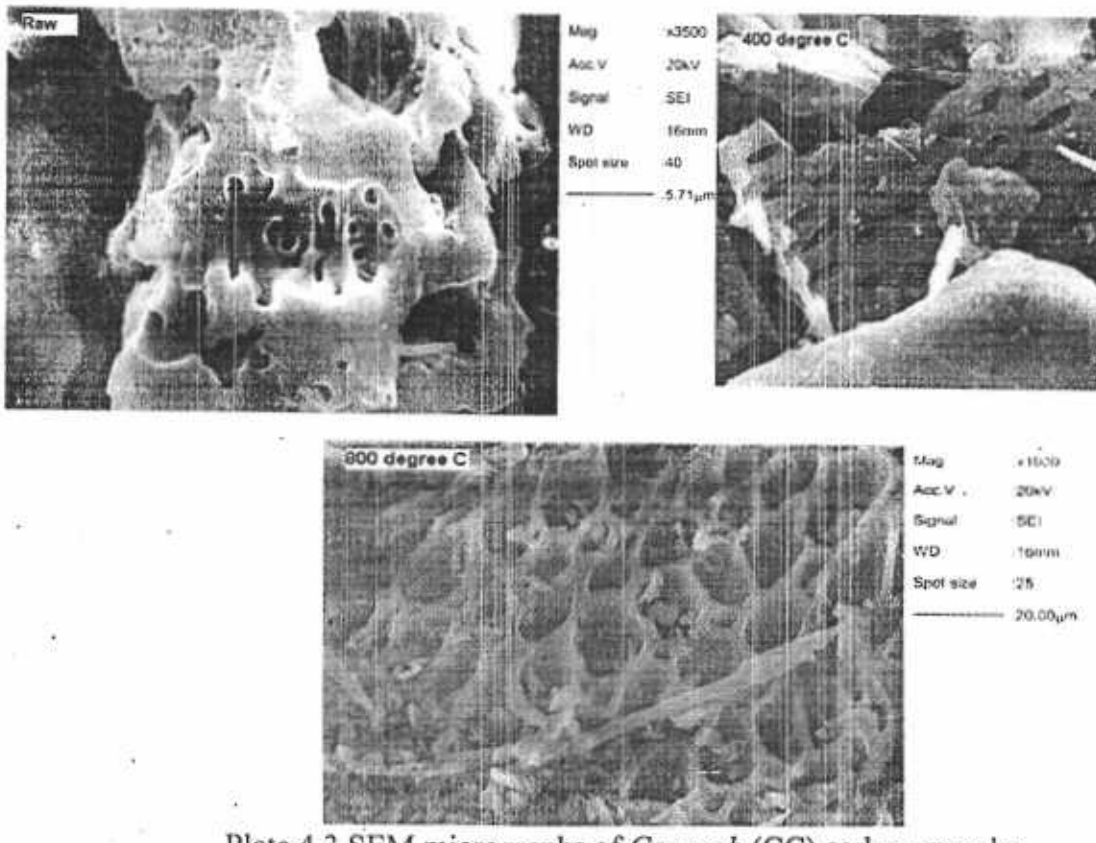


Plate 4.3 SEM micrographs of *Corncob* (CC) carbon samples

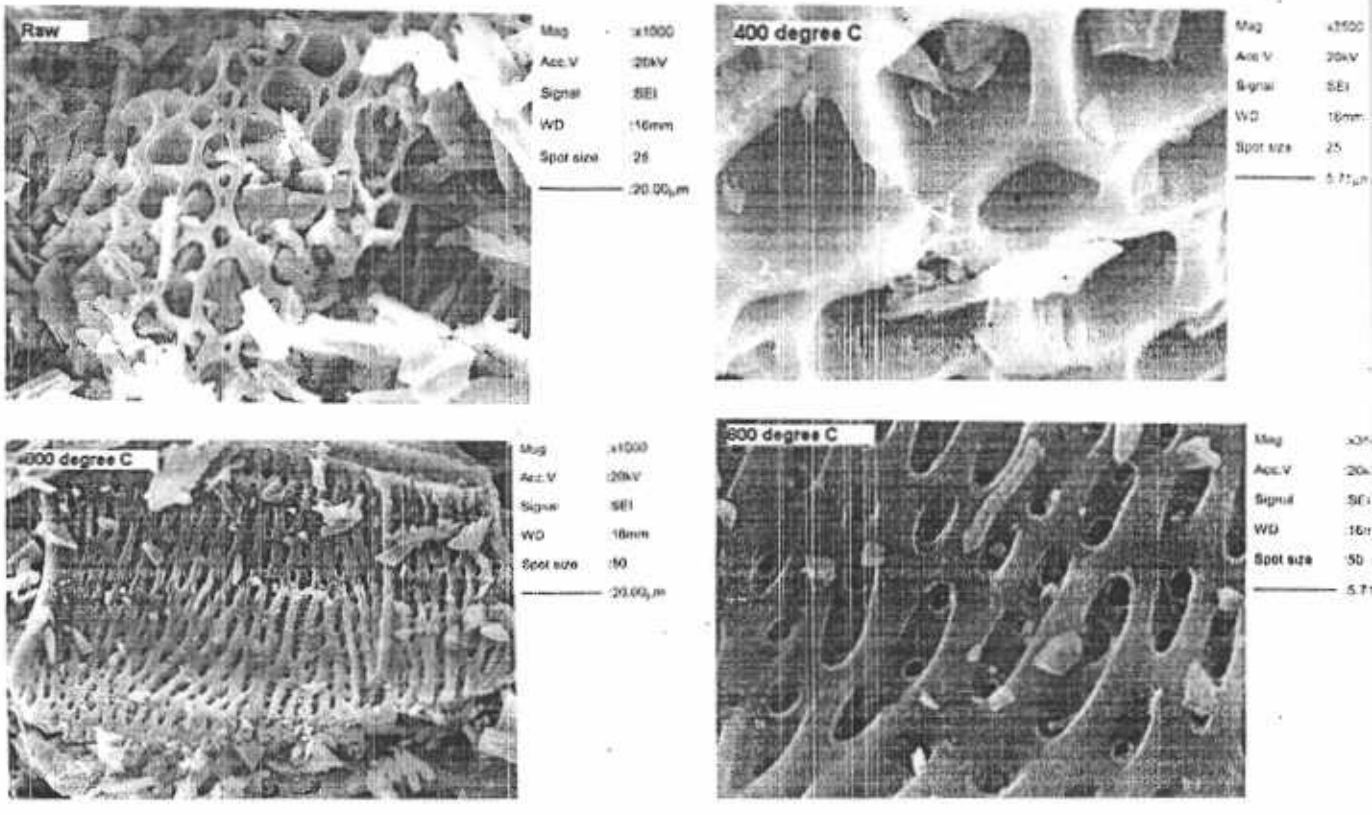


Plate 4.4 SEM micrographs of *Ailanthus altissima* (AA) carbon sample

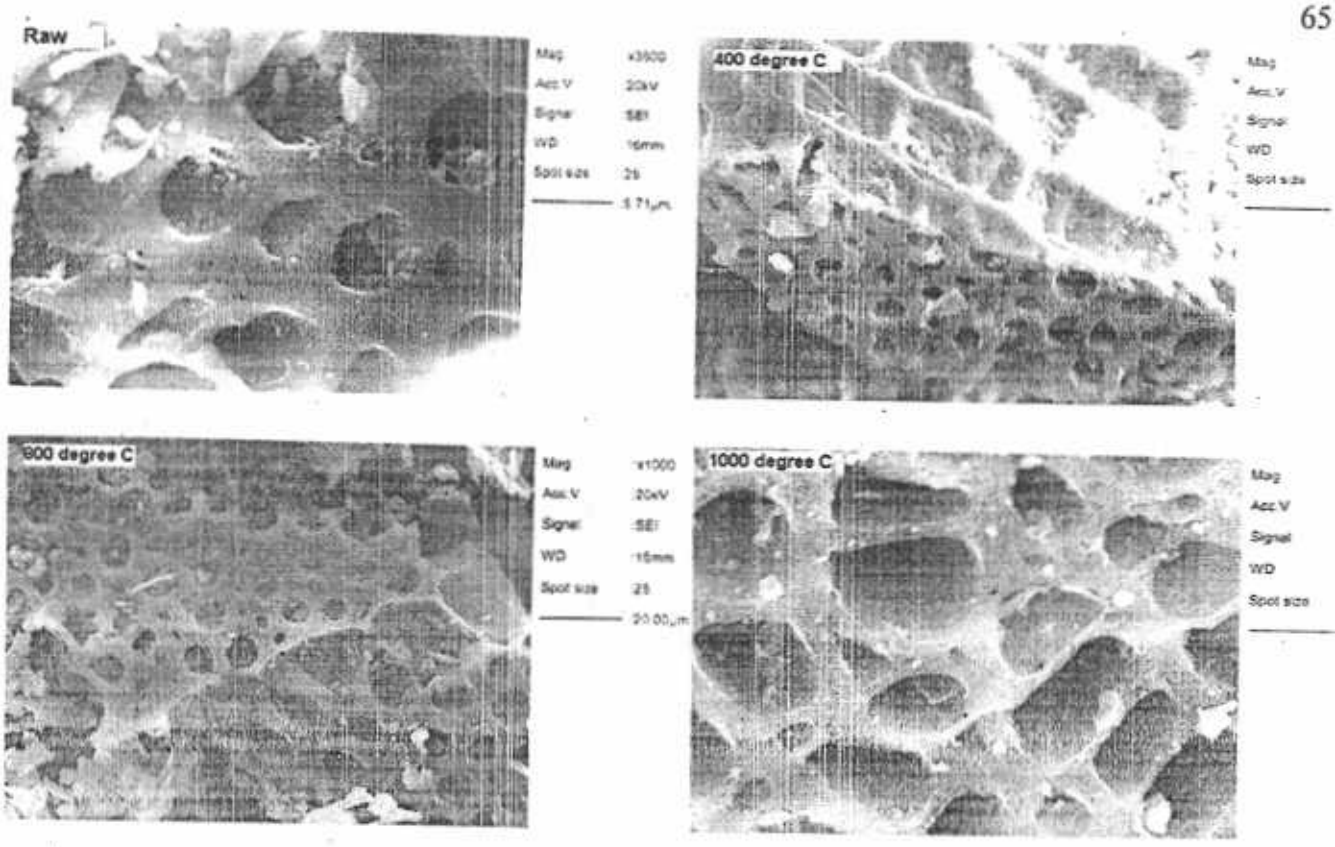


Plate 4.5 SEM micrographs of *Salvadora oleoides* (SO) carbon samples

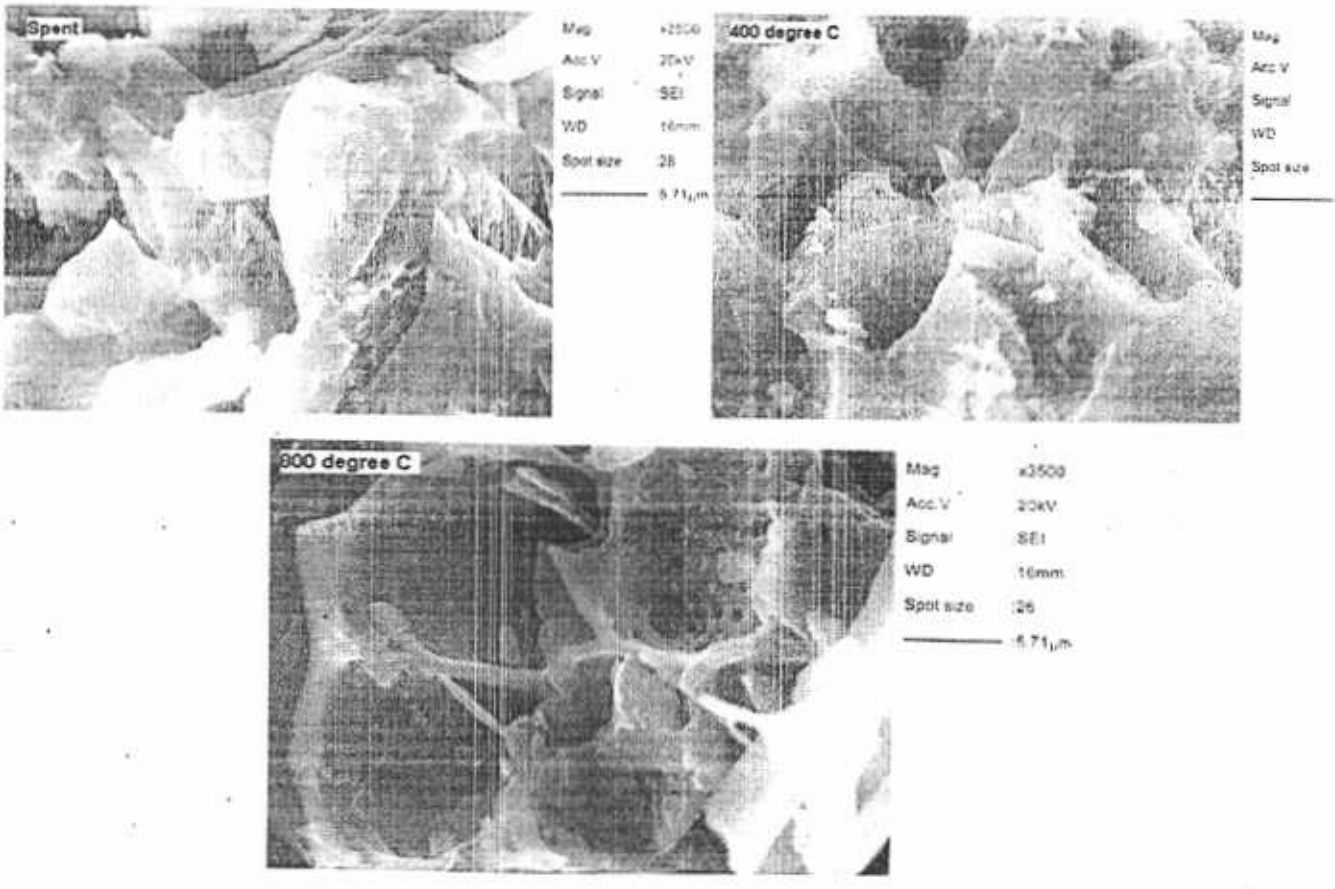


Plate 4.6 SEM micrographs of regenerated (RG) carbon samples

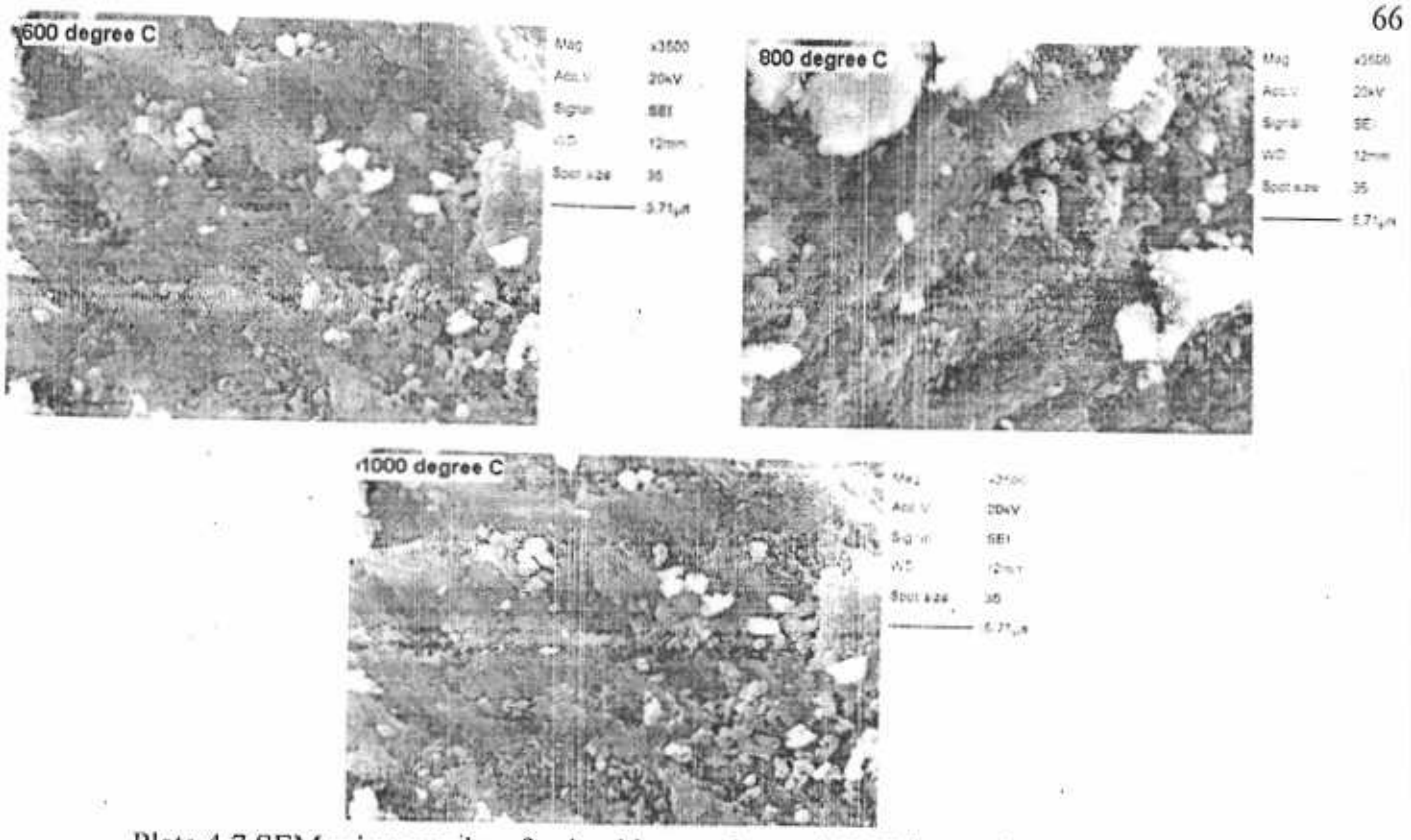


Plate 4.7 SEM micrographs of animal bones charcoal (ABC) samples.

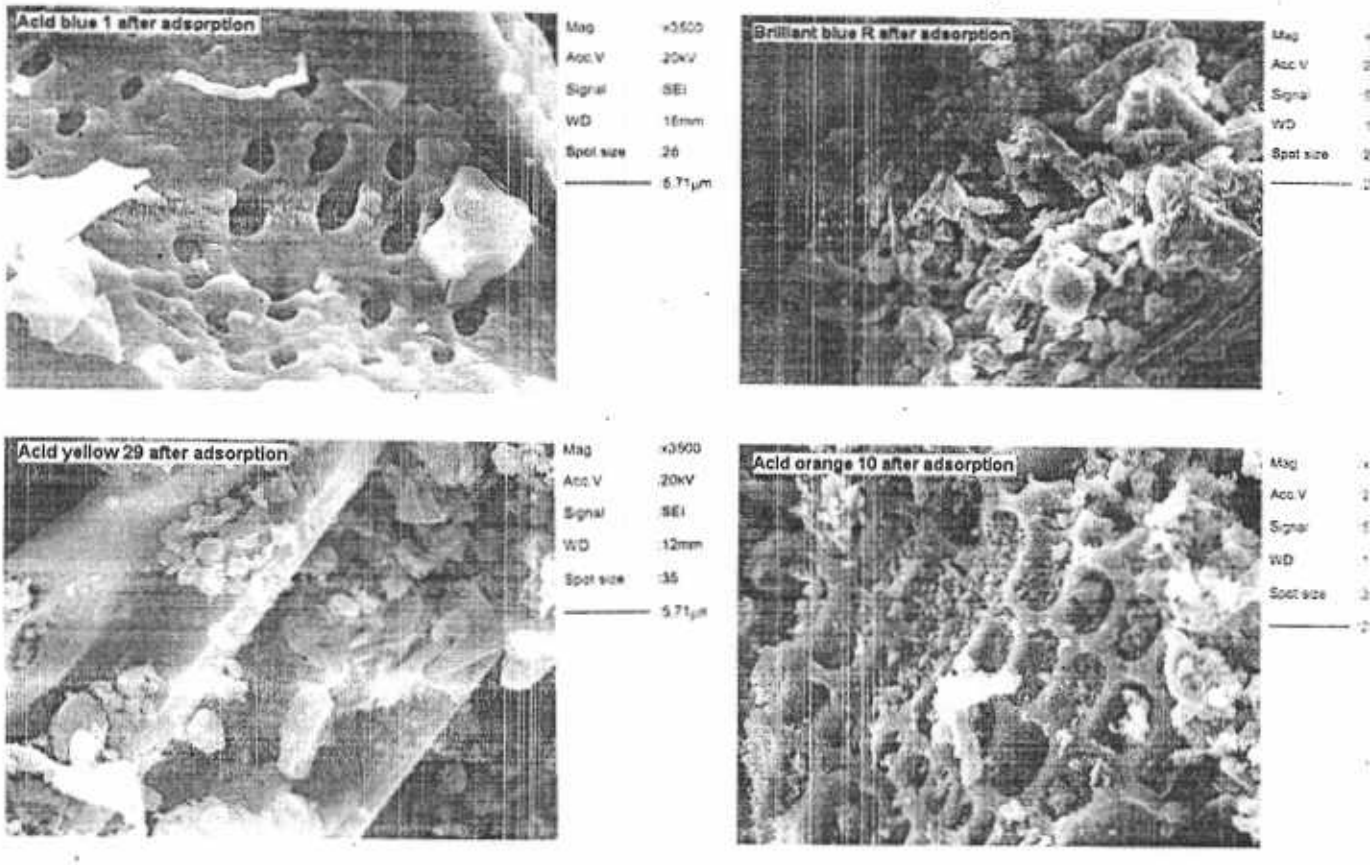


Plate 4.8 SEM micrographs of dyes after adsorption on carbon samples

Table 4.4 EDS analysis of carbon samples

Sample/ Degassed	Elements	*Paulownia Tomentosa (PT)*		*Populus caspica (PC)*		*Corncobs (CC)*		*Ailanthus altissima (AA)*	
		Weight (%)	Atomic (%)	Weight (%)	Atomic (%)	Weight (%)	Atomic (%)	Weight (%)	Atomic (%)
Raw	C	73.50	78.84	74.37	79.80	74.05	80.05	77.73	83.48
	O	26.09	21.01	24.71	19.90	23.25	18.88	20.33	16.18
	S	0.170	0.070	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
	K	0.240	0.080	0.630	0.210	1.130	0.380	0.410	0.130
	Ca	xxxx	xxxx	0.290	0.090	0.240	0.080	0.330	0.110
	Si	xxxx	xxxx	xxxx	xxxx	0.960	0.440	xxxx	xxxx
	Cl	xxxx	xxxx	xxxx	xxxx	0.370	0.140	xxxx	xxxx
	Mg	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	0.200	0.100
400 °C	C	79.07	83.78	80.49	85.36	78.34	84.76	89.92	86.89
	O	20.03	15.93	17.62	14.02	16.33	13.26	15.33	12.21
	K	0.890	0.290	0.140	0.050	2.650	0.880	2.210	0.720
	Cl	xxxx	xxxx	0.140	0.570	0.900	0.330	0.240	0.090
	Si	xxxx	xxxx	xxxx	xxxx	1.040	0.480	xxxx	xxxx
	Fe	xxxx	xxxx	xxxx	xxxx	0.290	0.070	0.300	0.090
	Mg	xxxx	xxxx	xxxx	xxxx	0.170	0.090	xxxx	xxxx
800 °C	C	89.46	92.59	80.76	85.89	81.88	88.30	86.97	91.57
	O	8.840	6.870	16.47	13.17	11.290	9.140	9.010	7.130
	Cl	0.170	0.060	0.210	0.080	1.150	0.420	0.420	0.150
	K	1.530	0.490	2.030	0.660	3.170	1.050	2.810	0.910
	S	xxxx	xxxx	0.160	0.060	xxxx	xxxx	xxxx	xxxx
	Ca	xxxx	xxxx	0.210	0.070	xxxx	xxxx	0.300	0.090
	Mg	xxxx	xxxx	0.140	0.080	0.250	0.130	0.170	0.090
	Fe	xxxx	xxxx	xxxx	xxxx	0.380	0.090	xxxx	xxxx
	Cu	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	0.320	0.060
	P	xxxx	xxxx	xxxx	xxxx	0.220	0.090	xxxx	xxxx
	Si	xxxx	xxxx	xxxx	xxxx	1.310	0.610	xxxx	xxxx

Table 4.5 EDS analysis of carbon samples

Sample/ Degassed	Elements	*Animal bone charcoal (ABC)*		*Salvadora oleoides (SO)*		*Regenerated (RG)*	
		Weight (%)	Atomic (%)	Weight (%)	Atomic (%)	Weight (%)	Atomic (%)
Raw/Spent	C	xxxx	xxxx	67.42	76.54	69.49	75.84
	O	xxxx	xxxx	22.92	19.54	28.34	23.22
	Al	xxxx	xxxx	xxxx	xxxx	0.200	0.100
	Si	xxxx	xxxx	xxxx	xxxx	1.140	0.530
	P	xxxx	xxxx	xxxx	xxxx	0.430	0.180
	S	xxxx	xxxx	2.760	1.180	0.220	0.090
	Fe	xxxx	xxxx	xxxx	xxxx	0.180	0.040
	Na	xxxx	xxxx	1.270	0.750	xxxx	xxxx
	Cl	xxxx	xxxx	1.580	0.610	xxxx	xxxx
	Ca	xxxx	xxxx	2.750	0.930	xxxx	xxxx
	K	xxxx	xxxx	1.300	0.450	xxxx	xxxx
400 °C/600 °C	C	15.70	25.29	68.60	76.73	83.29	86.02
	O	43.89	53.09	20.59	20.65	13.54	10.74
	Mg	0.450	0.350	xxxx	xxxx	xxxx	xxxx
	Na	0.680	0.570	0.410	0.240	xxxx	xxxx
	P	12.19	7.610	xxxx	xxxx	xxxx	xxxx
	Ca	27.10	13.08	3.070	1.030	0.110	0.040
	S	xxxx	xxxx	2.650	1.110	xxxx	xxxx
	Cl	xxxx	xxxx	0.260	0.100	xxxx	xxxx
	K	xxxx	xxxx	0.410	0.140	xxxx	xxxx
	Al	xxxx	xxxx	xxxx	xxxx	0.2300	0.110
	Si	xxxx	xxxx	xxxx	xxxx	1.5600	0.700
	P	xxxx	xxxx	xxxx	xxxx	0.670	0.270
	Fe	xxxx	xxxx	xxxx	xxxx	0.340	0.080
	Mo	xxxx	xxxx	xxxx	xxxx	0.260	0.030

Table 4.5 (continued) EDS analysis of carbon samples

Sample/ Degassed	Elements	*Animal bone charcoal (ABC)*		*Salvadora oleoides (SO)*		*Regenerated (RG)*	
		Weight (%)	Atomic (%)	Weight (%)	Atomic (%)	Weight (%)	Atomic (%)
800 °C	C	13.95	22.94	70.31	80.70	89.38	88.00
	O	43.75	54.04	16.31	14.06	9.034	10.74
	Na	0.850	0.740	0.300	0.180	xxxxx	xxxxx
	Al	0.300	0.220	xxxxx	xxxxx	0.28	0.120
	P	12.140	7.740	xxxxx	xxxxx	0.540	0.320
	Cl	0.2800	0.150	0.380	0.150	xxxxx	xxxxx
	Ca	28.730	14.16	6.310	2.170	0.200	0.032
	S	xxxxx	xxxxx	5.600	2.410	xxxxx	xxxxx
	Mg	xxxxx	xxxxx	0.260	0.150	xxxxx	xxxxx
	K	xxxxx	xxxxx	0.530	0.190	xxxxx	xxxxx
	Fe	xxxxx	xxxxx	xxxxx	xxxxx	0.190	0.095
	Si	xxxxx	xxxxx	xxxxx	xxxxx	1.560	0.700
1000 °C	C	22.980	34.850	76.56	86.29	xxxxx	xxxxx
	O	41.710	47.500	10.32	8.730	xxxxx	xxxxx
	Mg	0.5200	0.3900	0.230	0.130	xxxxx	xxxxx
	P	10.830	6.3700	6.330	2.140	xxxxx	xxxxx
	Ca	23.960	10.890	6.330	2.140	xxxxx	xxxxx
	Zn	xxxxx	xxxxx	0.050	0.010	xxxxx	xxxxx
	S	xxxxx	xxxxx	5.420	2.290	xxxxx	xxxxx
	Cl	xxxxx	xxxxx	0.440	0.170	xxxxx	xxxxx
	K	xxxxx	xxxxx	0.750	0.260	xxxxx	xxxxx

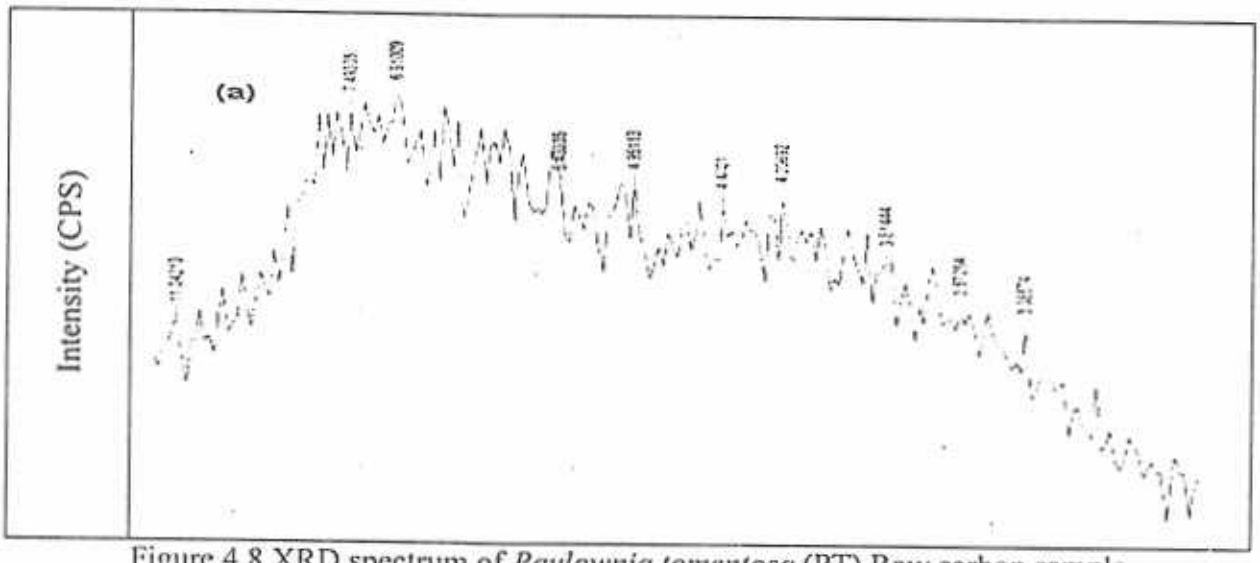


Figure 4.8 XRD spectrum of *Paulownia tomentosa* (PT) Raw carbon sample

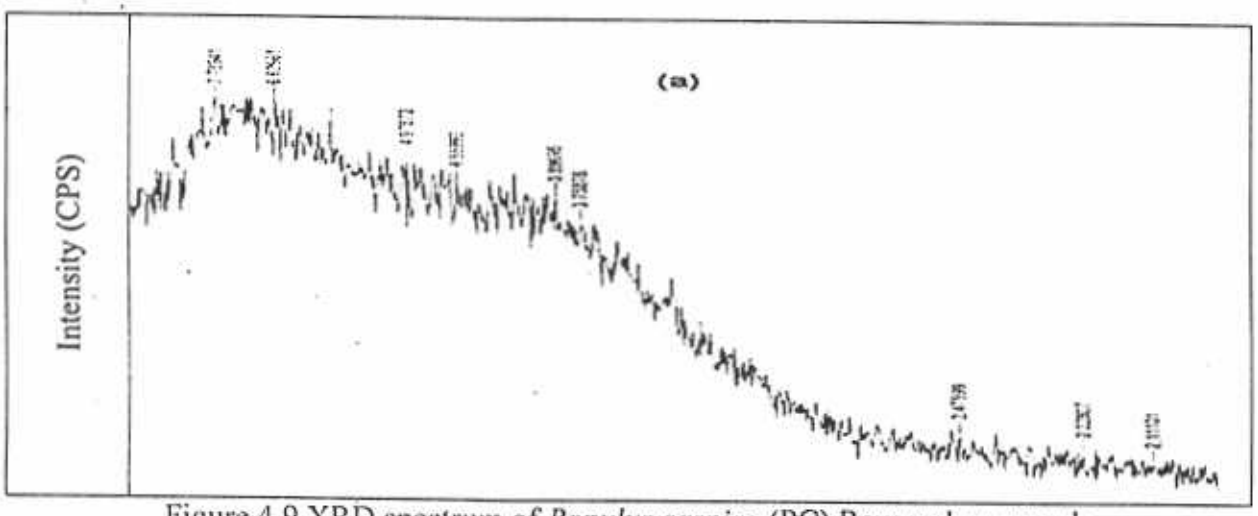


Figure 4.9 XRD spectrum of *Populus caspica* (PC) Raw carbon sample

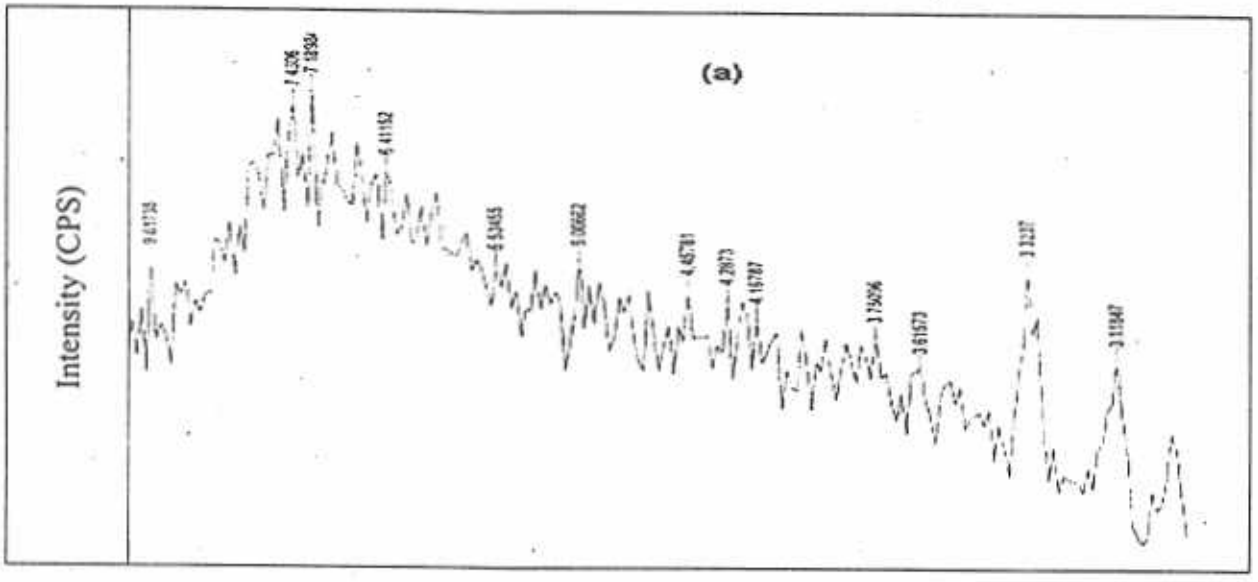


Figure 4.10 XRD spectrum of *Corncobs* (CC) Raw carbon sample

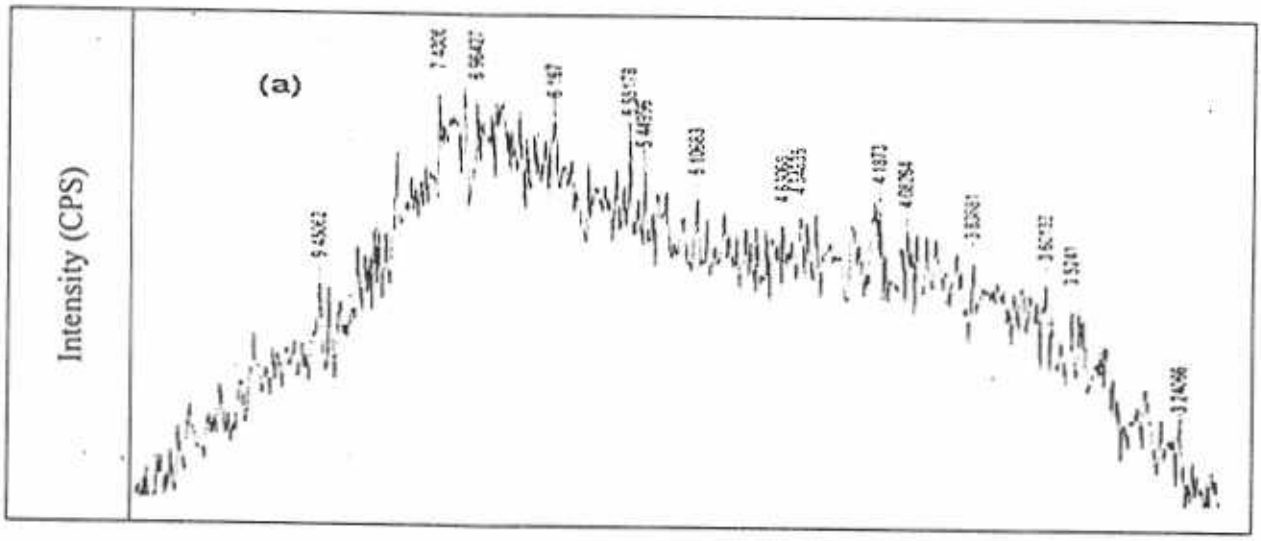


Figure 4.11 XRD spectrum of *Ailanthus altissima* (AA) Raw carbon sample

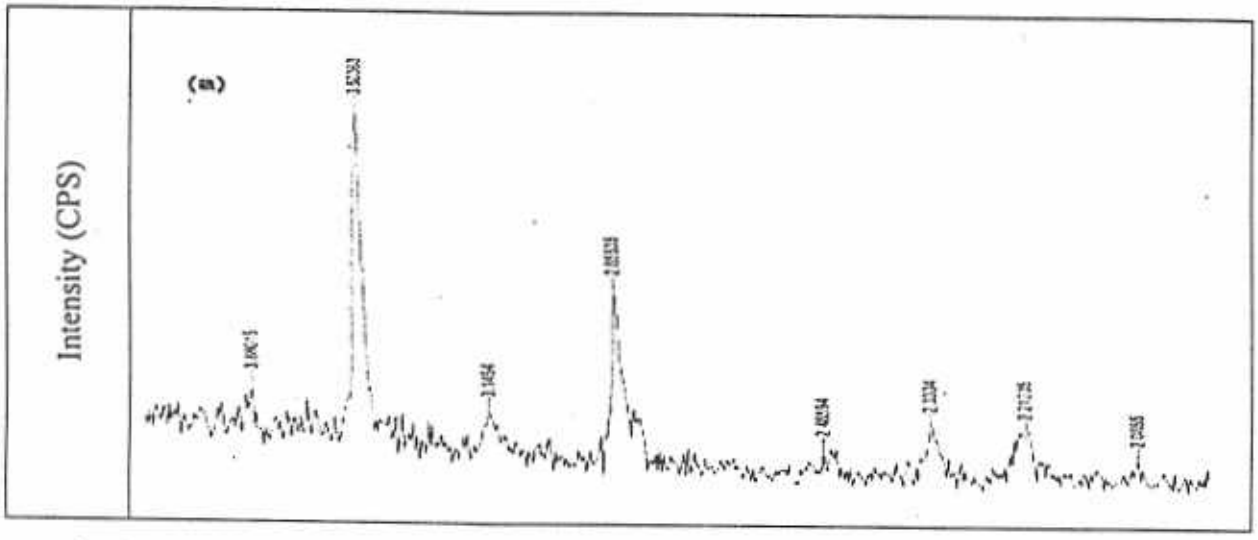


Figure 4.12 XRD spectrum of *Salvadora oleoides* (SO) Raw carbon sample

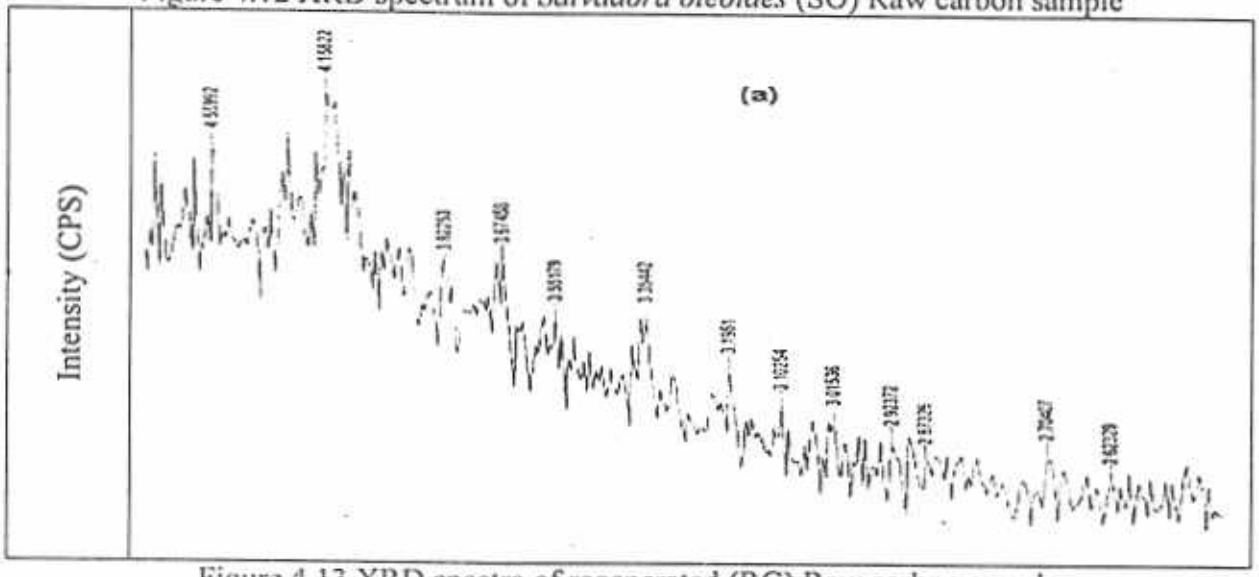


Figure 4.13 XRD spectra of regenerated (RG) Raw carbon sample

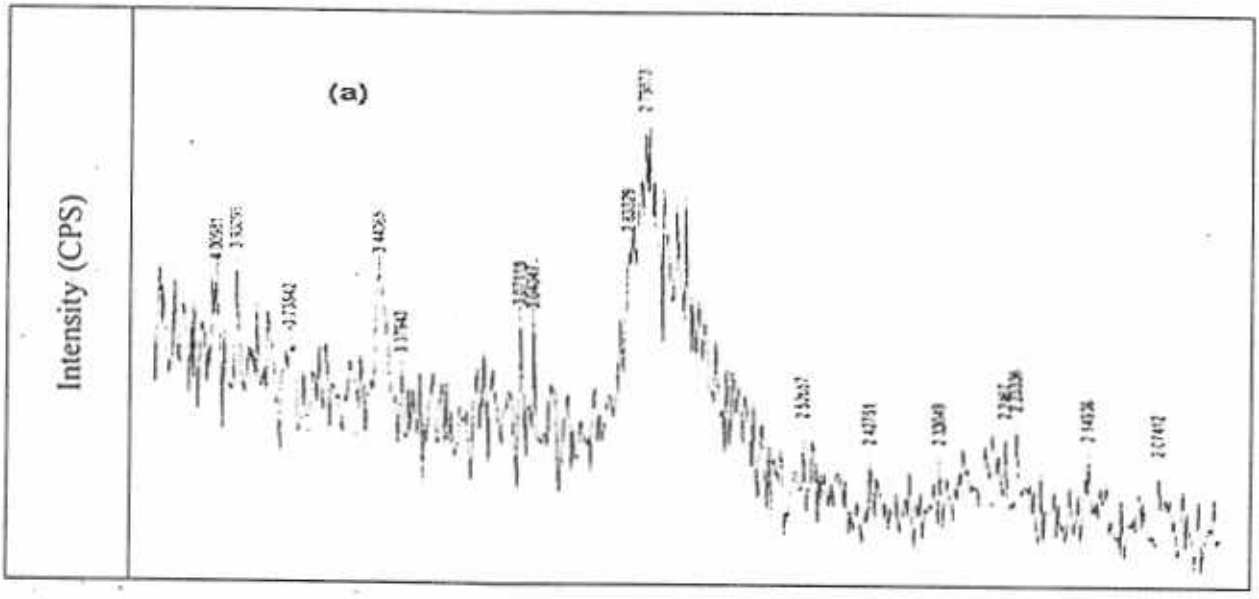


Figure 4.14 XRD spectrum of animal bones charcoal (ABC) 600 °C activated carbon sample.

Table 4.6 Adsorption kinetics of acid blue 1 on *Paulownia tomentosa* (PT) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_o (mol/L×10^{-5})	D_o-D_σ (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})	pH_M	Ab_M	D_o (mol/L×10^{-5})	D_o-D_σ (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})
Raw	05	6.89	1.240	1.7170	0.2830	0.2830	6.98	1.660	1.6600	0.3400	0.3400
	10	6.60	1.130	1.5650	0.4420	0.4420	7.00	1.520	1.5200	0.4800	0.4800
	15	6.50	1.100	1.5230	0.4800	0.4800	7.01	1.390	1.3900	0.6100	0.6100
	20	6.45	1.050	1.4540	0.5500	0.5500	7.11	1.370	1.3700	0.6300	0.6300
	25	6.42	1.000	1.3850	0.6150	0.6150	7.11	1.360	1.3600	0.6400	0.6400
	30	6.40	0.990	1.3830	0.6200	0.6200	7.11	1.350	1.3500	0.6500	0.6500
400 °C	05	6.40	0.975	1.3500	0.650	0.650	7.17	0.960	1.3300	0.6700	0.6700
	10	6.63	0.880	1.2200	0.780	0.780	7.31	0.870	1.2100	0.7900	0.7900
	15	6.62	0.812	1.1300	0.870	0.870	7.45	0.800	1.1100	0.8900	0.8900
	20	6.65	0.770	1.0700	0.930	0.930	7.50	0.760	1.0500	0.9500	0.9500
	25	6.66	0.750	1.0400	0.960	0.960	7.52	0.745	1.0300	0.9700	0.9700
	30	6.67	0.740	1.0250	0.974	0.974	7.54	0.735	1.0200	0.9810	0.9810
800 °C	05	9.10	0.772	1.0694	0.9306	0.9306	9.31	0.660	0.9142	1.0857	1.0857
	10	9.15	0.536	0.7425	1.2575	1.2575	9.37	0.495	0.6856	1.3143	1.3143
	15	9.30	0.422	0.5845	1.415	1.4150	9.40	0.371	0.5139	1.4860	1.4860
	20	9.35	0.400	0.5541	1.4459	1.4459	9.41	0.350	0.4848	1.5152	1.5152
	25	9.40	0.390	0.5402	1.4597	1.4597	9.42	0.345	0.4779	1.5221	1.5221
	30	9.45	0.380	0.5264	1.4736	1.4736	9.44	0.340	0.4709	1.5290	1.5290

Initial Concentration of AB1(D_o) = 2 × 10^{-3}mol.dm^{-3}, Adsorbent doze = 0.2 g, Adsorbate volume=20 Cm^{-3}, Particle size=150-180 µm, , pH of D_o before adsorption = 7.00.

Table 4.7 Adsorption kinetics of acid blue 1 on *Populus caspica* (PC) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_o (mol/L×10^{-5})	D_o-D_σ (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})	pH_M	Ab_M	D_o (mol/L×10^{-5})	D_o-D_σ (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})
Raw	05	5.13	1.300	1.8000	0.1991	0.1991	7.79	1.280	1.7700	0.2300	0.2300
	10	6.80	1.240	1.7000	0.3000	0.3000	7.81	1.200	1.6600	0.3400	0.3400
	15	6.85	1.220	1.6900	0.3100	0.3100	7.86	1.150	1.5900	0.4100	0.4100
	20	6.90	1.200	1.6600	0.3400	0.3400	7.90	1.080	1.4960	0.5040	0.5040
	25	6.95	1.180	1.6300	0.3700	0.3700	7.92	1.062	1.4710	0.5288	0.5288
	30	6.98	1.160	1.6000	0.4000	0.4000	7.91	1.043	1.4450	0.5552	0.5552
400 °C	05	8.88	1.085	1.5029	0.4971	0.4971	9.13	1.035	1.4337	0.5663	0.5663
	10	9.18	0.980	1.3575	0.6425	0.6425	9.28	0.900	1.2467	0.7532	0.7532
	15	9.41	0.870	1.2052	0.7948	0.7948	9.34	0.738	1.0223	0.9777	0.9777
	20	9.50	0.850	1.1775	0.8226	0.8226	9.44	0.700	0.9697	1.0303	1.0303
	25	9.60	0.840	1.1635	0.8364	0.8364	9.42	0.690	0.9558	1.0442	1.0442
	30	9.65	0.830	1.1497	0.8503	0.8503	9.45	0.680	0.9419	1.0581	1.0581
800 °C	05	10.00	1.035	1.4300	0.5662	0.5662	10.11	0.995	1.3780	0.6210	0.6210
	10	10.04	0.900	1.2460	0.7532	0.7532	10.08	0.850	1.1770	0.8225	0.8225
	15	10.08	0.738	1.0220	0.9780	0.9780	10.12	0.730	1.0110	0.9890	0.9890
	20	10.10	0.700	0.9700	1.0300	1.0300	10.14	0.700	0.9700	1.0300	1.0300
	25	10.11	0.690	0.9550	1.0450	1.0450	10.16	0.680	0.9400	1.0600	1.0600
	30	10.12	0.680	0.9420	1.0580	1.0580	10.15	0.670	0.9200	1.0800	1.0800

Initial Concentration of AB1(D_o) = 2 × 10^{-3}mol.dm^{-3}, Adsorbent doze = 0.2 g, Adsorbate volume=20 Cm^{-3}, Particle size=150-180 µm, , pH of D_o before adsorption = 7.00.

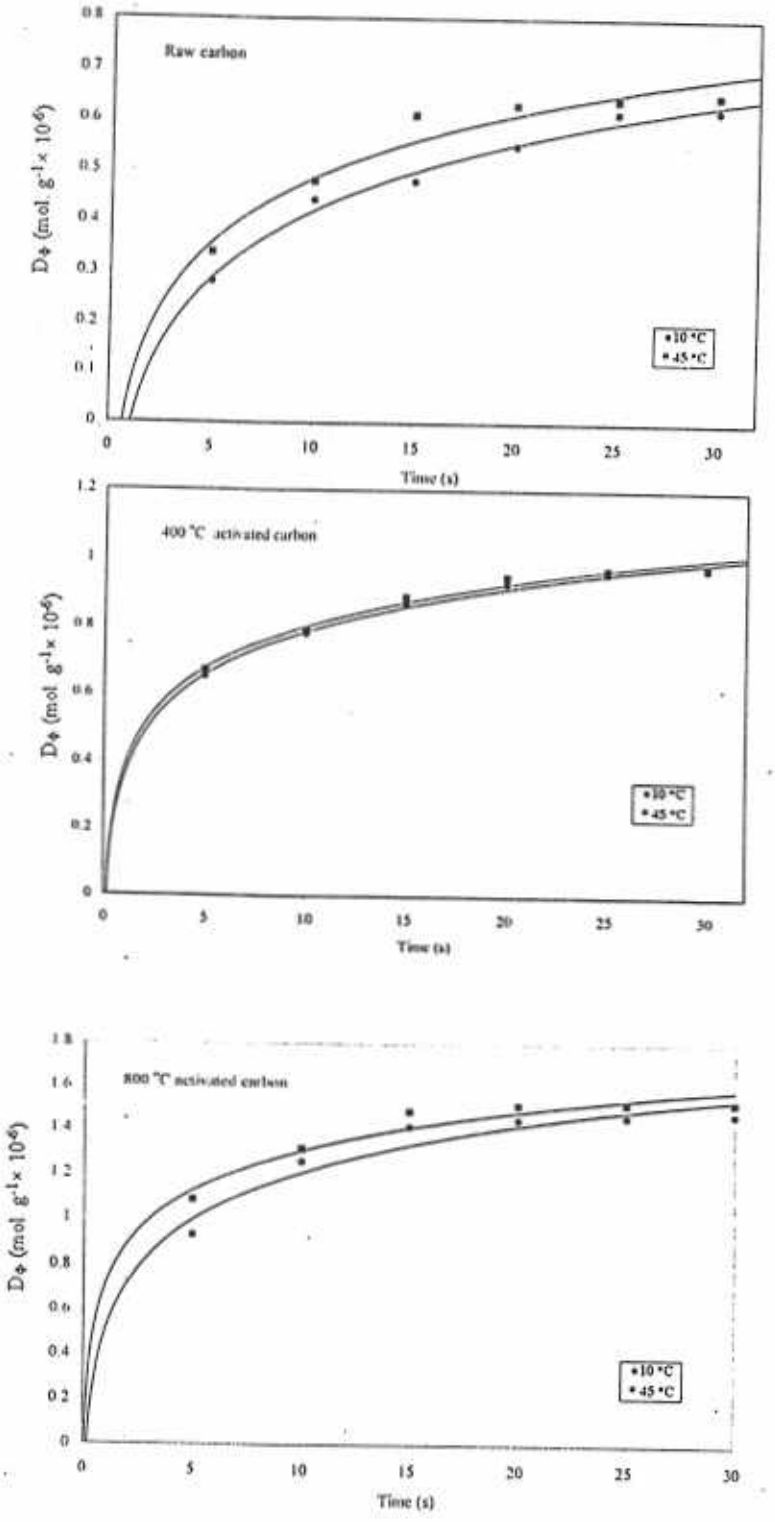


Figure 4.15 Adsorption kinetics of acid blue 1 on *Paulownia tomentosa* (PT) carbon samples

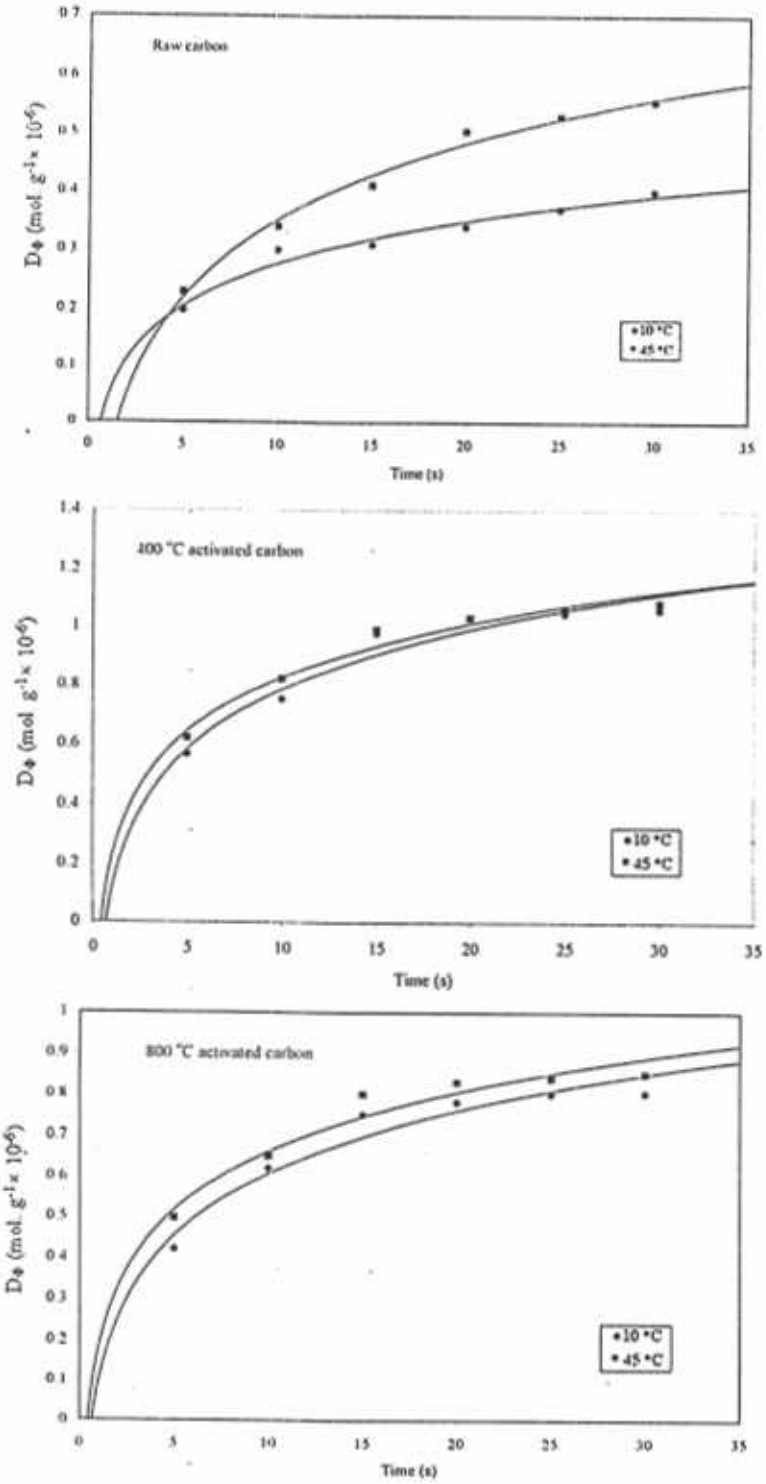


Figure 4.16 Adsorption kinetics of acid blue 1 on *Populus caspica* (PC) carbon samples

Table 4.8 Adsorption kinetics of acid blue 1 on *Corncobs* (CC) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	7.50	1.350	1.8700	0.1300	0.1300	8.95	1.300	1.8000	0.2000	0.2000
	10	7.10	1.300	1.8000	0.2000	0.2000	8.23	1.200	1.6600	0.3400	0.3400
	15	6.82	1.280	1.7700	0.2300	0.2300	8.20	1.120	1.5514	0.4490	0.4490
	20	6.73	1.260	1.7400	0.2600	0.2600	8.18	1.050	1.4500	0.5500	0.5500
	25	6.70	1.250	1.7300	0.2700	0.2700	8.15	1.000	1.3800	0.6200	0.6200
	30	6.68	1.240	1.7100	0.2900	0.2900	8.16	0.995	1.3700	0.6300	0.6300
400 °C	05	9.30	1.202	1.6650	0.3349	0.3349	9.44	1.020	1.4130	0.5870	0.5870
	10	9.50	1.000	1.3852	0.6147	0.6147	9.47	0.850	1.1800	0.8200	0.8200
	15	9.60	0.880	1.2200	0.7800	0.7800	9.53	0.800	1.1100	0.8900	0.8900
	20	9.62	0.860	1.2000	0.8000	0.8000	9.56	0.780	1.0800	0.9200	0.9200
	25	9.65	0.850	1.1800	0.8200	0.8200	9.60	0.760	1.0500	0.9500	0.9500
	30	9.67	0.845	1.1700	0.8300	0.8300	9.62	0.750	1.0300	0.9700	0.9700
800 °C	05	9.67	0.990	1.3714	0.6280	0.6280	9.820	0.840	1.1630	0.8360	0.8360
	10	9.66	0.860	1.1910	0.8086	0.8086	9.840	0.540	0.7800	1.2500	1.2500
	15	9.68	0.724	1.0030	0.9971	0.9971	9.850	0.440	0.6100	1.3900	1.3900
	20	9.70	0.618	0.8560	1.1440	1.1440	9.860	0.400	0.5500	1.4500	1.4500
	25	9.72	0.490	0.6780	1.3200	1.3200	9.880	0.390	0.5400	1.4500	1.4500
	30	9.74	0.482	0.6670	1.3300	1.3300	9.870	0.380	0.5200	1.4600	1.4600

Initial Concentration of AB1(D_o) = 2 × 10^{-3} mol.dm^{-3}, Adsorbent doze = 0.2 g, Adsorbate volume=20 Cm^{-3}, Particle size=150-180 μm, , pH of D_o before adsorption = 7.00

Table 4.9 Adsorption kinetics of acid blue 1 on *Ailanthus altissima* (AA) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	7.40	1.190	1.6500	0.3500	0.3500	8.69	1.100	1.5200	0.4760	0.4760
	10	7.20	1.090	1.5100	0.4900	0.4900	8.35	1.000	1.3800	0.6800	0.6800
	15	7.10	1.050	1.4540	0.5455	0.5455	8.38	0.900	1.2500	0.7500	0.7500
	20	7.00	0.998	1.3800	0.6200	0.6200	8.30	0.880	1.2200	0.7800	0.7800
	25	6.90	0.995	1.3780	0.6216	0.6216	8.29	0.870	1.2000	0.8000	0.8000
	30	6.83	0.994	1.3770	0.6230	0.6230	8.28	0.860	1.1900	0.8100	0.8100
400 °C	05	8.40	1.090	1.5100	0.490	0.490	9.33	1.000	1.3800	0.6200	0.6200
	10	8.90	0.960	1.3300	0.670	0.670	9.43	0.945	1.3100	0.6900	0.6900
	15	9.10	0.895	1.2400	0.760	0.760	9.45	0.870	1.2100	0.7900	0.7900
	20	9.15	0.880	1.2200	0.780	0.780	9.48	0.850	1.1800	0.8200	0.8200
	25	9.20	0.870	1.2100	0.790	0.790	9.50	0.840	1.1600	0.8400	0.8400
	30	9.25	0.865	1.2000	0.800	0.800	9.52	0.830	1.1500	0.8500	0.8500
800 °C	05	10.02	0.985	1.3644	0.6355	0.6355	10.10	0.880	1.2190	0.7809	0.7809
	10	10.06	0.862	1.1940	0.8059	0.8059	10.12	0.790	1.0943	0.9056	0.9056
	15	10.08	0.800	1.1082	0.8918	0.8918	10.14	0.680	0.9419	1.0580	1.0580
	20	10.10	0.750	1.0389	0.9610	0.9610	10.15	0.672	0.9308	1.0691	1.0691
	25	10.12	0.720	0.9973	1.0026	1.0026	10.16	0.665	0.9211	1.0788	1.0788
	30	10.14	0.702	0.9724	1.0275	1.0275	10.17	0.661	0.9156	1.0843	1.0843

Initial Concentration of AB1(D_o) = 2 × 10^{-3} mol.dm^{-3}, Adsorbent doze = 0.2 g, Adsorbate volume=20 Cm^{-3}, Particle size=150-180 μm, , pH of D_o before adsorption = 7.00,

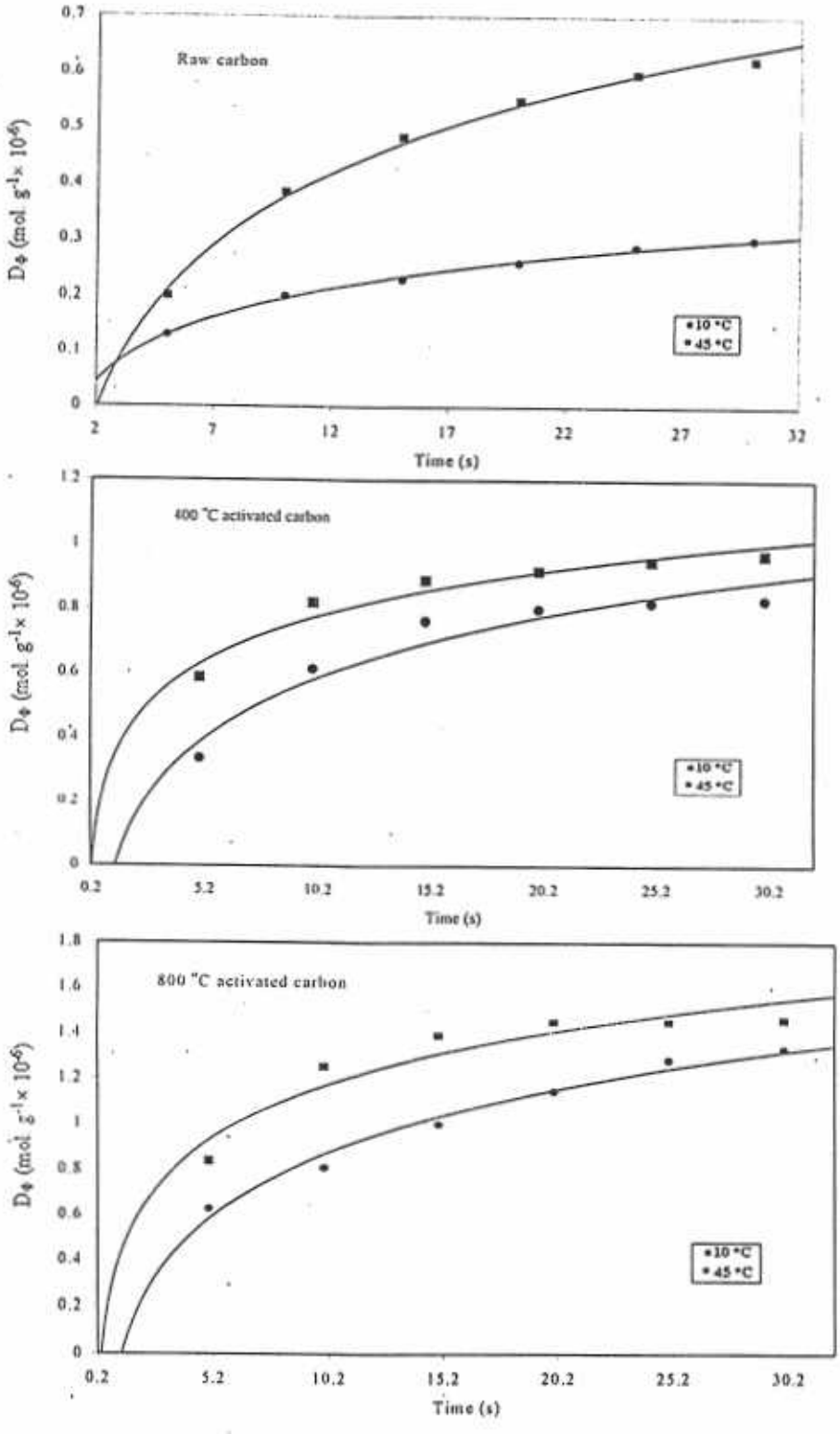


Figure 4.17 Adsorption kinetics of acid blue 1 on *corncobs* (CC) carbon samples

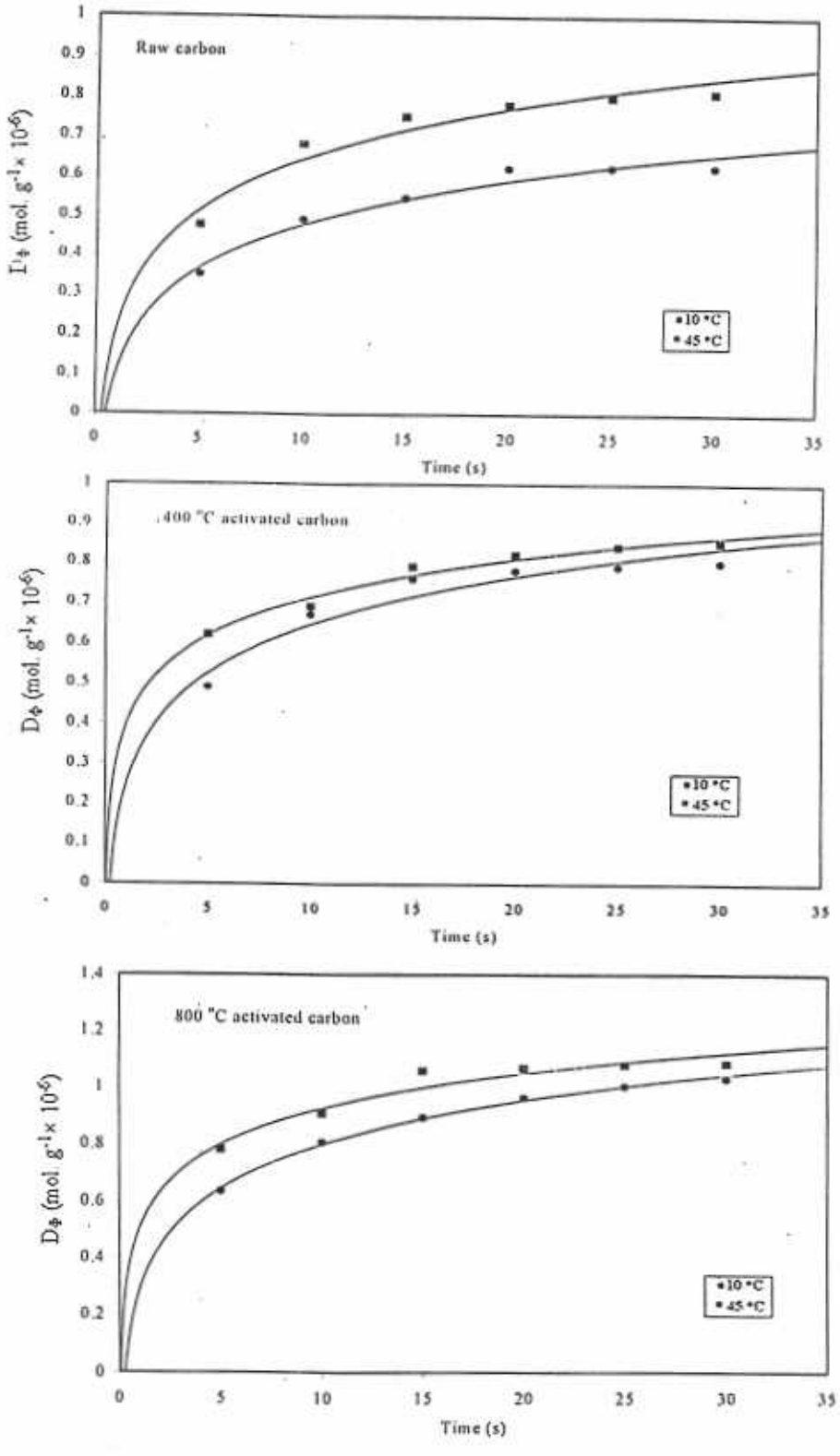
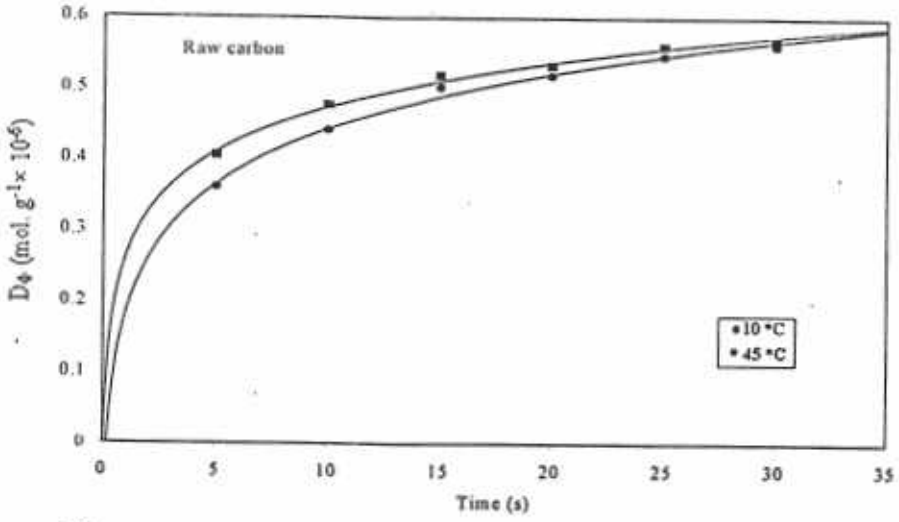


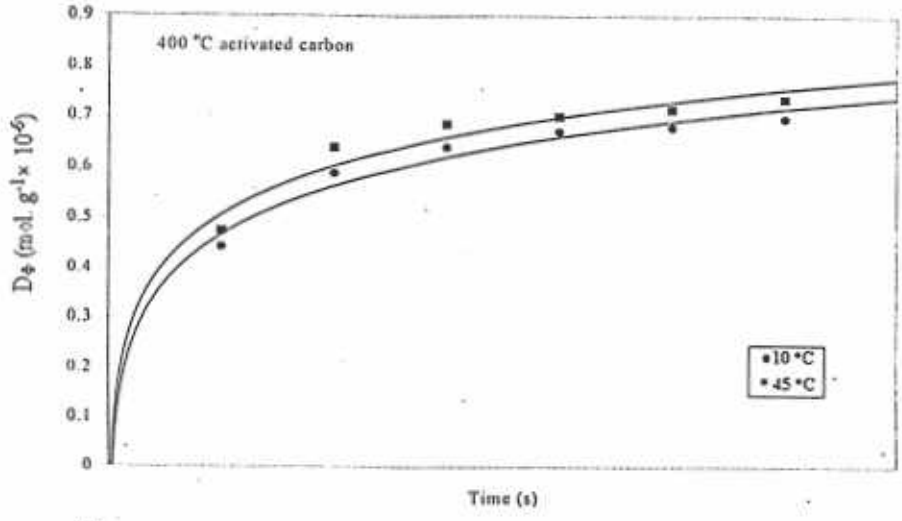
Figure 4.18 Adsorption kinetics of acid blue 1 on *Ailanthus altissima* (AA) carbon samples

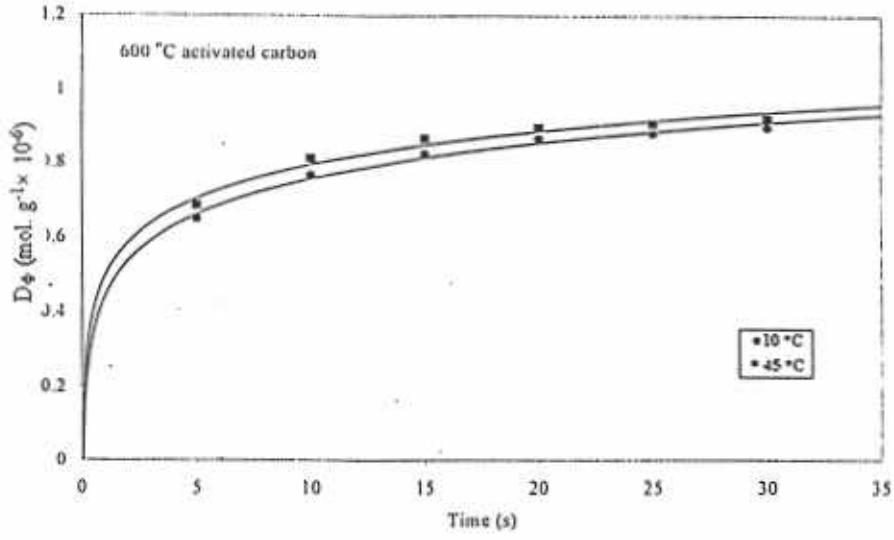
Table 4.10 Adsorption kinetics of acid blue 1 on *Salvadora oleoides* (SO) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	7.75	0.534	0.7397	0.3603	0.3603	7.85	0.502	0.6954	0.4046	0.4046
	10	7.75	0.476	0.6594	0.4406	0.4406	7.88	0.450	0.6233	0.4766	0.4766
	15	7.76	0.432	0.5984	0.5016	0.5016	7.89	0.420	0.5818	0.5182	0.5182
	20	7.77	0.420	0.5818	0.5182	0.5182	7.92	0.410	0.5679	0.5321	0.5321
	25	7.79	0.400	0.5541	0.5459	0.5459	7.96	0.390	0.5402	0.5597	0.5597
	30	7.82	0.390	0.5402	0.5598	0.5598	7.97	0.385	0.5333	0.5667	0.5667
400 °C	05	7.82	0.474	0.6560	0.4430	0.4430	7.88	0.451	0.6240	0.4750	0.4750
	10	7.86	0.370	0.5120	0.5880	0.5880	7.89	0.334	0.4620	0.6380	0.6380
	15	7.89	0.333	0.4610	0.6390	0.6390	7.96	0.300	0.4150	0.6850	0.6850
	20	7.93	0.310	0.4300	0.6700	0.6700	7.97	0.289	0.4000	0.7000	0.7000
	25	7.95	0.305	0.4220	0.6780	0.6780	7.99	0.279	0.3860	0.7140	0.7140
	30	7.99	0.292	0.4040	0.6960	0.6960	7.99	0.264	0.3650	0.7350	0.7350
600 °C	05	7.92	0.325	0.4150	0.6490	0.6490	7.96	0.300	0.4150	0.6850	0.6850
	10	7.99	0.214	0.3340	0.7660	0.7660	7.99	0.209	0.2890	0.8110	0.8110
	15	8.00	0.200	0.2770	0.8230	0.8230	8.07	0.170	0.2350	0.8650	0.8650
	20	8.09	0.170	0.2350	0.8650	0.8650	8.12	0.148	0.2050	0.8950	0.8950
	25	8.09	0.160	0.2220	0.8780	0.8780	8.13	0.140	0.1940	0.9060	0.9060
	30	8.10	0.149	0.2060	0.8940	0.8940	8.11	0.131	0.1810	0.9190	0.9190
800 °C	05	8.01	0.198	0.2740	0.8260	0.8260	8.09	0.151	0.2090	0.8910	0.8910
	10	8.09	0.129	0.1780	0.9220	0.9220	8.13	0.079	0.1100	0.9900	0.9900
	15	8.19	0.090	0.1250	0.9750	0.9750	8.15	0.048	0.0660	1.0340	1.0340
	20	8.19	0.071	0.0980	1.0020	1.0020	8.22	0.038	0.0530	1.0470	1.0470
	25	8.20	0.060	0.0830	1.0170	1.0170	8.23	0.022	0.0300	1.0700	1.0700
	30	8.11	0.047	0.0650	1.0350	1.0350	8.20	0.020	0.0280	1.0720	1.0720
900 °C	05	8.05	0.137	0.1890	0.9110	0.9110	8.15	0.121	0.1676	0.9324	0.9324
	10	8.16	0.090	0.1246	0.9754	0.9754	8.19	0.054	0.0748	1.0252	1.0252
	15	8.19	0.050	0.0692	1.0308	1.0308	8.23	0.020	0.0277	1.0723	1.0723
	20	8.28	0.038	0.0526	1.0474	1.0474	8.30	0.011	0.0152	1.0848	1.0848
	25	8.26	0.025	0.0346	1.0654	1.0654	8.31	0.012	0.0166	1.0834	1.0834
	30	8.25	0.015	0.0207	1.0793	1.0793	8.28	0.009	0.0124	1.0875	1.0875
1000 °C	05	8.17	0.133	0.1842	0.9158	0.9158	8.19	0.109	0.1510	0.9490	0.9490
	10	8.21	0.070	0.0969	1.0031	1.0031	8.23	0.048	0.0665	1.0335	1.0335
	15	8.27	0.055	0.0762	1.0238	1.0238	8.29	0.030	0.0415	1.0585	1.0585
	20	8.31	0.045	0.0623	1.0377	1.0377	8.36	0.025	0.0346	1.0654	1.0654
	25	8.33	0.040	0.0554	1.0446	1.0446	8.38	0.019	0.0263	1.0737	1.0737
	30	8.36	0.035	0.0485	1.0515	1.0515	8.30	0.007	0.0097	1.0903	1.0903

Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^{-3}, Particle Size= 150-180 µm, Initial Concentration of AB1(D_o) = 1.1 × 10^{-3}mol.dm^{-3}, pH of D_o Before Adsorption = 7.70


Raw carbon
D_ϕ (mol. g^{-1}× 10^{-6})
Time (s)
•10 °C
•45 °C


400 °C activated carbon
D_ϕ (mol. g^{-1}× 10^{-6})
Time (s)
•10 °C
•45 °C


600 °C activated carbon
D_ϕ (mol. g^{-1}× 10^{-6})
Time (s)
•10 °C
•45 °C

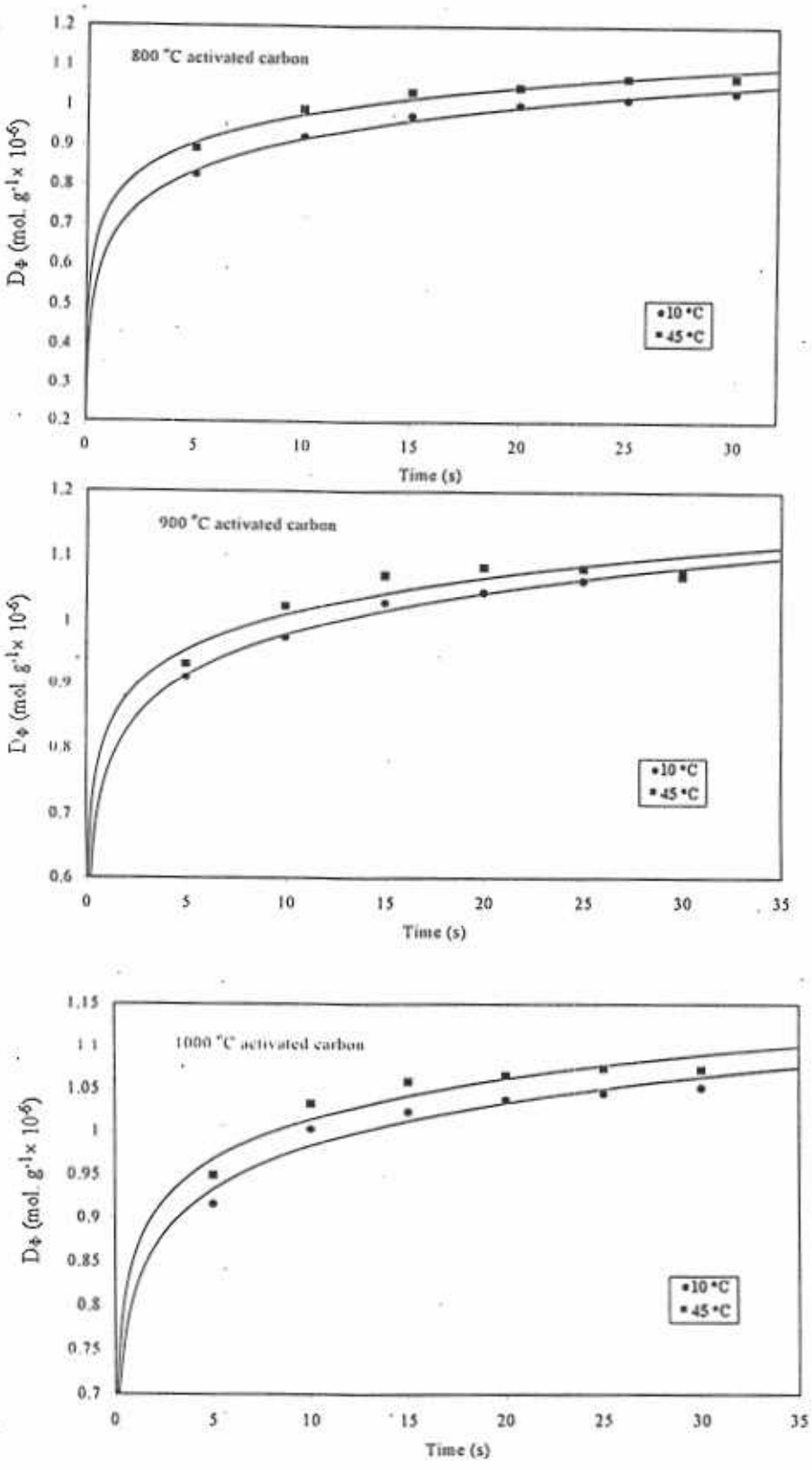
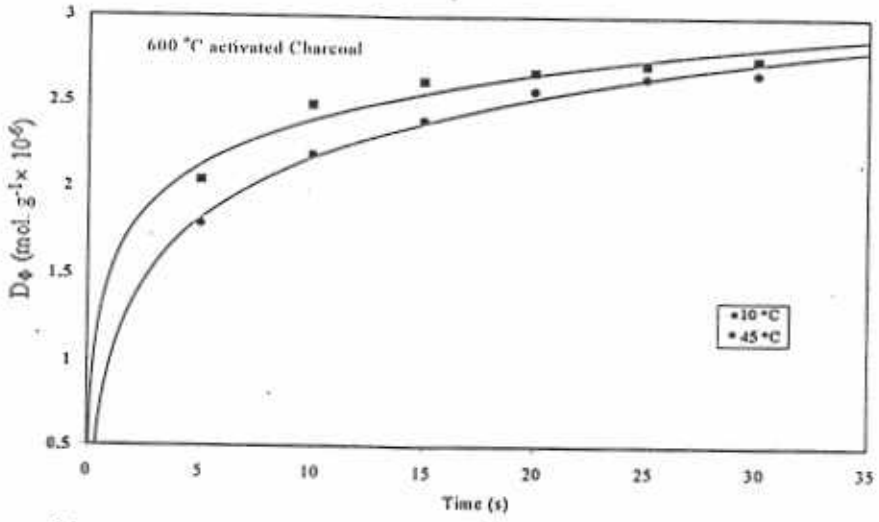


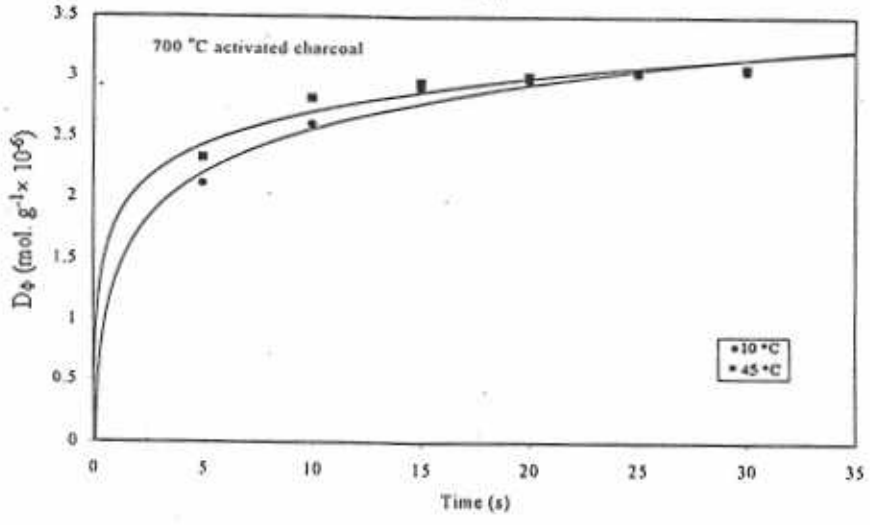
Figure 4.19 Adsorption kinetics of acid blue 1 on *Salvadora oleoides* (SO) carbon samples.

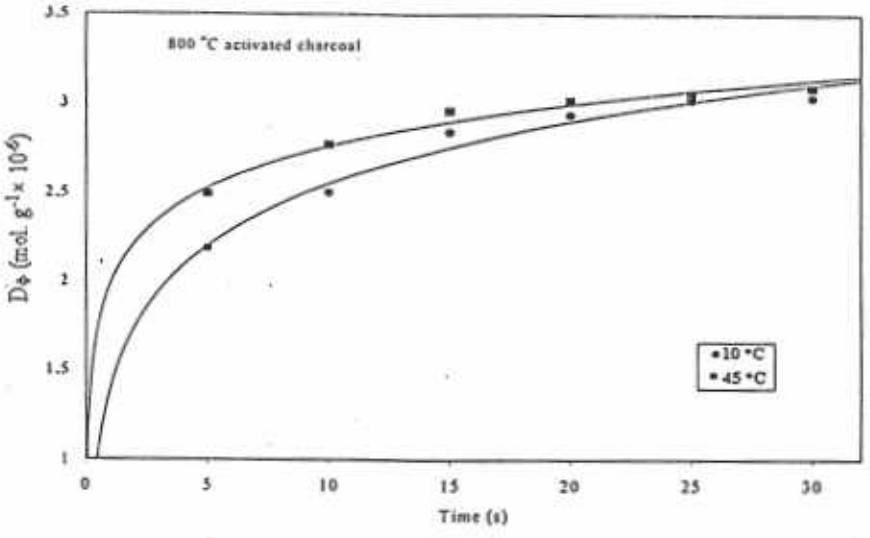
Table 4.11 Adsorption kinetics of acid blue 1 on animal bones charcoal (ABC) samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
600 °C	05	7.93	0.994	1.3760	1.7830	1.7830	7.99	0.808	1.1190	2.0400	2.0400
	10	7.96	0.702	0.9720	2.1880	2.1880	8.01	0.490	0.6780	2.4800	2.4800
	15	7.97	0.555	0.7680	2.3920	2.3920	8.05	0.392	0.5430	2.6170	2.6170
	20	7.98	0.432	0.5980	2.5620	2.5620	8.07	0.354	0.4900	2.6700	2.6700
	25	8.00	0.376	0.5210	2.6390	2.6390	8.10	0.324	0.4480	2.7120	2.7120
	30	8.03	0.358	0.4960	2.6640	2.6640	8.11	0.297	0.4110	2.7490	2.7490
700 °C	05	8.03	0.756	1.0470	2.1120	2.1120	8.09	0.601	0.8320	2.3270	2.3270
	10	8.07	0.399	0.5530	2.6070	2.6070	8.11	0.458	0.6340	2.5250	2.5250
	15	8.09	0.187	0.2590	2.9010	2.9010	8.12	0.151	0.2090	2.9510	2.9510
	20	8.12	0.140	0.1940	2.9660	2.9660	8.14	0.118	0.1630	2.9970	2.9970
	25	8.14	0.100	0.1380	3.0220	3.0220	8.17	0.090	0.1250	3.0350	3.0350
	30	8.18	0.084	0.1160	3.0440	3.0440	8.19	0.065	0.0900	3.0700	3.0700
800 °C	05	8.13	0.699	0.9682	2.1910	2.1910	8.15	0.480	0.6649	2.4950	2.4950
	10	8.17	0.473	0.6552	2.5040	2.5040	8.18	0.280	0.3878	2.7720	2.7720
	15	8.18	0.228	0.3160	2.8440	2.8440	8.19	0.144	0.1990	2.9610	2.9610
	20	8.12	0.159	0.2200	2.9400	2.9400	8.22	0.102	0.1410	3.0200	3.0200
	25	8.11	0.099	0.1370	3.0230	3.0230	8.20	0.074	0.1020	3.0580	3.0580
	30	8.22	0.088	0.1220	3.0380	3.0380	8.24	0.050	0.0700	3.0900	3.0900
900 °C	05	8.17	0.350	0.4840	2.6760	2.6760	8.19	0.312	0.4321	2.7270	2.7270
	10	8.19	0.185	0.2560	2.9040	2.9040	8.20	0.182	0.2521	2.9070	2.9070
	15	8.22	0.110	0.1520	3.0080	3.0080	8.24	0.107	0.1480	3.0120	3.0120
	20	8.23	0.060	0.0830	3.0770	3.0770	8.26	0.051	0.0700	3.0900	3.0900
	25	8.20	0.050	0.0690	3.0910	3.0910	8.29	0.042	0.0580	3.1020	3.1020
	30	8.27	0.033	0.0450	3.1150	3.1150	8.36	0.023	0.0320	3.1280	3.1280
1000 °C	05	8.21	0.300	0.4155	2.7445	2.7445	8.26	0.280	0.3878	2.7721	2.7721
	10	8.23	0.160	0.2215	2.9385	2.9385	8.29	0.100	0.1385	3.0215	3.0215
	15	8.25	0.100	0.1385	3.0215	3.0215	8.37	0.060	0.0830	3.0770	3.0770
	20	8.29	0.035	0.0484	3.1116	3.1116	8.41	0.020	0.0277	3.1323	3.1323
	25	8.23	0.020	0.0277	3.1323	3.1323	8.22	0.010	0.0138	3.1462	3.1462
	30	8.20	0.015	0.0207	3.1393	3.1393	8.17	0.003	0.0041	3.1558	3.1558

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 μm, Initial Concentration of AB1(D_o) = 3.16 × 10^{-5}mol.dm^3, pH of D_o Before Adsorption = 7.90*


600 °C activated Charcoal
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
•45 °C


700 °C activated charcoal
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
•45 °C


800 °C activated charcoal
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
•45 °C

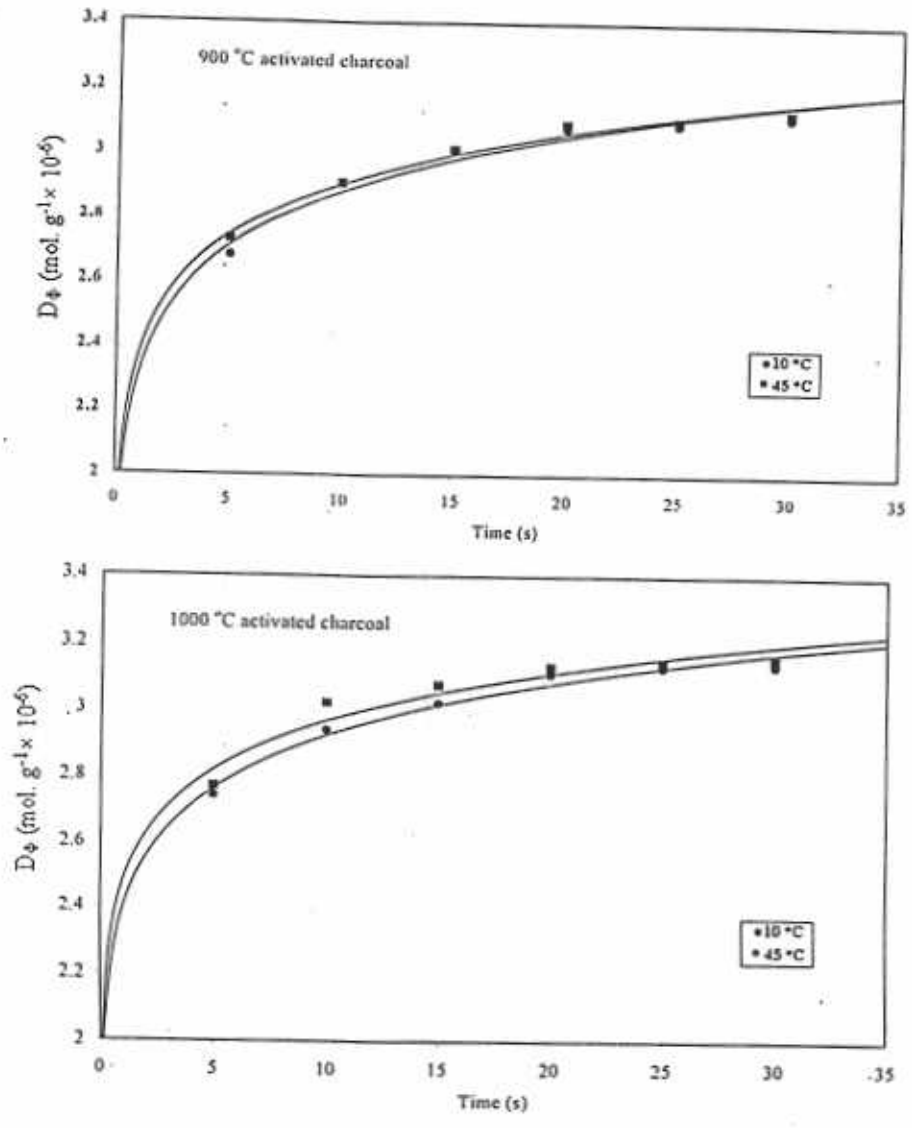
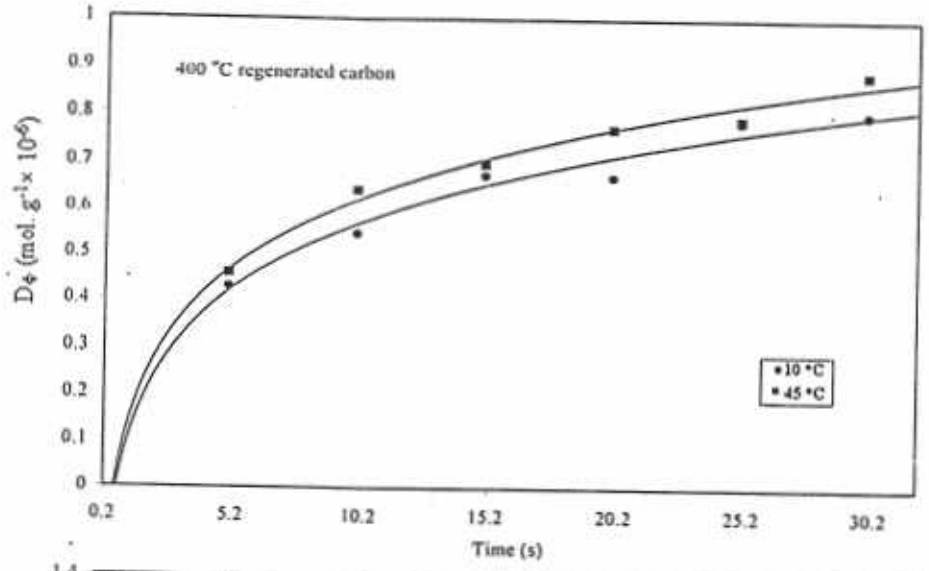


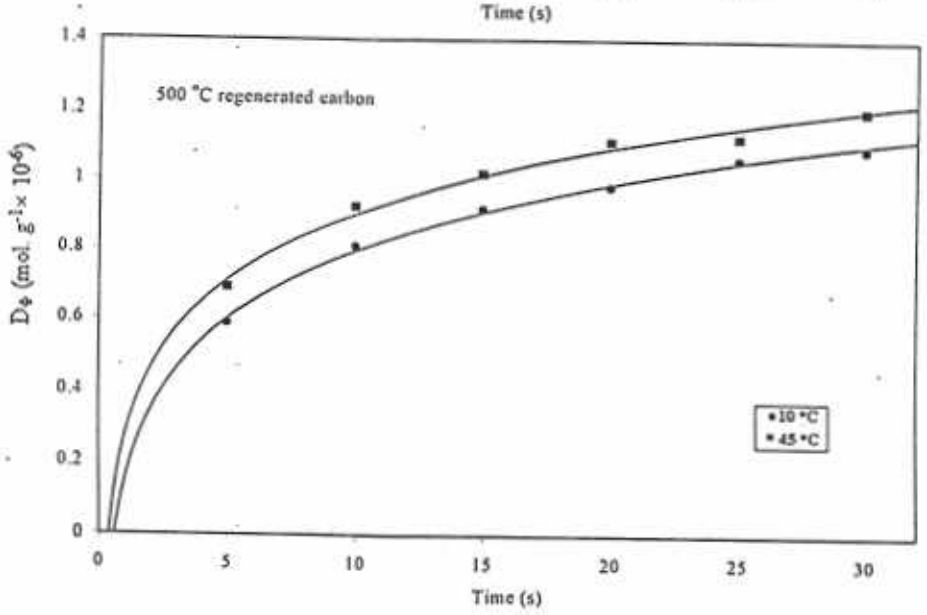
Figure 4.20 Adsorption kinetics of acid blue 1 on animal bones charcoal (ABC) samples

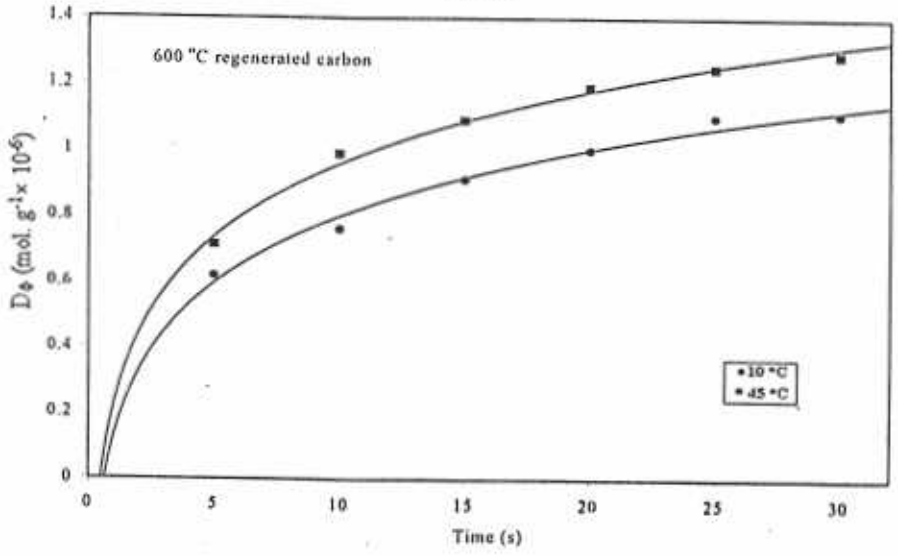
Table 4.12 Adsorption kinetics of acid blue 1 on regenerated carbon (RG) samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
400 °C	05	8.01	0.809	1.1206	0.4294	0.4294	8.03	0.788	1.0915	0.4585	0.4585
	10	8.02	0.725	1.0042	0.5458	0.5458	8.04	0.657	0.9101	0.6399	0.6399
	15	8.06	0.633	0.8768	0.6732	0.6732	8.07	0.616	0.8530	0.6970	0.6970
	20	8.07	0.635	0.8796	0.6704	0.6704	8.09	0.562	0.7785	0.7715	0.7715
	25	8.09	0.551	0.7632	0.7868	0.7868	8.14	0.549	0.7605	0.7895	0.7895
	30	8.11	0.540	0.7480	0.8020	0.8020	8.12	0.480	0.6649	0.8851	0.8851
500 °C	05	8.01	0.695	0.9627	0.5872	0.5872	8.08	0.620	0.8588	0.6911	0.6911
	10	8.04	0.535	0.7411	0.8089	0.8089	8.15	0.451	0.6247	0.9253	0.9253
	15	8.00	0.456	0.6316	0.9184	0.9184	8.17	0.384	0.5319	1.0181	1.0181
	20	8.03	0.410	0.5679	0.9821	0.9821	8.21	0.316	0.4377	1.1123	1.1123
	25	8.10	0.354	0.4903	1.0597	1.0597	8.23	0.308	0.4266	1.1234	1.1234
	30	7.98	0.333	0.4613	1.0887	1.0887	8.25	0.253	0.3504	1.1996	1.1996
600 °C	05	8.05	0.672	0.9308	0.6192	0.6192	8.09	0.603	0.8353	0.7147	0.7147
	10	8.13	0.569	0.7881	0.7619	0.7619	8.11	0.405	0.5610	0.9890	0.9890
	15	8.11	0.460	0.6372	0.9128	0.9128	8.17	0.331	0.4585	1.0915	1.0915
	20	8.29	0.396	0.5485	1.0015	1.0015	8.26	0.258	0.3574	1.1926	1.1926
	25	8.20	0.324	0.4488	1.1012	1.1012	8.27	0.217	0.3006	1.2494	1.2494
	30	8.24	0.317	0.4391	1.1109	1.1109	8.19	0.188	0.2604	1.2896	1.2896
800 °C	05	8.03	0.589	0.8159	0.7341	0.7341	8.15	0.480	0.6649	0.8850	0.8850
	10	7.96	0.481	0.6663	0.8837	0.8837	8.19	0.311	0.4308	1.1192	1.1192
	15	8.09	0.394	0.5457	1.0043	1.0043	8.23	0.269	0.3726	1.1774	1.1774
	20	8.15	0.322	0.4460	1.1040	1.1040	8.39	0.195	0.2701	1.2799	1.2799
	25	8.48	0.288	0.3989	1.1511	1.1511	8.49	0.163	0.2257	1.3243	1.3243
	30	8.33	0.244	0.3379	1.2121	1.2121	8.53	0.108	0.1496	1.4004	1.4004
900 °C	05	7.44	0.615	0.8519	0.6981	0.6981	9.50	0.454	0.6288	0.9211	0.9211
	10	8.00	0.518	0.7175	0.8324	0.8324	8.23	0.317	0.4391	1.1109	1.1109
	15	8.21	0.430	0.5956	0.9544	0.9544	8.40	0.232	0.3213	1.2287	1.2287
	20	8.37	0.357	0.4945	1.0555	1.0555	8.45	0.179	0.2479	1.3021	1.3021
	25	8.21	0.280	0.3878	1.1622	1.1622	8.46	0.150	0.2077	1.3423	1.3423
	30	8.03	0.237	0.3283	1.2217	1.2217	8.48	0.104	0.1440	1.4060	1.4060
1000 °C	05	9.59	0.488	0.6759	0.8741	0.8741	9.61	0.376	0.5200	1.0300	1.0300
	10	8.29	0.434	0.6012	0.9488	0.9488	8.31	0.274	0.3790	1.1710	1.1710
	15	8.42	0.361	0.5000	1.0500	1.0500	8.44	0.210	0.2908	1.2592	1.2592
	20	8.43	0.280	0.3878	1.1622	1.1622	8.47	0.183	0.2534	1.2966	1.2966
	25	8.49	0.230	0.3186	1.2314	1.2314	8.61	0.149	0.2064	1.3436	1.3436
	30	8.50	0.226	0.3130	1.2370	1.2370	8.23	0.109	0.1509	1.3991	1.3991

♦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 μm, Initial Concentration of AB1(D_o) = 1.55 × 10^{-5}mol.dm^3, pH of D_o Before Adsorption = 7.93*


400 °C regenerated carbon
Dϕ (mol. g-1 × 10-6)
Time (s)
•10 °C
▪45 °C


500 °C regenerated carbon
Dϕ (mol. g-1 × 10-6)
Time (s)
•10 °C
▪45 °C


600 °C regenerated carbon
Dϕ (mol. g-1 × 10-6)
Time (s)
•10 °C
▪45 °C

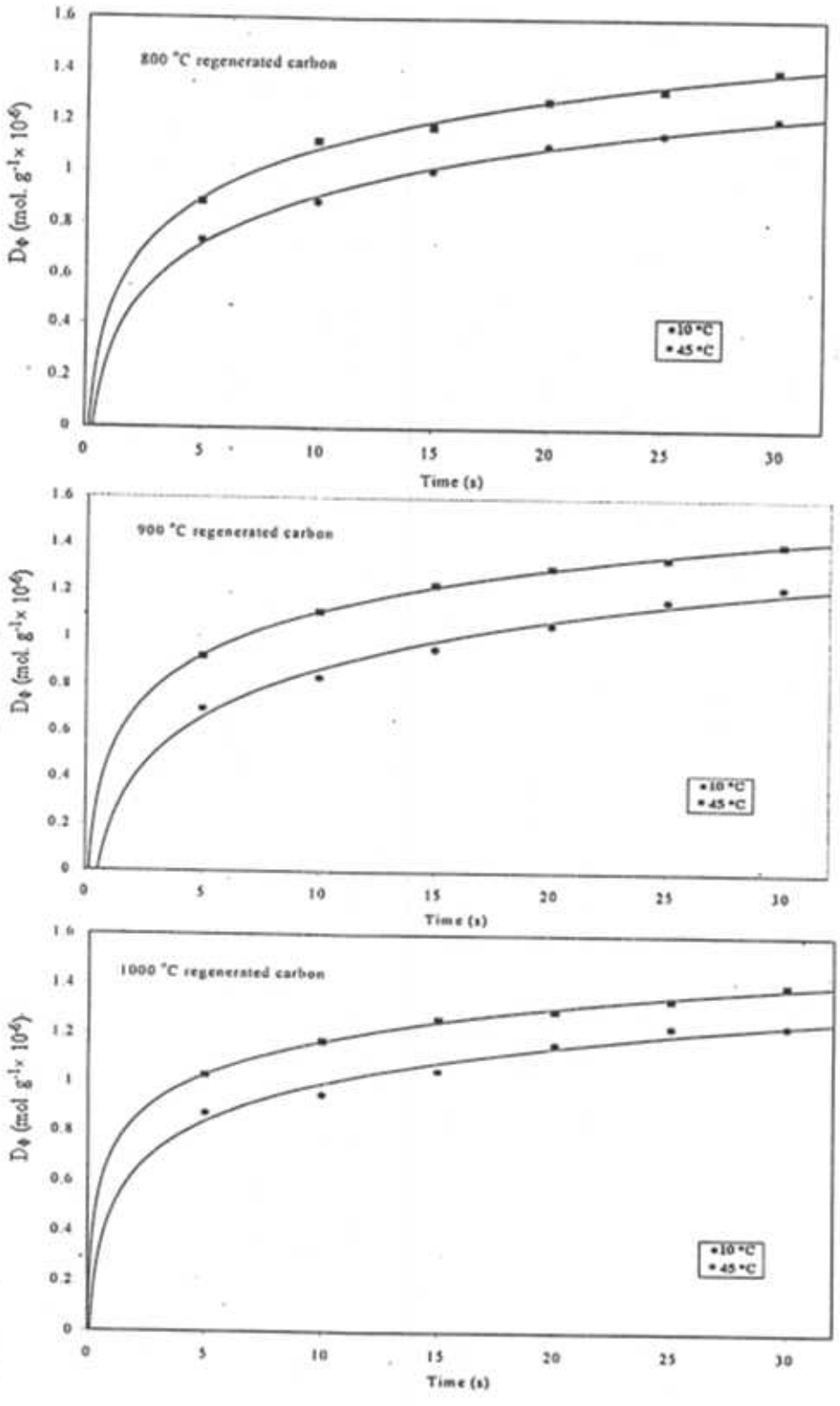


Figure 4.21 Adsorption kinetics of acid blue 1 on regenerated carbon (RG) samples

Table 4.13 Adsorption kinetics of brilliant blue R on *Paulownia tomentosa* (PT) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	6.09	0.294	2.6700	0.3300	0.330	7.48	0.258	2.3400	0.6600	0.6600
	10	6.10	0.261	2.3700	0.6300	0.630	7.02	0.221	2.0100	0.9900	0.9900
	15	6.24	0.250	2.2700	0.7300	0.730	6.96	0.201	1.8200	1.1800	1.1800
	20	6.25	0.241	2.1800	0.8200	0.820	6.95	0.190	1.7300	1.2700	1.2700
	25	6.25	0.230	2.1000	0.9000	0.900	6.94	0.185	1.6800	1.3200	1.3200
	30	6.27	0.225	2.0400	0.9600	0.960	6.93	0.180	1.6300	1.3700	1.3700
400 °C	05	6.21	0.268	2.4300	0.5700	0.5700	6.91	0.229	2.0820	0.9182	0.9182
	10	6.27	0.228	2.0700	0.9300	0.9300	6.07	0.199	1.8091	1.1910	1.1910
	15	6.40	0.208	1.9000	1.1000	1.1000	7.20	0.170	1.5500	1.4500	1.4500
	20	6.45	0.201	1.8100	1.1900	1.1900	7.30	1.600	1.4500	1.5500	1.5500
	25	6.47	0.195	1.7700	1.2300	1.2300	7.35	0.155	1.4100	1.5900	1.5900
	30	6.48	0.190	1.7200	1.2800	1.2800	7.40	0.150	1.3600	1.6400	1.6400
800 °C	05	8.29	0.199	1.8090	1.1910	1.1910	9.06	0.183	1.6630	1.3360	1.3360
	10	8.90	0.180	1.6360	1.3630	1.3630	9.10	0.160	1.4540	1.5450	1.5450
	15	8.91	0.166	1.5100	1.5000	1.5000	9.16	0.140	1.2700	1.7300	1.7300
	20	8.93	0.160	1.4500	1.5500	1.5500	9.21	0.135	1.2200	1.7800	1.7800
	25	8.95	0.155	1.4100	1.5900	1.5900	9.25	0.130	1.1800	1.8200	1.8200
	30	8.96	0.152	1.3800	1.6200	1.6200	9.25	0.125	1.1300	1.8700	1.8700

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of BBR (D_o) = 3 × 10^{-3}mol.dm^{-3}, pH of D_o Before Adsorption = 6.10*

Table 4.14 Adsorption kinetics of brilliant blue R on *Populus caspica* (PC) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	6.71	0.290	2.6400	0.3600	0.360	7.50	0.270	2.4540	0.5454	0.5454
	10	6.51	0.278	2.5200	0.4800	0.480	7.38	0.256	2.3270	0.6727	0.6727
	15	6.46	0.264	2.4000	0.6000	0.600	7.36	0.230	2.1000	0.9000	0.9000
	20	6.50	0.260	2.3600	0.6400	0.640	7.39	0.225	2.0500	0.9500	0.9500
	25	6.52	0.257	2.3300	0.6700	0.670	7.40	0.220	2.0000	1.0000	1.0000
	30	6.63	0.254	2.3100	0.6900	0.690	7.42	0.210	1.9100	1.1000	1.1000
400 °C	05	8.98	0.256	2.3270	0.6727	0.6727	7.98	0.220	2.0000	1.0000	1.0000
	10	9.05	0.225	2.0450	0.9545	0.9545	8.30	0.180	1.6360	1.3630	1.3630
	15	9.07	0.196	1.7800	1.2200	1.220	8.72	0.160	1.4500	1.5500	1.5500
	20	9.08	0.190	1.7200	1.2800	1.280	8.81	0.155	1.4100	1.5900	1.5900
	25	9.09	0.185	1.6800	1.3200	1.320	8.85	0.150	1.3600	1.6400	1.6400
	30	9.10	0.182	1.6500	1.3500	1.350	8.90	0.145	1.3100	1.6900	1.6900
800 °C	05	9.960	0.211	1.9181	1.0818	1.0818	10.07	0.190	1.7270	1.2720	1.2720
	10	9.980	0.187	1.7000	1.3000	1.3000	10.09	0.170	1.5450	1.4540	1.4540
	15	10.00	0.180	1.6400	1.3600	1.360	10.13	0.155	1.4100	1.5900	1.5900
	20	10.05	0.175	1.5900	1.4100	1.410	10.15	0.150	1.3600	1.6400	1.6400
	25	10.06	0.173	1.5700	1.4300	1.430	10.17	0.148	1.3400	1.6600	1.6600
	30	10.08	0.170	1.5400	1.4600	1.460	10.18	0.145	1.3100	1.6900	1.6900

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of BBR (D_o) = 3 × 10^{-3}mol.dm^{-3}, pH of D_o Before Adsorption = 6.10*

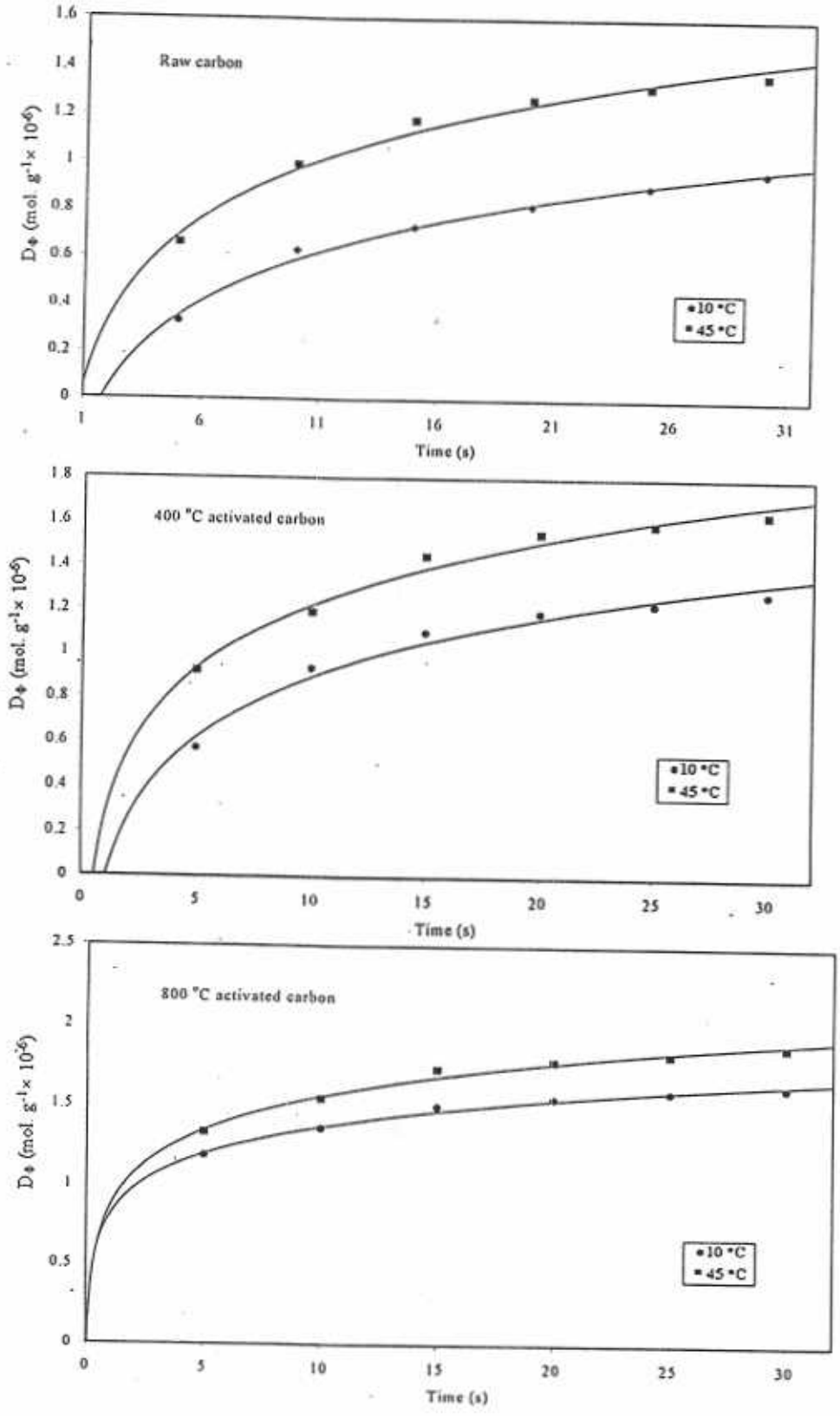


Figure 4.22 Adsorption kinetics of brilliant blue R on *Paulownia tomentosa* (PT) carbon samples

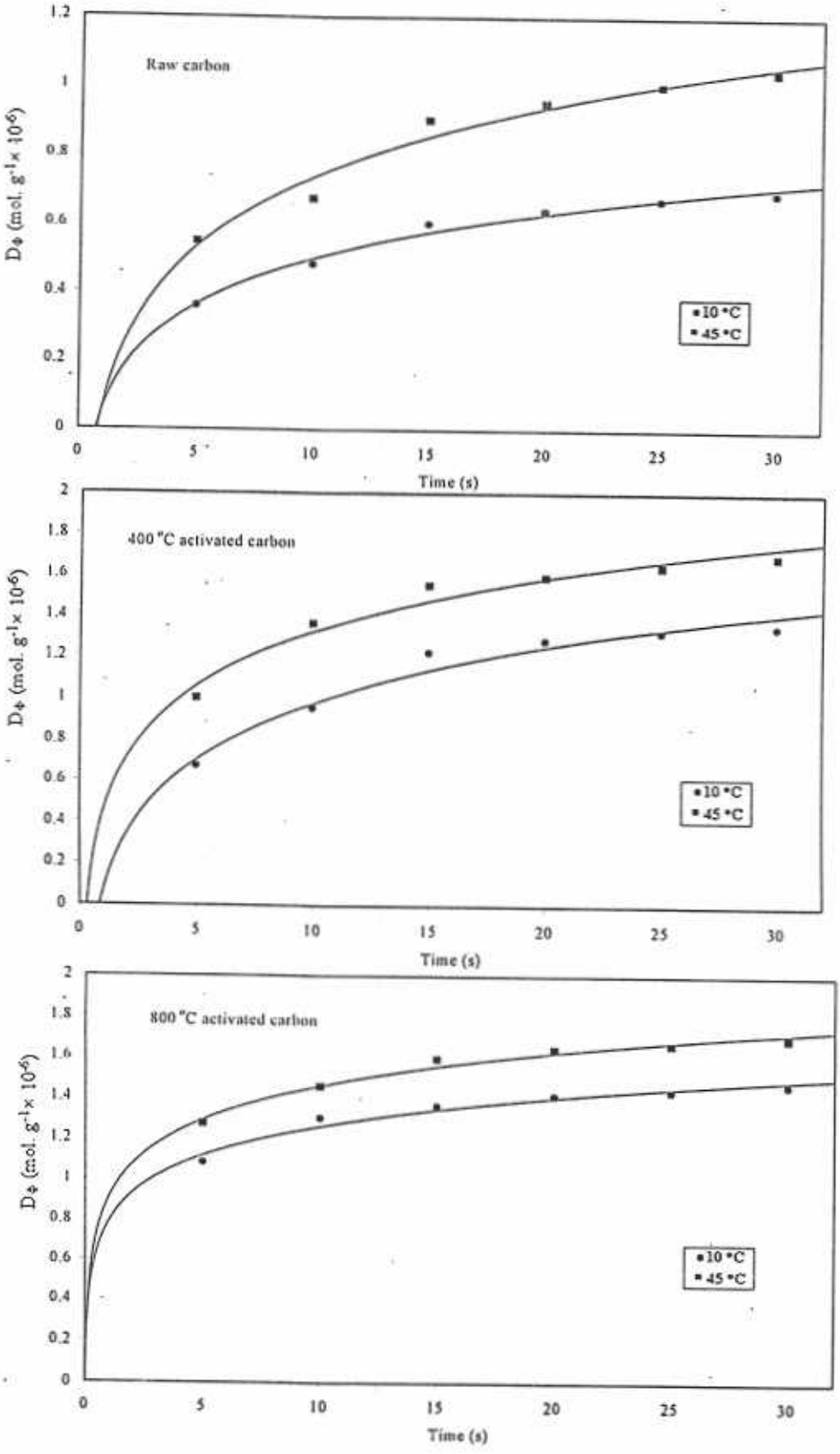


Figure 4.23 Adsorption kinetics of brilliant blue R on *Populus caspica* (PC) carbon samples

Table 4.15 Adsorption kinetics of brilliant blue R on *Corncobs* (CC) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	7.30	0.270	2.4500	0.5500	0.5500	8.50	0.250	2.2730	0.7270	0.7270
	10	6.80	0.240	2.1800	0.8200	0.8200	7.90	0.220	2.0000	1.0000	1.0000
	15	6.64	0.230	2.1000	0.9000	0.9000	7.85	0.190	1.7200	1.2800	1.2800
	20	6.65	0.220	2.0000	1.0000	1.0000	7.86	0.188	1.7100	1.2900	1.2900
	25	6.66	0.216	1.9600	1.0400	1.0400	7.87	0.185	1.6800	1.3200	1.3200
	30	6.67	0.210	1.9100	1.0900	1.0900	7.88	0.183	1.6600	1.3400	1.3400
400 °C	05	9.10	0.231	2.1000	0.9000	0.9000	8.70	0.220	2.0000	1.0000	1.0000
	10	9.15	0.205	1.8600	1.1400	1.1400	8.99	0.185	1.6820	1.3182	1.3180
	15	9.17	0.196	1.7800	1.2200	1.2200	9.05	0.170	1.5400	1.4600	1.4600
	20	9.19	0.190	1.7200	1.2800	1.2800	9.10	0.165	1.5000	1.5000	1.5000
	25	9.20	0.187	1.7000	1.3000	1.3000	9.12	0.160	1.4500	1.5500	1.5500
	30	9.22	0.183	1.6600	1.3400	1.3400	9.13	0.155	1.4100	1.5900	1.5900
800 °C	05	9.73	0.215	1.9545	1.0450	1.0450	9.63	0.200	1.8200	1.1820	1.1820
	10	9.74	0.192	1.7450	1.2540	1.2540	9.65	0.178	1.6200	1.3820	1.3820
	15	9.80	0.180	1.6400	1.3600	1.3600	9.75	0.148	1.3400	1.6600	1.6600
	20	9.85	0.175	1.5900	1.4100	1.4100	9.78	0.143	1.3000	1.7000	1.7000
	25	9.90	0.172	1.5600	1.4400	1.4400	9.82	0.140	1.2700	1.7300	1.7300
	30	9.92	0.170	1.5400	1.4600	1.4600	9.86	0.138	1.2500	1.7500	1.7500

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of BBR (D_o) = 3 × 10^{-5}mol.dm^{-3}, pH of D_o Before Adsorption = 6.10*

Table 4.16 Adsorption kinetics of brilliant blue R on *Ailanthus altissima*(AA) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	7.01	0.328	2.9800	0.0200	0.0200	8.16	0.300	2.7270	0.2727	0.2727
	10	5.69	0.322	2.9300	0.0700	0.0700	7.80	0.285	2.5910	0.4091	0.4091
	15	5.54	0.316	2.8700	0.1300	0.1300	7.77	0.250	2.2730	0.7270	0.7270
	20	6.53	0.313	2.8450	0.1545	0.1545	7.72	0.225	2.0500	0.9500	0.9500
	25	6.52	0.311	2.8270	0.1730	0.173	7.70	0.220	2.0000	1.0000	1.0000
	30	6.50	0.309	2.8200	0.1820	0.182	7.68	0.150	1.9500	1.0500	1.0500
400 °C	05	8.30	0.245	2.2200	0.7800	0.7800	8.59	0.230	2.0910	0.9091	0.9090
	10	8.44	0.217	1.9700	1.0300	1.0300	9.00	0.200	1.8180	1.1820	1.1820
	15	8.75	0.206	1.8700	1.1300	1.1300	9.10	0.175	1.6000	1.4000	1.4000
	20	8.80	0.200	1.8200	1.1800	1.1800	9.15	0.171	1.5400	1.4600	1.4600
	25	8.82	0.197	1.8000	1.2000	1.2000	9.18	0.166	1.5000	1.5000	1.5000
	30	8.83	0.195	1.7700	1.2300	1.2300	9.20	0.161	1.4500	1.5500	1.5500
800 °C	05	9.89	0.210	1.9091	1.0910	1.0910	10.00	0.200	1.8180	1.1820	1.1820
	10	9.90	0.185	1.6820	1.3200	1.3200	10.02	0.182	1.6540	1.3450	1.3450
	15	9.95	0.170	1.5400	1.4600	1.4600	10.03	0.150	1.3600	1.6400	1.6400
	20	9.99	0.165	1.5000	1.5000	1.5000	10.04	0.145	1.3200	1.6800	1.6800
	25	10.03	0.160	1.4500	1.5500	1.5500	10.05	0.141	1.2700	1.7300	1.7300
	30	10.5	0.155	1.4100	1.5900	1.5900	10.07	0.130	1.1800	1.8200	1.8200

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of BBR (D_o) = 3 × 10^{-5}mol.dm^{-3}, pH of D_o Before Adsorption = 6.10*

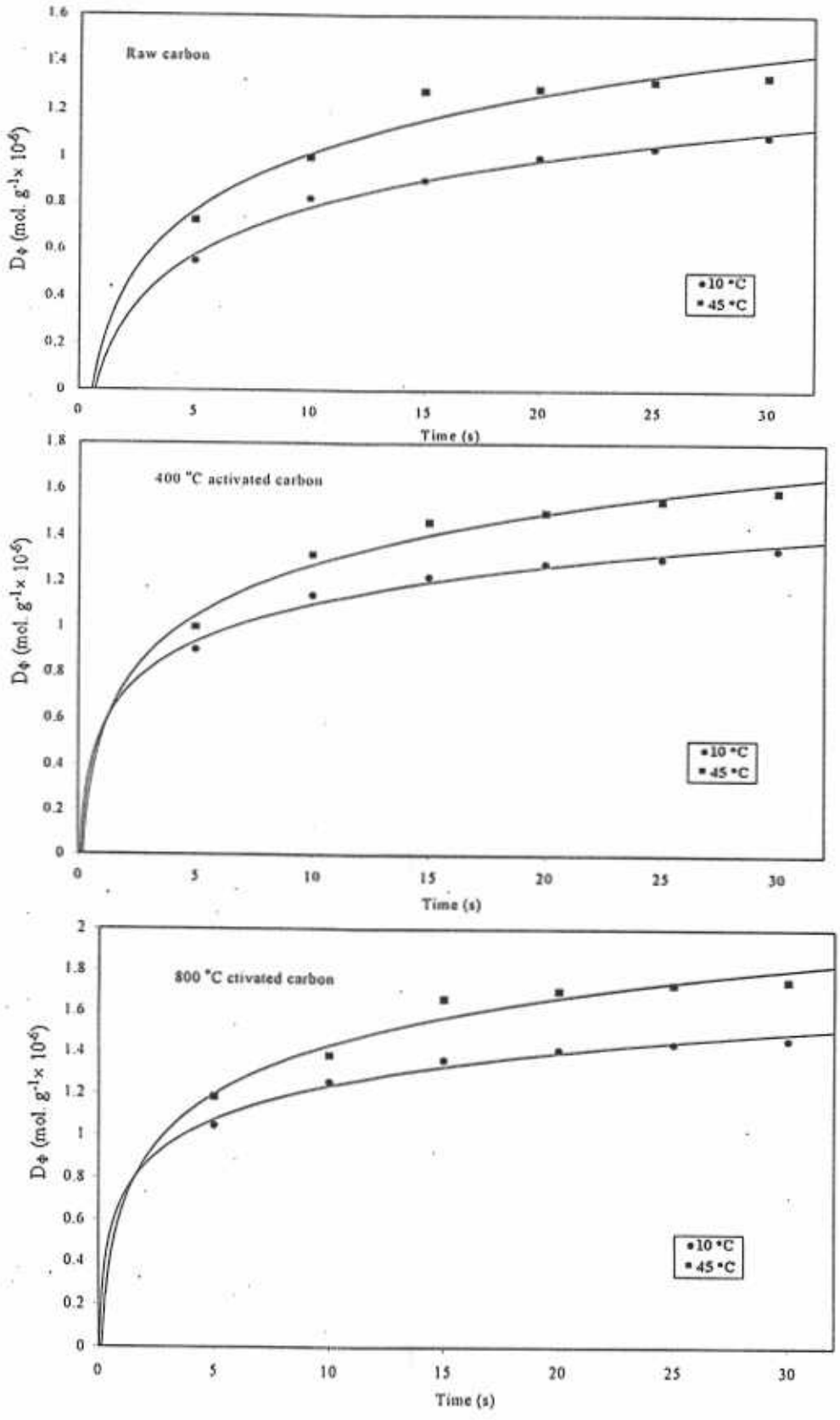


Figure 4.24 Adsorption kinetics of brilliant blue R on *Corncobs* (CC) carbon samples

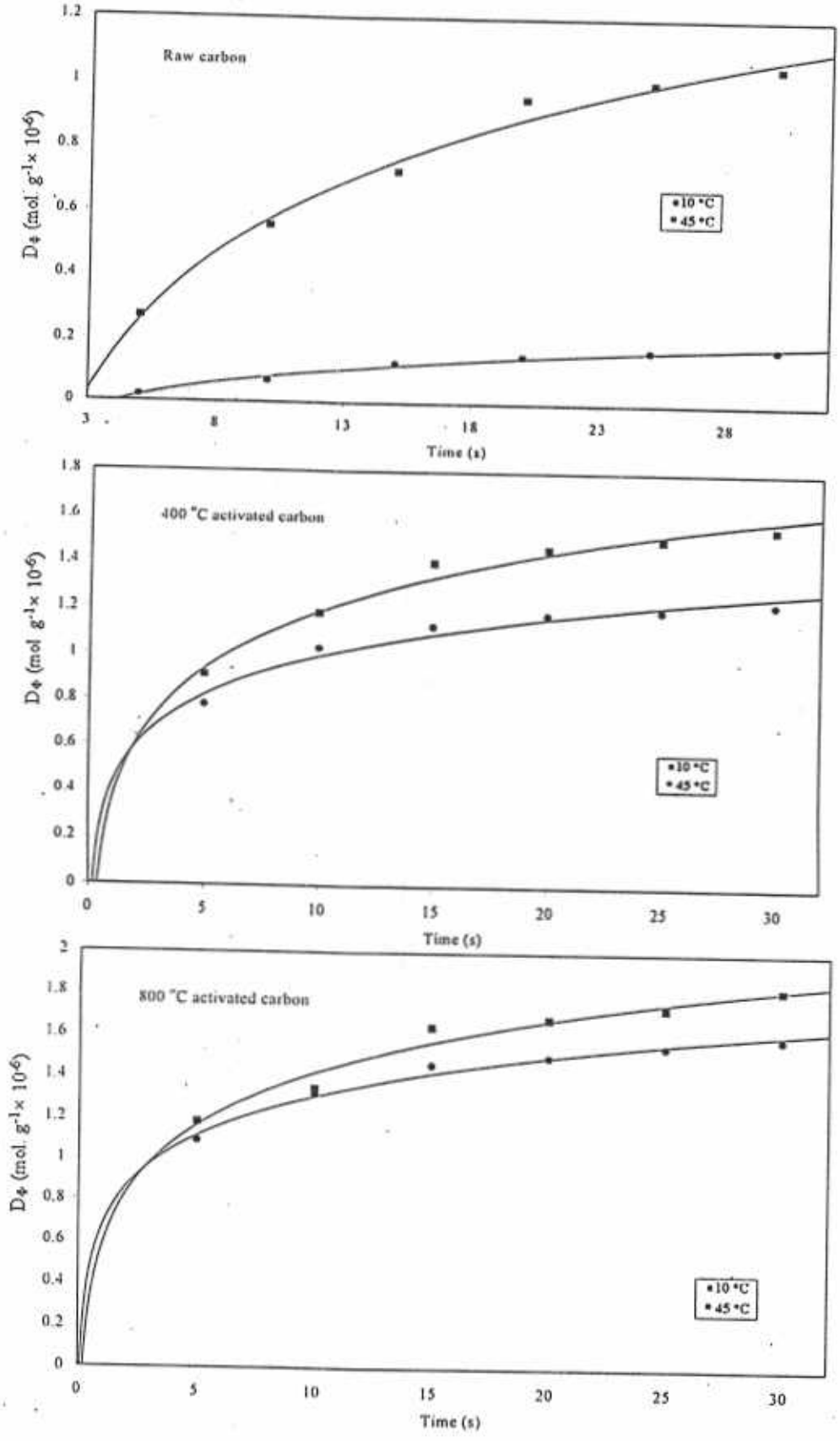
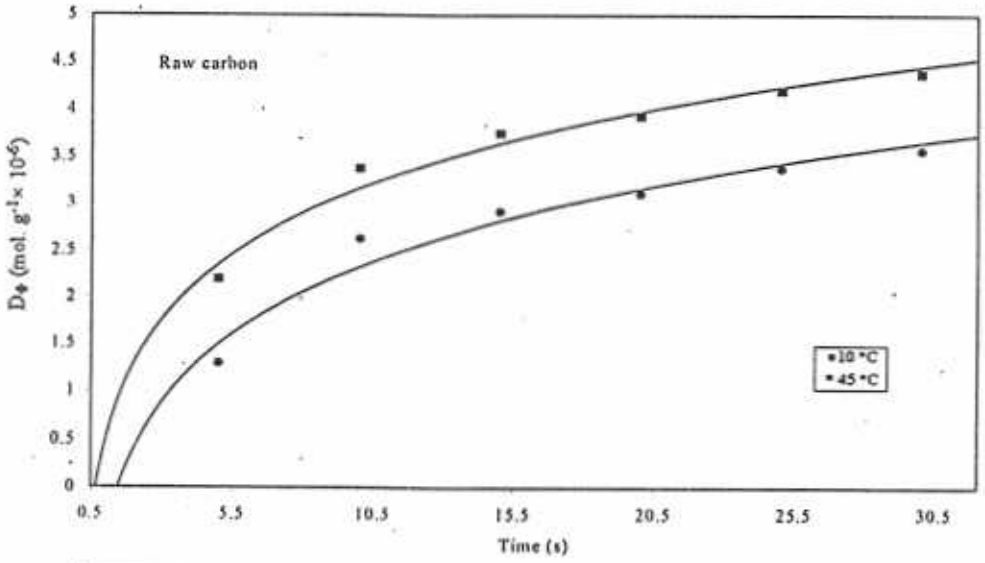


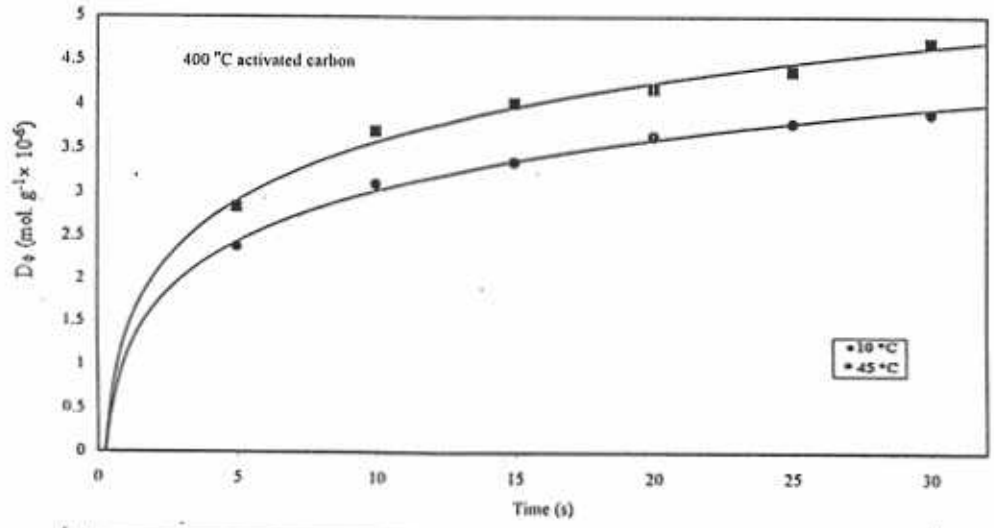
Figure 4.25 Adsorption kinetics of brilliant blue R on *Ailanthus altissima* (AA) carbon samples

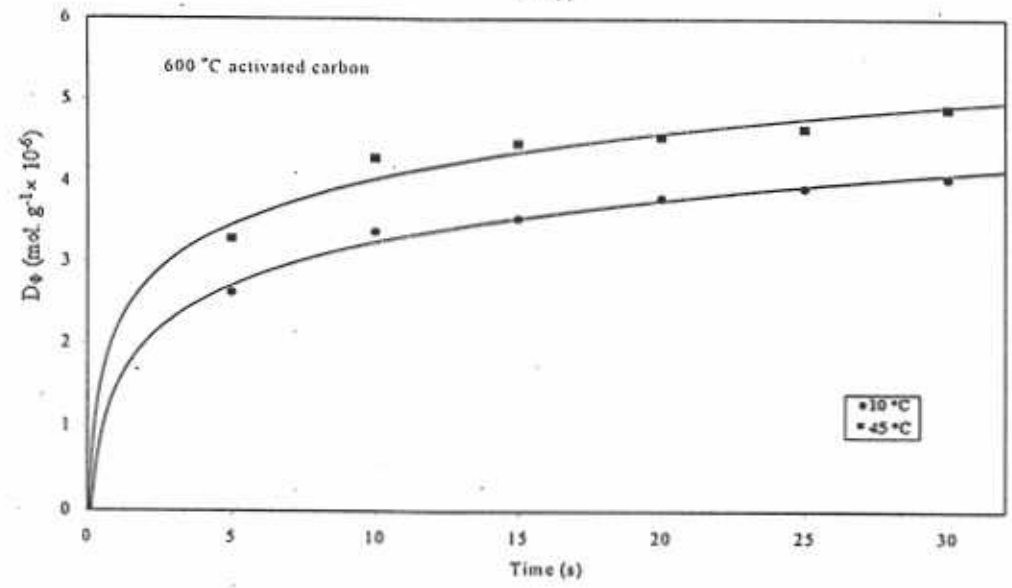
Table 4.17 Adsorption kinetics of brilliant blue R on *Salvadora oleoides* (SO) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	8.68	0.650	5.9090	1.2910	1.2910	7.59	0.550	5.0000	2.2000	2.2000
	10	8.77	0.503	4.5730	2.6300	2.6300	7.60	0.420	3.8200	3.3800	3.3800
	15	8.83	0.471	4.2820	2.9200	2.9200	7.63	0.380	3.4500	3.7500	3.7500
	20	8.84	0.450	4.0900	3.1100	3.1100	7.65	0.360	3.2700	3.9300	3.9300
	25	8.87	0.420	3.8200	3.3800	3.3800	7.67	0.330	3.0000	4.2000	4.2000
	30	8.89	0.400	3.6300	3.5700	3.5700	7.70	0.310	2.8200	4.3800	4.3800
400 °C	05	7.17	0.530	0.4818	2.3818	2.3818	7.23	0.480	4.3630	2.8370	2.8370
	10	7.21	0.451	4.1000	3.1000	3.1000	7.34	0.385	3.5000	3.7000	3.7000
	15	7.30	0.423	3.8454	3.3545	3.3545	7.35	0.350	3.1820	4.0180	4.0180
	20	7.31	0.391	3.5545	3.6454	3.6454	7.37	0.332	3.0180	4.1820	4.1820
	25	7.35	0.375	3.4090	3.7909	3.7909	7.39	0.310	2.8210	4.3790	4.3790
	30	7.39	0.363	3.3000	3.9000	3.9000	7.49	0.275	2.5000	4.7000	4.7000
600 °C	05	7.70	0.503	4.5727	2.6272	2.6272	7.48	0.430	3.9090	3.2909	3.2909
	10	8.34	0.420	3.8182	3.3818	3.3818	7.77	0.320	2.9090	4.2909	4.2909
	15	8.59	0.401	3.6454	3.5545	3.5545	7.86	0.300	2.7277	4.4723	4.4723
	20	8.62	0.373	3.3909	3.8090	3.8090	7.97	0.291	2.6454	4.5545	4.5545
	25	8.63	0.360	3.2727	3.9272	3.9272	7.99	0.280	2.5454	4.6545	4.6545
	30	8.65	0.347	3.1545	4.0454	4.0454	8.20	0.253	2.3000	4.9000	4.9000
800 °C	05	9.40	0.491	4.4636	2.7363	2.7363	9.70	0.375	3.4091	3.7909	3.7909
	10	9.61	0.381	3.4636	3.7363	3.7363	10.2	0.250	2.2727	4.9277	4.9277
	15	9.90	0.360	3.2727	3.9272	3.9272	10.7	0.210	1.9090	5.2909	5.2909
	20	9.92	0.350	3.1820	4.0182	4.0182	10.9	0.200	1.8182	5.3818	5.3818
	25	9.98	0.331	3.0090	4.1909	4.1909	11.0	0.185	1.6818	5.5182	5.5182
	30	10.1	0.317	2.8818	4.3181	4.3181	11.3	0.175	1.5909	5.6090	5.6090
900 °C	05	9.58	0.451	4.100	3.1000	3.1000	9.58	0.330	3.0000	4.2000	4.2000
	10	9.75	0.361	3.2820	3.9182	3.9182	9.95	0.210	1.9090	5.2909	5.2909
	15	10.38	0.320	2.9091	4.2909	4.2909	10.84	0.172	1.5636	5.6363	5.6363
	20	10.50	0.311	2.8272	4.3727	4.3727	10.88	0.150	1.3636	5.8363	5.8363
	25	10.60	0.292	2.6545	4.5454	4.5454	10.89	0.130	1.1818	6.0182	6.0182
	30	10.75	0.283	2.5727	4.6272	4.6272	10.99	0.115	1.0454	6.1545	6.1545
1000 °C	05	10.00	0.495	4.5000	2.7000	2.7000	9.97	0.410	3.7270	3.4730	3.4730
	10	10.05	0.399	3.6272	3.5730	3.5730	10.05	0.295	2.6820	4.5200	4.5200
	15	10.10	0.352	3.2000	4.0000	4.0000	9.97	0.198	1.8000	5.4000	5.4000
	20	10.20	0.331	3.0091	4.1909	4.1909	9.99	0.170	1.5454	5.6545	5.6545
	25	10.30	0.320	2.9100	4.2910	4.2910	10.10	0.166	1.5091	5.6901	5.6901
	30	10.39	0.315	2.8630	4.3363	4.3363	10.13	0.155	1.4909	5.7909	5.7909

♦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of BBR (D_o) = 7.2 × 10^{-3}mol.dm^{-3}, pH of D_o Before Adsorption = 8.75*


Raw carbon
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


400 °C activated carbon
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


600 °C activated carbon
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C

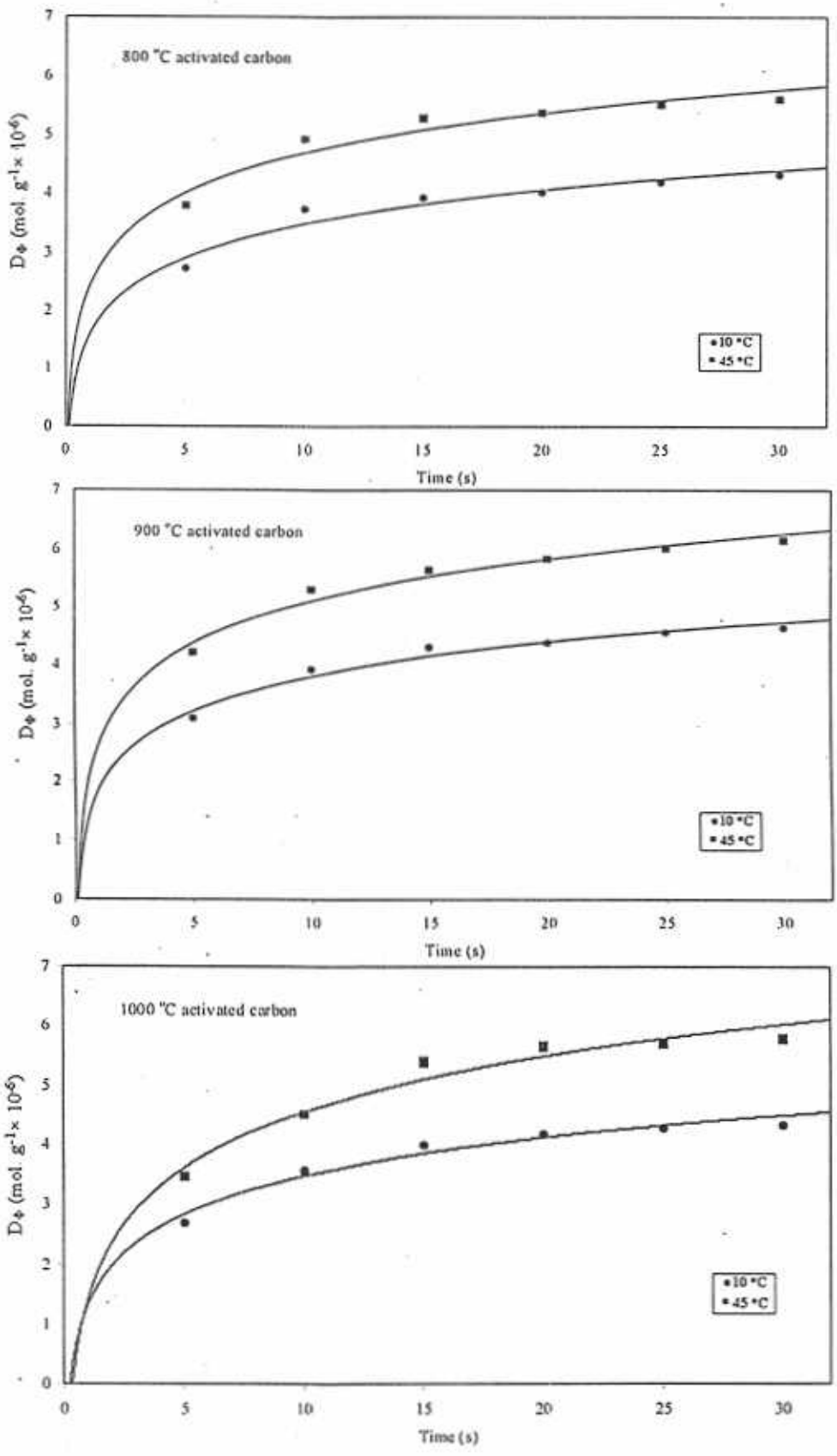
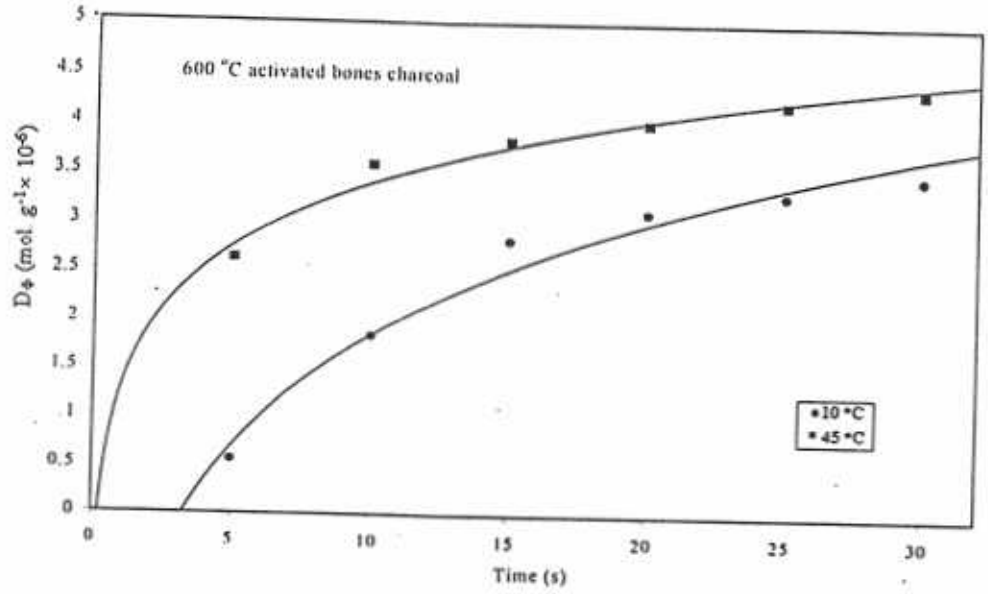
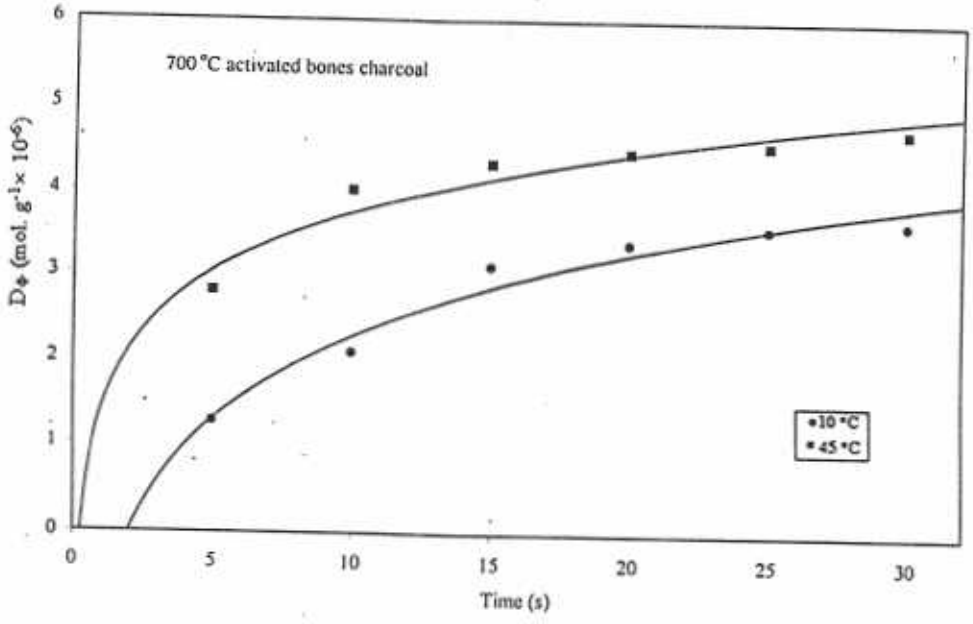
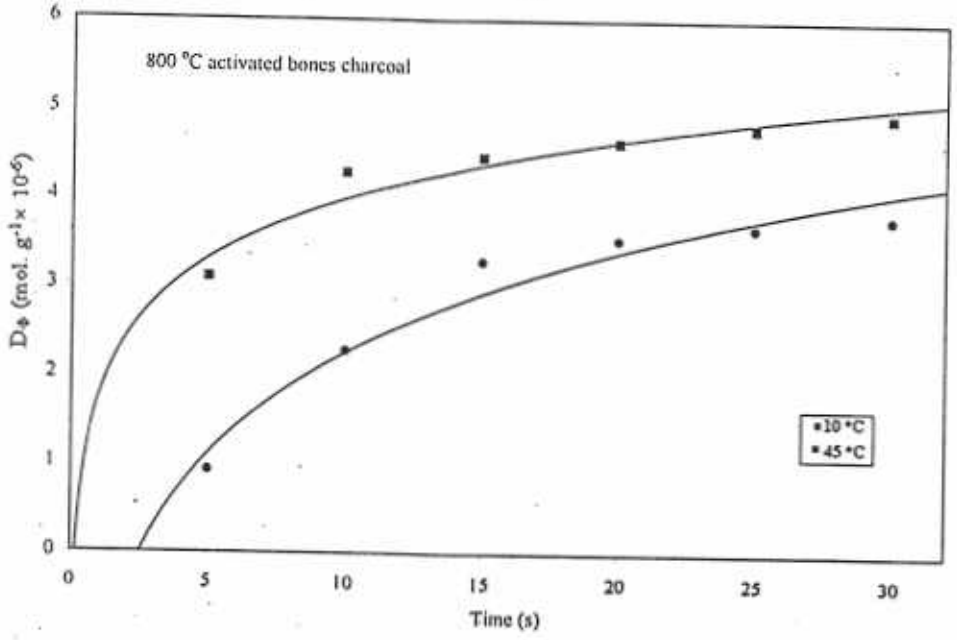


Figure 4.26 Adsorption kinetics of brilliant blue R on *Salvadora oleoides* (SO) carbon samples


600 °C activated bones charcoal
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


700 °C activated bones charcoal
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


800 °C activated bones charcoal
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C

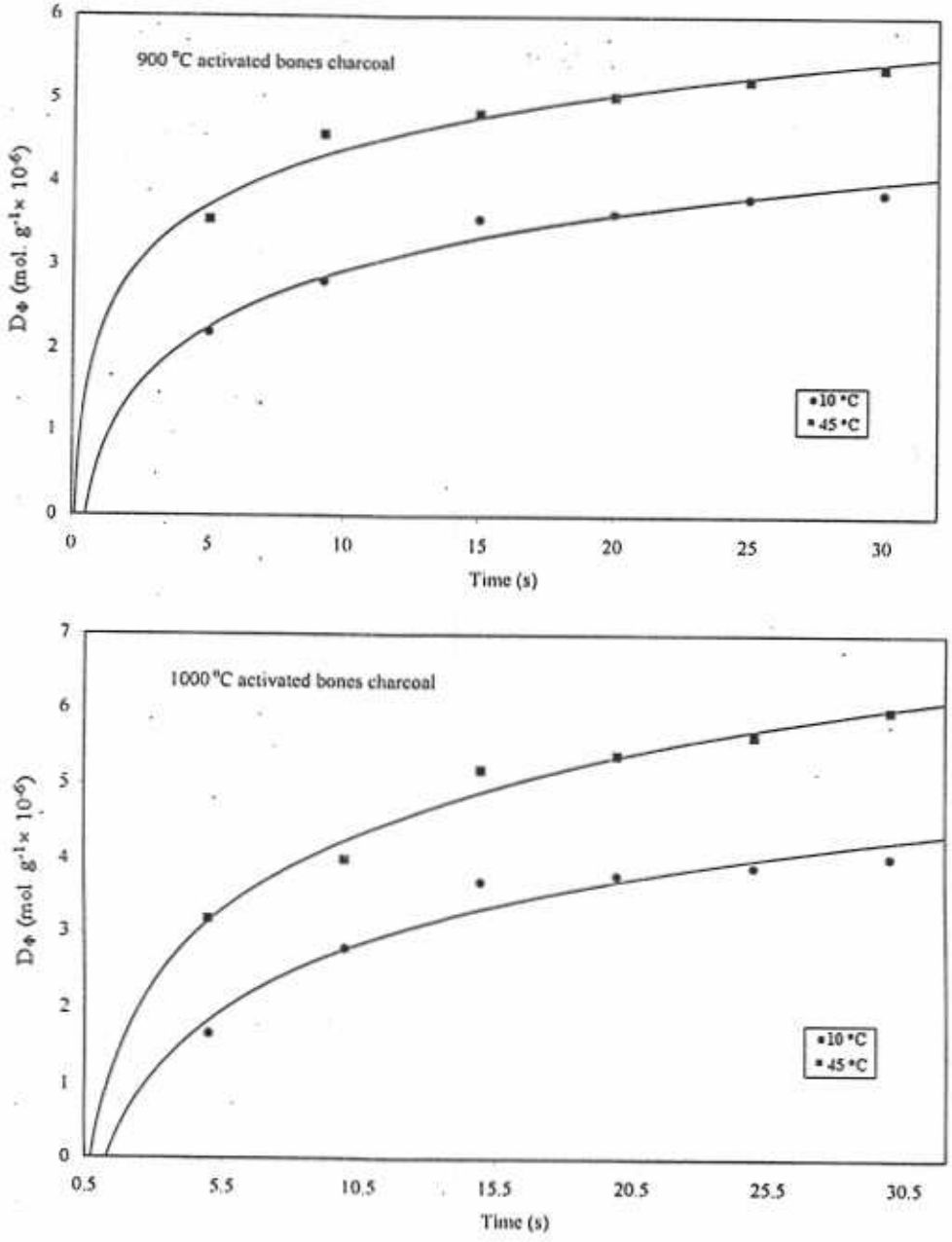
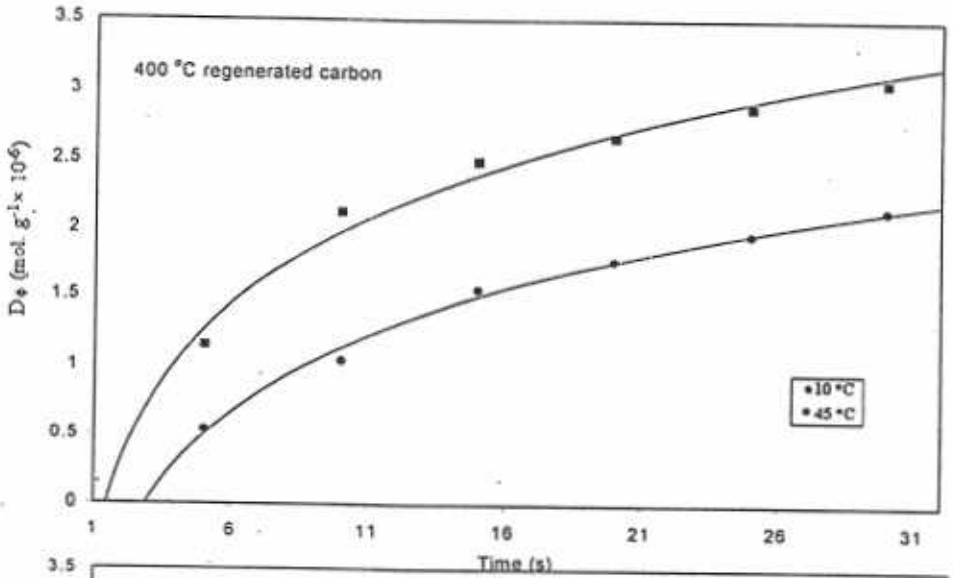


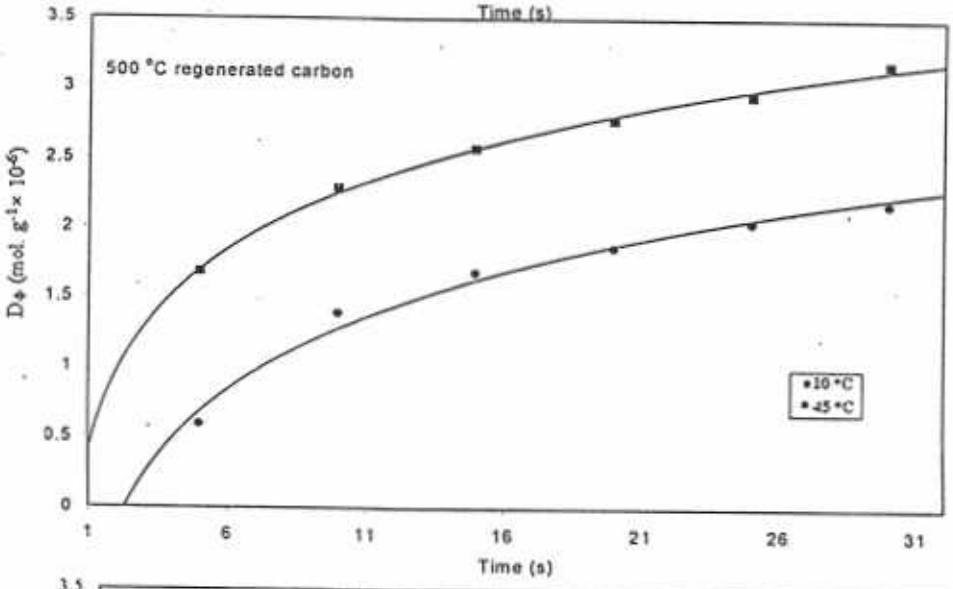
Figure 4.27 Adsorption kinetics of brilliant blue R on animal bones charcoal (ABC) samples

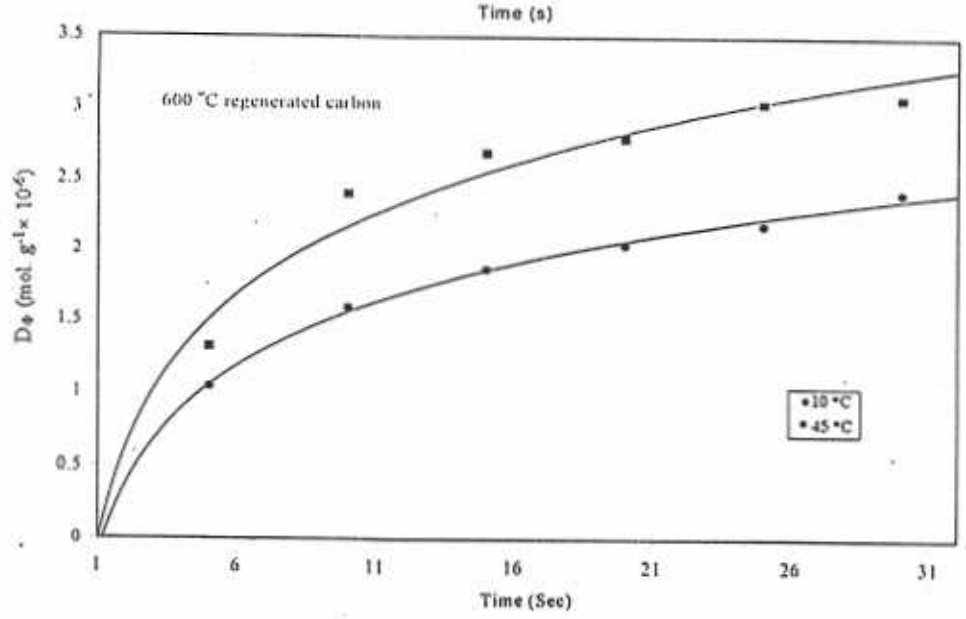
Table 4.19 Adsorption kinetics of brilliant blue R on regenerated (RG) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
400 °C	05	7.45	0.682	6.2000	0.3000	0.300	7.12	0.680	6.1800	0.3200	0.3200
	10	7.35	0.601	5.4600	1.0400	1.040	7.10	0.470	4.2700	2.2300	2.2300
	15	7.33	0.544	4.9500	1.5500	1.550	7.08	0.441	4.0100	2.4900	2.4900
	20	7.31	0.521	4.7300	1.7700	1.770	7.07	0.423	3.8400	2.6600	2.6600
	25	7.30	0.500	4.5400	1.9600	1.960	7.06	0.400	3.6300	2.8700	2.8700
	30	7.30	0.480	4.3000	2.1400	2.140	7.04	0.380	3.4500	3.0500	3.0500
500 °C	05	7.44	0.650	5.9091	0.5909	0.5909	7.10	0.530	4.8180	1.6820	1.6820
	10	7.50	0.562	5.1090	1.3909	1.3909	7.18	0.463	4.2100	2.2900	2.2900
	15	7.47	0.530	4.8180	1.6820	1.6820	7.29	0.431	3.9200	2.5800	2.5800
	20	7.46	0.510	4.6363	1.8630	1.8630	7.30	0.410	3.7200	2.7800	2.7800
	25	7.45	0.490	4.4540	2.0450	2.0450	7.32	0.391	3.5500	2.9500	2.9500
	30	7.44	0.475	4.3180	2.1820	2.1820	7.35	0.365	3.3200	3.1800	3.1800
600 °C	05	7.55	0.601	5.4600	1.0400	1.0400	7.09	0.570	5.1818	1.3182	1.3182
	10	7.58	0.540	4.9090	1.5910	1.5910	7.40	0.451	4.1000	2.4000	2.4000
	15	7.72	0.510	4.6360	1.8630	1.8630	7.43	0.419	3.8091	2.6909	2.6909
	20	7.73	0.491	4.4630	2.0360	2.0360	7.44	0.408	3.7091	2.7909	2.7909
	25	7.74	0.475	4.3180	2.1820	2.1820	7.45	0.381	3.4636	3.0363	3.0363
	30	7.75	0.450	4.0900	2.4090	2.4090	7.46	0.377	3.4272	3.0727	3.0727
800 °C	05	7.93	0.620	5.6363	0.8636	0.8636	7.42	0.543	4.9363	1.5636	1.5636
	10	8.20	0.525	4.7700	1.7270	1.7270	7.55	0.411	3.7363	2.7636	2.7636
	15	8.34	0.500	4.5450	1.9540	1.9540	7.50	0.388	3.5272	2.9727	2.9727
	20	8.35	0.476	4.3270	2.1720	2.1720	7.53	0.362	3.2909	3.2090	3.2090
	25	8.36	0.463	4.2100	2.2900	2.2900	7.55	0.340	3.0909	3.4090	3.4090
	30	8.37	0.450	4.0900	2.4090	2.4090	7.56	0.331	3.0090	3.4909	3.4909
900 °C	05	8.09	0.610	5.5450	0.9540	0.9540	7.50	0.523	4.7540	1.7450	1.7450
	10	8.26	0.523	4.7540	1.7450	1.7450	7.60	0.401	3.6450	2.8540	2.8540
	15	8.27	0.492	4.4720	2.0270	2.0270	7.46	0.371	3.3720	3.1270	3.1270
	20	8.29	0.465	4.2270	2.2720	2.2720	7.47	0.341	3.1000	3.4000	3.4000
	25	8.30	0.462	4.2000	2.3000	2.3000	7.48	0.322	2.9270	3.5720	3.5720
	30	8.32	0.459	4.1730	2.3272	2.3272	7.49	0.323	2.9360	3.5630	3.5630
1000 °C	05	8.70	0.640	5.8200	0.6800	0.6800	8.00	0.580	5.3000	1.2000	8.70
	10	8.90	0.600	5.4500	1.0500	1.0500	7.97	0.534	4.8200	1.6800	8.90
	15	8.95	0.560	5.0900	1.4100	1.4100	7.95	0.480	4.3600	2.1400	8.95
	20	8.96	0.540	4.9100	1.5900	1.5900	7.97	0.462	4.2000	2.3000	8.96
	25	8.97	0.537	4.8820	1.6200	1.6200	7.98	0.459	4.1700	2.3300	8.97
	30	8.98	0.532	4.8360	1.6630	1.6630	8.00	0.455	4.1400	2.3600	8.98

♦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 μm, Initial Concentration of BBR (D_o) = 6.5 × 10^{-4}mol.dm^3, pH of D_o Before Adsorption = 7.30*


400 °C regenerated carbon
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


500 °C regenerated carbon
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


600 °C regenerated carbon
Dφ (mol. g-1× 10-6)
Time (Sec)
•10 °C
▪45 °C

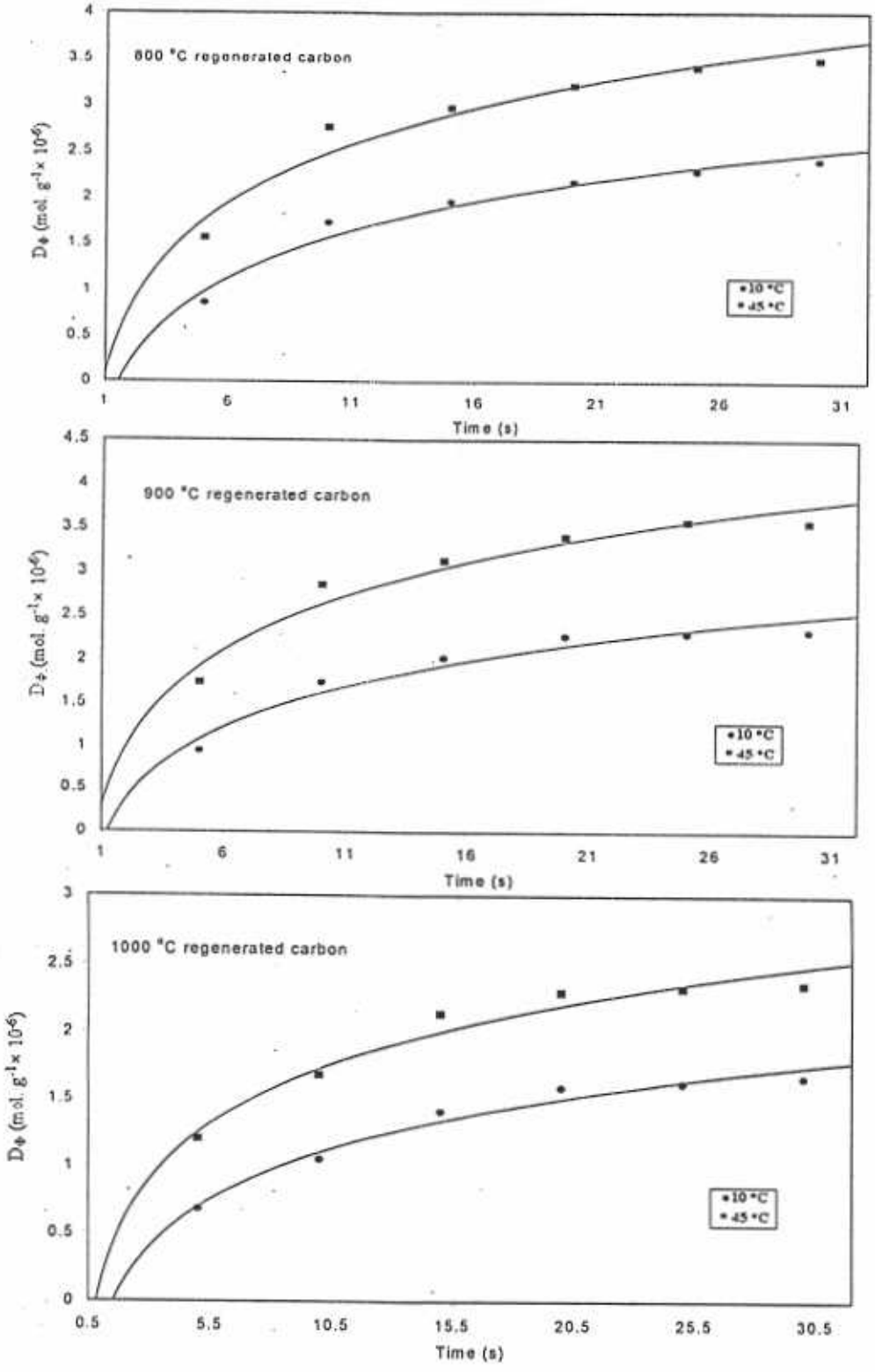


Figure 4.28 Adsorption kinetics of brilliant blue R on regenerated carbon (RG) samples

Table 4.20 Adsorption kinetics of acid yellow 29 on *Paulownia tomentosa* (PT) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	6.46	0.190	2.1500	0.8500	0.8500	7.70	0.157	1.7800	1.2200	1.2200
	10	6.49	0.170	1.9200	1.0800	1.0800	7.35	0.140	1.5800	1.4200	1.4200
	15	6.57	0.162	1.8360	1.1600	1.1600	7.33	0.130	1.4700	1.5300	1.5300
	20	6.59	0.150	1.7000	1.3000	1.3000	7.28	0.128	1.4500	1.5500	1.5500
	25	6.62	0.145	1.6400	1.3600	1.3600	7.27	0.125	1.4100	1.5900	1.5900
	30	6.62	0.140	1.5800	1.4200	1.4200	7.26	0.123	1.3900	1.6100	1.6100
400 °C	05	6.40	0.182	2.0600	0.9400	0.9400	7.33	0.160	1.8140	1.1859	1.1859
	10	6.61	0.140	1.5800	1.4200	1.4200	7.42	0.100	1.1340	1.8662	1.8662
	15	6.72	0.131	1.4700	1.5300	1.5300	7.60	0.046	0.5220	2.4785	2.4785
	20	6.75	0.15	1.4200	1.5800	1.5800	7.63	0.030	0.3400	2.6600	2.6600
	25	6.79	0.121	1.3700	1.6300	1.6300	7.68	0.026	0.2950	2.7000	2.7000
	30	6.80	0.117	1.3200	1.6800	1.6800	7.70	0.022	0.2490	2.7500	2.7500
800 °C	05	8.93	0.130	1.4700	1.5300	1.5300	9.30	0.115	1.3038	1.6960	1.6960
	10	9.10	0.100	1.1330	1.8600	1.8600	9.31	0.052	0.5895	2.4100	2.4100
	15	9.40	0.087	0.9860	2.0100	2.0100	9.32	0.030	0.3400	2.6600	2.6600
	20	9.43	0.081	0.9070	2.1000	2.1000	9.36	0.020	0.2260	2.7700	2.7700
	25	9.45	0.073	0.8270	2.1700	2.1700	9.38	0.011	0.0100	2.8800	2.8800
	30	9.47	0.070	0.7930.	2.2000	2.2000	9.40	0.003	0.0340	2.9600	2.9600

♦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AY29 (D_o) = 3 × 10^{-5}mol.dm^3, pH of D_o Before Adsorption = 6.55*

Table 4.21 Adsorption kinetics of acid yellow 29 on carbon *Populus caspica* (PC) samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	7.24	0.195	2.2100	0.7900	0.7900	7.80	0.180	2.0400	0.9600	0.9600
	10	6.94	0.180	2.0400	0.9600	0.9600	7.72	0.160	1.8200	1.1800	1.1800
	15	6.80	0.185	1.9800	1.0200	1.0200	7.70	0.150	1.7000	1.3000	1.3000
	20	6.78	0.170	1.9200	1.0800	1.0800	7.68	0.145	1.6400	1.3600	1.3600
	25	6.75	0.165	1.8700	1.1300	1.1300	7.67	0.140	1.5800	1.4200	1.4200
	30	6.70	0.160	1.8200	1.1800	1.1800	6.65	0.133	1.5100	1.4900	1.4900
400 °C	05	9.24	0.170	1.9300	1.0700	1.0700	8.66	0.150	1.7010	1.3000	1.3000
	10	9.35	0.151	1.7000	1.3000	1.3000	9.00	0.110	1.2470	1.7500	1.7500
	15	9.40	0.132	1.4700	1.5300	1.5300	9.10	0.072	0.8200	2.1800	2.1800
	20	9.43	0.121	1.3600	1.6400	1.6400	9.12	0.065	0.7300	2.2700	2.2700
	25	9.44	0.110	1.2500	1.7500	1.7500	9.15	0.060	0.6800	2.3200	2.3200
	30	9.45	0.101	1.1300	1.8700	1.8700	9.17	0.053	0.6000	2.4000	2.4000
800 °C	05	10.00	0.140	1.5800	1.4200	1.4200	10.11	0.110	1.2500	1.7500	1.7500
	10	10.03	0.110	1.2500	1.7500	1.7500	1015	0.080	0.9100	2.0900	2.0900
	15	10.04	0.091	1.0200	1.9800	1.9800	10.20	0.070	0.7900	2.2100	2.2100
	20	10.05	0.085	0.9600	2.0400	2.0400	10.22	0.065	0.7300	2.2700	2.2700
	25	10.06	0.080	0.9100	2.0900	2.0900	10.25	0.061	0.6800	2.3200	2.3200
	30	10.07	0.074	0.8500	2.1500	2.1500	10.25	0.058	0.6500	2.3500	2.3500

♦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AY29 (D_o) = 3 × 10^{-5}mol.dm^3, pH of D_o Before Adsorption = 6.55*

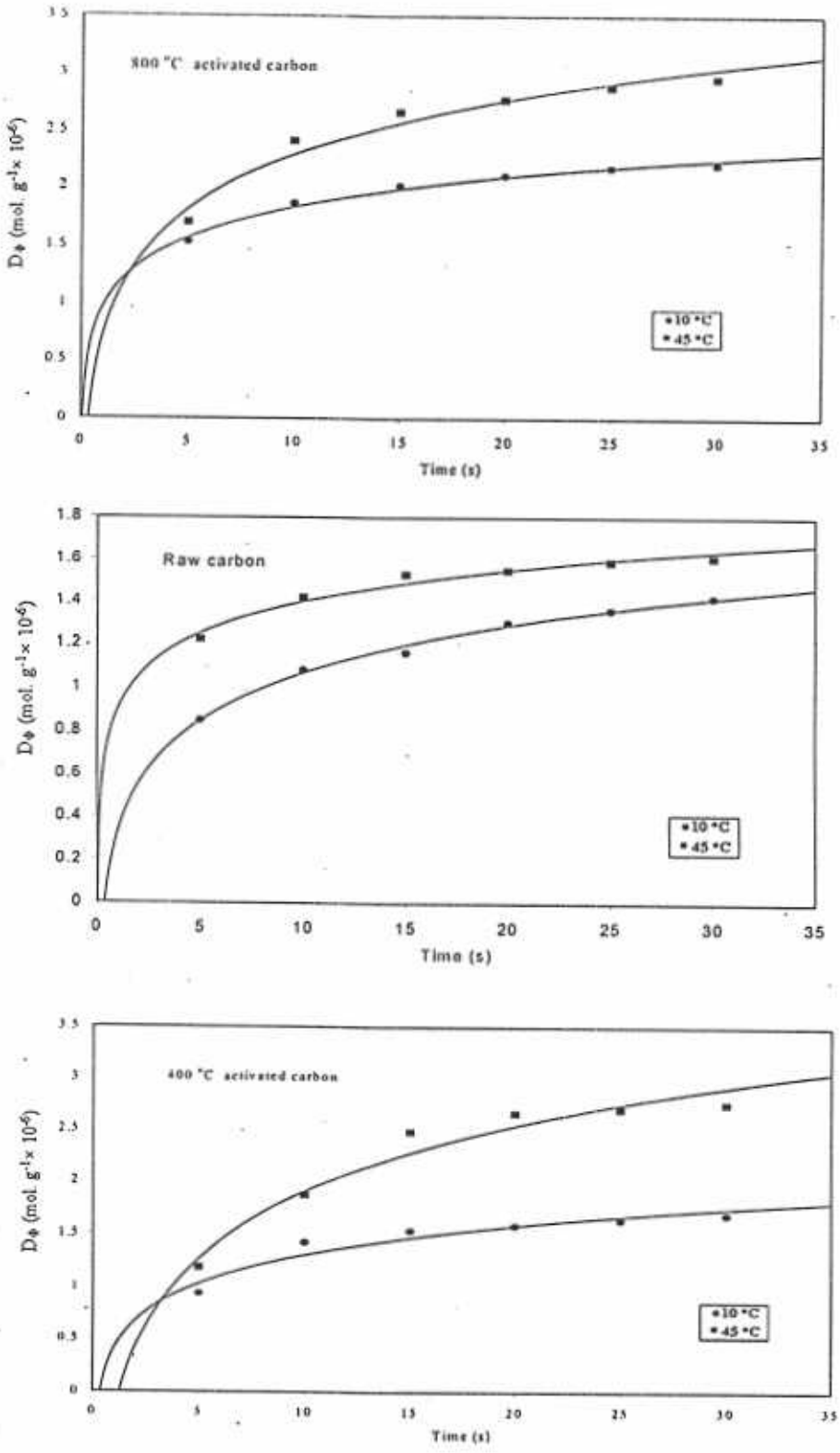
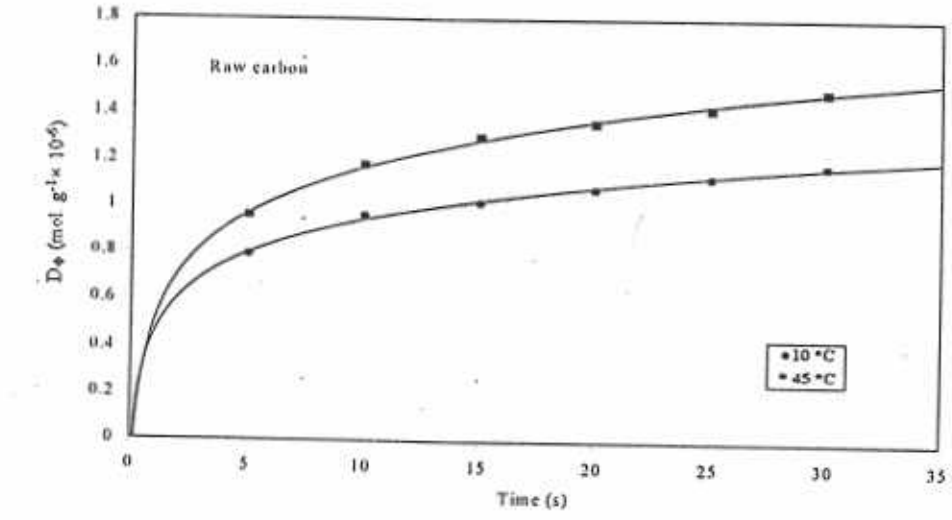
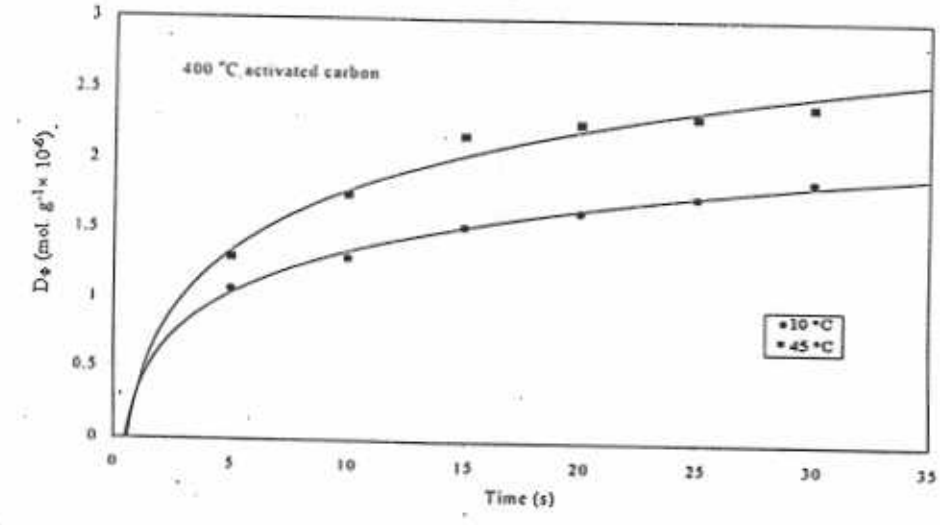
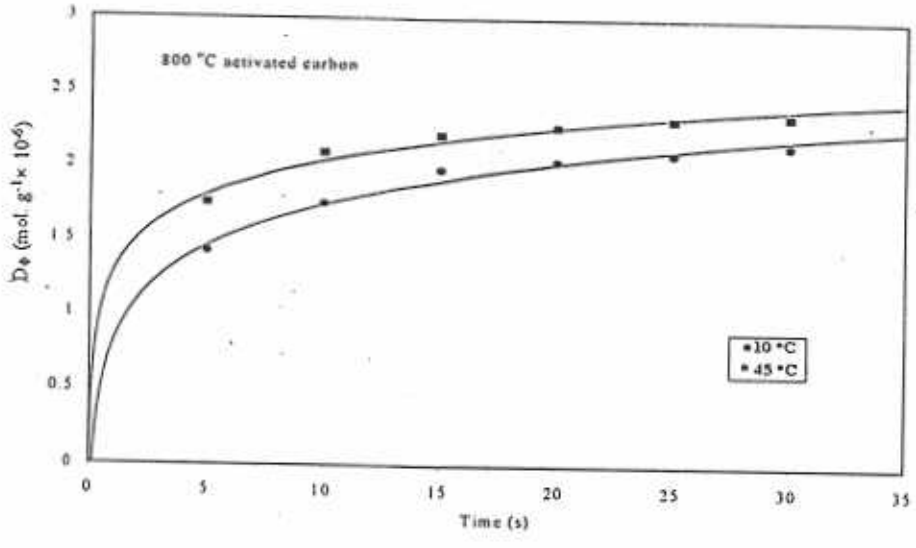


Figure 4.29 Adsorption kinetics of acid yellow 29 on *Paulownia tomentosa* (PT) carbon samples







igure 4.30 Adsorption kinetics of acid yellow 29 on *Populus caspica* (PC) carbon samples

Table 4.22 Adsorption kinetics of acid yellow 29 on *Corncobs* (CC) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	7.96	0.190	2.1500	0.8500	0.8500	8.70	0.160	1.8100	1.1900	1.1900
	10	7.00	0.170	1.9300	1.0700	1.0700	8.16	0.141	1.5800	1.4200	1.4200
	15	6.88	0.161	1.8100	1.1900	1.1900	8.12	0.130	1.4700	1.5300	1.5300
	20	6.82	0.155	1.7500	1.2500	1.2500	8.11	0.120	1.3600	1.6400	1.6400
	25	6.82	0.150	1.7000	1.3000	1.3000	8.10	0.110	1.2500	1.7500	1.7500
	30	6.82	0.144	1.6400	1.3600	1.3600	8.10	0.101	1.1300	1.8700	1.8700
400 °C	05	8.75	0.141	1.5800	1.4200	1.4200	9.04	0.130	1.4700	1.5300	1.5300
	10	9.22	0.100	1.1300	1.8700	1.8700	9.20	0.100	1.1300	1.8700	1.8700
	15	9.30	0.090	1.0200	1.9800	1.9800	9.23	0.070	0.8000	2.2000	2.2000
	20	9.35	0.081	0.9100	2.0900	2.0900	9.25	0.055	0.6200	2.3800	2.3800
	25	9.39	0.075	0.8500	2.1500	2.1500	9.30	0.040	0.4500	2.5500	2.5500
	30	9.42	0.070	0.7900	2.2100	2.2100	9.31	0.031	0.3400	2.6600	2.6600
800 °C	05	9.74	0.100	1.1300	1.8700	1.8700	9.75	0.081	0.9100	2.0900	2.0900
	10	9.77	0.071	0.7900	2.2100	2.2100	9.78	0.050	0.5600	2.4400	2.4400
	15	9.82	0.060	0.6800	2.3200	2.3200	9.80	0.030	0.3400	2.6600	2.6600
	20	9.85	0.055	0.6200	2.3800	2.3800	9.81	0.230	0.2600	2.7400	2.7400
	25	9.87	0.050	0.5670	2.4300	2.4300	9.83	0.018	0.2000	2.8000	2.8000
	30	9.90	0.041	0.4600	2.5400	2.5400	9.87	0.015	0.1700	2.8300	2.8300

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AY29 (D_o) = 3 × 10^{-3}mol.dm^{-3}, pH of D_o Before Adsorption = 6.55*

Table 4.23 Adsorption kinetics of acid yellow 29 on *Ailanthus altissima* (AA) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	8.57	0.196	2.2200	0.7800	0.7800	7.90	0.181	2.0400	0.9600	0.9600
	10	8.21	0.185	2.0900	0.9100	0.9100	7.20	0.160	1.8100	1.1900	1.1900
	15	8.20	0.180	2.0400	0.9600	0.9600	7.10	0.155	1.7600	1.2400	1.2400
	20	8.19	0.176	1.9800	1.0200	1.0200	7.00	0.150	1.7000	1.3000	1.3000
	25	8.17	0.170	1.9300	1.0700	1.0700	7.00	0.145	1.6400	1.3600	1.3600
	30	8.16	0.165	1.8700	1.1300	1.1300	7.00	0.141	1.5800	1.4200	1.4200
400 °C	05	7.75	0.170	1.9300	1.0700	1.0700	9.20	0.120	1.3600	1.6400	1.6400
	10	8.74	0.155	1.7600	1.2400	1.2400	9.39	0.101	1.1400	1.8700	1.8700
	15	8.86	0.140	1.5800	1.4200	1.4200	9.42	0.091	1.0250	1.9800	1.9800
	20	8.90	0.136	1.5200	1.4800	1.4800	9.50	0.083	0.9400	2.0600	2.0600
	25	8.92	0.131	1.4800	1.5300	1.5300	9.52	0.078	0.8800	2.1200	2.1200
	30	8.94	0.125	1.4200	1.5800	1.5800	9.55	0.760	0.8600	2.1400	2.1400
800 °C	05	9.900	0.120	1.3600	1.6400	1.6400	10.09	0.110	1.2470	1.7530	1.7530
	10	10.02	0.100	1.1300	1.8700	1.8700	10.12	0.080	0.9070	2.0930	2.0930
	15	10.03	0.091	1.0200	1.9800	1.9800	10.13	0.068	0.7700	2.2300	2.2300
	20	10.04	0.085	0.9600	2.0400	2.0400	10.14	0.062	0.7000	2.3000	2.3000
	25	10.05	0.080	0.9100	2.0900	2.0900	10.15	0.058	0.6600	2.3400	2.3400
	30	10.06	0.075	0.8500	2.1500	2.1500	10.16	0.055	0.6200	2.3800	2.3800

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AY29 (D_o) = 3 × 10^{-3}mol.dm^{-3}, pH of D_o Before Adsorption = 6.55*

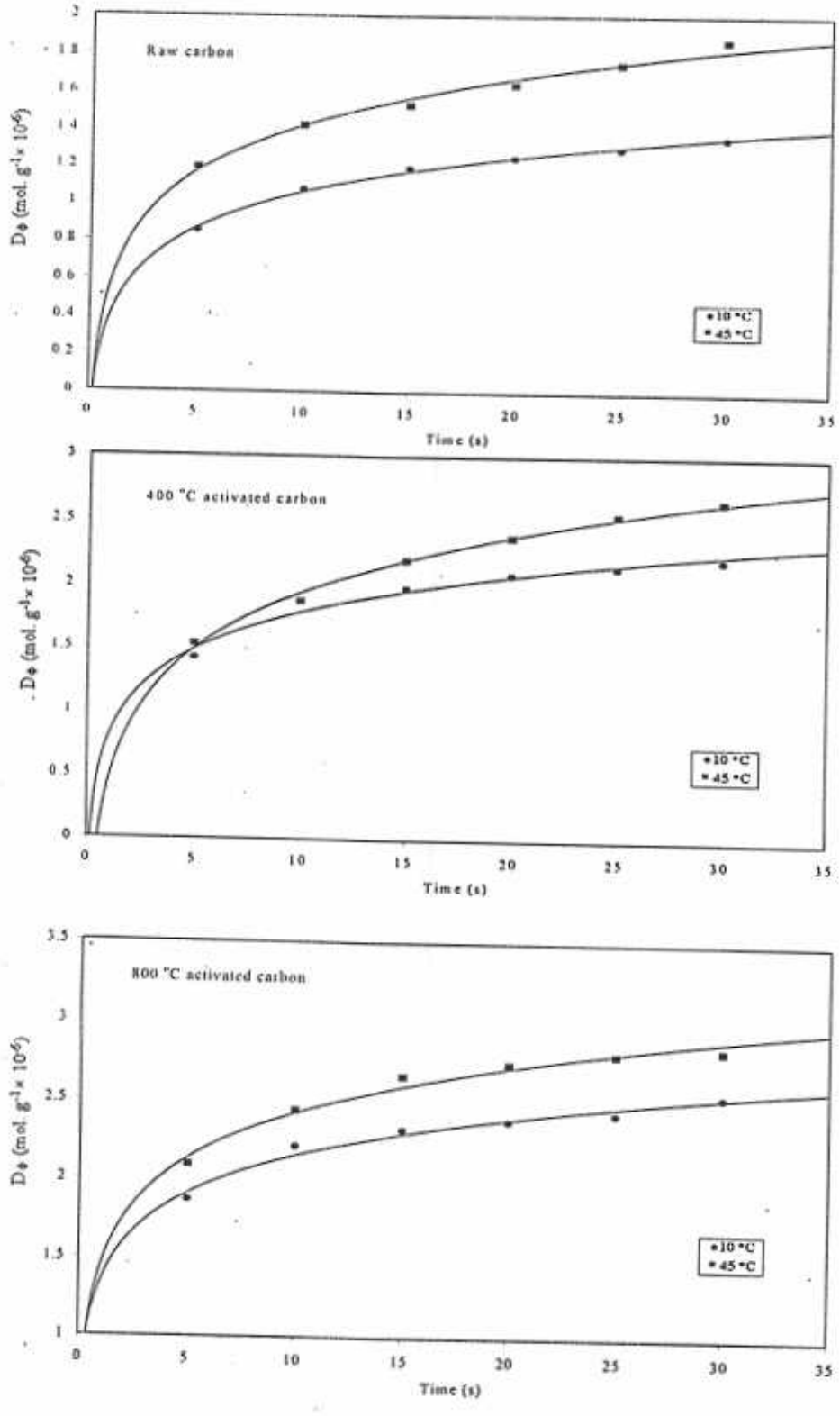


Figure 4.31 Adsorption kinetics of acid yellow 29 on *Corncobs* (CC) carbon samples

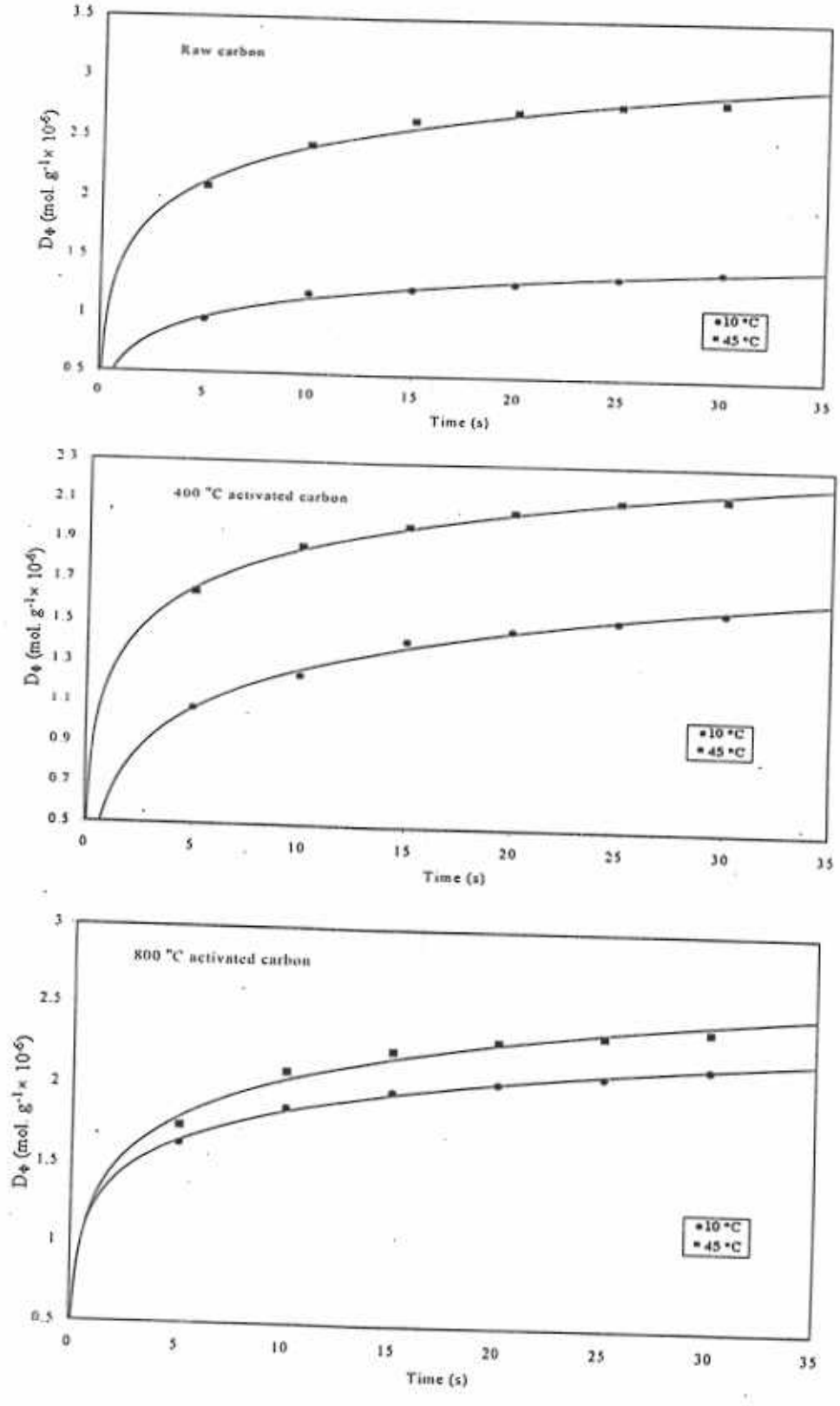
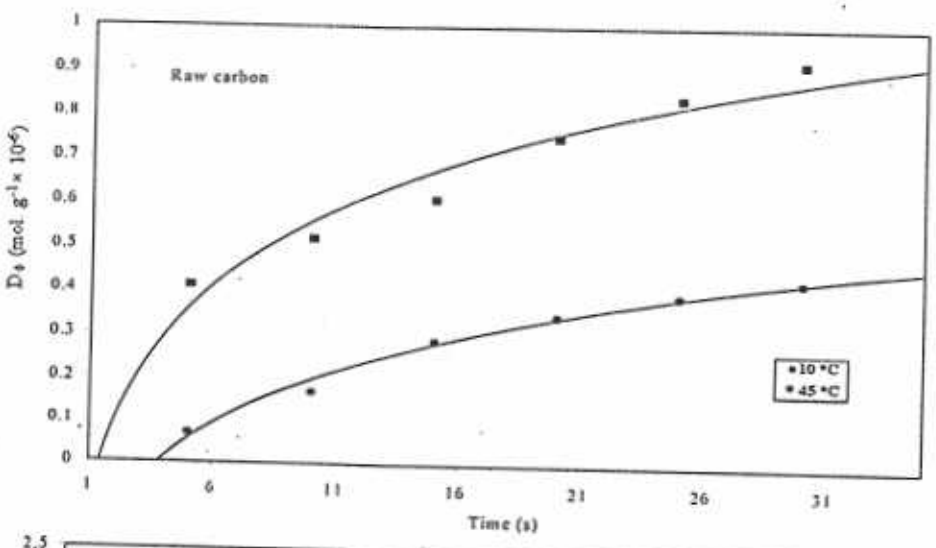


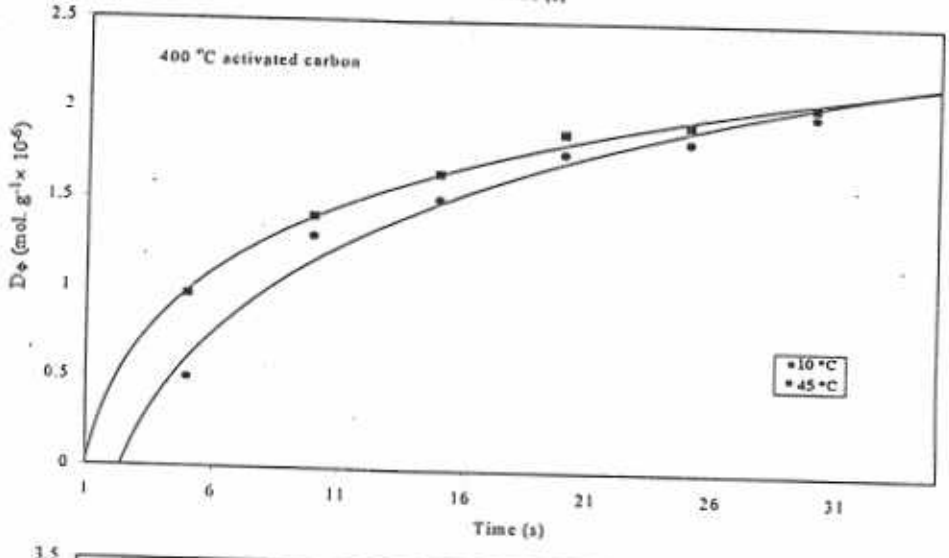
Figure 4.32 Adsorption kinetics of acid yellow 29 on *Ailanthus altissima* (AA) carbon sample

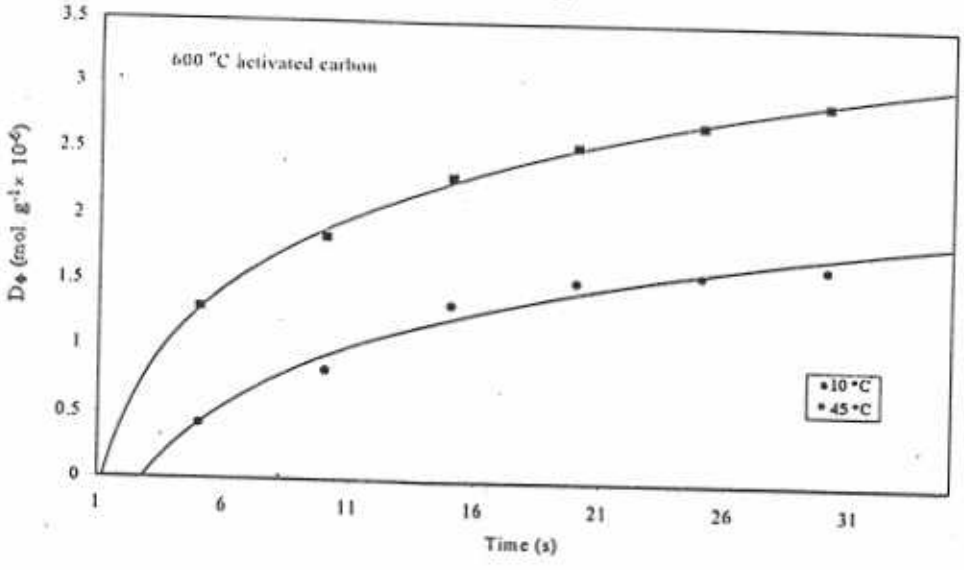
Table 4.24 Adsorption kinetics of acid yellow 29 on *Salvadora oleoides* (SO) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	7.32	0.700	7.9300	0.0700	0.0700	8.50	0.670	7.5900	0.4100	0.4100
	10	7.54	0.691	7.8300	0.1700	0.1700	8.22	0.660	7.4800	0.5200	0.5200
	15	7.72	0.681	7.7100	0.2900	0.2900	8.20	0.652	7.3900	0.6100	0.6100
	20	7.76	0.675	7.6530	0.3470	0.3470	8.15	0.640	7.2500	0.7500	0.7500
	25	7.82	0.671	7.6070	0.3930	0.3930	8.14	0.632	7.1600	0.8400	0.8400
	30	7.88	0.668	7.5730	0.4270	0.4270	8.12	0.625	7.0800	0.9200	0.9200
400 °C	05	6.73	0.662	7.5000	0.5000	0.5000	6.88	0.620	7.0300	0.9700	0.9700
	10	6.78	0.591	6.7000	1.3000	1.3000	7.00	0.581	6.5900	1.4100	1.4100
	15	6.80	0.573	6.4900	1.5100	1.5100	7.08	0.560	6.3500	1.6510	1.6510
	20	6.84	0.550	6.2300	1.7700	1.7700	7.11	0.540	6.1220	1.8800	1.8800
	25	6.86	0.544	6.1600	1.8400	1.8400	7.15	0.536	6.0800	1.9300	1.9300
	30	6.92	0.530	6.0100	1.9900	1.9900	7.17	0.526	5.9600	2.0400	2.0400
600 °C	05	6.95	0.668	7.5700	0.4300	0.4300	7.39	0.591	6.7000	1.3000	1.3000
	10	7.15	0.633	7.1700	0.8300	0.8300	7.56	0.543	6.1500	1.8500	1.8500
	15	7.38	0.588	6.6600	1.3400	1.3400	7.67	0.502	5.6900	2.3100	2.3100
	20	7.45	0.571	6.4740	1.5260	1.5260	7.70	0.481	5.4500	2.5500	2.5500
	25	7.49	0.566	6.4170	1.5830	1.5830	7.76	0.463	5.2500	2.7200	2.7200
	30	7.52	0.560	6.3450	1.6510	1.6510	7.80	0.451	5.1100	2.8900	2.8900
800 °C	05	9.41	0.565	6.4000	1.6000	1.6000	9.64	0.524	5.9400	2.0400	2.0400
	10	9.55	0.541	6.1300	1.8700	1.8700	9.80	0.511	5.7900	2.2100	2.2100
	15	9.63	0.518	5.8700	2.1300	2.1300	10.02	0.489	5.5400	2.4600	2.4600
	20	9.69	0.501	5.6800	2.3200	2.3200	10.04	0.461	5.2200	2.7800	2.7800
	25	9.72	0.483	5.4700	2.5300	2.5300	10.06	0.441	5.0000	3.0000	3.0000
	30	9.79	0.460	5.2100	2.7900	2.7900	10.08	0.421	4.7700	3.2300	3.2300
900 °C	05	9.58	0.521	5.9100	2.0900	2.0900	9.67	0.503	5.7000	2.3000	2.3000
	10	9.63	0.511	5.7900	2.2100	2.2100	9.84	0.466	5.2800	2.7200	2.7200
	15	9.74	0.481	5.4500	2.4500	2.4500	10.00	0.451	5.1100	2.8900	2.8900
	20	9.76	0.460	5.2100	2.7900	2.7900	1010	0.431	4.8800	3.1200	3.1200
	25	9.79	0.440	4.9800	3.0200	3.0200	1012	0.410	4.6500	3.3500	3.3500
	30	9.82	0.420	4.7600	3.2400	3.2400	1013	0.400	4.5300	3.4700	3.4700
1000 °C	05	9.71	0.500	5.6600	2.3400	2.3400	9.76	0.495	5.6100	2.3900	2.3900
	10	9.73	0.450	5.1000	2.9000	2.9000	9.81	0.401	4.5460	3.4530	3.4530
	15	9.74	0.400	4.5300	3.4700	3.4700	9.92	0.352	3.9900	4.0100	4.0100
	20	9.82	0.380	4.3100	3.6900	3.6900	9.99	0.331	3.7500	4.2500	4.2500
	25	9.84	0.360	4.0800	3.9200	3.9200	10.01	0.310	3.5100	4.4900	4.4900
	30	9.88	0.350	3.9700	4.0300	4.0300	10.03	0.300	3.4000	4.6000	4.6000

♦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AY29 (D_o) = 8.0 × 10^{-5}mol.dm^3, pH of D_o Before Adsorption = 7.0*


Raw carbon
Dϕ (mol g-1× 10-6)
Time (s)
•10 °C
•45 °C


400 °C activated carbon
Dϕ (mol g-1× 10-6)
Time (s)
•10 °C
•45 °C


600 °C activated carbon
Dϕ (mol g-1× 10-6)
Time (s)
•10 °C
•45 °C

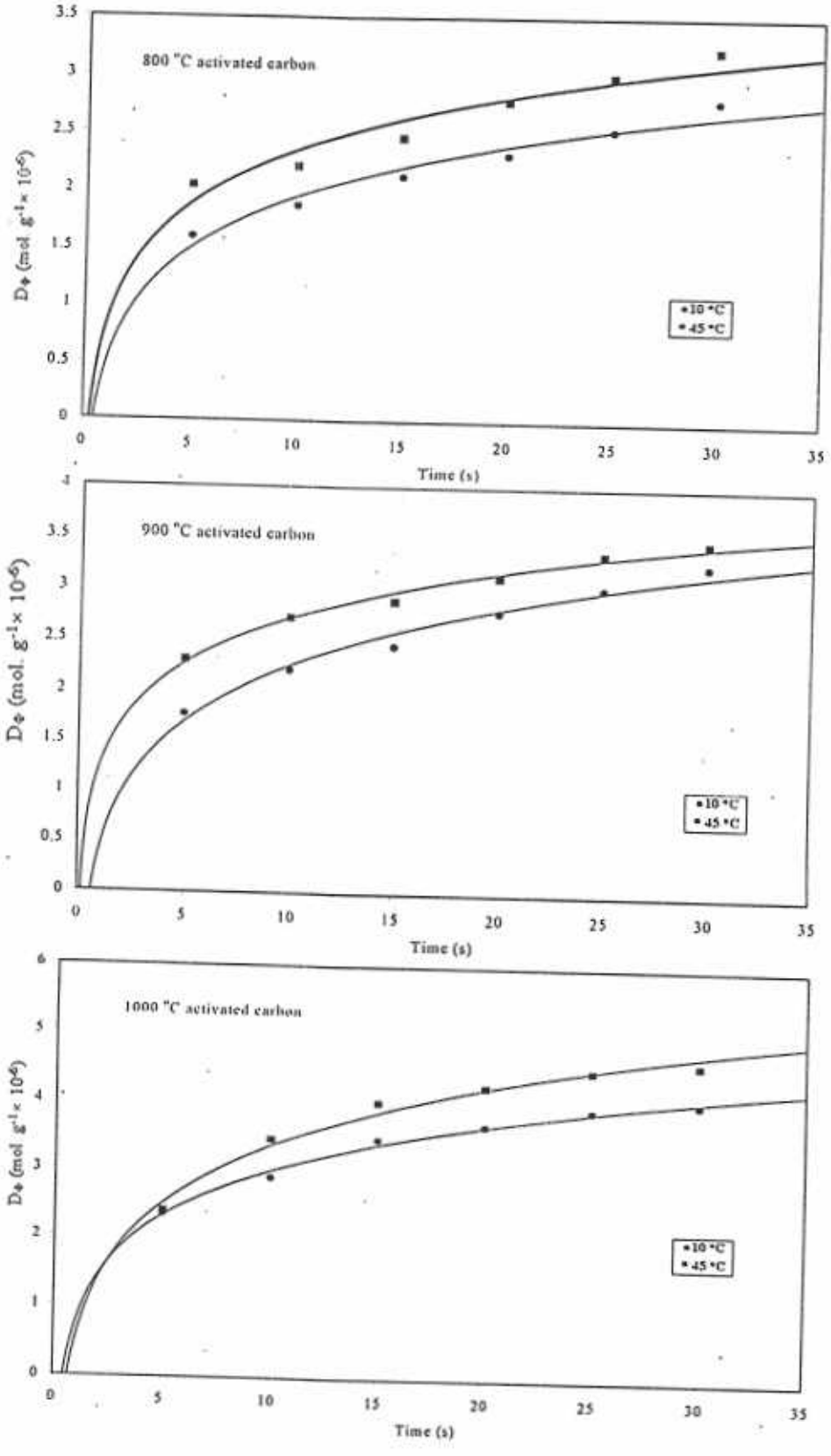
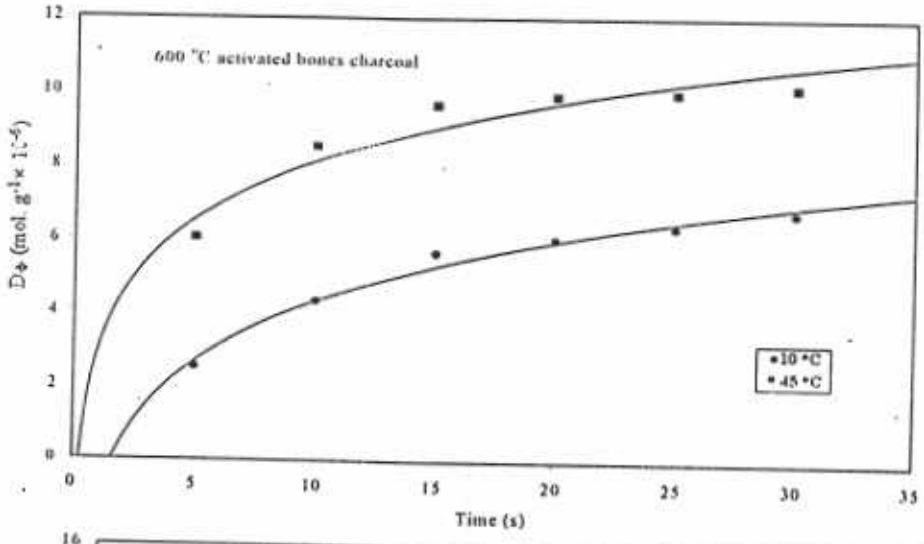


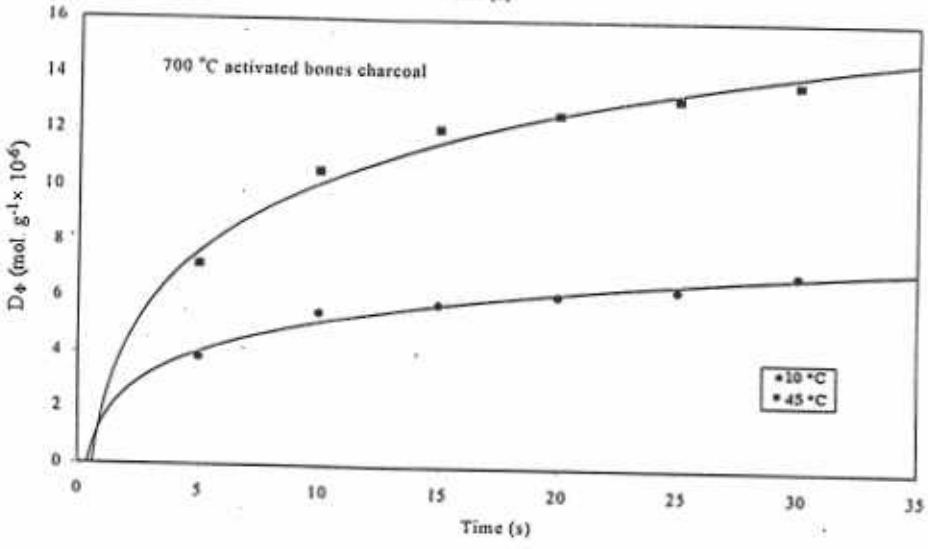
Figure 4.33 Adsorption kinetics of acid yellow 29 on *Salvadora oleoides* (SO) carbon samples

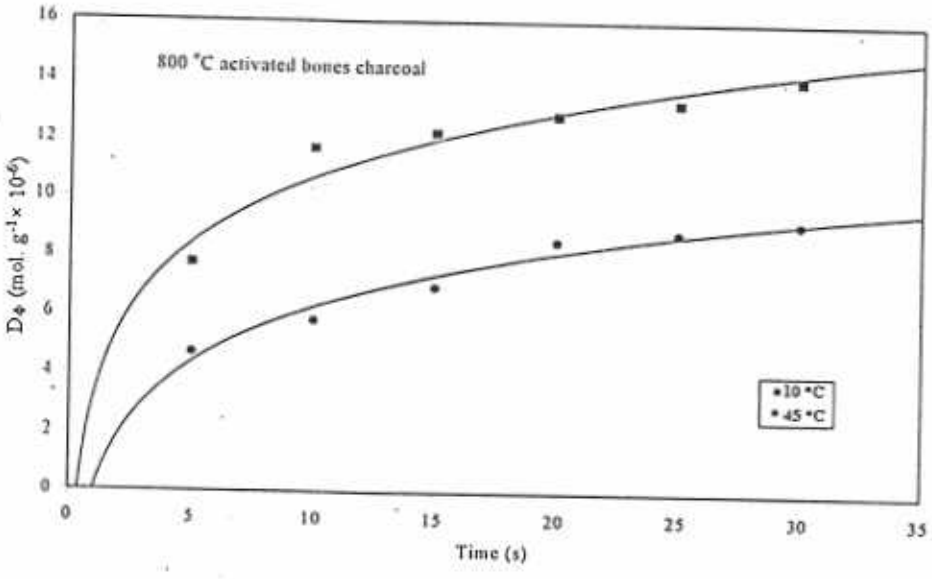
Table 25 Adsorption kinetics of acid yellow 29 on animal bone charcoal (ABC) samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
600 °C	05	8.00	1.540	17.460	2.5400	2.5400	7.95	1.230	13.940	6.0600	6.0600
	10	8.03	1.380	15.640	4.3530	4.3530	7.90	1.010	11.450	8.5500	8.5500
	15	8.05	1.263	14.320	5.6800	5.6800	7.98	0.911	10.330	9.6700	9.6700
	20	8.10	1.230	13.940	6.0600	6.0600	7.94	0.891	10.100	9.9000	9.9000
	25	8.15	1.200	13.600	6.4000	6.4000	7.95	0.883	10.010	9.9900	9.9900
	30	8.23	1.170	13.200	6.8000	6.8000	7.94	0.870	9.8600	10.140	10.140
700 °C	05	7.90	1.424	16.140	3.8600	3.8600	7.72	1.130	12.810	7.1900	7.1900
	10	8.01	1.280	14.510	5.4900	5.4900	7.86	0.830	9.4100	10.590	10.590
	15	8.02	1.251	14.180	5.8200	5.8200	7.98	0.700	7.9300	12.070	12.070
	20	8.05	1.220	13.830	6.1700	6.1700	7.99	0.651	7.3800	12.620	12.620
	25	8.10	1.200	13.600	6.4000	6.4000	8.03	0.600	6.8000	13.200	13.200
	30	8.15	1.150	13.040	6.9610	6.9610	8.06	0.550	6.2300	13.770	13.770
800 °C	05	8.22	1.350	15.300	4.7000	4.7000	8.10	1.080	12.240	7.7600	7.7600
	10	8.50	1.250	14.170	5.8000	5.8000	8.34	0.730	8.2700	11.730	11.730
	15	8.65	1.150	13.040	6.9610	6.9610	8.42	0.680	7.7100	12.290	12.290
	20	8.70	1.010	11.450	8.5500	8.5500	8.46	0.630	7.1400	12.890	12.890
	25	8.73	0.983	11.140	8.8600	8.8600	8.49	0.590	6.6800	13.320	13.320
	30	8.77	0.951	10.780	9.2200	9.2200	8.51	0.520	5.8900	14.110	14.110
900 °C	05	8.91	1.311	14.850	5.1500	5.1500	8.98	1.010	11.450	8.5500	8.5500
	10	9.01	1.180	13.380	6.6210	6.6210	9.16	0.700	7.9300	12.070	12.070
	15	9.12	1.150	13.040	6.9610	6.9610	9.23	0.653	7.4000	12.600	12.600
	20	9.19	1.010	11.450	8.5500	8.5500	9.25	0.610	6.9200	13.080	13.080
	25	9.21	0.973	11.030	8.9700	8.9700	9.29	0.570	6.4600	13.540	13.540
	30	9.28	0.943	10.690	9.3100	9.3100	9.30	0.540	6.1200	13.880	13.880
1000 °C	05	9.910	1.230	13.940	6.0600	6.0600	9.56	0.925	10.480	9.5200	9.5200
	10	10.05	1.175	13.320	6.6800	6.6800	9.71	0.647	7.3300	12.670	12.670
	15	10.20	1.030	11.670	8.3300	8.3300	9.76	0.607	6.8800	13.120	13.120
	20	10.25	0.984	11.150	8.8500	8.8500	9.80	0.550	6.2300	13.770	13.770
	25	10.27	0.960	10.880	9.1200	9.1200	9.82	0.500	5.6700	14.330	14.330
	30	10.33	0.930	10.540	9.4600	9.4600	9.90	0.450	5.1000	14.900	14.900

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AY29 (D_o) =20 × 10^{-5}mol.dm^{-3}, pH of D_o Before Adsorption = 7.70*


600 °C activated bones charcoal
Dϕ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


700 °C activated bones charcoal
Dϕ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


800 °C activated bones charcoal
Dϕ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C

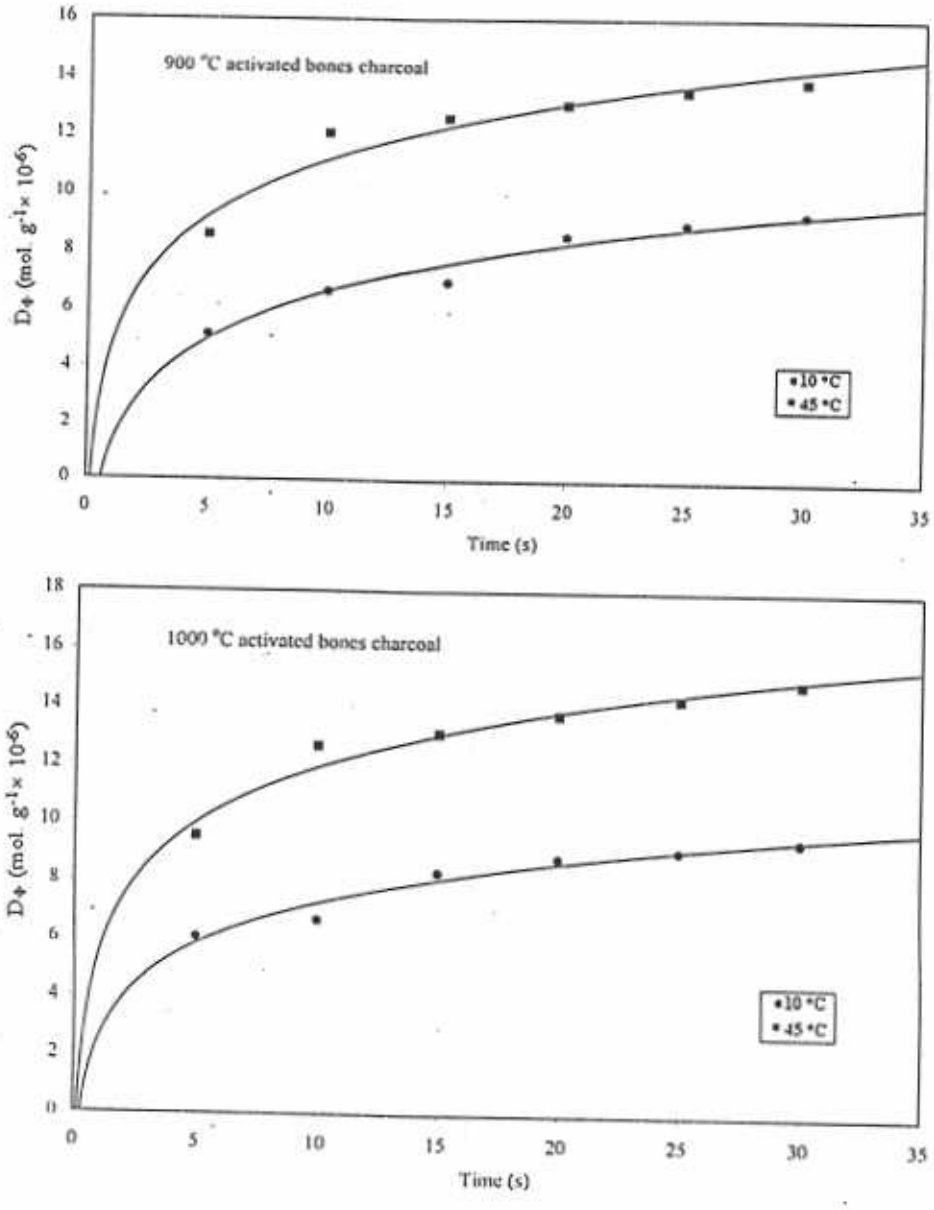
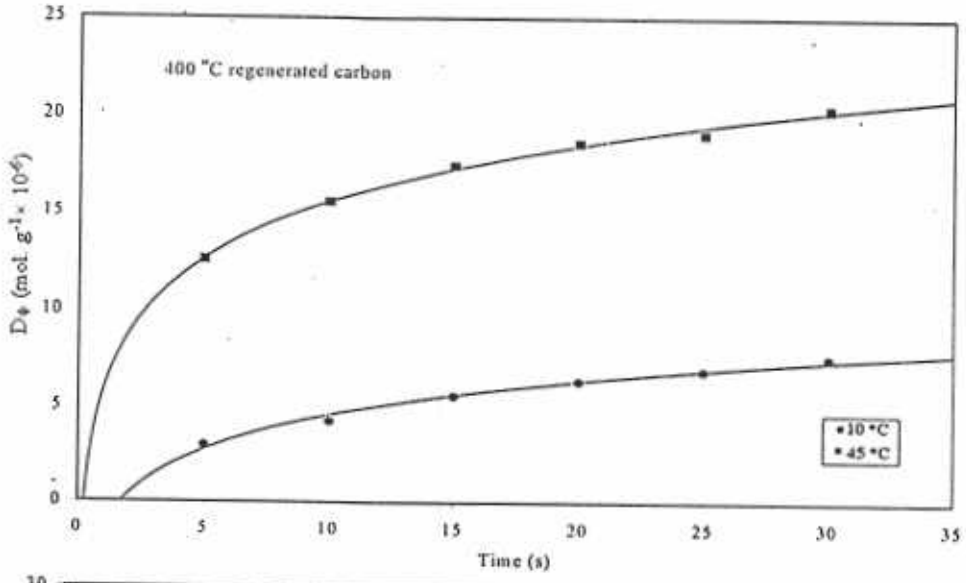


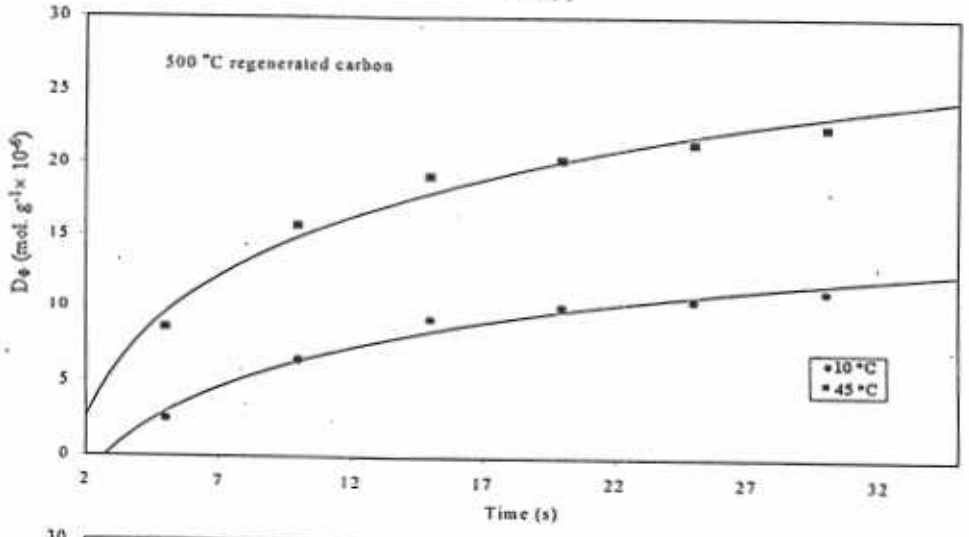
Figure 4.34 Adsorption kinetics of acid yellow 29 on animal bones (ABC) charcoal samples

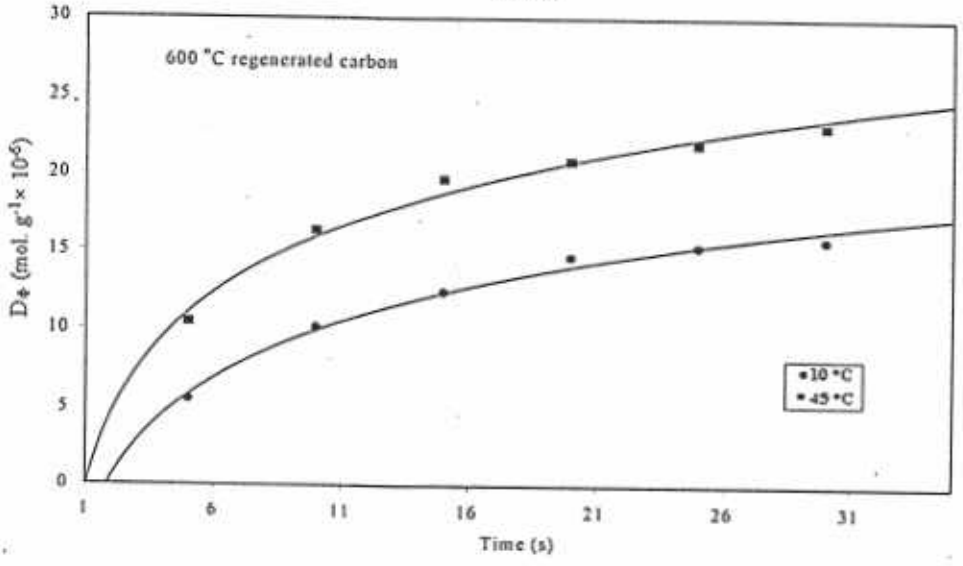
Table 4.26 Adsorption kinetics of acid yellow 29 on regenerated (RG) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
400 °C	05	7.15	2.28	25.850	0.1496	0.1496	6.95	2.20	24.940	1.0560	1.0560
	10	7.10	2.00	22.670	3.3240	3.3240	6.93	1.95	22.110	4.8910	4.8910
	15	7.08	1.90	21.542	4.4580	4.4580	6.92	1.86	21.080	4.9110	4.9110
	20	7.06	1.82	20.625	5.3650	5.3650	6.89	1.78	20.180	5.8200	5.8200
	25	7.04	1.75	19.841	6.1587	6.1587	6.88	1.71	19.380	6.6120	6.6120
	30	7.03	1.70	19.274	6.7256	6.7256	6.85	1.67	18.930	7.0650	7.0650
500 °C	05	6.90	2.070	23.460	2.5400	2.5400	7.00	1.534	17.390	8.6070	8.6070
	10	6.93	1.720	19.500	6.5000	6.5000	7.05	0.903	10.240	15.760	15.760
	15	6.96	1.480	16.780	9.2200	9.2200	7.06	0.600	6.8000	19.200	19.200
	20	6.97	1.400	15.870	10.130	10.130	7.08	0.501	5.6700	20.330	20.330
	25	6.98	1.360	15.420	10.580	10.580	7.09	0.402	4.5600	21.440	21.440
	30	6.99	1.300	14.740	11.260	11.260	7.11	0.302	3.4200	22.580	22.580
600 °C	05	6.90	1.801	20.410	05.590	05.590	7.01	1.37	15.530	10.460	10.460
	10	6.97	1.400	15.870	10.130	10.130	7.20	0.851	9.6400	16.360	16.360
	15	7.00	1.210	13.600	12.400	12.400	7.22	0.551	6.2800	19.720	19.720
	20	7.02	1.000	11.330	14.670	14.670	7.23	0.450	5.1000	20.900	20.900
	25	7.03	0.940	10.650	15.340	15.340	7.24	0.352	3.9900	22.010	22.010
	30	7.04	0.900	10.200	15.790	15.790	7.25	0.250	2.8300	23.170	23.170
800 °C	05	6.97	1.400	15.870	10.130	10.130	7.21	1.100	12.470	13.530	13.530
	10	7.07	1.000	11.330	14.670	14.670	7.27	0.604	6.8500	19.150	19.150
	15	7.09	0.800	9.0700	16.930	16.930	7.32	0.452	5.1200	20.880	20.880
	20	7.10	0.600	6.8000	19.200	19.200	7.35	0.352	3.9900	22.010	22.010
	25	7.11	0.590	6.6893	19.310	19.310	7.36	0.300	3.4000	22.600	22.600
	30	7.13	0.582	6.5986	19.401	19.401	7.40	0.115	1.3000	24.700	24.700
900 °C	05	6.98	1.210	13.720	13.281	13.281	7.25	1.15	14.780	11.210	11.210
	10	7.05	0.830	9.4100	17.590	17.590	7.28	0.722	8.1860	17.810	17.810
	15	7.10	0.601	6.8140	19.186	19.186	7.30	0.400	4.5300	21.470	21.470
	20	7.11	0.580	6.5760	19.424	19.424	7.36	0.303	3.4300	22.570	22.570
	25	7.13	0.573	6.4965	19.503	19.503	7.37	0.225	2.5500	23.450	23.450
	30	7.15	0.562	6.3718	19.628	19.628	7.39	0.101	1.1450	24.855	24.855
1000 °C	05	7.14	1.01	11.451	14.548	14.548	7.21	0.950	10.770	15.220	15.220
	10	7.16	0.601	6.8140	20.186	20.186	7.26	0.465	5.2720	20.730	20.730
	15	7.27	0.400	4.5300	21.464	21.464	7.38	0.352	3.9900	22.010	22.010
	20	7.29	0.385	4.3651	21.635	21.635	739	0.202	2.2900	23.710	23.710
	25	7.30	0.371	4.2363	21.793	21.793	7.42	0.040	0.4500	25.550	25.550
	30	7.31	0.363	4.1156	21.884	21.884	7.43	0.020	0.2260	25.770	25.770

* *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AY29 (D_o) = 26 ×10^{-5}mol.dm^3, pH of D_o Before Adsorption = 7.70*


400 °C regenerated carbon
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


500 °C regenerated carbon
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


600 °C regenerated carbon
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C

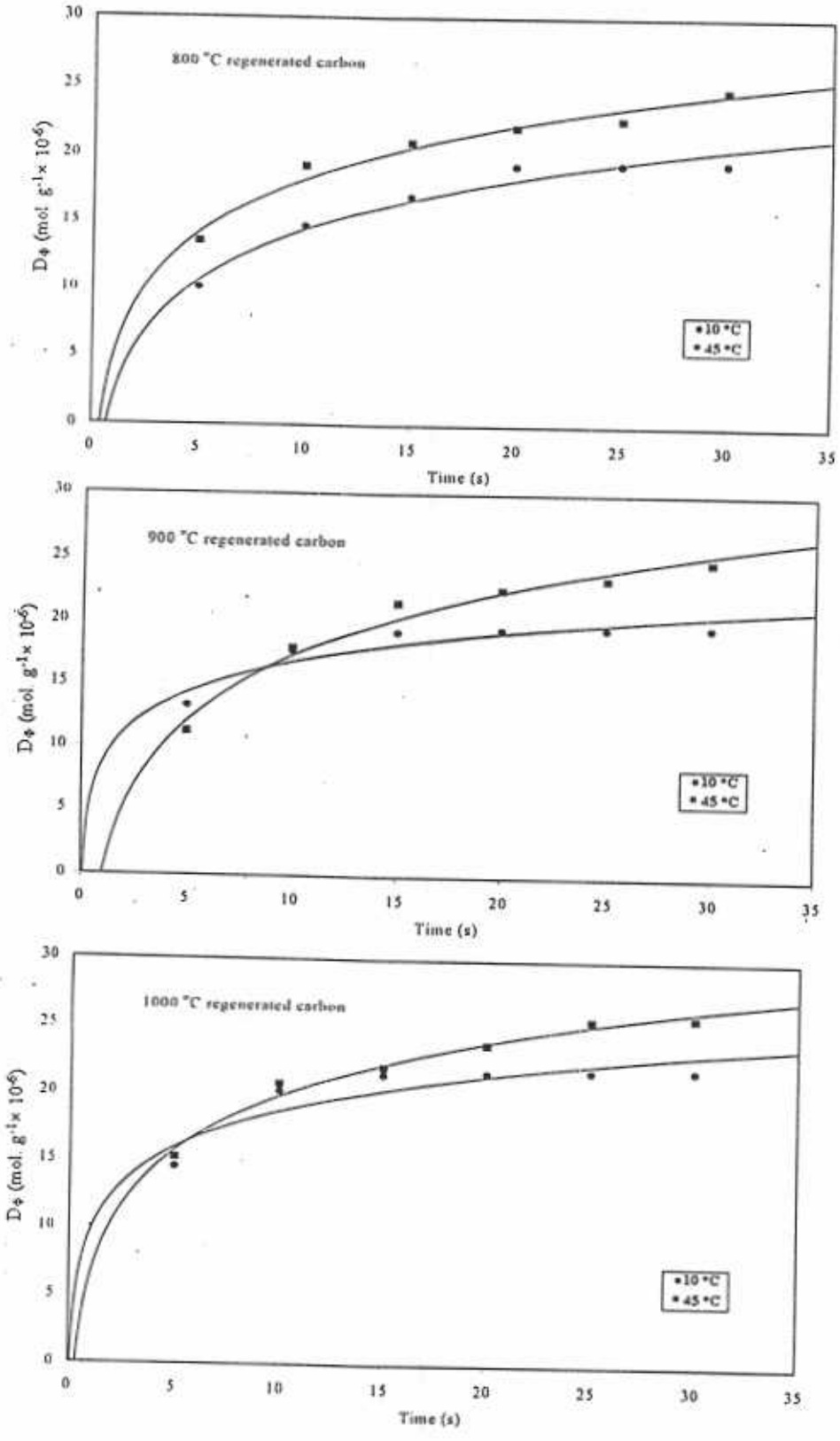


Figure 4.35 Adsorption kinetics of acid yellow 29 on regenerated (RG) carbon samples

Table 4.27 Adsorption kinetics of acid yellow 34 on *Paulownia tomentosa* (PT) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})
Raw	05	6.80	0.380	2.7200	0.2800	0.2800	6.70	0.341	2.4350	0.5640	0.5640
	10	6.75	0.360	2.5700	0.4300	0.4300	6.50	0.299	2.1350	0.8640	0.8640
	15	6.70	0.345	2.4600	0.5400	0.5400	6.55	0.270	1.9280	1.0710	1.0710
	20	6.65	0.340	2.4200	0.5800	0.5800	6.58	0.245	1.7500	1.2500	1.2500
	25	6.62	0.335	2.4000	0.6000	0.6000	6.60	0.240	1.7100	1.2900	1.2900
	30	6.61	0.330	2.3500	0.6500	0.6500	6.62	0.235	1.6700	1.3300	1.3300
400 °C	05	6.69	0.275	1.9600	1.0400	1.0400	6.74	0.202	1.4430	1.5570	1.5570
	10	6.95	0.240	1.7100	1.2900	1.2900	6.80	0.154	1.1000	2.0000	2.0000
	15	6.96	0.221	1.5800	1.4200	1.4200	6.84	0.130	0.9200	2.0800	2.0800
	20	6.97	0.215	1.5300	1.4700	1.4700	6.86	0.125	0.8900	2.1100	2.1100
	25	6.99	0.210	1.5000	1.5000	1.5000	6.88	0.120	0.8500	2.1500	2.1500
	30	7.00	0.200	1.4200	1.5800	1.5800	6.90	0.119	0.8500	2.1500	2.1500
800 °C	05	9.19	0.190	1.3570	1.6430	1.6430	8.60	0.145	1.0360	1.9640	1.9640
	10	9.40	0.145	1.0360	1.9640	1.9640	8.71	0.075	0.5350	2.4600	2.4600
	15	9.49	0.115	0.8200	2.1800	2.1800	8.77	0.030	0.2140	2.7900	2.7900
	20	9.52	0.110	0.7800	2.2200	2.2200	8.80	0.025	0.1800	2.8200	2.8200
	25	9.55	0.100	0.7200	2.2800	2.2800	8.83	0.020	0.1420	2.8600	2.8600
	30	9.57	0.095	0.6800	2.3200	2.3200	8.85	0.017	0.1210	2.8800	2.8800

♦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AY34 (D_o) = 3 × 10^{-5}mol.dm^{-3}, pH of D_o Before Adsorption = 7.30*

Table 4.28 Adsorption kinetics of acid yellow 34 on *Populus caspica* (PC) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})
Raw	05	7.93	0.388	2.7710	0.2300	0.2300	7.18	0.334	2.3850	0.6140	0.6140
	10	7.60	0.351	2.5000	0.5000	0.5000	7.00	0.280	200000	1.0000	1.0000
	15	7.53	0.330	2.3500	0.6500	0.6500	6.99	0.245	1.7500	1.2500	1.2500
	20	7.50	0.320	2.2800	0.7200	0.7200	6.98	0.241	1.7100	1.2900	1.2900
	25	7.49	0.316	2.2600	0.7420	0.7420	6.97	0.234	1.6800	1.3200	1.3200
	30	7.46	0.310	2.2100	0.7850	0.7850	6.96	0.230	1.6400	1.3600	1.3600
400 °C	05	9.46	0.290	2.0700	0.9280	0.9280	7.17	0.242	1.7300	1.2700	1.2700
	10	9.59	0.245	1.7500	1.2500	1.2500	7.40	0.195	1.3930	1.6100	1.6100
	15	9.60	0.225	1.6100	1.3900	1.3900	7.60	0.141	1.0000	2.0000	2.0000
	20	9.62	0.200	1.4300	1.5700	1.5700	7.65	0.135	0.9600	2.0400	2.0400
	25	9.65	0.195	1.4000	1.5400	1.5400	7.71	0.130	0.9200	2.0800	2.0800
	30	9.68	0.190	1.3500	1.6000	1.6000	7.79	0.125	0.8900	2.1100	2.1100
800 °C	05	10.02	0.280	2.0000	1.0000	1.0000	9.800	0.224	1.6000	1.4000	1.4000
	10	10.05	0.230	1.6430	1.3580	1.3580	10.00	0.160	1.1400	1.8600	1.8600
	15	10.06	0.210	1.5000	1.5000	1.5000	10.02	0.130	0.9300	2.0700	2.0700
	20	10.07	0.190	1.3600	1.6400	1.6400	10.03	0.120	0.8600	2.1400	2.1400
	25	10.09	0.185	1.3200	1.6800	1.6800	10.04	0.114	0.8200	2.1800	2.1800
	30	10.10	0.182	1.3000	1.7000	1.7000	10.05	0.110	0.7900	2.2100	2.2100

♦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AY34 (D_o) = 3 × 10^{-5}mol.dm^{-3}, pH of D_o Before Adsorption = 7.30*

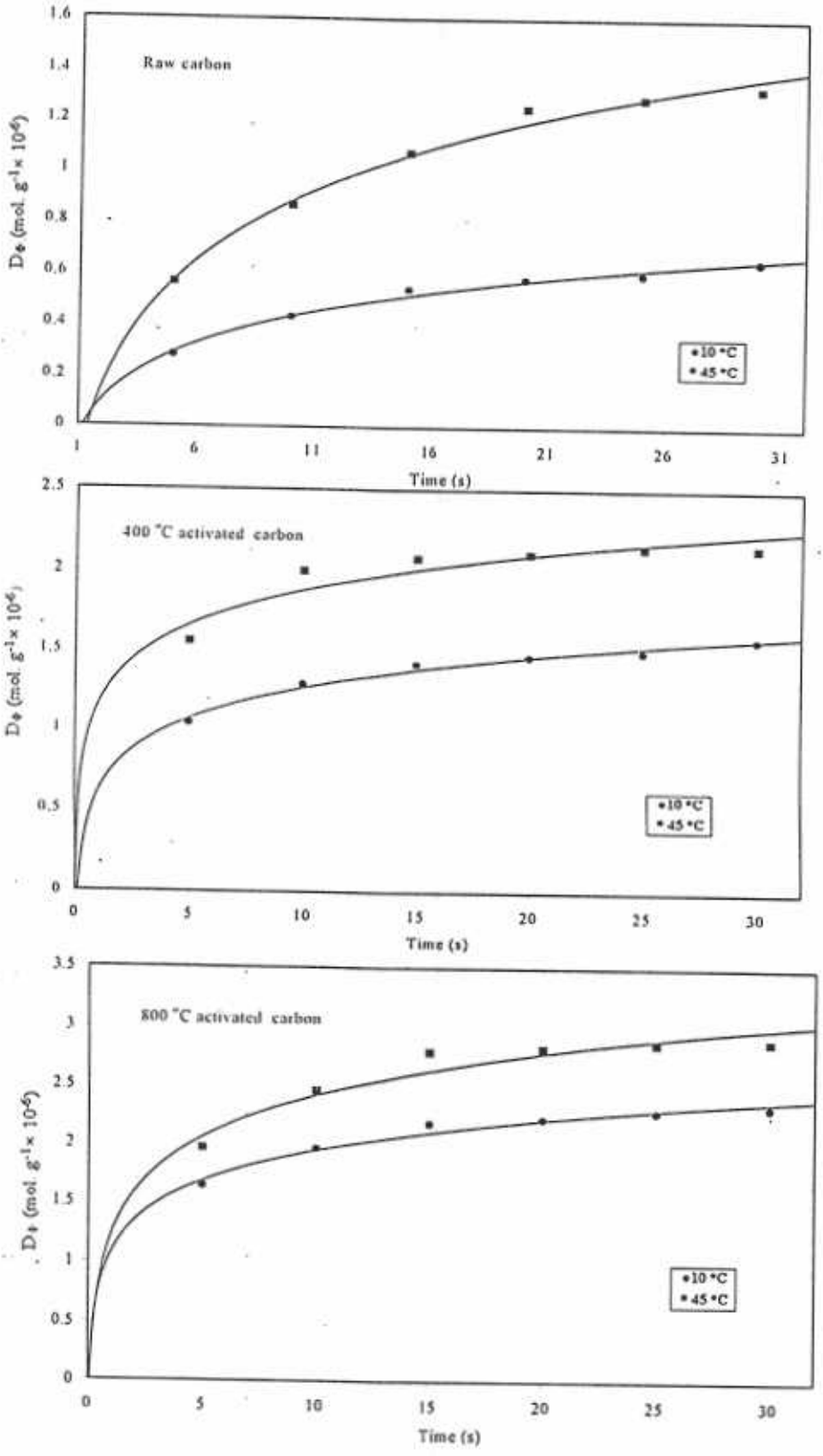


Figure 4.36 Adsorption kinetics of acid yellow 34 on *Paulownia tomentosa* (PT) carbon samples

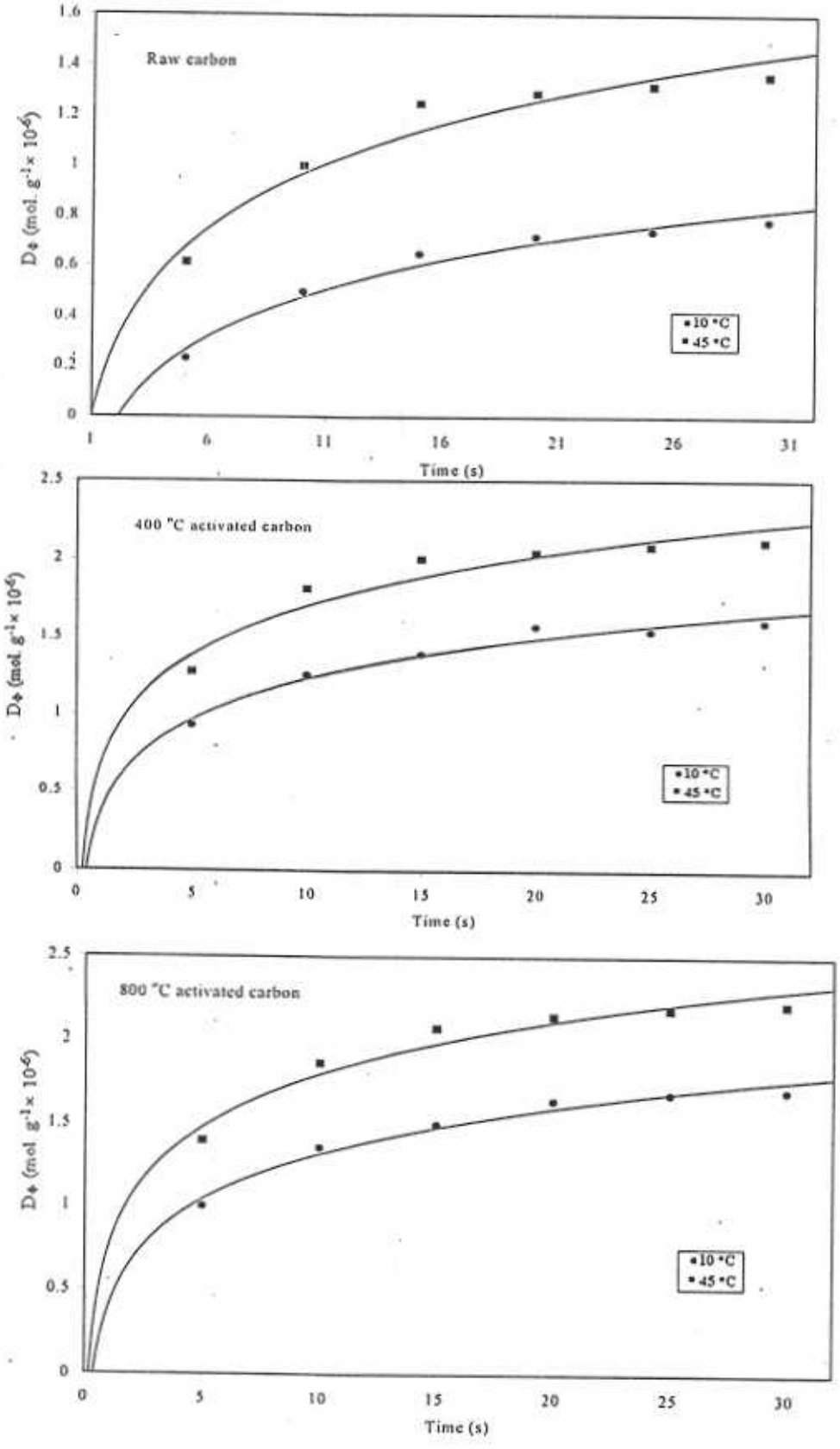


Figure 4.37 Adsorption kinetics of acid yellow 34 on *Populus caspica* (PC) carbon samples

Table 4.29 Adsorption kinetics of acid yellow 34 on Corncobs (CC) carbon samples.

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})
Raw	05	8.31	0.350	2.500	0.500	0.500	8.00	0.320	2.2800	0.7200	0.7200
	10	7.70	0.336	2.400	0.600	0.600	7.40	0.280	2.0000	1.0000	1.0000
	15	7.40	0.320	2.280	0.720	0.720	7.25	0.260	1.8600	1.1400	1.1400
	20	7.35	0.13	2.230	0.770	0.770	7.20	0.230	1.6400	1.3600	1.3600
	25	7.33	0.308	2.200	0.800	0.800	7.10	0.225	1.6000	1.4000	1.4000
	30	7.30	0.302	2.160	0.840	0.840	7.05	0.220	1.5700	1.4300	1.4300
400 °C	05	9.26	0.295	2.1100	0.8900	0.8900	7.68	0.225	1.6100	1.1400	1.4000
	10	9.37	0.254	1.8100	1.1800	1.1800	8.20	0.193	1.3800	1.6200	1.6200
	15	9.52	0.225	1.6100	1.4000	1.4000	8.60	0.160	1.1400	1.8600	1.8600
	20	9.62	0.209	1.5000	1.5000	1.5000	8.70	0.115	0.8200	2.1800	2.1800
	25	9.67	0.06	1.4700	1.5300	1.5300	8.72	0.110	0.7800	2.2200	2.2200
	30	9.72	0.200	1.4200	1.5800	1.5800	8.75	0.102	0.7300	2.2700	2.2700
800 °C	05	9.73	0.281	2.0000	1.0000	1.0000	9.45	0.198	1.4200	1.5800	1.5800
	10	9.85	0.241	1.7200	1.2800	1.2800	9.36	0.150	1.0700	1.9300	1.9300
	15	9.87	0.201	1.4400	1.5600	1.5600	9.44	0.131	0.9400	2.0600	2.0600
	20	9.88	0.171	1.2200	1.7800	1.7800	9.50	0.122	0.8700	2.1300	2.1300
	25	9.90	0.156	1.1100	1.8800	1.8800	9.52	0.115	0.8200	2.1800	2.1800
	30	9.92	0.148	1.0600	1.9400	1.9400	9.54	0.110	0.7800	2.2100	2.2100

♦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AY34 (D_o) = 3 × 10^{-5}mol.dm^3, pH of D_o Before Adsorption = 7.30*

Table 4.30 Adsorption kinetics of acid yellow 34 on *Ailanthus altissima* (AA) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})
Raw	05	8.60	0.350	2.500	0.500	0.5000	7.40	0.293	2.0900	0.9070	0.9070
	10	7.40	0.325	2.320	0.680	0.6800	7.20	0.265	1.8900	1.1100	1.1100
	15	7.35	0.305	2.180	0.820	0.8200	7.15	0.240	1.7100	1.2900	1.2900
	20	7.32	0.295	2.110	0.890	0.8900	7.10	0.230	1.6400	1.3600	1.3600
	25	7.30	0.291	2.070	0.930	0.9300	7.08	0.224	1.6000	1.4000	1.4000
	30	7.27	0.286	2.030	0.970	0.9700	7.06	0.219	1.5700	1.4300	1.4300
400 °C	05	9.11	0.271	1.940	1.060	1.0600	7.75	0.240	1.7100	1.2800	1.2800
	10	9.15	0.240	1.710	1.280	1.2800	8.25	0.191	1.3600	1.6300	1.6300
	15	9.30	0.209	1.500	1.500	1.5000	8.60	0.150	1.0700	1.9300	1.9300
	20	9.35	0.200	1.430	1.570	1.5700	8.65	0.120	0.8600	2.1400	2.1400
	25	9.40	0.194	1.390	1.610	1.6100	8.75	0.110	0.7600	2.2400	2.2400
	30	9.45	0.192	1.370	1.630	1.6300	8.80	0.105	0.7500	2.2500	2.2500
800 °C	05	10.03	0.250	1.7800	1.2200	1.2200	9.90	0.180	1.2900	1.7100	1.7100
	10	10.08	0.220	1.5700	1.4300	1.4300	9.76	0.141	1.0100	1.9900	1.9900
	15	10.09	0.210	1.5000	1.5000	1.5000	9.70	0.120	0.8600	2.1400	2.1400
	20	10.10	0.192	1.3700	1.6300	1.6300	9.65	0.090	0.6420	2.3500	2.3500
	25	10.12	0.186	1.3300	1.6700	1.6700	9.70	0.085	0.6070	2.3900	2.3900
	30	10.13	0.183	1.3100	1.6900	1.6900	9.80	0.082	0.5860	2.4100	2.4100

♦ *Particle Size= 150-180 µm, Initial Concentration of AY34 (D_o) = 3 × 10^{-5}mol.dm^3, pH of D_o Before Adsorption = 7.30,*

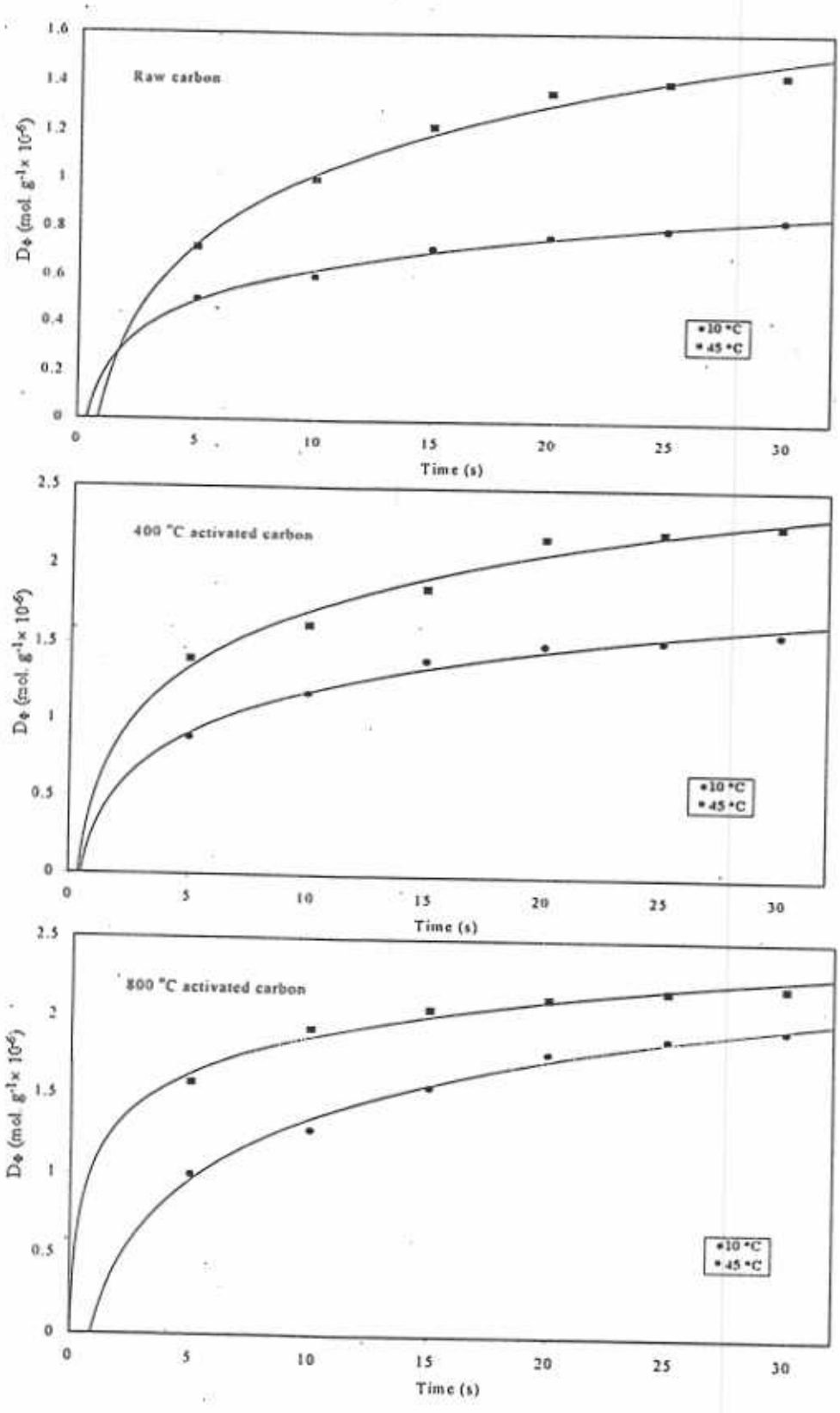


Figure 4.38 Adsorption kinetics of acid yellow 34 on *Corncobs* (CC) carbon samples

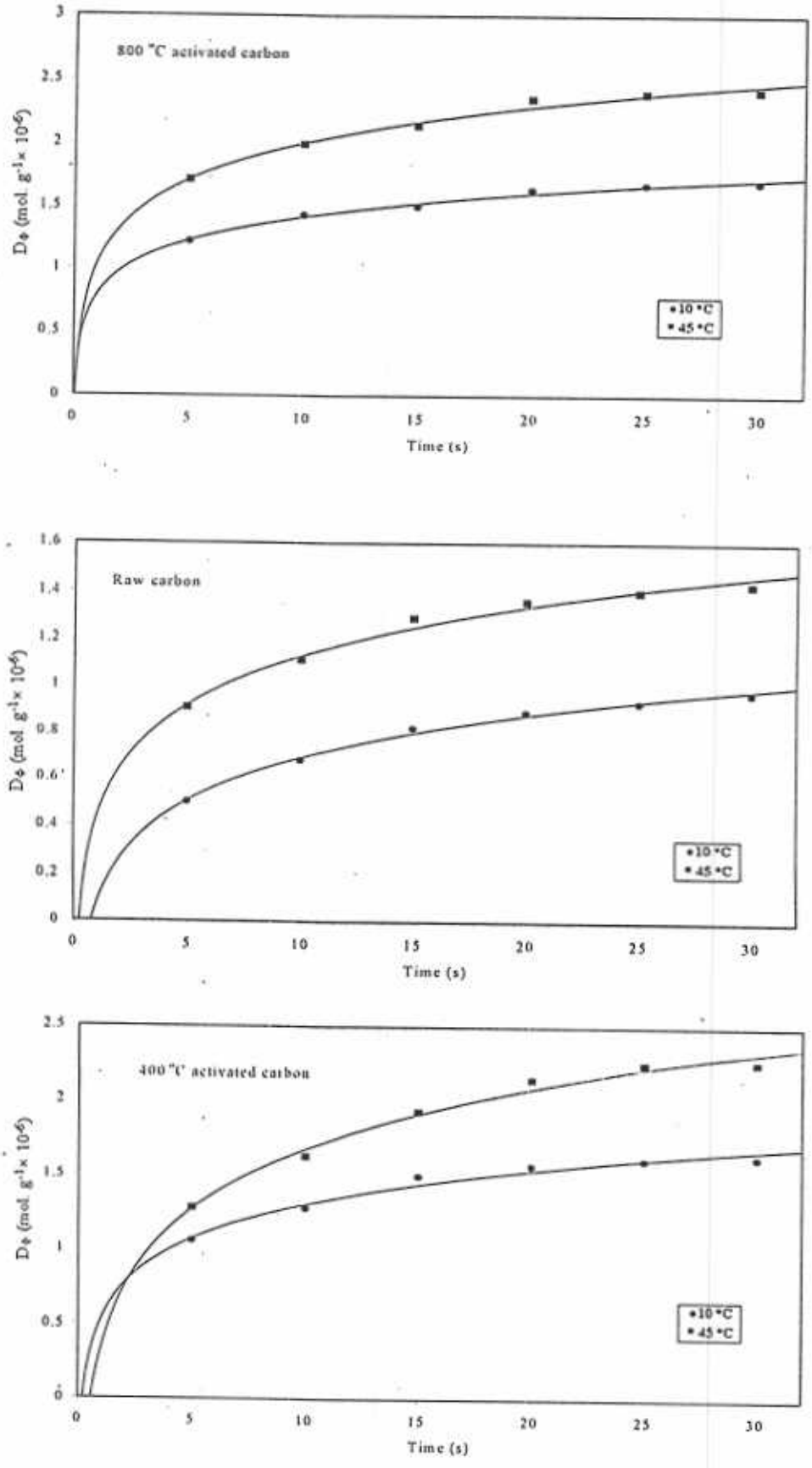
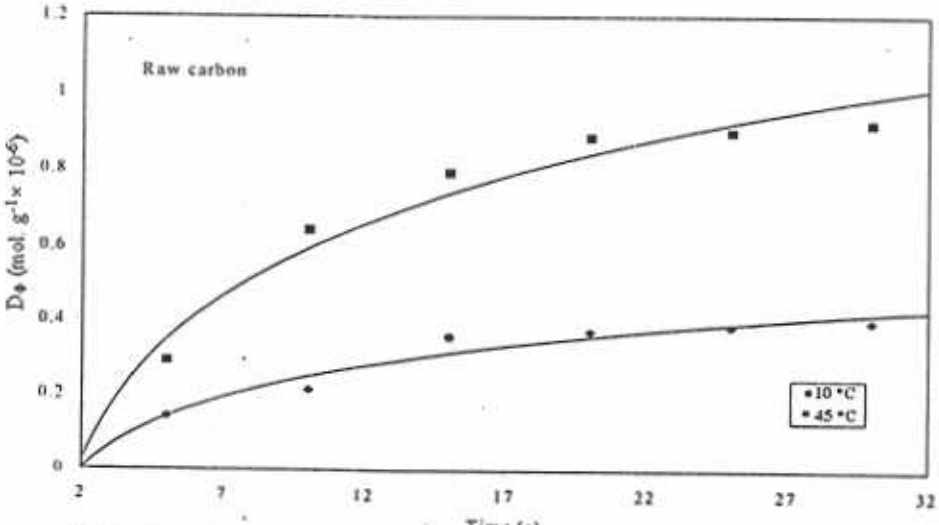


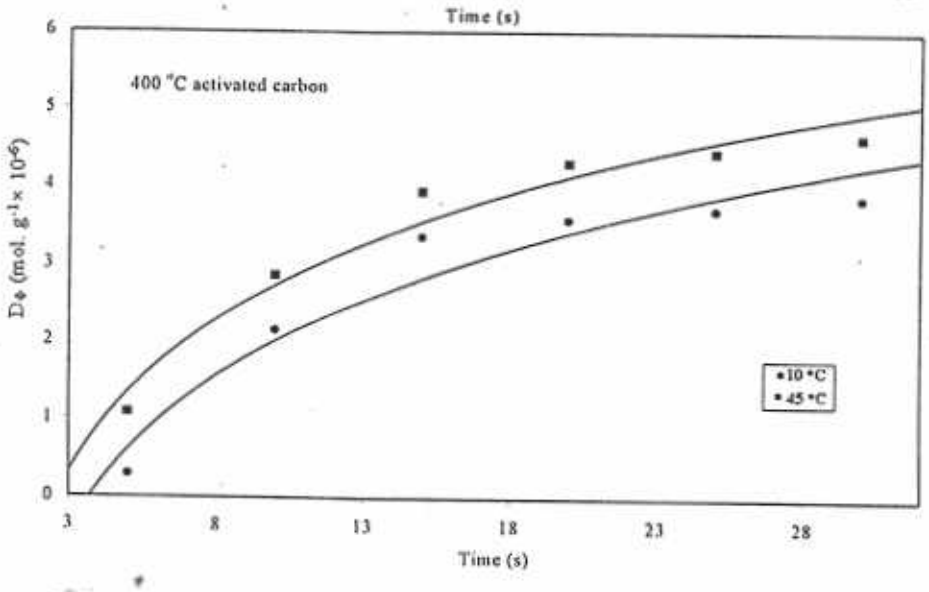
Figure 4.39 Adsorption kinetics of acid yellow 34 on *Ailanthus altissima* (AA) carbon samples

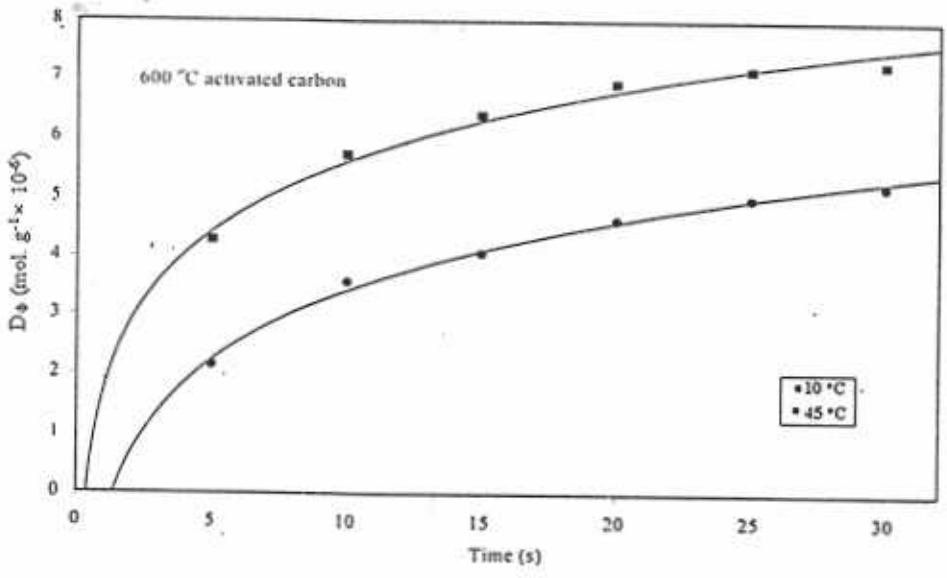
Table 4.31 Adsorption kinetics of acid yellow 34 on *Salvadora oleoides* (SO) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	6.90	1.380	9.8570	0.1430	0.1430	6.51	1.360	9.7100	0.2900	0.2900
	10	7.05	1.370	9.7850	0.2143	0.2143	6.94	1.335	9.5400	0.4640	0.4640
	15	7.21	1.350	9.6420	0.3571	0.3571	7.30	1.289	9.2100	0.7930	0.7930
	20	7.25	1.348	9.6280	0.3714	0.3714	7.33	1.276	9.1100	0.8860	0.8860
	25	7.26	1.346	9.6140	0.3857	0.3857	7.35	1.274	9.1000	0.9000	0.9000
	30	7.29	1.344	9.6000	0.4000	0.4000	7.38	1.271	9.0800	0.9210	0.9210
400 °C	05	6.45	1.360	9.714	0.2857	0.2857	6.50	1.250	8.9200	1.0800	1.0800
	10	6.51	1.100	7.8571	2.1430	2.1430	6.70	1.000	7.1400	2.8600	2.8600
	15	6.52	0.930	6.6430	3.3570	3.3570	6.71	0.850	6.0700	3.9300	3.9300
	20	6.54	0.900	6.4280	3.5710	3.5710	6.73	0.800	5.7100	4.2900	4.2900
	25	6.56	0.882	6.3000	3.7000	3.7000	6.74	0.780	5.5700	4.4300	4.4300
	30	6.57	0.861	6.1500	3.8500	3.8500	6.75	0.751	5.3600	4.6300	4.6300
600 °C	05	6.50	1.100	7.8571	2.1428	2.1428	6.90	0.801	5.7100	4.2900	4.2900
	10	6.77	0.900	6.4285	3.5714	3.5714	6.95	0.600	4.2800	5.7200	5.7200
	15	7.00	0.830	5.9285	4.0714	4.0714	7.17	0.505	3.6100	6.3900	6.3900
	20	7.26	0.750	5.3571	4.6428	4.6428	7.19	0.432	3.0800	6.9200	6.9200
	25	7.38	0.700	5.0000	5.0000	5.0000	7.30	0.400	2.8200	7.1500	7.1500
	30	7.41	0.670	4.7857	5.2142	5.2142	7.39	0.380	2.7100	7.2500	7.2500
800 °C	05	9.70	0.775	5.5350	4.4642	4.4642	9.18	0.630	4.5000	5.0000	5.0000
	10	9.90	0.550	3.9285	6.0714	6.0714	9.65	0.482	3.4428	6.5571	6.5571
	15	10.02	0.500	3.5714	6.4285	6.4285	9.90	0.301	2.7363	7.2636	7.2636
	20	10.5	0.443	3.1643	6.8357	6.8357	9.95	0.260	1.8571	8.1428	8.1428
	25	10.6	0.400	2.8571	7.1428	7.1428	9.99	0.200	1.4285	8.5714	8.5714
	30	10.10	0.393	2.8071	7.1928	7.1928	10.0	0.180	1.2857	8.7142	8.7142
900 °C	05	9.83	0.610	4.3571	5.6428	5.6428	9.48	0.430	3.0714	6.9280	6.9280
	10	9.81	0.400	2.8571	7.1428	7.1428	9.53	0.250	1.7857	8.2142	8.2142
	15	10.00	0.350	2.5000	7.5000	7.5000	10.19	0.200	1.4285	8.5714	8.5714
	20	1006	0.332	2.3714	7.6285	7.6285	10.23	0.151	1.0785	8.9214	8.9214
	25	10.09	0.315	2.2500	7.7500	7.7500	10.25	0.143	1.0214	8.9785	8.9785
	30	10.11	0.300	2.1428	7.8571	7.8571	10.29	0.133	0.9500	9.0500	9.0500
1000 °C	05	10.00	0.660	4.7143	5.2857	5.2857	9.62	0.520	3.7143	6.2857	6.2857
	10	10.05	0.440	3.1428	6.8571	6.8571	9.64	0.310	2.2142	7.7857	7.7857
	15	10.7	0.382	2.7285	7.2714	7.2714	9.80	0.240	1.7143	8.2857	8.2857
	20	10.09	0.342	2.4428	7.5571	7.5571	9.88	0.180	1.2857	8.7143	8.7143
	25	10.10	0.325	2.3214	7.6785	7.6785	9.95	0.166	1.1857	8.8143	8.8143
	30	10.12	0.311	2.2214	7.7785	7.7785	9.97	0.146	1.0428	8.9571	8.9571

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AY34 (D_o) = 10 × 10^{-5}mol.dm^3, pH of D_o Before Adsorption = 6.10*


Raw carbon
Dϕ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


400 °C activated carbon
Dϕ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


600 °C activated carbon
Dϕ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C

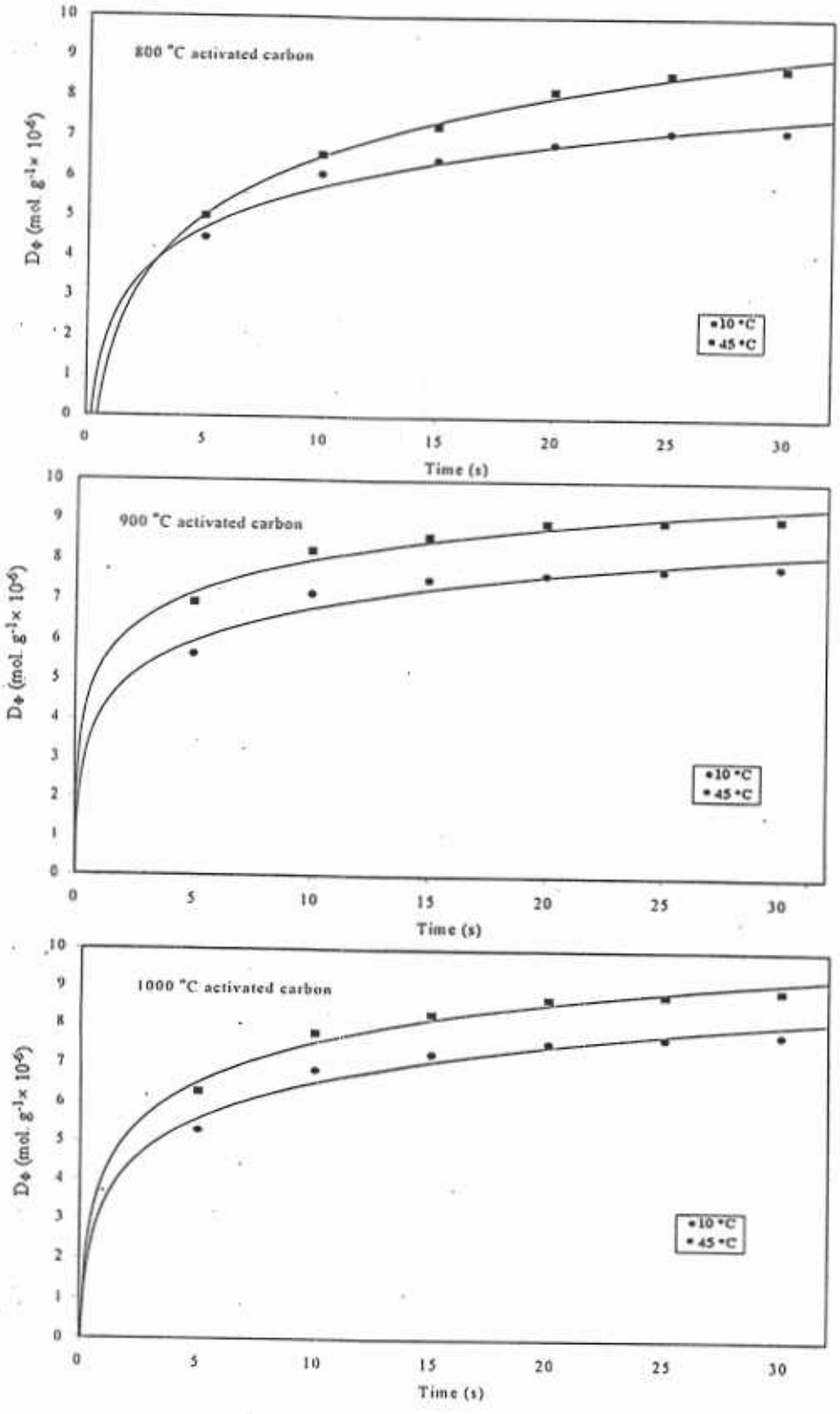
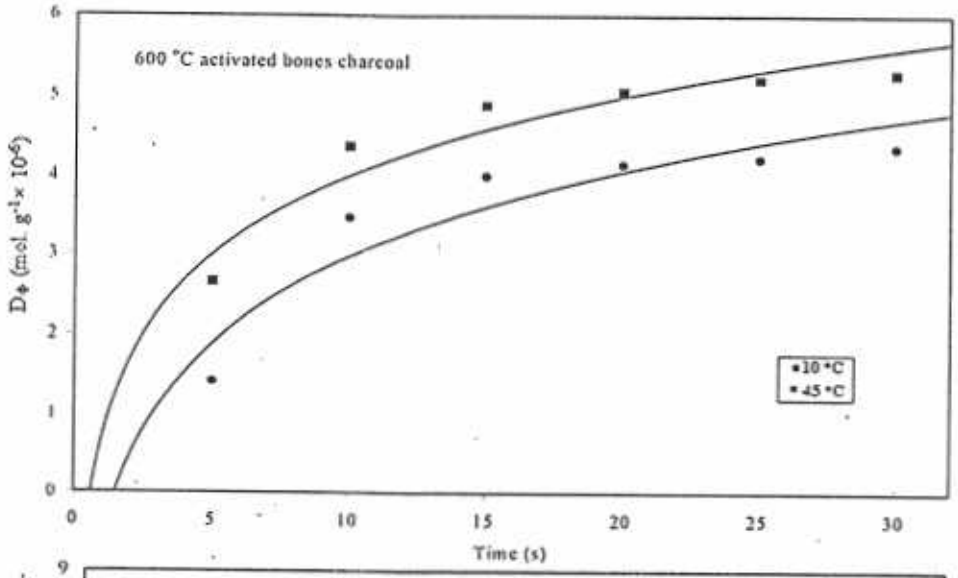


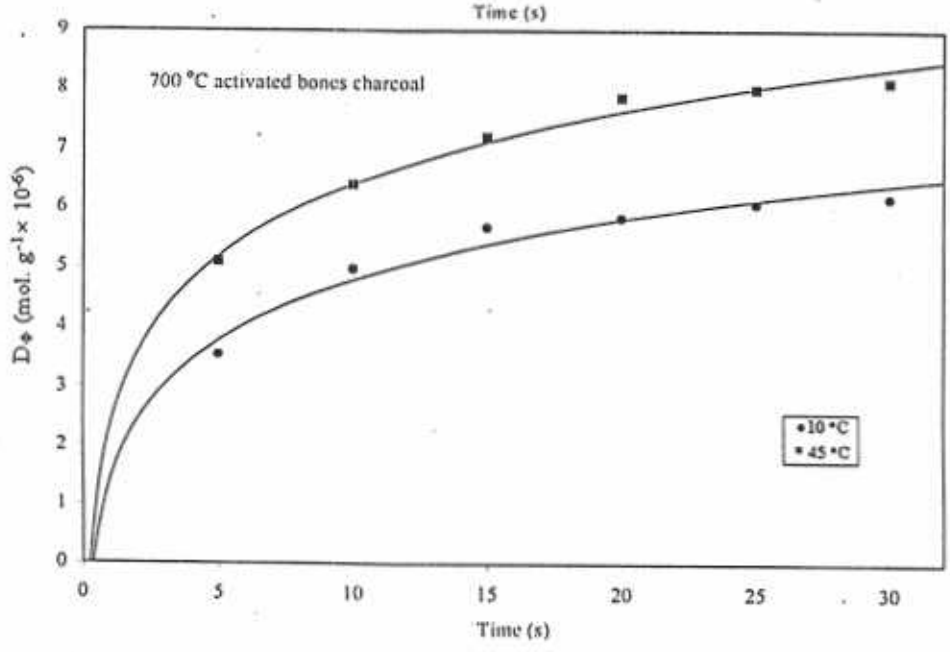
Figure 4.40 Adsorption kinetics of acid yellow 34 on *Salvadora oleoides* (SO) carbon samples

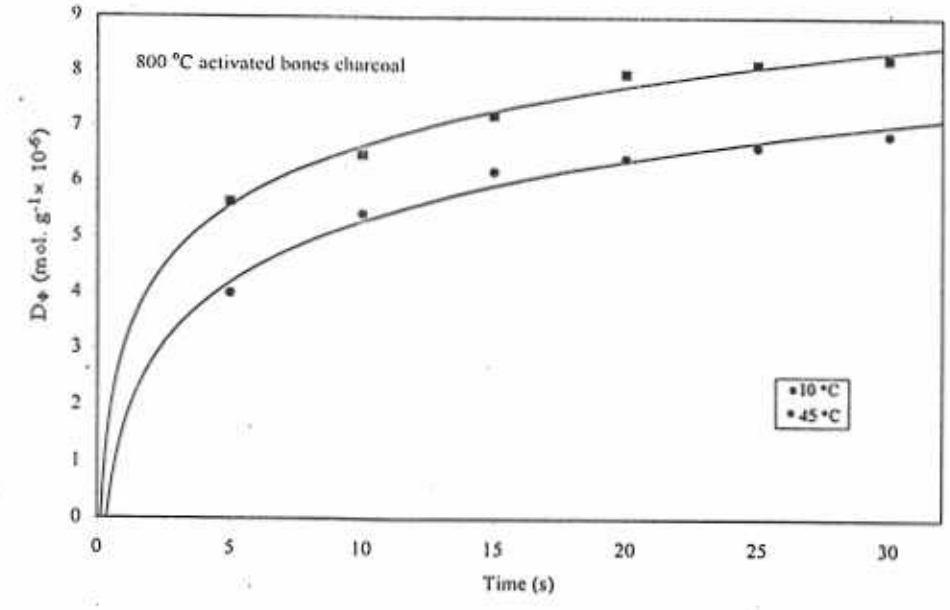
Table 4.32 Adsorption kinetics of acid yellow 34 on animal bones (ABC) charcoal samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH$_{St}$	Ab$_{St}$	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH$_{St}$	Ab$_{St}$	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
600 °C	05	8.76	1.200	8.5700	1.4300	1.4300	7.71	1.030	7.3500	2.6500	2.6500
	10	8.50	0.915	6.5300	3.4700	3.4700	8.13	0.788	5.6300	4.3700	4.3700
	15	8.30	0.841	6.0000	4.0000	4.0000	8.12	0.716	5.1100	4.8900	4.8900
	20	8.25	0.820	5.8500	4.1500	4.1500	8.20	0.690	4.9300	5.0700	5.0700
	25	8.20	0.810	5.7800	4.2200	4.2200	8.22	0.670	4.7800	5.2200	5.2200
	30	8.19	0.790	5.6400	4.3600	4.3600	8.24	0.660	4.7100	5.2900	5.2900
700 °C	05	8.00	0.903	6.4500	3.5500	3.5500	8.40	0.686	4.9000	5.1000	5.1000
	10	8.50	0.703	5.0200	4.9800	4.9800	8.53	0.504	3.6000	6.4000	6.4000
	15	8.61	0.606	4.3300	5.6700	5.6700	8.75	0.392	2.8000	7.2000	7.2000
	20	8.70	4.17	4.1700	5.8300	5.8300	8.81	0.300	2.1400	7.8600	7.8600
	25	8.77	3.93	3.9300	6.0700	6.0700	8.83	0.280	2.0000	8.0000	8.0000
	30	8.84	3.82	3.8200	6.1800	6.1800	8.85	0.263	1.8800	8.1200	8.1200
800 °C	05	8.80	0.841	6.000	4.000	4.0000	9.02	0.613	4.3700	5.6300	5.6300
	10	9.00	0.642	4.580	5.420	5.4200	9.30	0.491	3.5100	6.4900	6.4900
	15	9.11	0.534	3.810	6.190	6.1900	9.44	0.392	2.8000	7.2000	7.2000
	20	9.00	0.500	3.570	6.430	6.4300	9.49	0.285	2.0300	7.9700	7.9700
	25	8.90	0.471	3.360	6.640	6.6400	9.55	0.260	1.8500	8.1500	8.1500
	30	8.86	0.440	3.140	6.860	6.8600	9.59	0.245	1.7500	8.2500	8.2500
900 °C	05	9.36	0.668	4.770	5.230	5.2300	9.60	0.620	4.4300	5.5700	5.5700
	10	9.60	0.534	3.810	6.190	6.1900	9.65	0.430	3.0700	6.9300	6.9300
	15	9.72	0.452	3.220	6.780	6.7800	9.70	0.336	2.4000	7.6000	7.6000
	20	9.74	0.403	2.870	7.130	7.1300	9.77	0.251	1.7900	8.2100	8.2100
	25	9.76	0.381	2.720	7.280	7.2800	9.80	0.222	1.5800	8.4200	8.4200
	30	9.78	0.372	2.650	7.350	7.3500	9.82	0.200	1.4200	8.5800	8.5800
1000 °C	05	10.42	0.630	4.5000	5.5000	5.5000	10.10	0.598	4.2700	5.7300	5.7300
	10	10.61	0.454	3.2400	6.7600	6.7600	10.60	0.464	3.3100	6.6800	6.6800
	15	10.65	0.351	2.5100	7.4900	7.4900	10.61	0.376	2.6800	7.3100	7.3100
	20	10.71	0.321	2.2900	7.7100	7.7100	10.63	0.281	2.0100	7.9900	7.9900
	25	10.73	0.290	2.0700	7.9300	7.9300	10.65	0.200	1.4300	8.5700	8.5700
	30	10.81	0.270	1.9300	8.0700	8.0700	10.67	0.181	1.2900	8.7100	8.7100

♦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AY34 (D_o) = 10 × 10^{-5}mol.dm^{-3}, pH of D_o Before Adsorption = 6.10*


600 °C activated bones charcoal
D_Φ (mol. $g^{-1} \times 10^{-6}$)
Time (s)
•10 °C
•45 °C


700 °C activated bones charcoal
D_Φ (mol. $g^{-1} \times 10^{-6}$)
Time (s)
•10 °C
•45 °C


800 °C activated bones charcoal
D_Φ (mol. $g^{-1} \times 10^{-6}$)
Time (s)
•10 °C
•45 °C

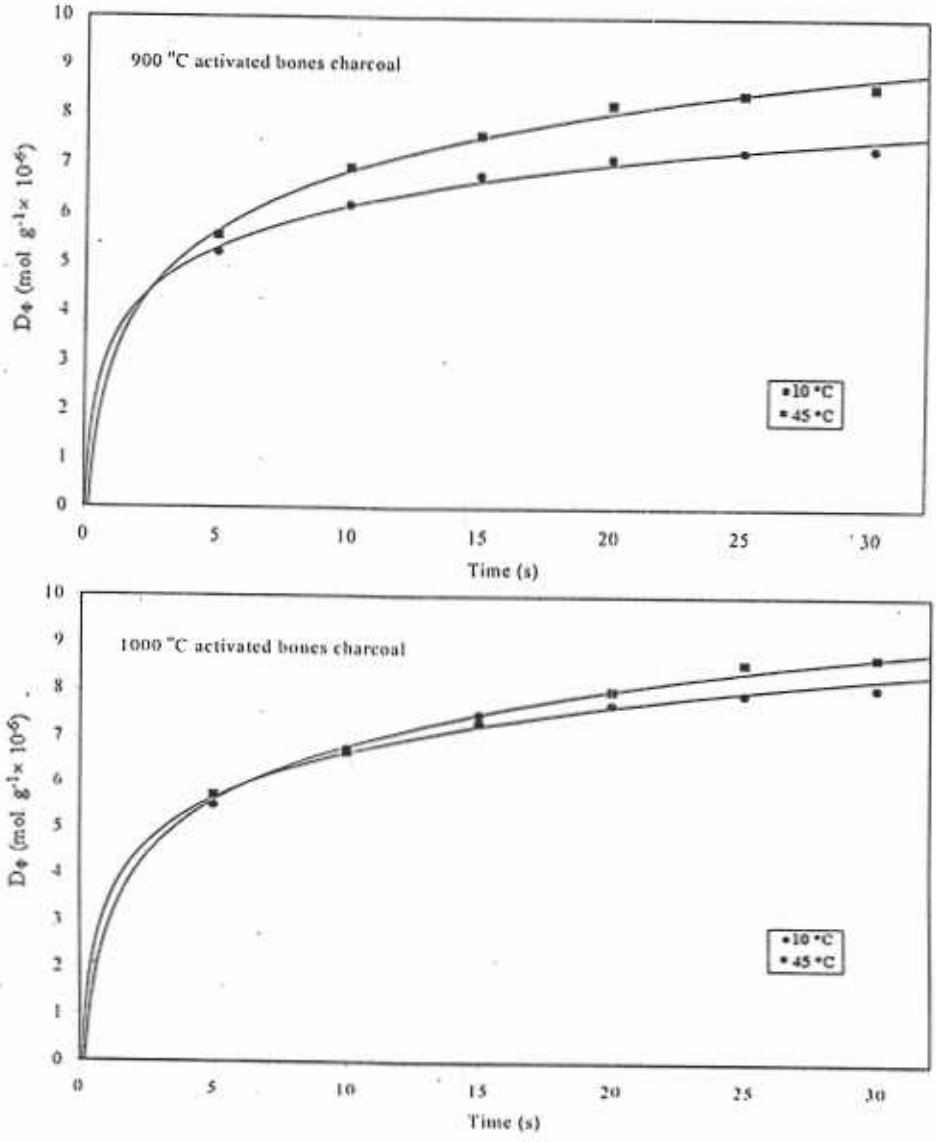
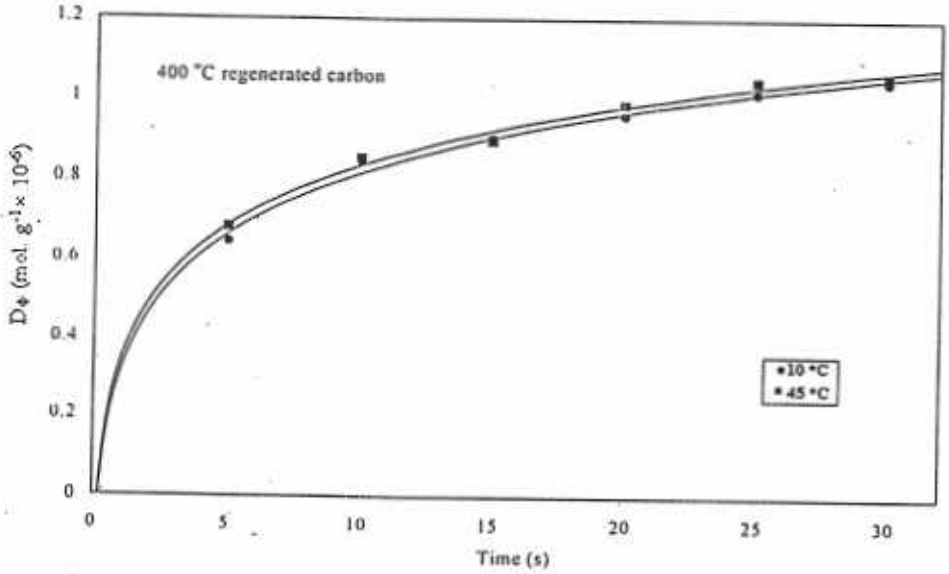


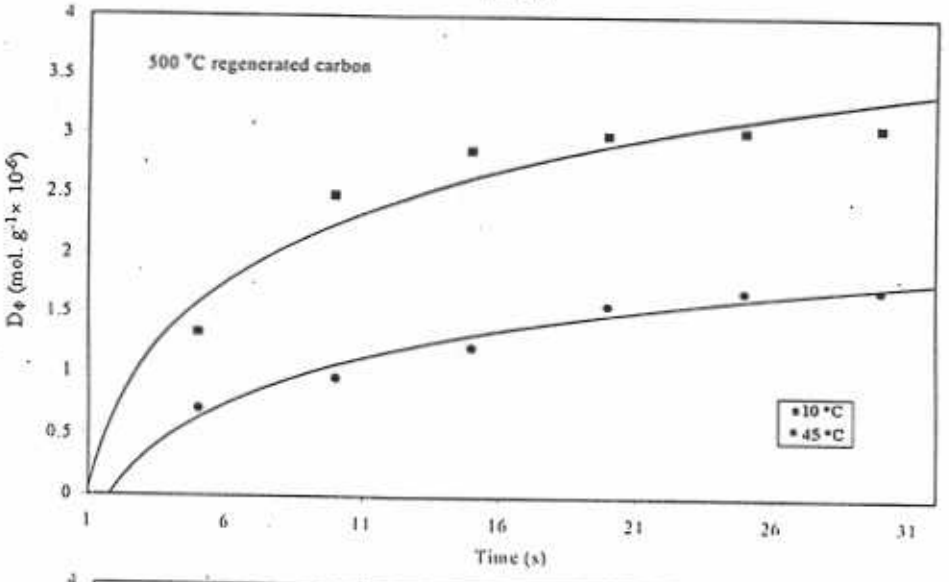
Figure 4.41 Adsorption kinetics of acid yellow 34 on animal bones charcoal (ABC) samples

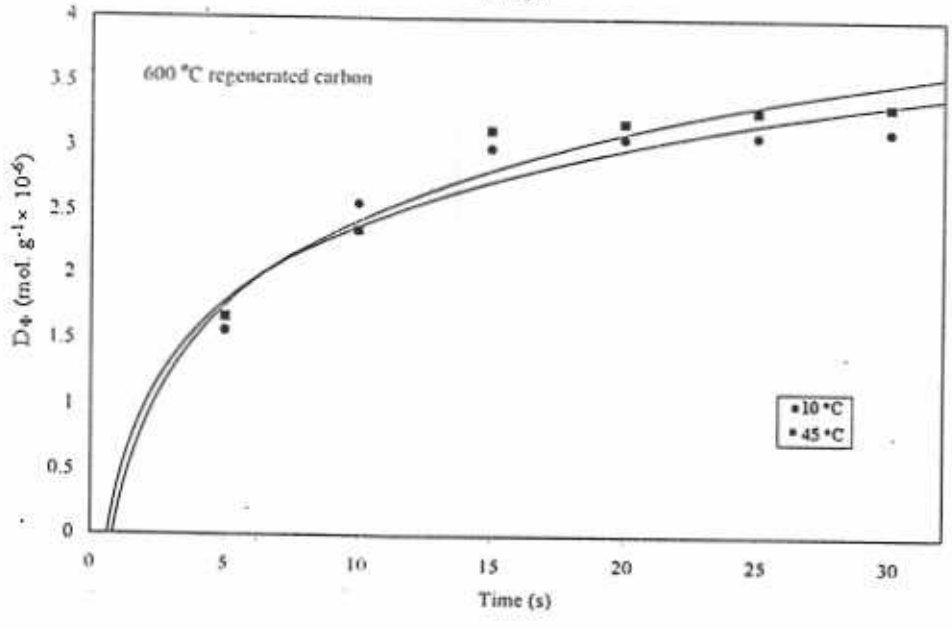
Table 4.33 Adsorption kinetics of acid yellow 34 on regenerated (RG) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
400 °C	05	6.93	1.030	7.3570	0.6430	0.6430	6.91	1.025	7.3214	0.6785	0.6785
	10	6.90	1.002	7.1570	0.8430	0.8430	6.86	1.001	7.1500	0.8500	0.8500
	15	6.88	0.994	7.1000	0.9000	0.9000	6.79	0.995	7.1071	0.8928	0.8928
	20	6.87	0.986	7.0430	0.9570	0.9570	9.78	0.982	7.0143	0.9857	0.9857
	25	6.86	0.978	6.9850	1.0140	1.0140	6.75	0.974	6.9571	1.0428	1.0428
	30	6.85	0.974	6.9570	1.0430	1.0430	6.74	0.972	6.9428	1.0571	1.0571
500 °C	05	6.88	1.020	7.2850	0.7140	0.7140	6.85	0.907	6.4700	1.3300	1.3300
	10	7.11	0.985	7.0350	0.9640	0.9640	6.98	0.771	5.5100	2.4900	2.4900
	15	7.12	0.950	6.7850	1.2140	1.2140	7.00	0.718	5.1300	2.8700	2.8700
	20	7.15	0.899	6.4210	1.5780	1.5780	7.02	0.700	5.0000	3.0000	3.0000
	25	7.19	0.882	6.3000	1.7000	1.7000	7.03	0.695	4.9640	3.0350	3.0350
	30	7.20	0.879	6.2780	1.7210	1.7210	7.04	0.690	4.9280	3.0710	3.0710
600 °C	05	7.11	0.900	6.4280	1.5710	1.5710	7.00	0.886	6.3280	1.6714	1.6714
	10	7.09	0.760	5.4280	2.5710	2.5710	6.96	0.789	5.6350	2.3643	2.3643
	15	7.07	0.700	5.0000	3.0000	3.0000	6.85	0.681	4.8640	3.1357	3.1357
	20	7.06	0.690	4.9280	3.0710	3.0710	6.84	0.673	4.8071	3.1930	3.1930
	25	7.04	0.687	4.9070	3.0930	3.0930	6.80	0.660	4.7143	3.2857	3.2857
	30	7.03	0.681	4.8640	3.1350	3.1350	6.79	0.654	4.6713	3.3285	3.3285
800 °C	05	7.60	0.700	5.0000	3.0000	3.0000	7.23	0.610	4.3570	3.6430	3.6430
	10	7.50	0.584	4.1710	3.8280	3.8280	7.40	0.499	3.5640	4.4350	4.4350
	15	7.48	0.502	3.5850	4.4140	4.4140	7.31	0.440	3.1430	4.8570	4.8570
	20	7.47	0.480	3.4280	4.5710	4.5710	7.30	0.420	3.0000	5.0000	5.0000
	25	7.45	0.471	3.3640	4.6350	4.6350	7.29	0.400	2.8570	5.1430	5.1430
	30	7.44	0.458	3.2710	4.7280	4.7280	7.28	0.392	2.8000	5.2000	5.2000
900 °C	05	7.15	0.530	3.7850	4.2140	4.2140	7.08	0.520	3.7140	4.2850	4.2850
	10	7.14	0.409	2.9210	5.0780	5.0780	7.06	0.399	2.8500	5.1500	5.1500
	15	7.11	0.330	2.3570	5.6420	5.6420	7.05	0.300	2.1430	5.8570	5.8570
	20	7.05	0.310	2.2140	5.7850	5.7850	7.03	0.273	1.9500	6.0500	6.0500
	25	7.00	0.302	2.1570	5.8420	5.8420	7.01	0.252	1.8000	6.2000	6.2000
	30	6.99	0.289	2.1280	5.8710	5.8710	7.00	0.239	1.7070	6.2930	6.2930
1000 °C	05	7.45	0.950	6.780	1.220	1.2200	6.96	0.870	6.2140	1.7850	1.7850
	10	7.40	0.805	5.750	2.250	2.2500	7.19	0.765	5.4640	2.5350	2.5350
	15	7.38	0.768	5.480	2.520	2.5200	7.18	0.680	4.8570	3.1430	3.1430
	20	7.37	0.711	5.070	2.930	2.9300	7.17	0.620	4.4300	3.5710	3.5710
	25	7.35	0.700	5.000	3.000	3.0000	7.16	0.602	4.3000	3.7000	3.7000
	30	7.34	0.688	4.914	3.085	3.0850	7.14	0.584	4.1700	3.8200	3.8200

♦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 μm, Initial Concentration of AY34 (D_o) = 8 × 10^{-3}mol.dm^3, pH of D_o Before Adsorption = 6.20*


400 °C regenerated carbon
Dϕ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


500 °C regenerated carbon
Dϕ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


600 °C regenerated carbon
Dϕ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C

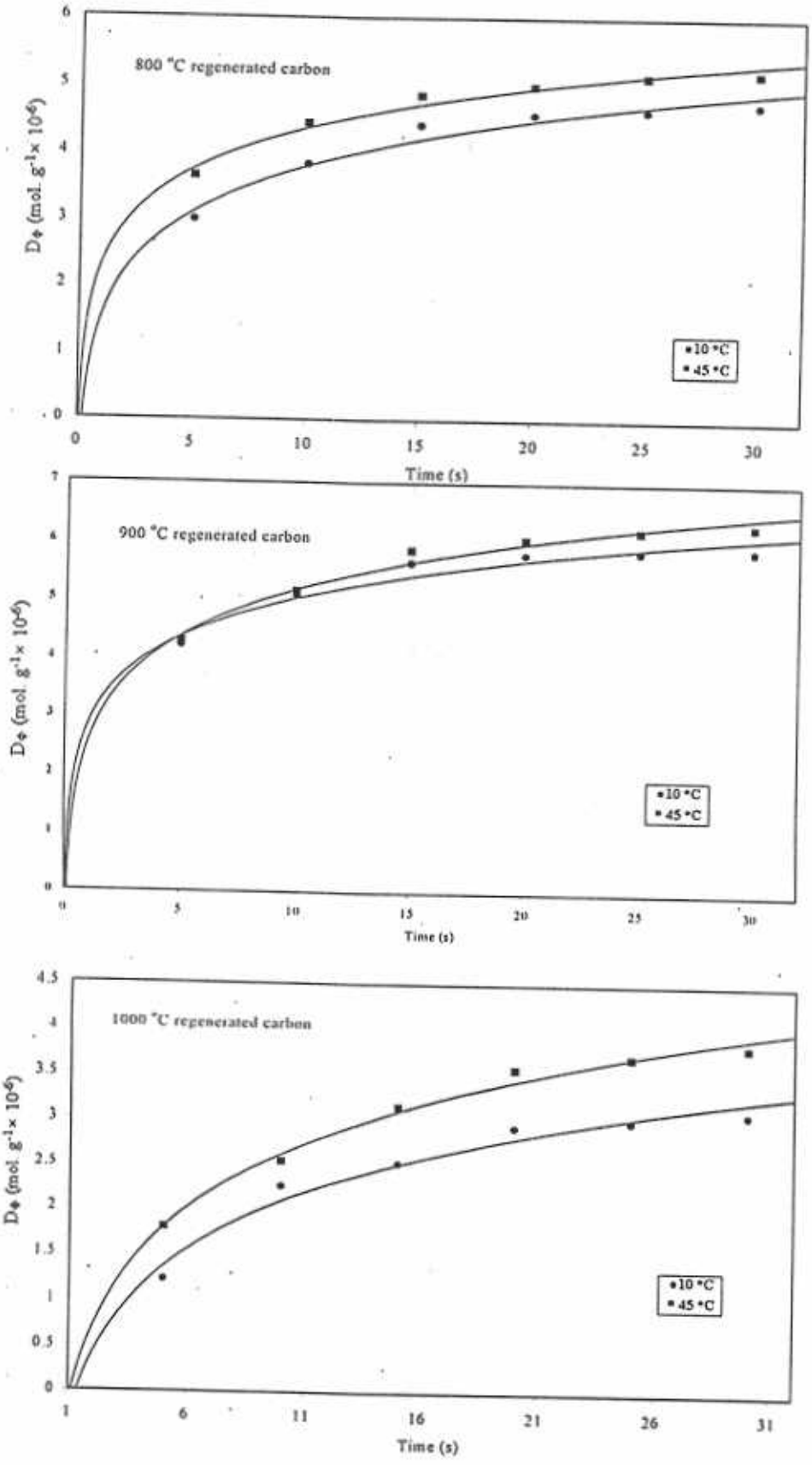


Figure 4.42 Adsorption kinetics of acid yellow 34 on regenerated (RG) carbon samples

Table 4.34 Adsorption kinetics of acid orange 7 on *Paulownia tomentosa* (PT) carbon

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	8.08	0.420	2.650	0.350	0.350	7.50	0.402	2.530	0.470	0.470
	10	7.43	0.400	2.520	0.480	0.480	7.26	0.390	2.460	0.540	0.540
	15	7.29	0.395	2.490	0.510	0.510	7.23	0.380	2.390	0.610	0.610
	20	7.20	0.390	2.460	0.540	0.540	7.20	0.370	2.330	0.670	0.670
	25	7.15	0.384	2.420	0.580	0.580	7.18	0.365	2.300	0.700	0.700
	30	7.10	0.382	2.400	0.600	0.600	7.17	0.360	2.270	0.730	0.730
400 °C	05	7.30	0.376	2.37	0.630	0.630	7.14	0.356	2.24	0.760	0.760
	10	7.23	0.350	2.20	0.800	0.800	7.34	0.333	2.10	0.900	0.900
	15	7.30	0.330	2.08	0.920	0.920	7.50	0.320	2.01	0.990	0.990
	20	7.35	0.325	2.05	0.950	0.950	7.60	0.310	1.95	1.050	1.050
	25	7.38	0.320	2.01	0.990	0.990	7.65	0.305	1.92	1.080	1.080
	30	7.44	0.315	1.98	1.020	1.020	7.70	0.301	1.89	1.110	1.110
800 °C	05	9.16	0.261	1.640	1.360	1.360	9.28	0.205	1.292	1.707	1.707
	10	9.54	0.220	1.380	1.620	1.620	9.31	0.138	0.870	2.130	2.130
	15	9.65	0.200	1.260	1.740	1.740	9.34	0.130	0.820	2.180	2.180
	20	9.70	0.190	1.190	1.810	1.810	9.36	0.123	0.770	2.230	2.230
	25	9.73	0.185	1.160	1.840	1.840	9.40	0.120	0.750	2.250	2.250
	30	9.74	0.180	1.130	1.870	1.870	9.43	0.114	0.720	2.280	2.280

♦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size = 150-180 µm, Initial Concentration of AO-7 (D_o) = 3 × 10^{-3}mol.dm^{-3}, pH of D_o Before Adsorption = 8.10*

Table 4.35Adsorption kinetics of acid orange 7 on *Populus caspica* (PC) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	7.95	0.450	2.830	0.170	0.170	7.91	0.410	2.58	0.420	0.420
	10	7.70	0.420	2.650	0.350	0.350	7.75	0.380	2.39	0.610	0.610
	15	7.50	0.400	2.520	0.480	0.480	7.72	0.371	2.33	0.670	0.670
	20	7.45	0.390	2.460	0.540	0.540	7.70	0.360	2.27	0.730	0.730
	25	7.40	0.385	2.420	0.580	0.580	7.68	0.354	2.23	0.770	0.770
	30	7.38	0.380	2.390	0.610	0.610	7.67	0.350	2.20	0.800	0.800
400 °C	05	9.42	0.390	2.46	0.540	0.540	9.51	0.370	2.33	0.670	0.670
	10	9.66	0.381	2.40	0.600	0.600	9.61	0.351	2.21	0.790	0.790
	15	9.68	0.370	2.33	0.670	0.670	9.65	0.332	2.09	0.910	0.910
	20	9.70	0.360	2.27	0.730	0.730	9.70	0.324	2.04	0.960	0.960
	25	9.72	0.356	2.24	0.760	0.760	9.72	0.317	1.99	1.010	1.010
	30	9.74	0.350	2.20	0.800	0.800	9.73	0.307	1.93	1.070	1.070
800 °C	05	10.09	0.350	2.200	0.800	0.800	10.07	0.321	2.020	0.980	0.980
	10	10.14	0.330	2.080	0.920	0.920	10.09	0.310	1.950	1.050	1.050
	15	10.15	0.320	2.010	0.990	0.990	10.10	0.300	1.890	1.110	1.110
	20	10.17	0.310	1.950	1.050	1.050	10.11	0.292	1.840	1.160	1.160
	25	10.18	0.306	1.920	1.080	1.080	10.12	0.284	1.790	1.210	1.210
	30	10.19	0.300	1.860	1.140	1.140	10.13	0.277	1.740	1.260	1.260

♦ *Initial Concentration of AB1(D_o) = 2 × 10^{-3}mol.dm^{-3}, Adsorbent doze = 0.2 g, Adsorbate volume=20 Cm^3, Particle size=150-180 µm, , pH of D_o before adsorption = 7.00*

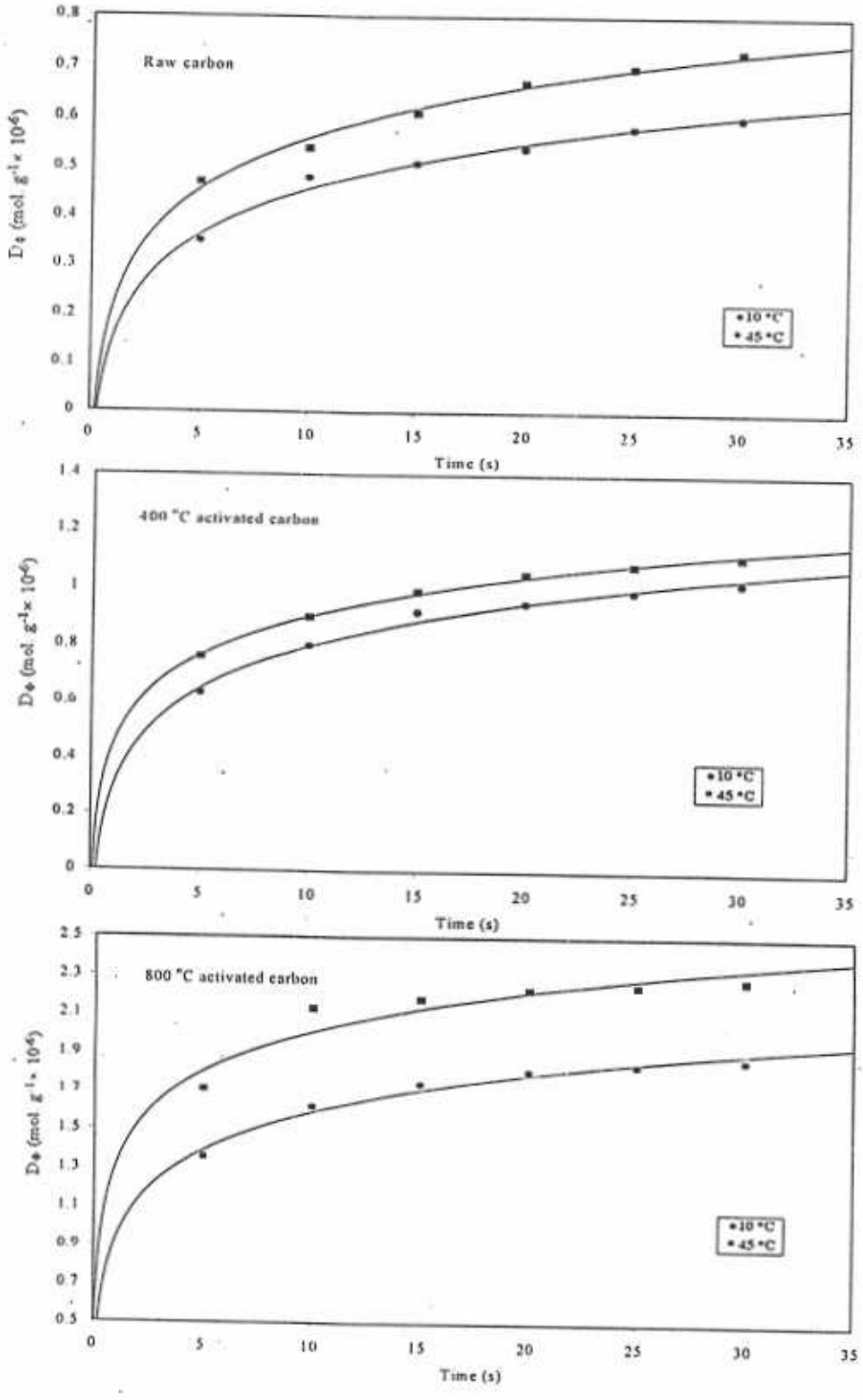


Figure 4.43 Adsorption kinetics of acid orange 7 on *Paulownia tomentosa* (PT) carbon samples

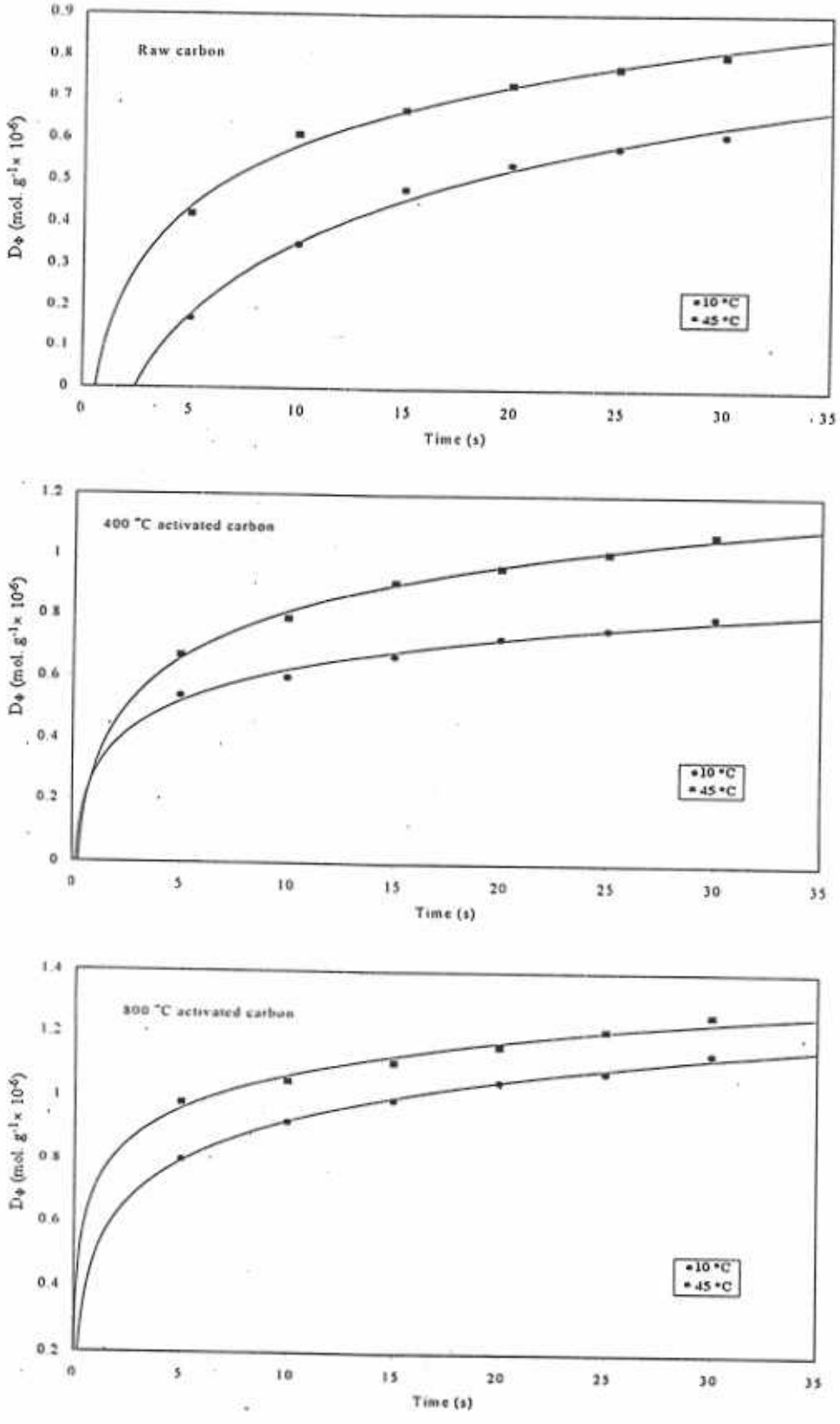


Figure 4.44 Adsorption kinetics of acid orange 7 on *Populus caspica* (PC) carbon samples

Table 4.36 Adsorption kinetics of acid orange 7 on corncobs (CC) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})
Raw	05	8.72	0.460	2.90	0.100	0.100	8.93	0.420	2.650	0.350	0.350
	10	8.20	0.435	2.74	0.260	0.260	8.16	0.400	2.520	0.480	0.480
	15	7.90	0.410	2.58	0.420	0.420	8.06	0.390	2.460	0.540	0.540
	20	7.80	0.405	2.55	0.450	0.450	8.00	0.381	2.390	0.610	0.610
	25	7.70	0.400	2.52	0.480	0.480	7.99	0.370	2.330	0.670	0.670
	30	7.60	0.397	2.50	0.500	0.500	7.98	0.362	2.280	0.720	0.720
400 °C	05	9.70	0.360	2.270	0.730	0.730	9.70	0.348	2.190	0.810	0.810
	10	9.83	0.340	2.140	0.860	0.860	9.72	0.334	2.100	0.900	0.900
	15	9.85	0.330	2.080	0.920	0.920	9.74	0.321	2.020	0.980	0.980
	20	9.88	0.325	2.050	0.950	0.950	9.76	0.311	1.960	1.040	1.040
	25	9.90	0.320	2.010	0.990	0.990	9.77	0.33	1.890	1.110	1.110
	30	9.92	0.310	1.950	1.050	1.050	9.79	0.290	1.820	1.180	1.180
800 °C	05	10.00	0.260	1.640	1.360	1.360	9.930	0.248	1.5637	1.4364	1.4364
	10	10.01	0.251	1.570	1.430	1.430	9.950	0.220	1.3872	1.6129	1.6129
	15	10.03	0.40	1.510	1.490	1.490	9.980	0.200	1.2620	1.7389	1.7389
	20	10.04	0.235	1.480	1.520	1.520	10.00	0.180	1.1349	1.8650	1.8650
	25	10.05	0.230	1.450	1.550	1.550	10.03	0.160	1.0089	1.9920	1.9920
	30	10.06	0.223	1.410	1.590	1.590	10.04	0.143	0.9017	2.0984	2.0984

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size = 150-180 µm, Initial Concentration of AO-7 (D_o) = 3 × 10^{-3}mol.dm^3, pH of D_o Before Adsorption = 8.10*

Table 4.37 Adsorption kinetics of acid orange 7 on *Ailanthus altissima* (AA) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})
Raw	05	9.02	0.471	2.970	0.030	0.030	8.91	0.450	2.850	0.150	0.150
	10	8.70	0.447	2.810	0.190	0.190	8.36	0.435	2.740	0.260	0.260
	15	8.65	0.433	2.730	0.270	0.270	8.31	0.421	2.650	0.350	0.350
	20	8.64	0.423	2.660	0.340	0.340	8.30	0.410	2.580	0.420	0.420
	25	8.63	0.415	2.610	0.390	0.390	8.28	0.402	2.530	0.470	0.470
	30	8.62	0.411	2.580	0.420	0.420	8.26	0.400	2.520	0.480	0.480
400 °C	05	9.51	0.390	2.460	0.540	0.540	9.48	0.370	2.330	0.670	0.670
	10	9.57	0.380	2.390	0.610	0.610	9.50	0.358	2.250	0.750	0.750
	15	9.60	0.371	2.330	0.670	0.670	9.58	0.350	2.200	0.800	0.800
	20	9.63	0.360	2.260	0.740	0.740	9.60	0.344	2.170	0.830	0.830
	25	9.65	0.352	2.220	0.780	0.780	9.62	0.339	2.130	0.870	0.870
	30	9.69	0.346	2.180	0.820	0.820	9.64	0.334	2.100	0.900	0.900
800 °C	05	10.01	0.330	2.080	0.920	0.920	10.07	0.320	2.010	0.990	0.990
	10	10.12	0.320	2.01	0.990	0.990	10.09	0.301	1.900	1.100	1.100
	15	10.14	0.310	1.950	1.050	1.050	10.10	0.295	1.860	1.140	1.140
	20	10.15	0.300	1.890	1.110	1.110	10.11	0.291	1.830	1.170	1.170
	25	10.16	0.290	1.820	1.180	1.180	10.12	0.285	1.790	1.210	1.210
	30	10.18	0.285	1.790	1.210	1.210	10.14	0.281	1.770	1.230	1.230

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size = 150-180 µm, Initial Concentration of AO-7 (D_o) = 3 × 10^{-3}mol.dm^3, pH of D_o Before Adsorption = 8.10*

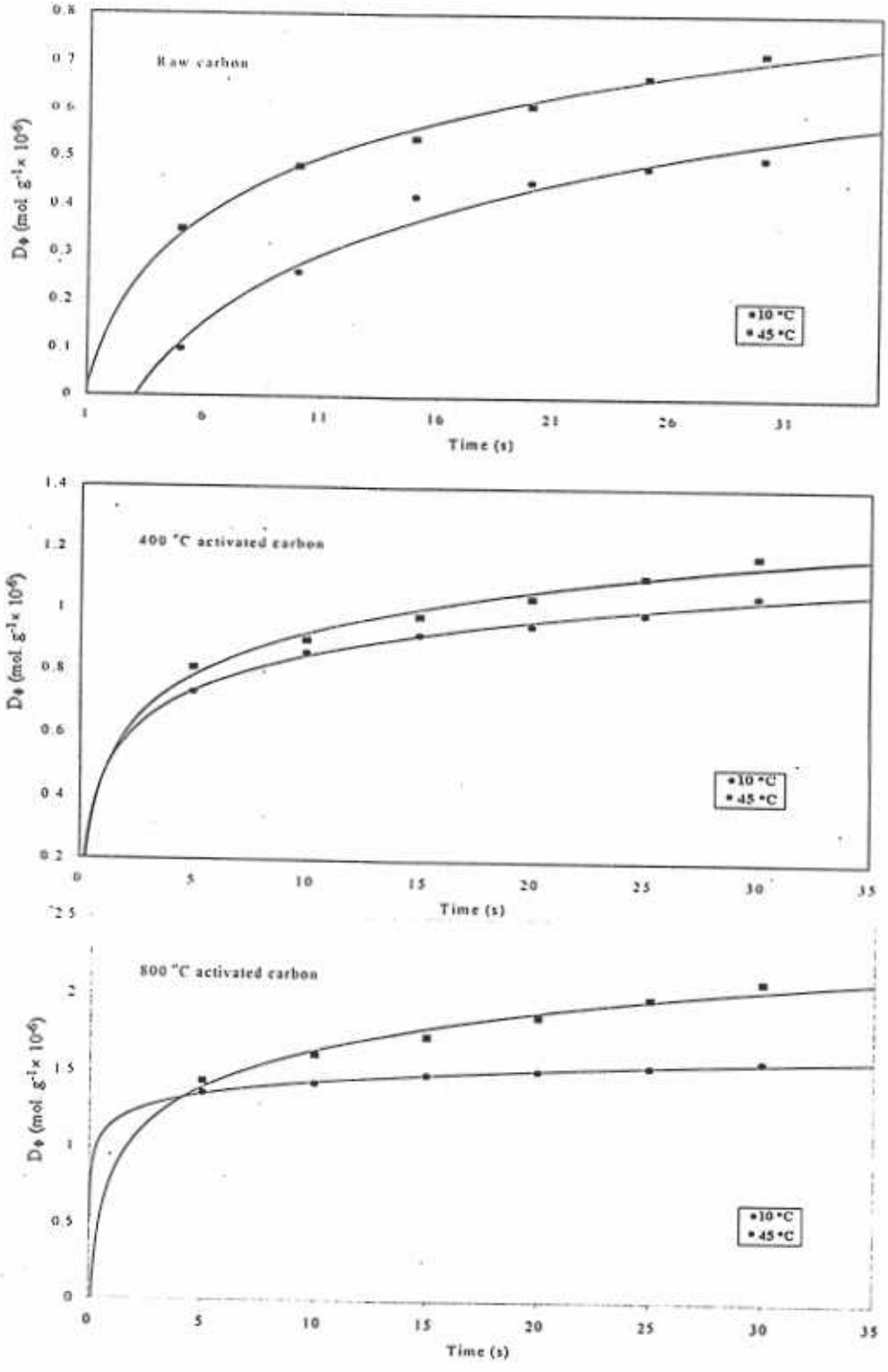


Figure 4.45 Adsorption kinetics of acid orange 7 on *Corncobs* (CC) carbon samples

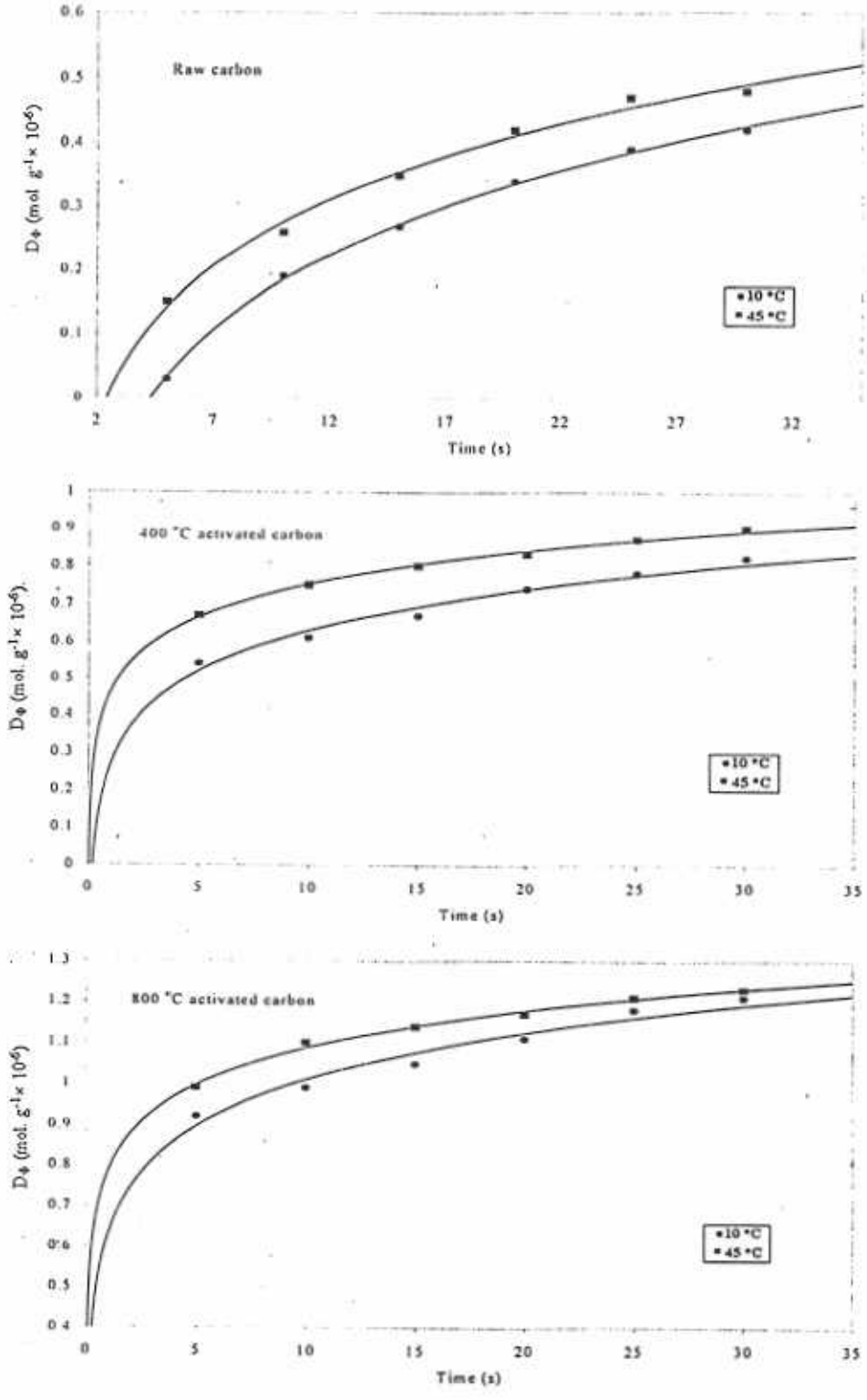
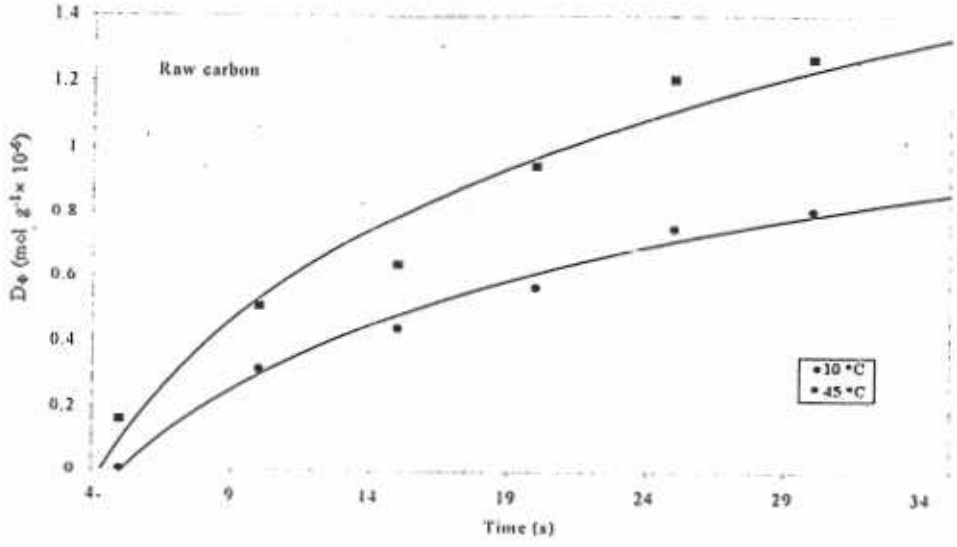


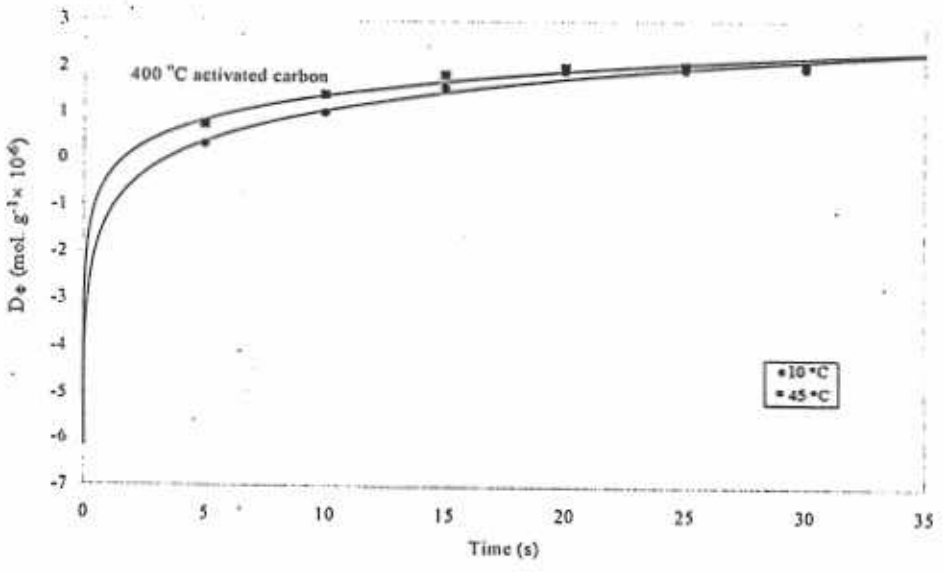
Figure 4.46 Adsorption kinetics of acid orange 7 on *Ailanthus altissima* (AA) carbon samples

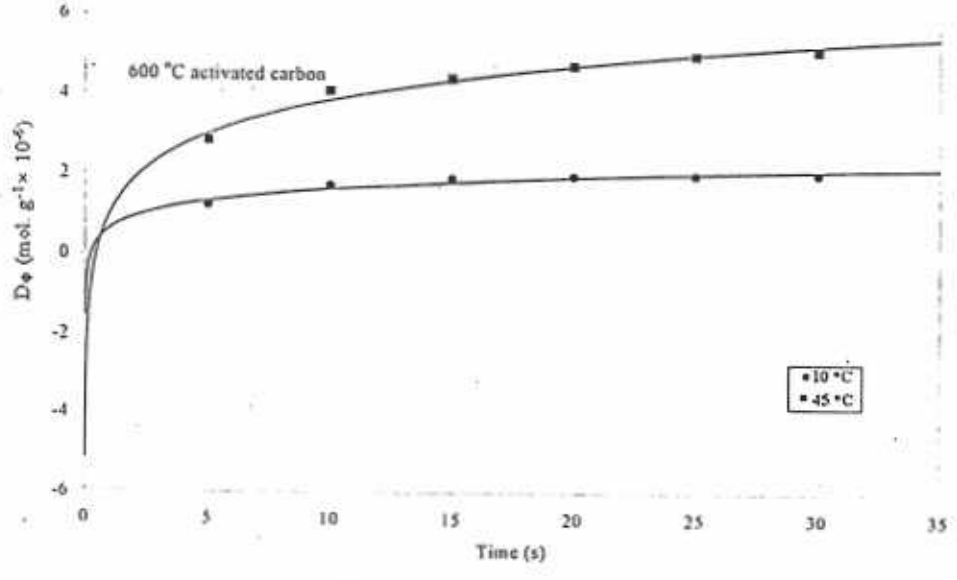
Table 4.38 Adsorption kinetics of acid orange 7 on *Salvadora oleoides* (SO) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_a (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_a (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	8.48	1.300	8.1967	0.0032	0.0032	7.64	1.275	8.0400	0.1600	0.1600
	10	8.61	1.250	7.8814	0.3185	0.3185	8.44	1.220	7.6900	0.5100	0.5100
	15	8.65	1.230	7.7553	0.4446	0.4446	8.62	1.200	7.5600	0.6400	0.6400
	20	8.67	1.210	7.6292	0.5707	0.5707	8.64	1.150	7.2500	0.9500	0.9500
	25	8.70	1.181	7.4464	0.7539	0.7539	8.70	1.110	6.9900	1.2100	1.2100
	30	8.71	1.172	7.3896	0.8103	0.8103	8.75	1.100	6.9300	1.2700	1.2700
400 °C	05	6.78	1.250	7.88	0.320	0.320	7.16	1.000	6.300	1.900	1.900
	10	6.80	1.140	7.18	1.020	1.020	7.28	0.990	6.240	1.960	1.960
	15	6.84	1.050	6.62	1.580	1.580	7.24	0.985	6.210	1.990	1.990
	20	6.86	0.995	6.27	1.930	1.930	7.26	0.980	6.180	2.020	2.020
	25	6.90	0.990	6.24	1.960	1.960	7.28	0.975	6.140	2.060	2.060
	30	6.92	0.985	6.21	1.990	1.990	7.32	0.971	6.110	2.090	2.090
600 °C	05	7.86	1.105	6.96	1.240	1.240	8.18	0.850	5.36	2.840	2.840
	10	8.21	1.025	6.46	1.740	1.740	8.45	0.650	4.10	4.100	4.100
	15	8.40	0.996	6.28	1.920	1.920	8.47	0.600	3.78	4.420	4.420
	20	8.45	0.987	6.22	1.980	1.980	8.49	0.550	3.46	4.740	4.740
	25	8.50	0.983	6.19	2.01	2.01	8.52	0.510	3.21	4.990	4.990
	30	8.65	0.977	6.16	2.04	2.04	8.53	0.490	3.09	5.110	5.110
800 °C	05	9.780	0.910	5.730	2.470	2.470	9.880	0.645	4.066	4.130	4.130
	10	9.960	0.774	4.880	3.320	3.320	10.02	0.510	3.210	4.990	4.990
	15	9.990	0.750	4.730	3.470	3.470	10.15	0.460	2.900	5.300	5.300
	20	10.00	0.742	4.680	3.520	3.520	10.20	0.410	2.580	5.620	5.620
	25	10.05	0.732	4.610	3.590	3.590	10.25	0.390	2.460	5.740	5.740
	30	10.10	0.732	4.610	3.590	3.590	10.27	0.370	2.330	5.870	5.870
900 °C	05	9.800	0.772	4.860	3.340	3.340	9.520	0.600	3.783	4.416	4.416
	10	9.850	0.640	4.030	4.170	4.170	10.00	0.450	2.840	5.360	5.360
	15	9.930	0.575	3.620	4.580	4.580	10.21	0.400	2.520	5.680	5.680
	20	10.00	0.561	3.540	4.660	4.660	10.30	0.380	2.390	5.810	5.810
	25	10.05	0.552	3.480	4.720	4.720	10.35	0.370	2.330	5.870	5.870
	30	10.10	0.542	3.410	4.790	4.790	10.40	0.362	2.280	5.920	5.920
1000 °C	05	9.900	0.752	4.730	3.470	3.470	9.76	0.450	2.840	5.360	5.360
	10	9.980	0.600	3.780	4.420	4.420	9.84	0.300	1.890	6.310	6.310
	15	10.00	0.550	3.460	4.740	4.740	9.95	0.270	1.700	6.500	6.500
	20	10.10	0.541	3.410	4.790	4.790	9.99	0.251	1.570	6.630	6.630
	25	10.15	0.531	3.350	4.850	4.850	10.03	0.240	1.510	6.690	6.690
	30	10.20	0.520	3.270	4.930	4.930	10.04	0.230	1.450	6.750	6.750

Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^{-3}, Particle Size= 150-180 µm, Initial Concentration of AO-7 (D_o) = 8.2 × 10^{-5}mol.dm^{-3}, pH of D_o Before Adsorption = 6.09


Raw carbon
D_ϕ (mol $g^{-1}\times 10^{-6}$)
Time (s)
•10 °C
▪45 °C


400 °C activated carbon
D_ϕ (mol $g^{-1}\times 10^{-6}$)
Time (s)
•10 °C
▪45 °C


600 °C activated carbon
D_ϕ (mol $g^{-1}\times 10^{-6}$)
Time (s)
•10 °C
▪45 °C

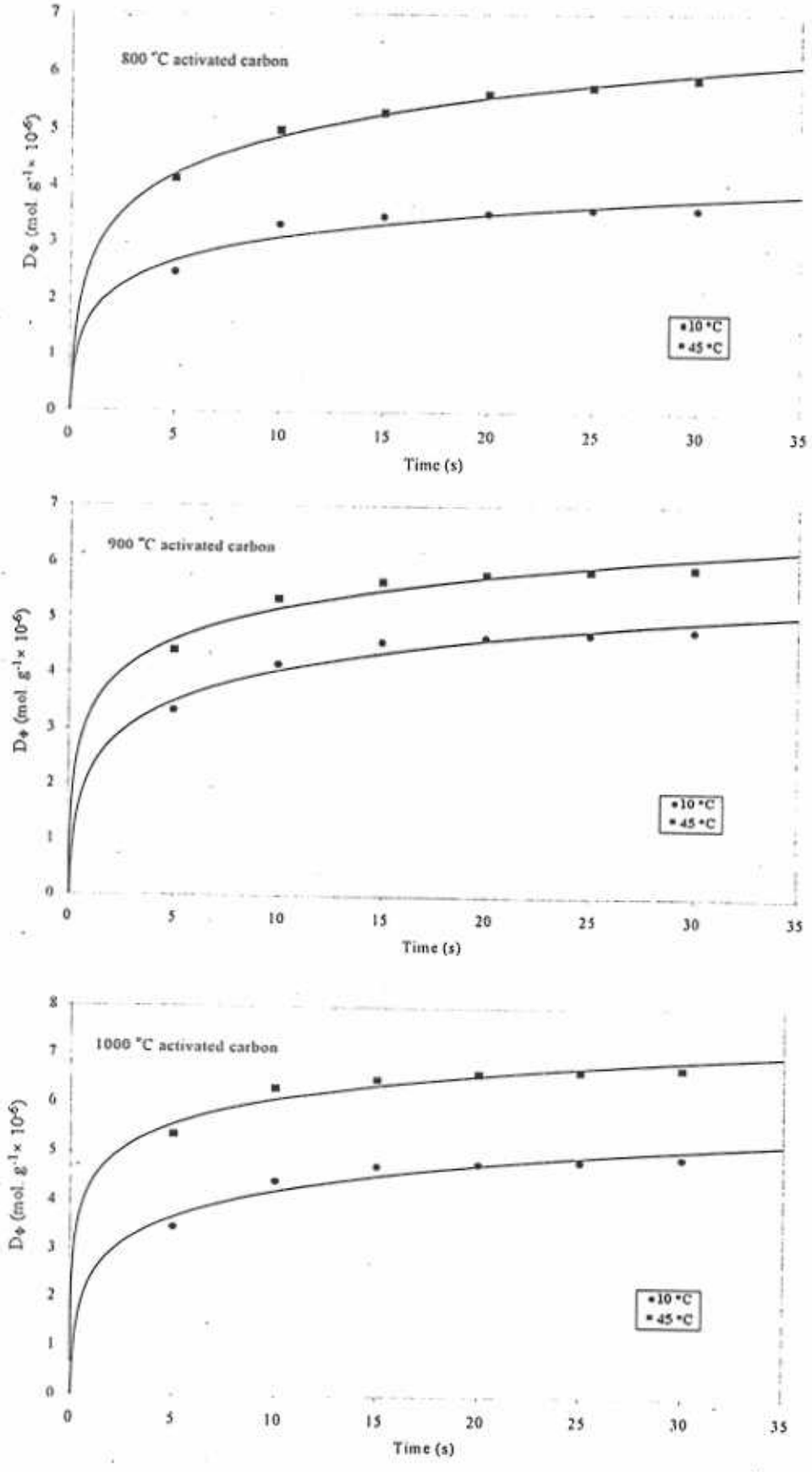
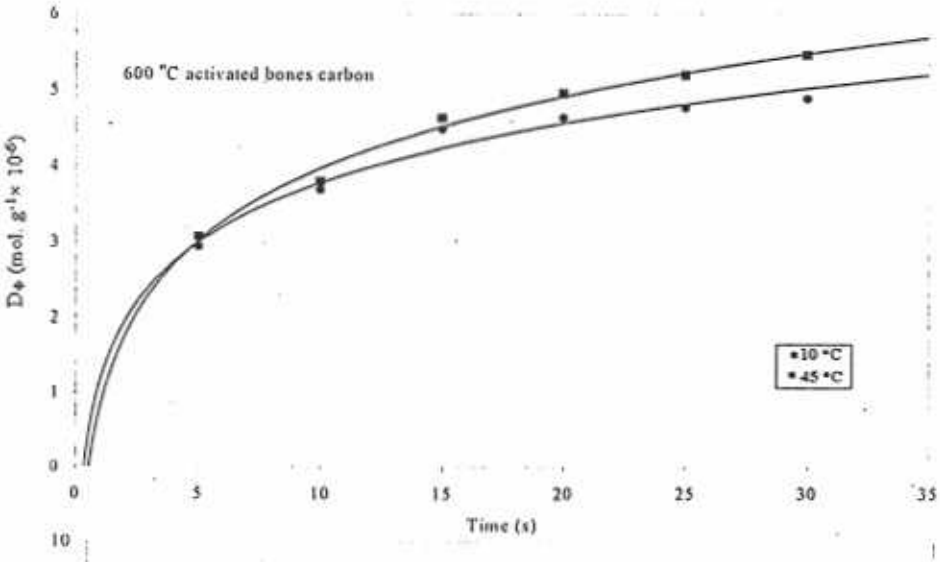


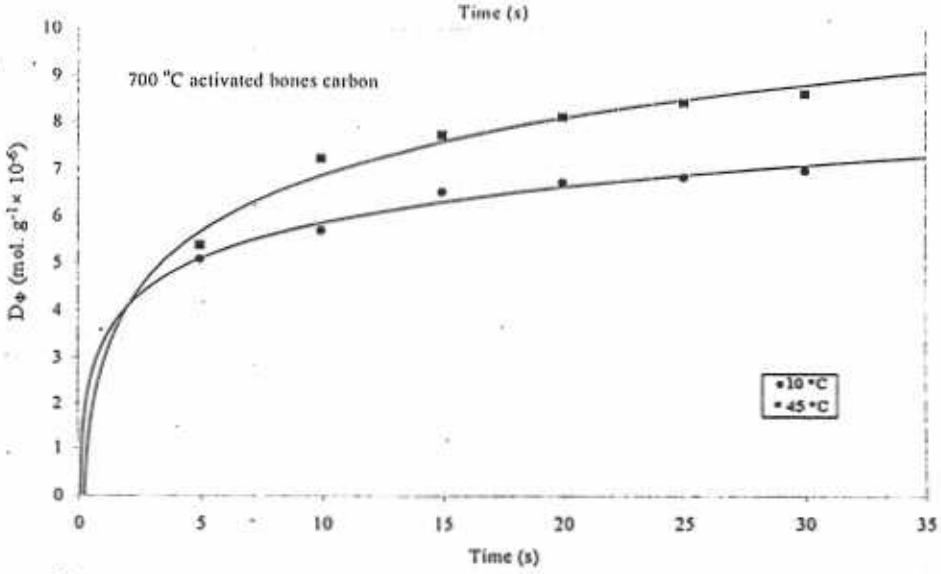
Figure 4.47 Adsorption kinetics of acid orange 7 on *Salvadora oleoides* (SO) carbon samples

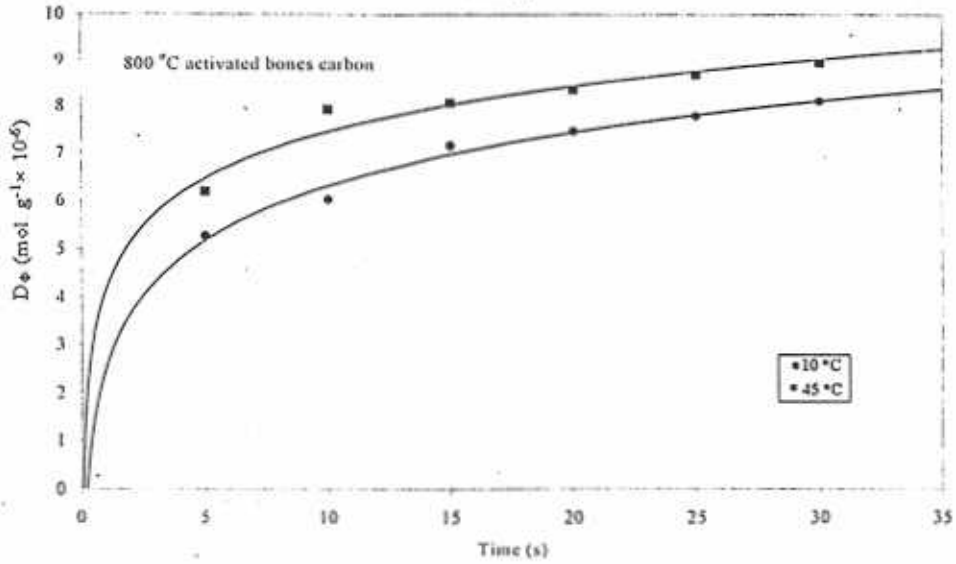
Table 4.39 Adsorption kinetics of acid orange 7 on animal bones charcoal (ABC) samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10
600 °C	05	7.18	1.120	7.060	2.940	2.940	8.81	1.100	6.930	3.070	3.070
	10	7.36	1.000	6.310	3.690	3.690	8.44	0.984	6.200	3.800	3.800
	15	7.51	0.875	5.510	4.490	4.490	8.25	0.850	5.360	4.640	4.640
	20	7.55	0.851	5.360	4.640	4.640	8.22	0.800	5.040	4.960	4.960
	25	7.61	0.830	5.230	4.770	4.770	8.20	0.761	4.800	5.200	5.200
	30	7.65	0.810	5.110	4.890	4.890	8.19	0.72	4.540	5.460	5.460
700 °C	05	7.38	0.781	4.920	5.080	5.080	8.13	0.733	4.622	5.378	5.378
	10	7.51	0.682	4.300	5.700	5.700	8.21	0.438	2.760	7.240	7.240
	15	7.62	0.551	3.470	6.530	6.530	8.30	0.361	2.270	7.730	7.730
	20	7.68	0.520	3.270	6.730	6.730	8.31	0.300	1.890	8.110	8.110
	25	7.70	0.503	3.170	6.830	6.830	8.33	0.251	1.580	8.420	8.420
	30	7.70	0.481	3.030	6.970	6.970	8.36	0.221	1.390	8.610	8.610
800 °C	05	8.55	0.750	4.730	5.270	5.270	8.94	0.605	3.810	6.190	6.190
	10	8.92	0.630	3.970	6.030	6.030	8.99	0.331	2.080	7.920	7.920
	15	9.01	0.451	2.840	7.160	7.160	9.01	0.306	1.930	8.070	8.070
	20	9.04	0.402	2.530	7.470	7.470	9.05	0.261	1.640	8.360	8.360
	25	9.08	0.351	2.210	7.790	7.790	9.06	0.210	1.320	8.680	8.680
	30	9.10	0.300	1.890	8.110	8.110	9.10	0.171	1.070	8.930	8.930
900 °C	05	9.35	0.651	4.105	4.095	4.095	9.50	0.502	3.165	6.835	6.835
	10	9.44	0.486	3.060	6.940	6.940	9.51	0.280	1.760	8.240	8.240
	15	9.47	0.271	1.710	8.290	8.290	9.56	0.134	0.848	9.150	9.150
	20	9.49	0.251	1.580	8.420	8.420	9.60	0.100	0.630	9.370	9.370
	25	9.51	0.230	1.450	8.550	8.550	9.62	0.081	0.511	9.500	9.500
	30	9.53	0.221	1.390	8.610	8.610	9.63	0.061	0.384	9.620	9.620
1000 °C	05	10.00	0.580	3.657	6.343	6.343	10.03	0.438	2.760	7.240	7.240
	10	1.100	0.388	2.440	7.560	7.560	10.06	0.244	1.540	8.460	8.460
	15	10.13	0.251	1.580	8.420	8.420	10.09	0.120	0.750	9.250	9.250
	20	10.14	0.221	1.390	8.610	8.610	10.10	0.090	0.560	9.440	9.440
	25	10.17	0.200	1.260	8.740	8.740	10.12	0.070	0.4410	9.560	9.560
	30	10.20	0.181	1.140	8.860	8.860	10.16	0.052	0.350	9.650	9.650

Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 μm, Initial Concentration of AO-7 (D_o) =10 × 10^{-5}mol.dm^{-3}, pH of D_o Before Adsorption = 6.00


600 °C activated bones carbon
Dϕ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


700 °C activated bones carbon
Dϕ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


800 °C activated bones carbon
Dϕ (mol g-1× 10-6)
Time (s)
•10 °C
▪45 °C

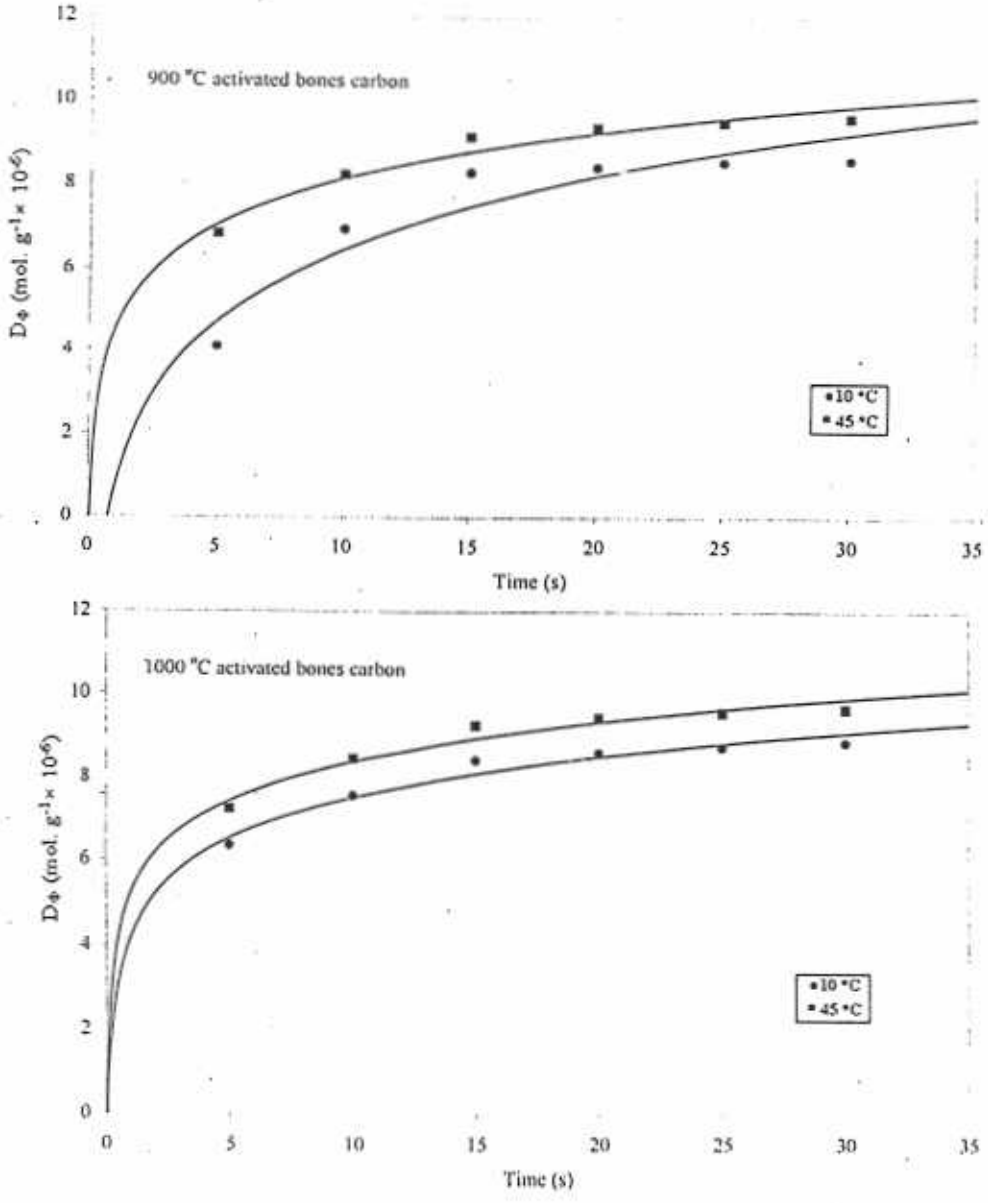
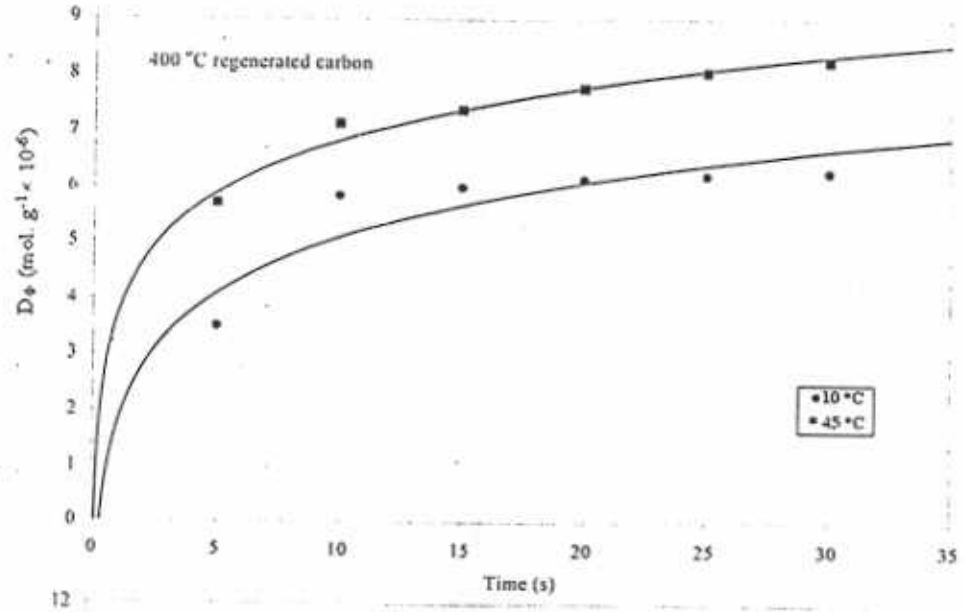


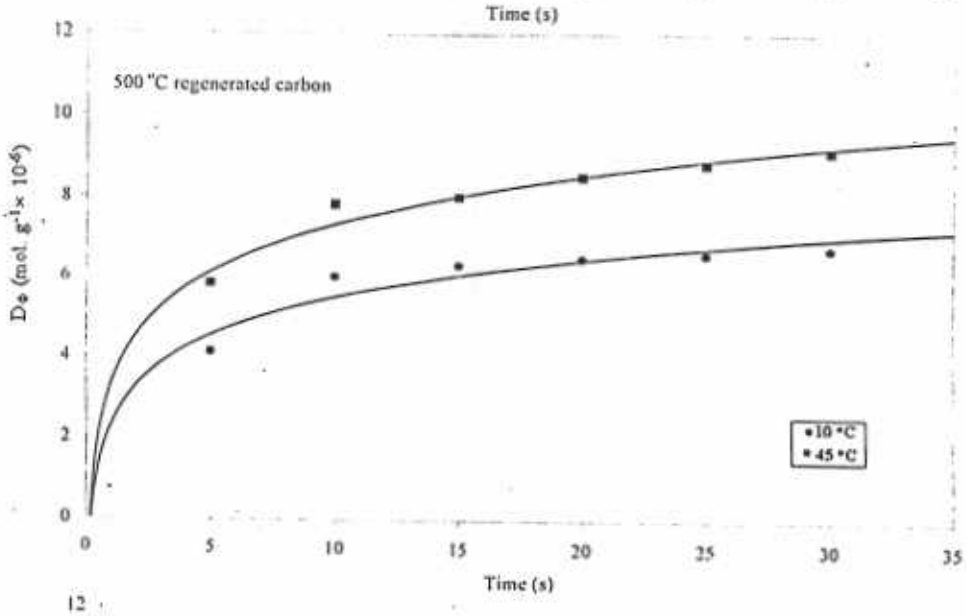
Figure 4.48 Adsorption kinetics of acid orange 7 on animal bones charcoal (ABC) samples

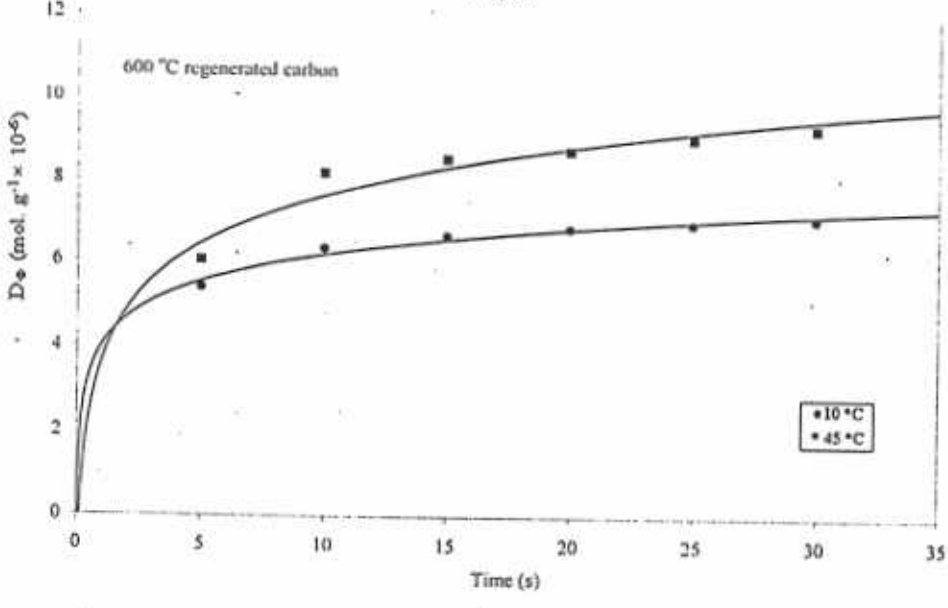
Table 4.40 Adsorption kinetics of acid orange 7 on regenerated (RG) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Abs_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Abs_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
400 °C	05	6.71	2.30	14.50	3.498	3.498	6.65	1.950	12.29	5.700	5.700
	10	6.67	1.930	12.16	5.84	5.84	6.69	1.725	10.870	7.130	7.130
	15	6.65	1.904	12.00	6.00	6.00	6.65	1.685	10.620	7.380	7.380
	20	6.64	1.881	11.86	6.14	6.14	6.64	1.625	10.240	7.760	7.760
	25	6.63	1.870	11.79	6.21	6.21	6.63	1.580	9.960	8.040	8.040
	30	6.62	1.861	11.73	6.27	6.27	6.62	1.550	9.770	8.230	8.230
500 °C	05	6.70	2.200	13.870	4.1286	4.1286	6.87	1.930	12.16	5.8400	5.8400
	10	6.85	1.900	11.97	6.0300	6.0300	6.85	1.610	10.15	7.8500	7.8500
	15	6.90	1.850	11.66	6.3400	6.3400	6.90	1.580	9.960	8.0400	8.0400
	20	6.92	1.821	11.48	6.5200	6.5200	6.92	1.50	9.450	8.5500	8.5500
	25	6.95	1.803	11.37	6.6300	6.6300	6.93	1.450	9.140	8.8600	8.8600
	30	6.96	1.781	11.22	6.7800	6.7800	6.94	1.40	8.820	9.1800	9.1800
600 °C	05	6.77	2.000	12.61	5.390	5.390	6.81	1.900	11.97	6.0300	6.0300
	10	7.05	1.853	11.68	6.32	6.320	6.90	1.560	9.830	8.1700	8.1700
	15	7.10	1.801	11.35	6.65	6.650	6.92	1.500	9.458	8.5420	8.5420
	20	7.12	1.770	11.16	6.84	6.840	6.95	1.470	9.260	8.7400	8.7400
	25	7.13	1.751	11.04	6.96	6.960	6.99	1.420	8.950	9.0500	9.0500
	30	7.14	1.730	10.91	7.09	7.090	7.05	1.380	8.700	9.3000	9.3000
800 °C	05	6.67	1.900	11.97	6.030	6.030	7.16	1.850	11.66	6.340	6.340
	10	7.00	1.750	6.97	6.97	6.970	7.20	1.500	9.450	8.550	8.550
	15	7.05	1.700	7.28	7.28	7.280	7.25	1.475	9.300	8.700	8.700
	20	7.04	1.653	7.58	7.58	7.580	7.30	1.380	8.700	9.300	9.300
	25	7.10	1.603	7.90	7.90	7.900	7.33	1.300	8.190	9.810	9.810
	30	7.13	1.550	8.23	8.23	8.230	7.35	1.250	7.880	10.12	10.12
900 °C	05	6.75	1.880	11.853	6.146	6.146	7.40	1.840	11.600	6.400	6.400
	10	6.84	1.700	10.71	7.290	7.290	7.42	1.400	8.820	9.180	9.180
	15	6.92	1.653	10.42	7.580	7.580	7.45	1.351	8.520	9.480	9.480
	20	6.95	1.600	10.08	7.920	7.920	7.50	1.280	8.070	9.930	9.930
	25	6.98	1.550	9.770	8.230	8.230	7.55	1.230	7.750	10.250	10.250
	30	7.00	1.480	9.330	8.670	8.670	7.60	1.155	7.280	10.720	10.720
1000 °C	05	7.11	1.850	11.66	6.340	6.340	7.11	1.821	11.482	6.518	6.518
	10	7.20	1650	10.400	7.600	7.600	7.20	1.350	8.510	9.490	9.490
	15	7.22	1.560	9.830	8.170	8.170	7.22	1.310	8.260	9.740	9.740
	20	7.30	1.500	9.450	8.550	8.550	7.30	1.250	7.880	10.12	10.12
	25	7.32	1.430	9.010	8.990	8.990	7.32	1.210	7.630	10.37	10.37
	30	7.33	1.380	8.700	9.300	9.300	7.33	1.150	7.250	10.75	10.75

* *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^{-3}, Particle Size= 150-180 μm, Initial Concentration of AO-7 (D_o) = 18 ×10^{-5}mol.dm^{-3}, pH of D_o Before Adsorption = 6.00*


400 °C regenerated carbon
D♦ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


500 °C regenerated carbon
D♦ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


600 °C regenerated carbon
D♦ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C

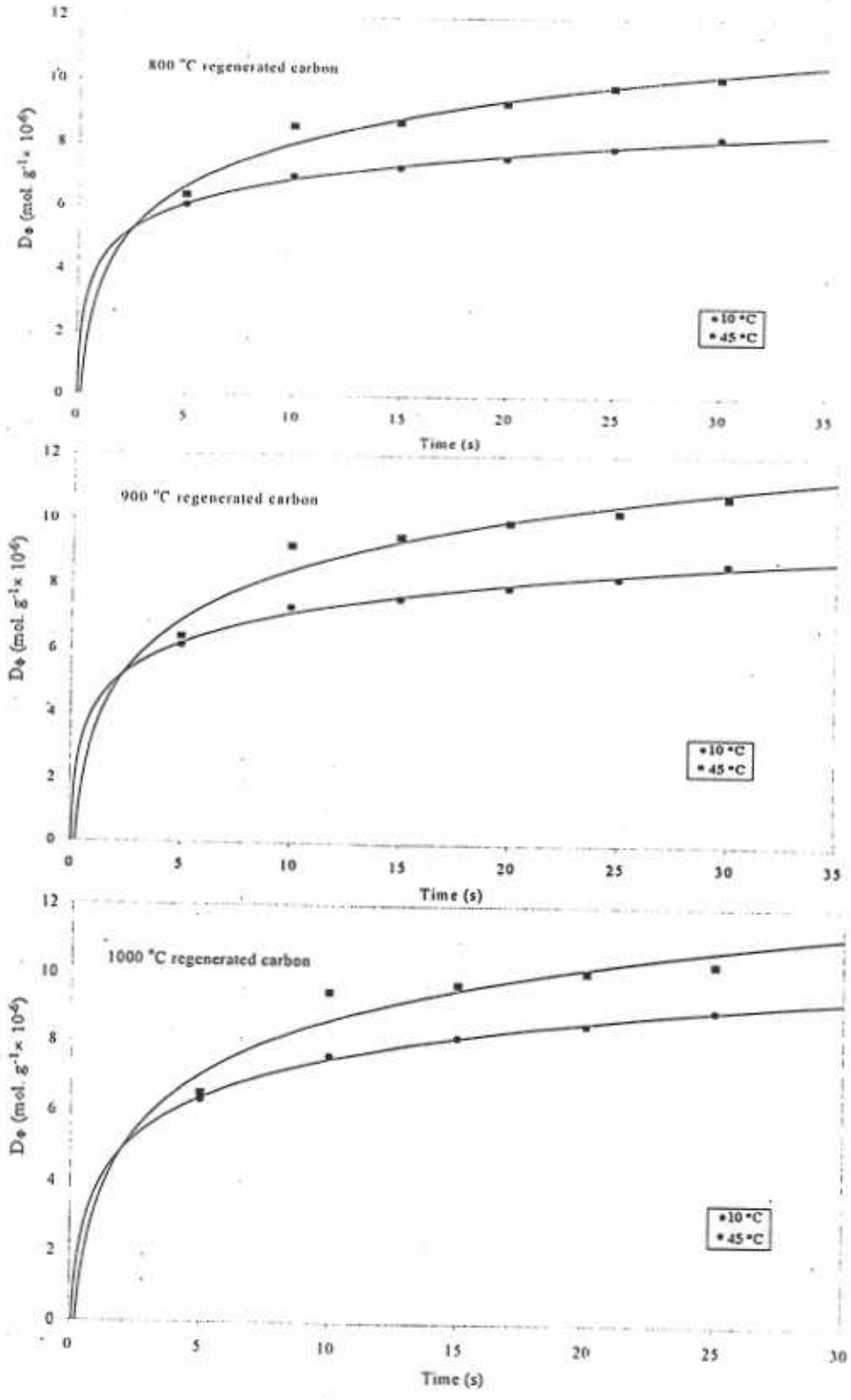


Figure 4.49 Adsorption kinetics of acid orange 7 on regenerated (RG) carbon samples

Table 4.41 Adsorption kinetics of acid orange 10 on carbon *Paulownia tomentosa* (PT) samples

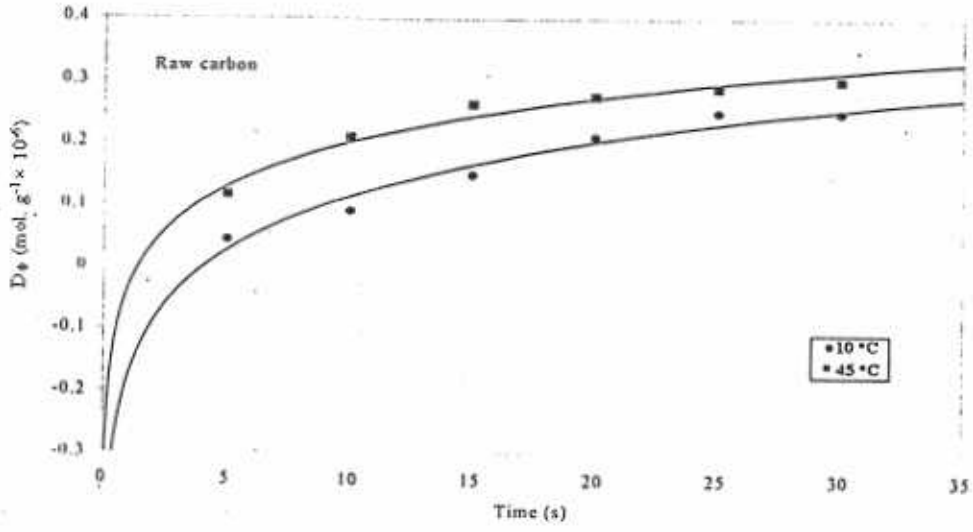
Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})
Raw	05	7.25	0.295	1.956	0.0437	0.0437	6.81	0.284	1.883	0.1170	0.1170
	10	7.04	0.288	1.910	0.0910	0.0910	7.00	0.270	1.791	0.2095	0.2095
	15	7.00	0.280	1.850	0.1500	0.1500	7.10	0.262	1.737	0.2630	0.2630
	20	6.98	0.270	1.790	0.2100	0.2100	7.11	0.260	1.724	0.2760	0.2760
	25	6.96	0.265	1.750	0.2500	0.2500	7.12	0.258	1.711	0.2891	0.2891
	30	6.95	0.265	1.750	0.2600	0.2600	7.13	0.256	1.697	0.3024	0.3024
400 °C	05	6.91	0.225	1.49	0.510	0.510	7.00	0.218	1.440	0.560	0.560
	10	6.96	0.210	1.39	0.610	0.610	7.32	0.200	1.320	0.680	0.680
	15	7.21	0.200	1.33	0.670	0.670	7.47	0.190	1.260	0.740	0.740
	20	7.25	0.198	1.32	0.680	0.680	7.50	0.185	1.220	0.780	0.780
	25	7.30	0.195	1.29	0.710	0.710	7.51	0.182	1.200	0.800	0.800
	30	7.33	0.192	1.27	0.730	0.730	7.53	0.180	1.190	0.810	0.810
800 °C	05	8.97	0.180	1.190	0.810	0.810	9.31	0.100	0.660	1.340	1.340
	10	9.33	0.160	1.060	0.940	0.940	9.37	0.080	0.530	1.470	1.470
	15	9.41	0.150	0.990	1.010	1.010	9.39	0.070	0.460	1.540	1.540
	20	9.45	0.145	0.960	1.040	1.040	9.40	0.063	0.410	1.590	1.590
	25	9.49	0.140	0.920	1.080	1.080	9.42	0.060	0.390	1.610	1.610
	30	9.52	0.135	0.890	1.110	1.110	9.43	0.050	0.330	1.670	1.670

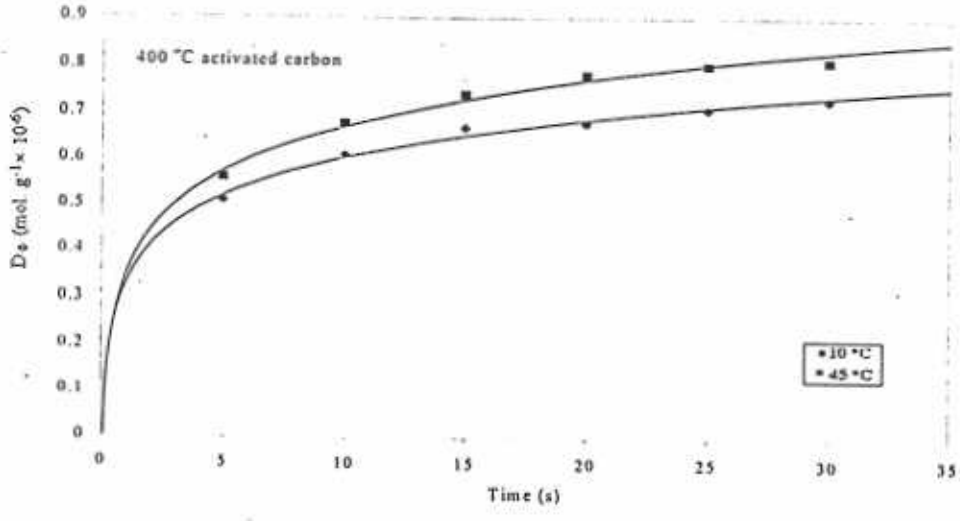
• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AO-10 (D_o) = 2 × 10^{-5}mol.dm^{-3}, pH of D_o Before Adsorption = 6.25*

Table 4.42 Adsorption kinetics of acid orange 10 on *Populus caspica* (PC) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-6})
Raw	05	7.76	0.290	1.920	0.080	0.080	7.91	0.268	1.770	0.230	0.230
	10	7.50	0.270	1.790	0.210	0.210	7.76	0.250	1.650	0.350	0.350
	15	7.45	0.260	1.720	0.280	0.280	7.74	0.240	1.590	0.410	0.410
	20	7.43	0.250	1.650	0.350	0.350	7.71	0.230	1.520	0.480	0.480
	25	7.42	0.245	1.620	0.380	0.380	7.68	0.228	1.510	0.490	0.490
	30	7.40	0.242	1.600	0.400	0.400	7.67	0.225	1.490	0.510	0.510
400 °C	05	9.10	0.252	1.670	0.330	0.330	9.61	0.232	1.540	0.460	0.460
	10	9.21	0.232	1.530	0.470	0.470	9.63	0.210	1.390	0.610	0.610
	15	9.31	0.220	1.450	0.550	0.550	9.64	0.200	1.320	0.680	0.680
	20	9.35	0.217	1.430	0.570	0.570	9.65	0.195	1.290	0.710	0.710
	25	9.37	0.212	1.400	0.600	0.600	9.67	0.193	1.280	0.720	0.720
	30	9.38	0.205	1.360	0.640	0.640	9.70	0.187	1.240	0.760	0.760
800 °C	05	10.01	0.199	1.320	0.680	0.680	10.07	0.190	1.260	0.760	0.760
	10	10.03	0.180	1.190	0.810	0.810	10.08	0.170	1.120	0.880	0.880
	15	10.04	0.172	1.140	0.860	0.860	10.09	0.160	1.060	0.940	0.940
	20	10.05	0.167	1.100	0.900	0.900	10.10	0.150	0.990	1.010	1.010
	25	10.06	0.160	1.060	0.940	0.940	10.11	0.145	0.960	1.040	1.040
	30	10.08	0.155	1.020	0.980	0.980	10.12	0.135	0.900	1.100	1.100

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AO-10 (D_o) = 2 × 10^{-5}mol.dm^{-3}, pH of D_o Before Adsorption = 6.25*





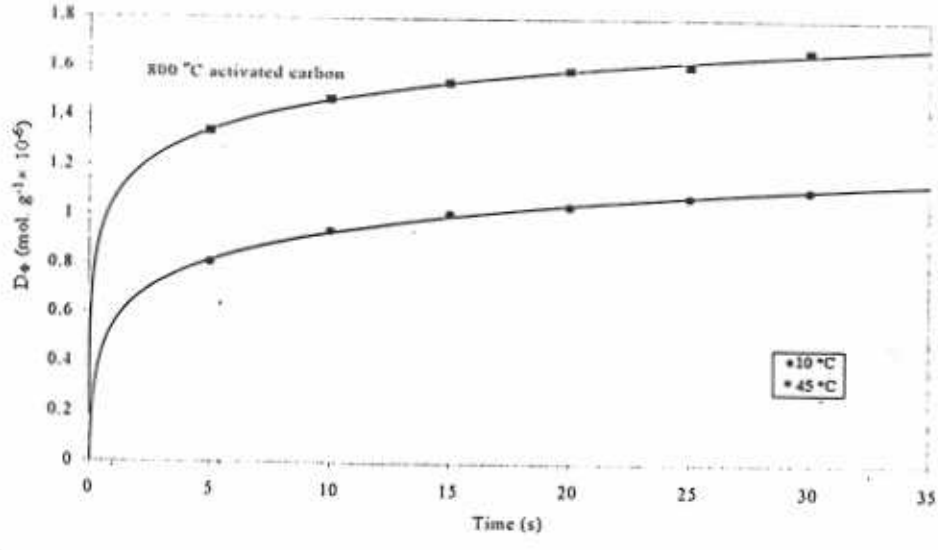


Figure 4.50 Adsorption kinetics of acid orange 10 on *Paulownia tomentosa* (PT) carbon samples

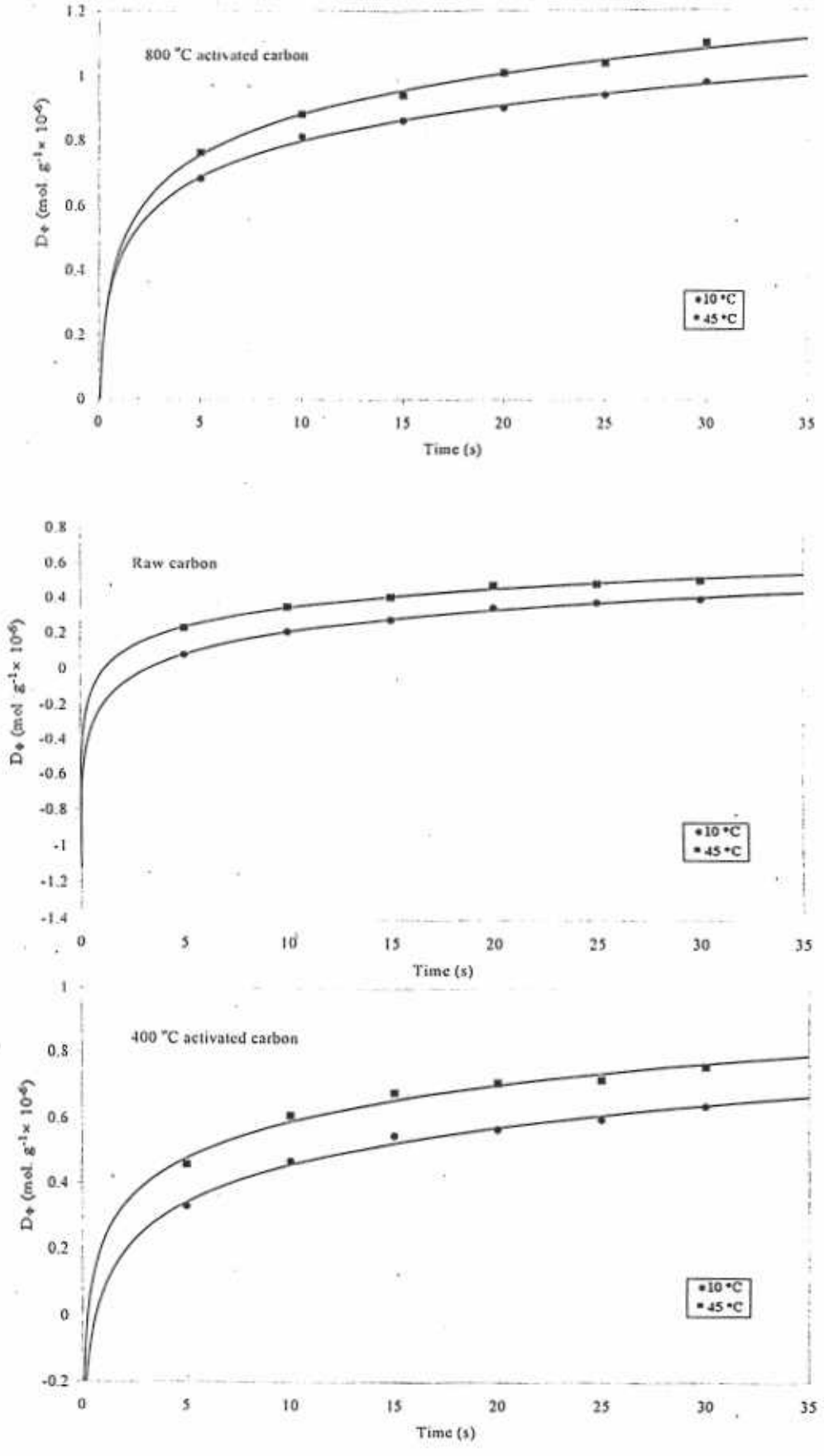


Figure 4.51 Adsorption kinetics of acid orange 10 on *Populus caspica* (PC) carbon samples

Table 4.43 Adsorption kinetics of acid orange 10 on *corncobs* (CC) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10
Raw	05	8.60	0.300	1.980	0.020	0.020	8.76	0.275	1.820	0.180	0.180
	10	8.08	0.290	1.920	0.080	0.080	8.13	0.262	1.730	0.270	0.270
	15	7.89	0.285	1.880	0.120	0.120	8.04	0.250	1.650	0.350	0.350
	20	7.82	0.272	1.800	0.200	0.200	8.02	0.245	1.620	0.380	0.380
	25	7.80	0.268	1.770	0.230	0.230	8.01	0.240	1.590	0.410	0.410
	30	7.80	0.266	1.760	0.240	0.240	8.00	0.235	1.560	0.440	0.440
400 °C	05	9.47	0.239	1.580	0.420	0.420	9.77	0.223	1.480	0.520	0.520
	10	9.50	0.220	1.450	0.550	0.550	9.78	0.200	1.320	0.680	0.680
	15	9.56	0.215	1.420	0.580	0.580	9.79	0.190	1.260	0.740	0.740
	20	9.59	0.209	1.390	0.610	0.610	9.80	0.185	1.230	0.770	0.770
	25	9.62	0.202	1.340	0.660	0.660	9.81	0.182	1.200	0.800	0.800
	30	9.63	0.197	1.300	0.700	0.700	9.82	0.176	1.160	0.840	0.840
800 °C	05	9.830	0.190	1.259	0.740	0.740	9.950	0.150	0.995	1.005	1.005
	10	9.930	0.122	0.810	1.190	1.190	9.970	0.100	0.660	1.340	1.340
	15	9.950	0.110	0.720	1.280	1.280	9.980	0.080	0.530	1.470	1.470
	20	9.990	0.100	0.660	1.340	1.340	9.990	0.070	0.460	1.540	1.540
	25	10.00	0.090	0.590	1.410	1.410	10.00	0.060	0.390	1.610	1.610
	30	10.01	0.086	0.570	1.430	1.430	10.01	0.050	0.330	1.670	1.670

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AO-10 (D_o) = 2 10^{-5}mol.dm^3, pH of D_o Before Adsorption = 6.25*

Table 4.44 Adsorption kinetics of acid orange 10 on *Ailanthus altissima* (AA) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	8.90	0.270	1.790	0.210	0.210	8.79	0.250	1.650	0.350	0.350
	10	8.68	0.250	1.650	0.350	0.350	8.28	0.220	1.460	0.540	0.540
	15	8.65	0.240	1.590	0.410	0.410	8.27	0.200	1.330	0.670	0.670
	20	8.64	0.230	1.520	0.480	0.480	8.26	0.190	1.260	0.740	0.740
	25	8.62	0.228	1.511	0.4880	0.4880	8.25	0.180	1.190	0.810	0.810
	30	8.60	0.226	1.498	0.5013	0.5013	8.24	0.170	1.112	0.880	0.880
400 °C	05	9.15	0.230	1.520	0.480	0.480	9.45	0.200	1.3200	0.680	0.680
	10	9.26	0.200	1.320	0.680	0.680	9.48	0.170	1.1270	0.873	0.873
	15	9.34	0.180	1.200	0.800	0.800	9.52	0.160	1.0600	0.940	0.940
	20	9.41	0.160	1.060	0.940	0.940	9.54	0.150	0.9900	1.010	1.010
	25	9.44	0.150	0.990	1.010	1.010	9.58	0.142	0.9420	1.058	1.058
	30	9.49	0.144	0.954	1.045	1.045	9.59	0.140	0.9284	1.072	1.072
800 °C	05	10.03	0.200	1.330	0.670	0.670	10.09	0.180	1.200	0.800	0.800
	10	10.04	0.170	1.130	0.870	0.870	10.10	0.150	0.990	1.010	1.010
	15	10.05	0.150	0.990	1.010	1.010	10.11	0.120	0.790	1.210	1.210
	20	10.06	0.130	0.860	1.140	1.140	10.12	0.101	0.660	1.340	1.340
	25	10.07	0.110	0.730	1.270	1.270	10.13	0.091	0.590	1.410	1.410
	30	10.08	0.100	0.660	1.340	1.340	10.14	0.080	0.530	1.470	1.470

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AO-10 (D_o) = 2 × 10^{-5}mol.dm^3, pH of D_o Before Adsorption = 6.25*

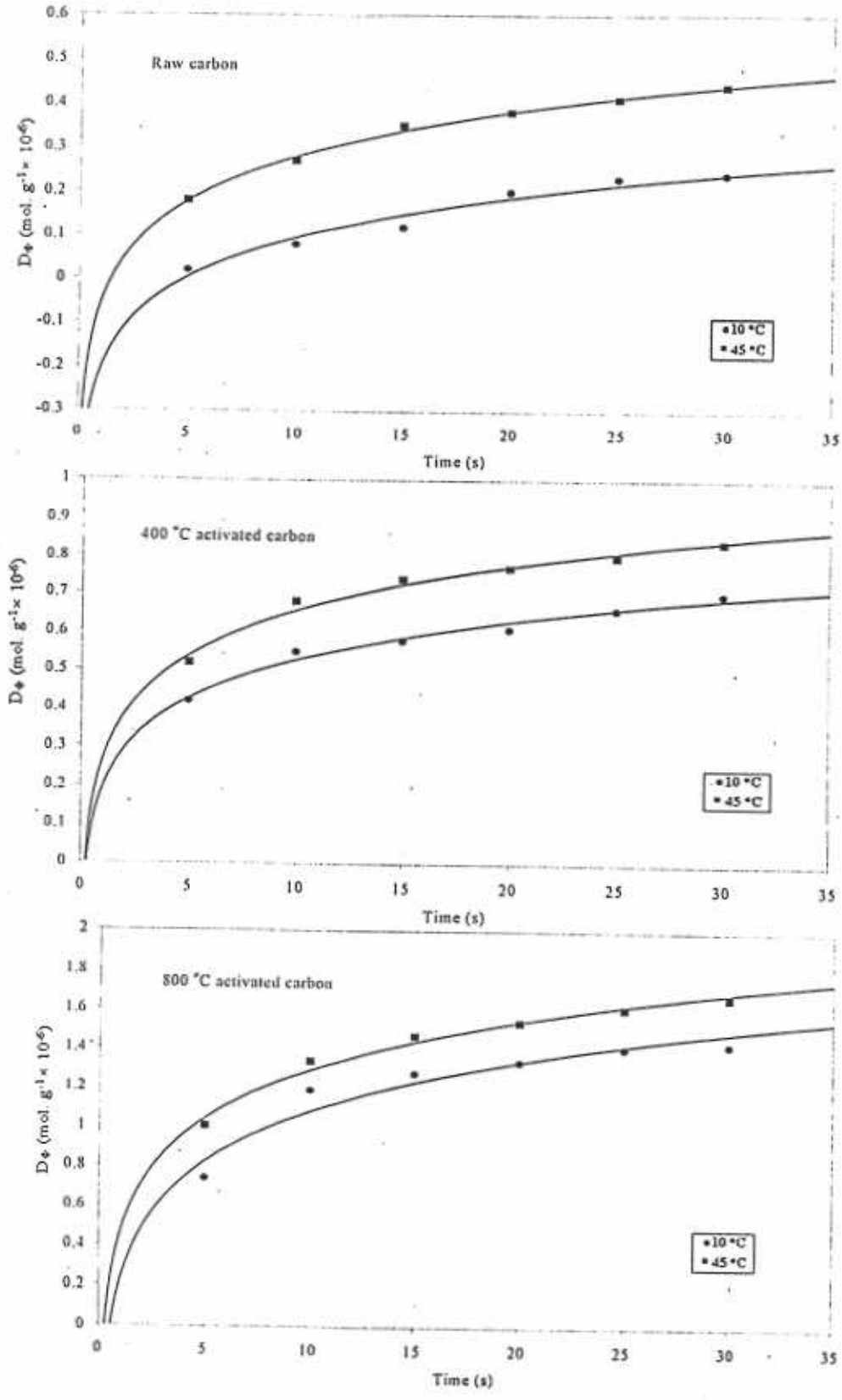


Figure 4.52 Adsorption kinetics of acid orange 10 on *Corncobs* (CC) carbon samples

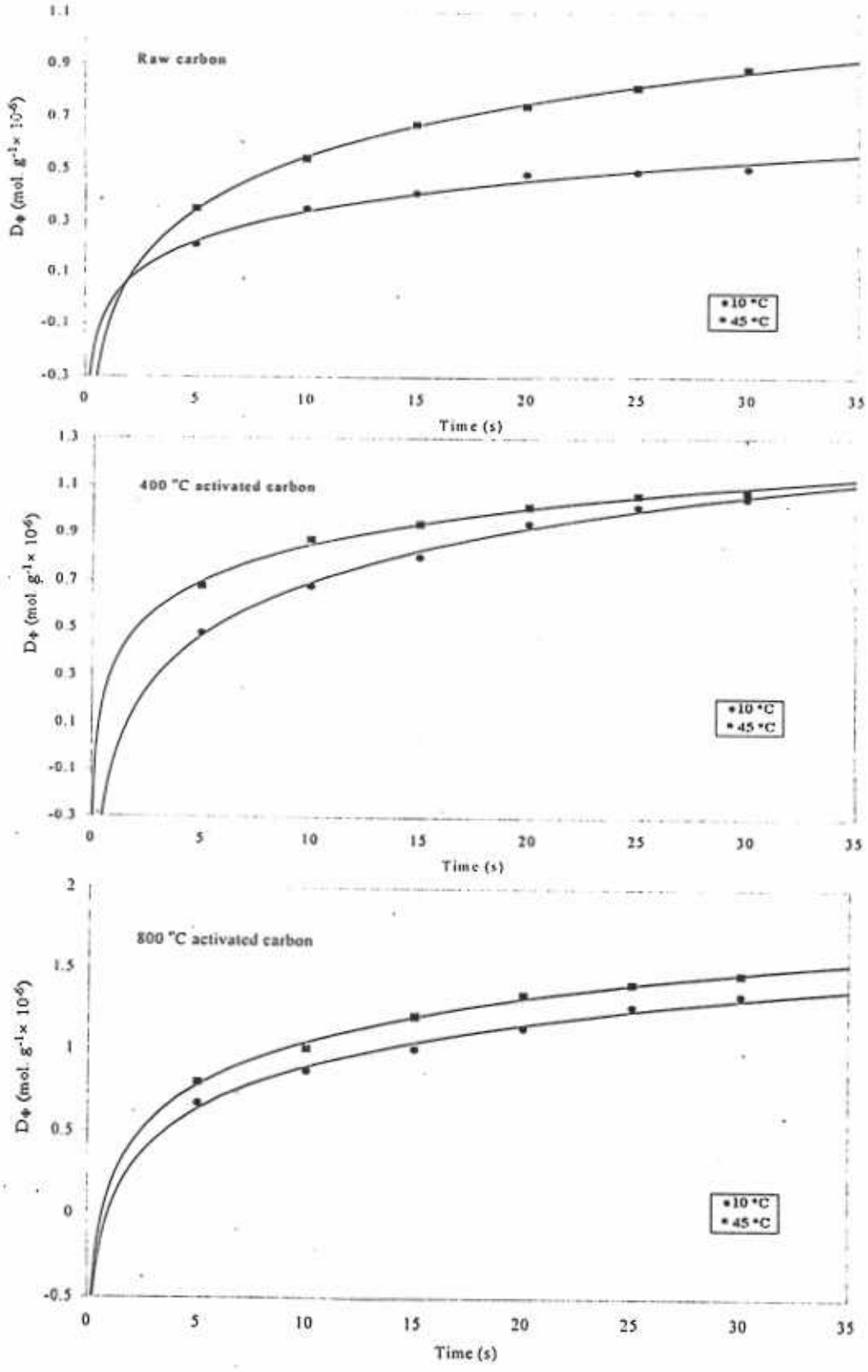
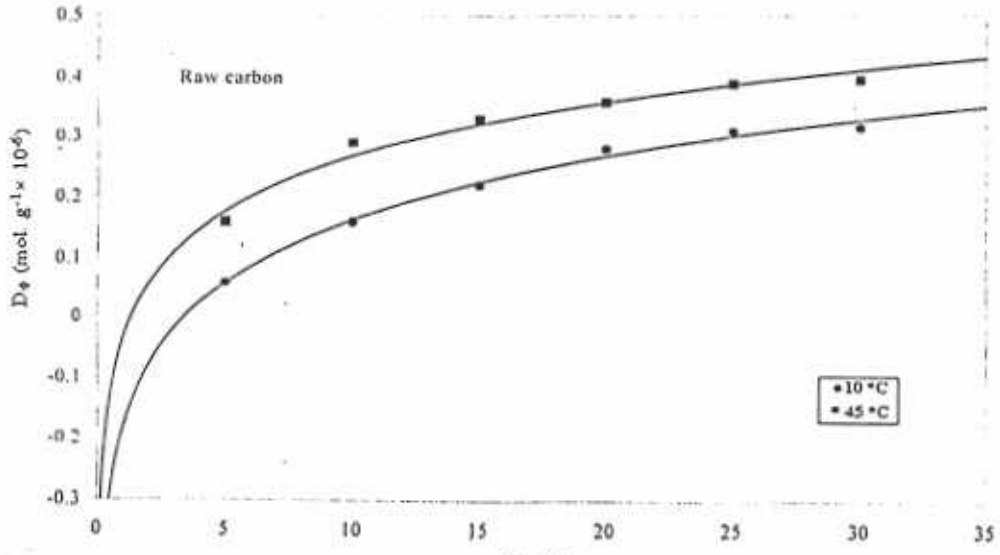


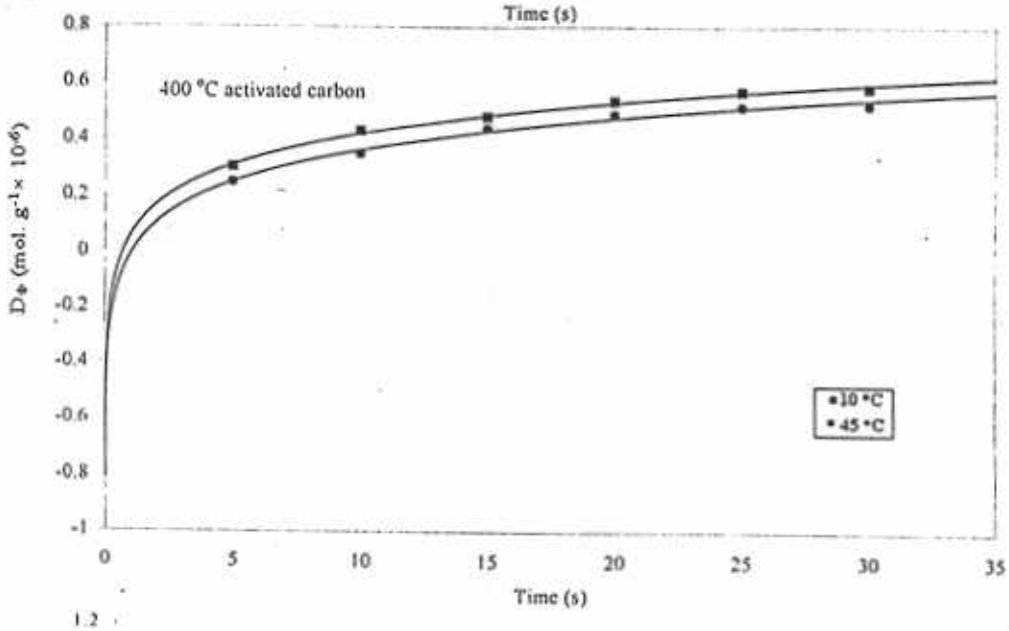
Figure 4.53 Adsorption kinetics of acid orange 10 on *Ailanthus altissima* (AA) carbon samples

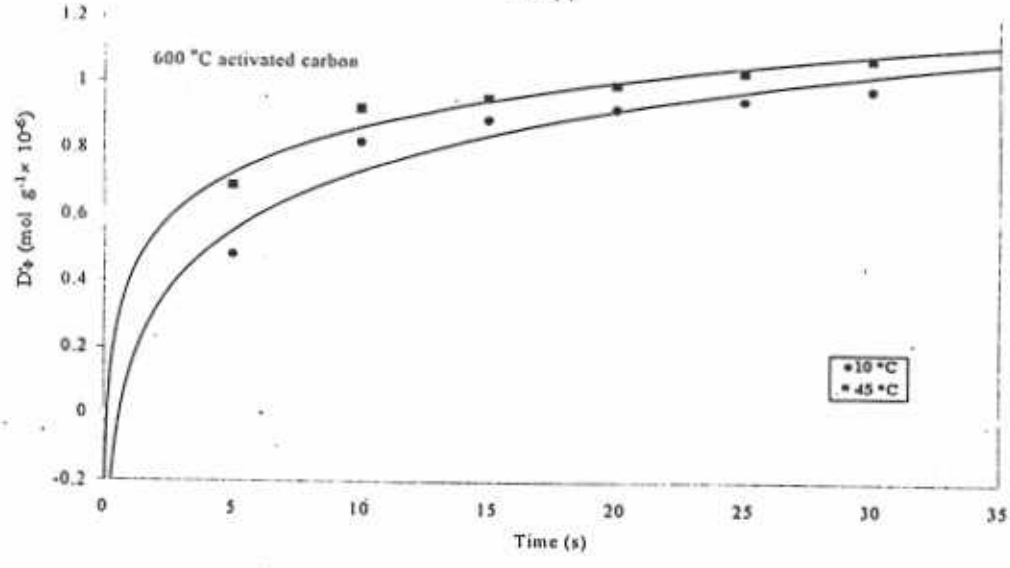
Table 4.45 Adsorption kinetics of acid orange 10 on *Salvadora oleoides* (SO) carbon samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
Raw	05	6.65	0.715	4.7400	0.060	0.060	8.53	0.700	4.6400	0.160	0.160
	10	6.90	0.700	4.6400	0.160	0.160	8.11	0.680	4.5100	0.290	0.290
	15	7.00	0.691	4.5800	0.220	0.220	7.97	0.675	4.4700	0.330	0.330
	20	7.10	0.682	4.5200	0.280	0.280	7.90	0.670	4.4400	0.360	0.360
	25	7.20	0.677	4.4900	0.310	0.310	7.85	0.665	4.4100	0.390	0.390
	30	7.22	0.676	4.4830	0.317	0.317	7.80	0.664	4.4032	0.397	0.397
400 °C	05	6.18	0.686	4.5500	0.2500	0.2500	6.69	0.678	4.496	0.3039	0.3039
	10	6.26	0.672	4.4500	0.3500	0.3500	6.72	0.660	4.370	0.430	0.4300
	15	6.41	0.658	4.3600	0.4400	0.4400	6.81	0.652	4.320	0.480	0.4800
	20	6.45	0.650	4.3100	0.4896	0.4896	6.84	0.643	4.264	0.5360	0.5360
	25	6.50	0.646	4.2840	0.5162	0.5162	6.86	0.638	4.230	0.5692	0.5692
	30	6.52	0.645	4.2772	0.5228	0.5228	6.90	0.636	4.217	0.5825	0.5825
600 °C	05	6.39	0.651	4.3169	0.4830	0.4830	7.04	0.620	4.110	0.6900	0.6900
	10	6.54	0.600	3.978	0.8212	0.8212	7.20	0.585	3.879	0.9210	0.9210
	15	6.75	0.590	3.912	0.8875	0.8875	7.39	0.580	3.846	0.9538	0.9538
	20	6.85	0.585	3.8790	0.9206	0.9206	7.45	0.574	3.8063	0.9936	0.9936
	25	6.90	0.581	3.8527	0.9470	0.9470	7.50	0.568	3.7665	1.0334	1.0334
	30	7.00	0.576	3.8196	0.9803	0.9803	7.55	0.562	3.7268	1.0732	1.0732
800 °C	05	8.95	0.530	3.51	1.290	1.290	9.680	0.505	3.3488	1.4512	1.4512
	10	9.27	0.471	3.12	1.680	1.680	10.00	0.434	2.8780	1.9220	1.9220
	15	9.30	0.464	3.07	1.730	1.730	10.38	0.396	2.6260	2.1740	2.1740
	20	9.35	0.458	3.04	1.763	1.763	10.50	0.382	2.5330	2.2670	2.2670
	25	9.40	0.449	2.98	1.823	1.823	10.60	0.374	2.4801	2.3198	2.3198
	30	9.43	0.445	2.951	1.849	1.849	10.70	0.367	2.4337	2.3663	2.3663
900 °C	05	9.20	0.490	3.5200	1.2800	1.2800	9.910	0.423	2.8050	1.9949	1.9949
	10	9.24	0.444	2.9400	1.8600	1.8600	10.17	0.336	2.2300	2.5700	2.5700
	15	9.27	0.416	2.7500	2.0500	2.0500	10.45	0.293	1.9400	2.8600	2.8600
	20	9.30	0.408	2.7100	2.0940	2.0940	10.53	0.280	1.8567	2.9432	2.9432
	25	9.33	0.400	2.6500	2.1470	2.1470	10.60	0.273	1.8103	2.9896	2.9896
	30	9.34	0.395	2.6200	2.1810	2.1810	10.65	0.266	1.7639	3.0360	3.0360
1000 °C	05	9.52	0.470	3.116	1.684	1.684	9.780	0.395	2.6200	2.1810	2.1810
	10	9.57	0.402	2.665	2.134	2.134	9.920	0.288	1.9098	2.8902	2.8902
	15	9.58	0.374	2.180	2.320	2.320	10.15	0.258	1.7108	3.0891	3.0891
	20	9.60	0.365	2.420	2.380	2.380	10.20	0.227	1.5053	3.2946	3.2946
	25	9.62	0.360	2.387	2.413	2.413	10.25	0.220	1.4588	3.3411	3.3411
	30	9.65	0.354	2.347	2.452	2.452	10.30	0.216	1.4323	3.3678	3.3678

✦ *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AO-10 (D_o) = 4.8× 10^{-4}mol.dm^{-3}, pH of D_o Before Adsorption = 6.20*


Raw carbon
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪ 45 °C


400 °C activated carbon
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪ 45 °C


600 °C activated carbon
Dφ (mol g-1× 10-6)
Time (s)
•10 °C
▪ 45 °C

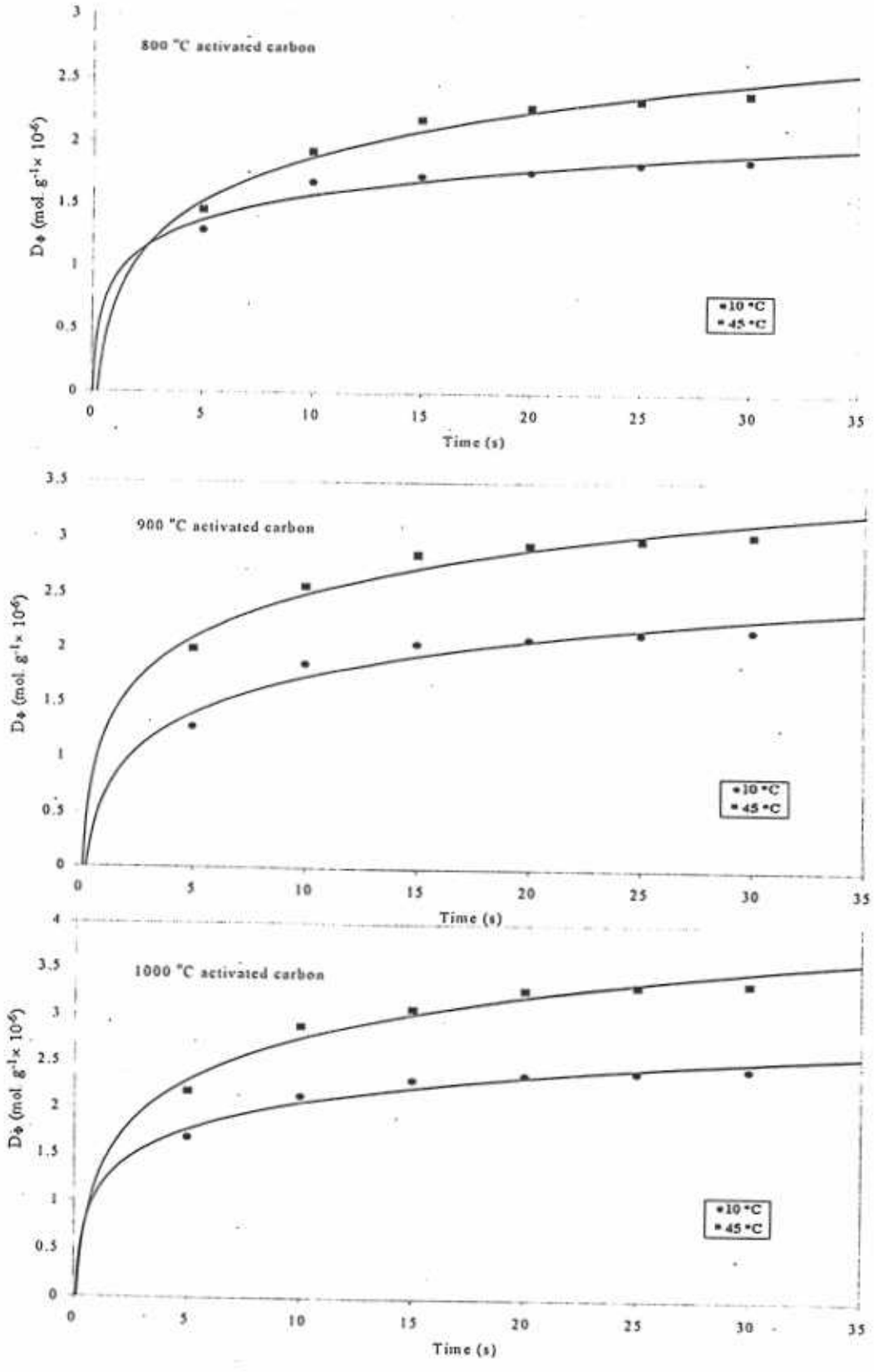
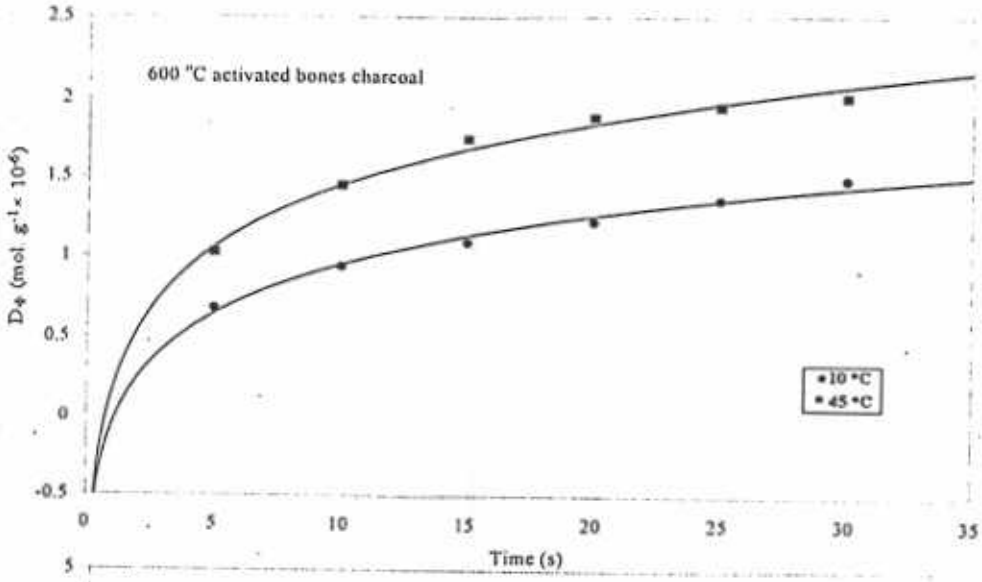


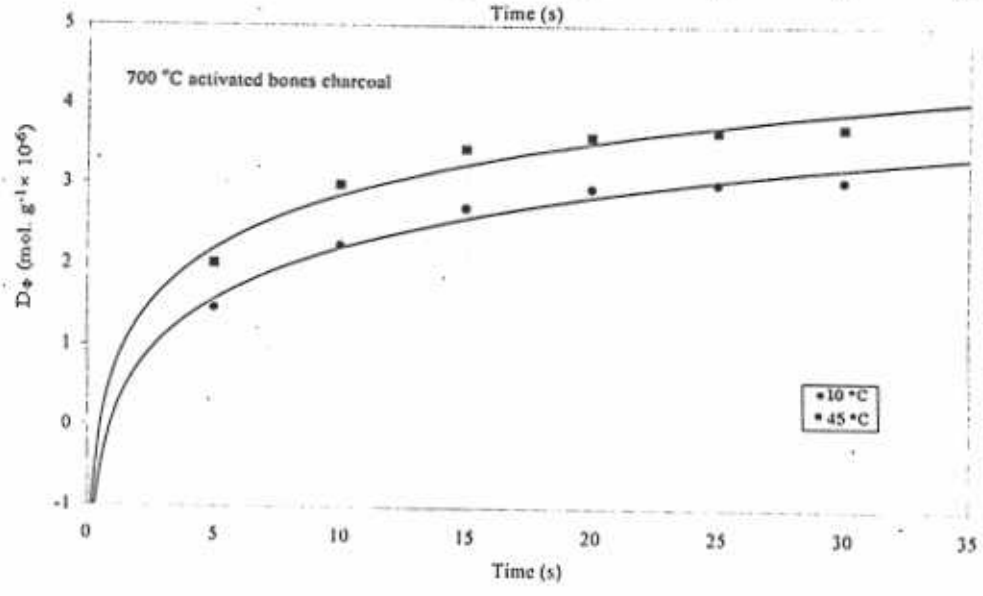
Figure 4.54 Adsorption kinetics of acid orange 10 on *Salvadora oleoides* (SO) carbon samples

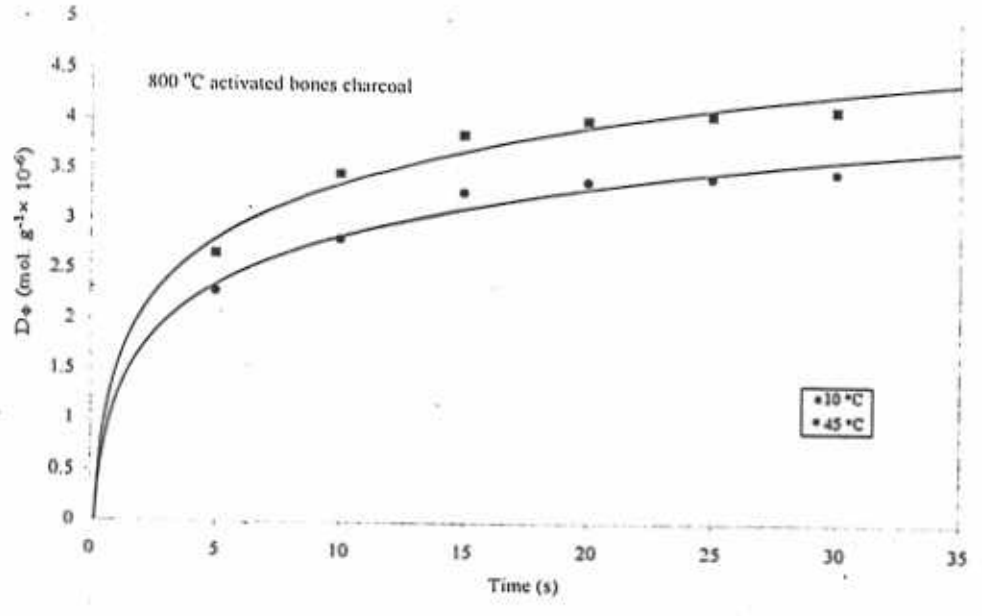
Table 4.46 Adsorption kinetics of acid orange 10 on animal bones charcoal (ABC) samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH_M	Ab_M	D_e (mol/L×10^{-5})	D_o-D_e (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})
600 °C	05	7.00	0.802	5.320	0.680	0.680	8.05	0.750	4.9734	1.0265	1.0265
	10	7.10	0.764	5.060	0.940	0.940	8.16	0.686	4.5491	1.4509	1.4509
	15	7.30	0.740	4.910	1.090	1.090	8.20	0.641	4.2500	1.7500	1.7500
	20	7.35	0.721	4.780	1.220	1.220	8.25	0.620	4.111	1.8886	1.8886
	25	7.40	0.700	4.640	1.360	1.360	8.30	0.610	4.0451	1.9549	1.9549
	30	7.46	0.681	4.510	1.490	1.490	8.35	0.601	3.9854	2.0145	2.0145
700 °C	05	7.20	0.682	4.5220	1.4780	1.4780	8.03	0.600	3.978	2.0210	2.0210
	10	7.25	0.566	3.7533	2.2466	2.2466	8.15	0.455	3.010	2.9900	2.9900
	15	7.35	0.496	3.2891	2.7108	2.7108	8.18	0.384	2.550	3.4500	3.4500
	20	7.40	0.460	3.0503	2.9496	2.9496	8.20	0.362	2.401	3.5990	3.5990
	25	7.42	0.450	2.9841	3.0159	3.0159	8.25	0.351	2.327	3.6724	3.6724
	30	7.50	0.443	2.9376	3.0623	3.0623	8.30	0.342	2.2679	3.7320	3.7320
800 °C	05	8.24	0.560	3.7135	2.2864	2.2864	8.60	0.503	3.335	2.6640	2.6640
	10	8.40	0.480	3.1830	2.8169	2.8169	8.69	0.380	2.520	3.4800	3.4800
	15	8.60	0.407	2.6989	3.3010	3.3010	8.75	0.350	2.320	3.6800	3.6800
	20	8.69	0.391	2.5928	3.4071	3.4071	8.80	0.300	1.990	4.0100	4.0100
	25	8.75	0.384	2.5464	3.4535	3.4535	8.90	0.291	1.9297	4.0703	4.0703
	30	8.80	0.375	2.4867	3.5132	3.5132	8.95	0.283	1.8766	4.1233	4.1233
900 °C	05	9.17	0.510	3.3819	2.6180	2.6180	6.27	0.450	2.9840	3.0160	3.0160
	10	9.24	0.380	2.5198	3.4801	3.4801	9.38	0.281	1.8600	4.1400	4.1400
	15	9.28	0.333	2.2100	3.7900	3.7900	9.40	0.211	1.3900	4.6100	4.6100
	20	9.30	0.290	1.9200	4.0800	4.0800	9.45	0.182	1.2068	4.7932	4.7932
	25	9.35	0.282	1.8700	4.1299	4.1299	9.50	0.175	1.1604	4.5396	4.5396
	30	9.50	0.277	1.8368	4.1631	4.1631	9.60	0.168	1.114	4.8859	4.8859
1000 °C	05	10.05	0.395	2.6193	3.3806	3.3806	10.12	0.338	2.2413	3.7586	3.7586
	10	10.15	0.243	1.6114	4.3886	4.3886	10.17	0.200	1.3262	4.6737	4.6737
	15	10.26	0.126	0.8350	5.1650	5.1650	10.22	0.105	0.6963	5.3037	5.3037
	20	10.30	0.113	0.7493	5.2507	5.2507	10.40	0.081	0.5370	5.4630	5.4630
	25	10.33	0.100	0.6632	5.3368	5.3368	10.50	0.050	0.3315	5.6684	5.6684
	30	10.40	0.092	0.5880	5.4199	5.4199	10.55	0.040	0.2652	5.7343	5.7343

• *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 μm, Initial Concentration of AO-10 (D_o) = 6.0× 10^{-5}mol.dm^3 , pH of D_o Before Adsorption = 6.30*


600 °C activated bones charcoal
Dφ (mol g-1× 10-6)
Time (s)
•10 °C
▪45 °C


700 °C activated bones charcoal
Dφ (mol. g-1× 10-6)
Time (s)
•10 °C
▪45 °C


800 °C activated bones charcoal
Dφ (mol g-1× 10-6)
Time (s)
•10 °C
▪45 °C

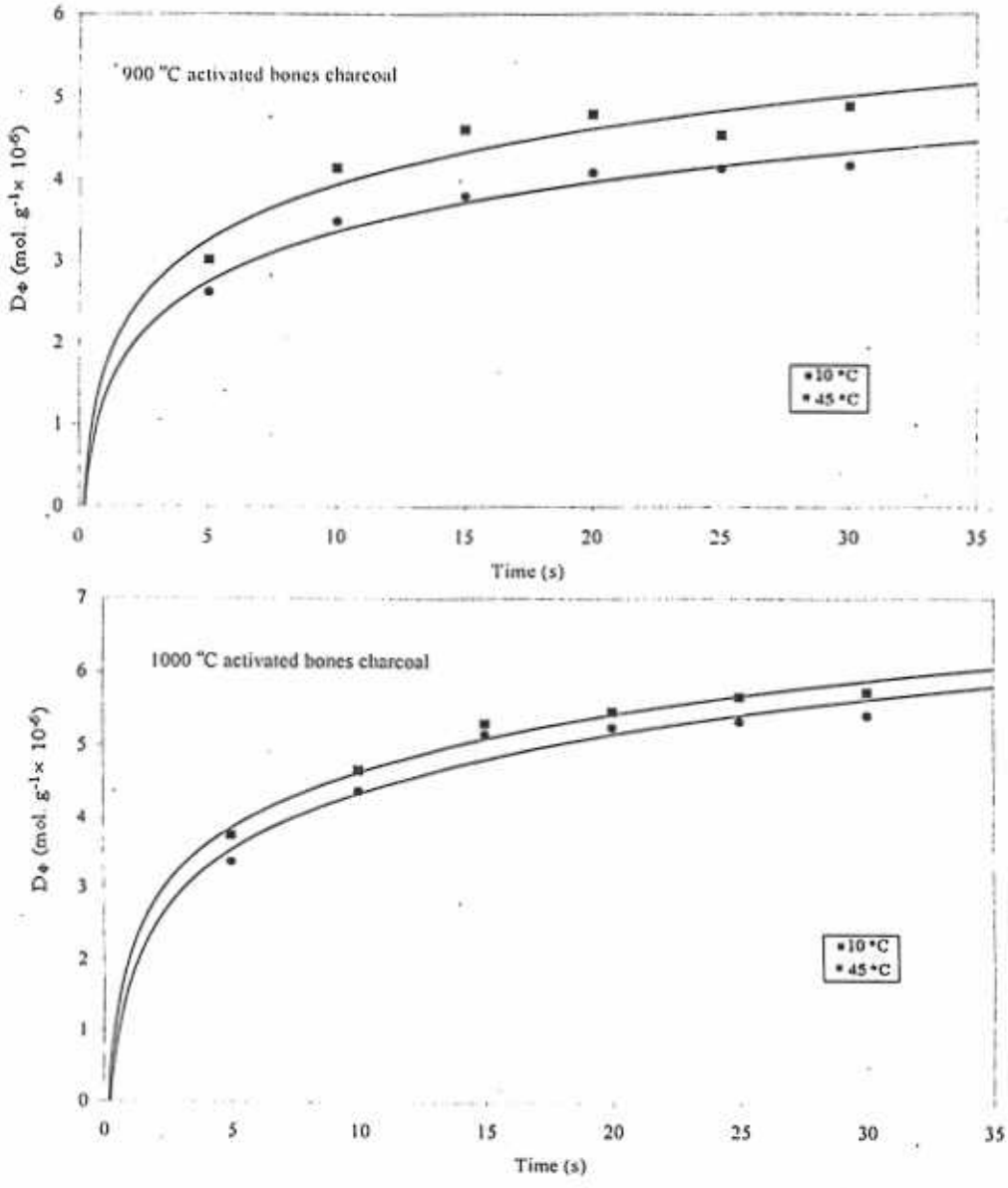
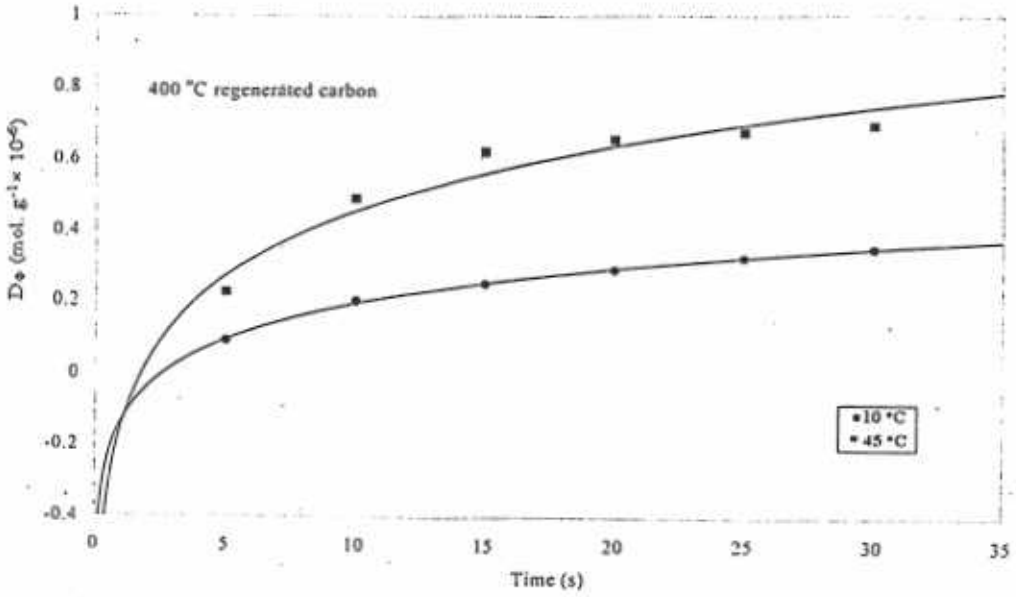


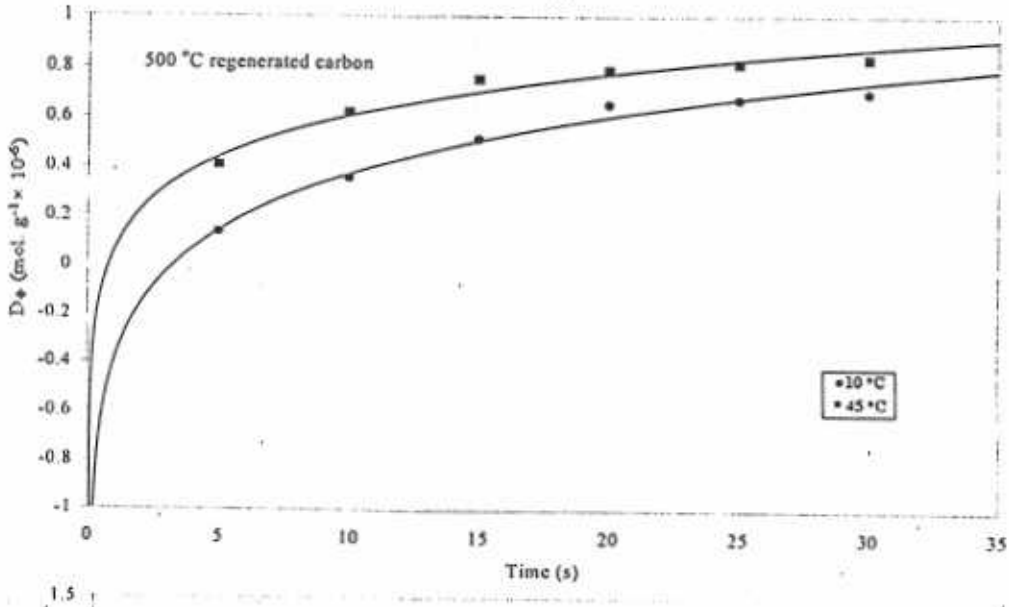
Figure 4.55 Adsorption kinetics of acid orange 10 on animal bones charcoal (ABC) samples

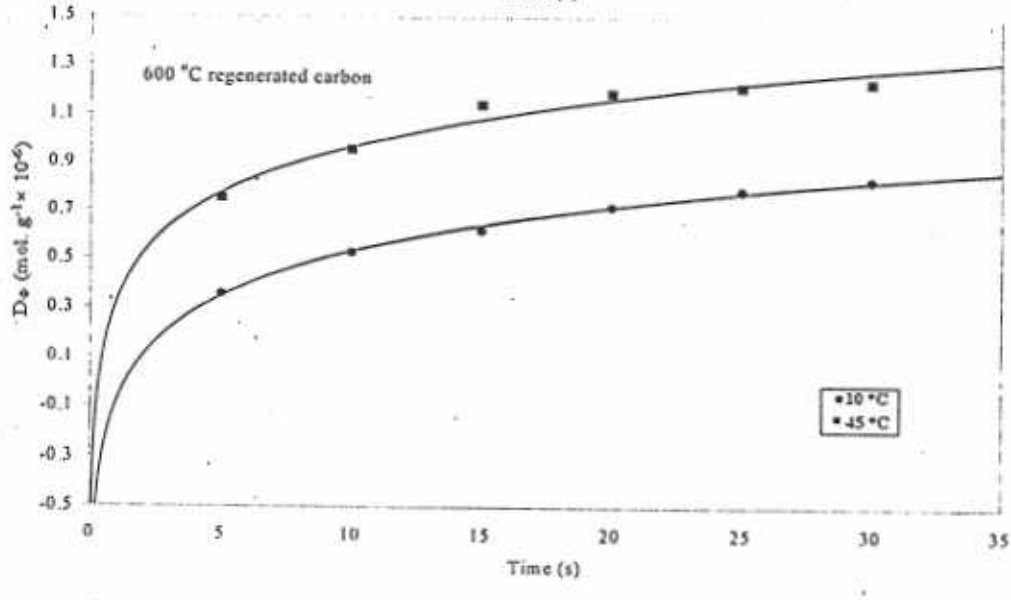
Table 4.47 Adsorption kinetics of acid orange 10 on regenerated carbon (RG) samples

Sample	Time (s)	at 10 °C					at 45 °C				
		pH$_M$	Ab$_M$	D_o (mol/L×10^{-5})	D_o-D_σ (mol/L×10^{-5})	D_ϕ (mol/g×10^{-4})	pH$_M$	Ab$_M$	D_o (mol/L×10^{-5})	D_o-D_σ (mol/L×10^{-5})	D_ϕ (mol/g×10
400 °C	05	6.61	0.710	4.7082	0.0917	0.0917	6.50	0.690	4.5756	0.2244	0.2244
	10	6.70	0.694	4.600	0.2000	0.2000	6.68	0.650	4.3103	0.4896	0.4896
	15	6.58	0.686	4.550	0.2500	0.2500	6.62	0.630	4.1777	0.6223	0.6223
	20	6.55	0.680	4.510	0.2900	0.2900	6.69	0.625	4.1445	0.6554	0.6554
	25	6.52	0.675	4.476	0.3240	0.3240	6.70	0.622	4.1246	0.6753	0.6753
	30	6.50	0.671	4.449	0.3504	0.3504	6.73	0.619	4.1047	0.6952	0.6952
500 °C	05	6.40	0.703	4.6618	0.1382	0.1382	6.70	0.662	4.3899	0.4101	0.4101
	10	6.50	0.670	4.4430	0.3571	0.3571	6.75	0.630	4.1777	0.6223	0.6223
	15	6.70	0.646	4.2838	0.5162	0.5162	6.80	0.610	4.0451	0.7549	0.7549
	20	6.75	0.625	1.1445	0.6554	0.6554	6.85	0.605	4.0119	0.7881	0.7881
	25	6.76	0.622	4.1246	0.6753	0.6753	6.88	0.601	3.9854	0.8145	0.8145
	30	6.78	0.618	4.0981	0.7018	0.7018	6.90	0.598	3.9655	0.8345	0.8345
600 °C	05	6.60	0.670	4.3899	0.3600	0.3600	6.70	0.610	4.0451	0.7549	0.7549
	10	6.55	0.645	4.1777	0.5300	0.5300	7.10	0.579	3.8395	0.9604	0.9604
	15	6.57	0.630	4.0451	0.6223	0.6223	7.20	0.551	3.6538	1.1461	1.1461
	20	6.56	0.615	4.0119	0.7217	0.7217	7.25	0.544	3.6074	1.1925	1.1925
	25	6.54	0.605	3.9854	0.7881	0.7881	7.30	0.540	3.5809	1.2191	1.2191
	30	6.52	0.598	3.9655	0.8345	0.8345	7.35	0.537	3.5610	1.2389	1.2389
800 °C	05	6.54	0.630	4.1777	0.6223	0.6223	6.98	0.550	3.6472	1.1527	1.1527
	10	6.80	0.584	3.8726	0.9274	0.9274	6.85	0.482	3.1962	1.6037	1.6037
	15	6.95	0.542	3.5900	1.2100	1.2100	6.80	0.461	3.0570	1.7429	1.7429
	20	6.99	0.534	3.5411	1.2588	1.2588	6.78	0.452	2.9973	1.8026	1.8026
	25	7.01	0.527	3.4946	1.3053	1.3053	6.75	0.447	2.9642	1.8358	1.8358
	30	7.03	0.519	3.4420	1.3583	1.3583	6.72	0.443	2.9737	1.8623	1.8623
900 °C	05	7.00	0.619	4.1047	0.6952	0.6952	7.60	0.534	3.5411	1.2588	1.2588
	10	7.80	0.580	3.8461	0.9538	0.9538	8.00	0.459	3.0437	1.7562	1.7562
	15	8.00	0.560	3.7100	1.0900	1.0900	7.90	0.441	2.9244	1.8755	1.8755
	20	8.10	0.544	3.6074	1.1925	1.1925	7.89	0.430	2.8514	1.9485	1.9485
	25	8.13	0.540	3.5800	1.2200	1.2200	7.85	0.426	2.8249	1.9750	1.9750
	30	8.16	0.534	3.5400	1.2600	1.2600	7.80	0.423	2.8050	1.9949	1.9949
1000 °C	05	6.85	0.608	4.0318	0.7682	0.7682	7.20	0.499	3.3090	1.4910	1.4910
	10	7.00	0.573	3.7997	1.0002	1.0002	7.30	0.423	2.8050	1.9949	1.9949
	15	7.11	0.550	3.6472	1.1527	1.1527	7.35	0.395	2.6194	2.1806	2.1806
	20	7.20	0.542	3.5941	1.2058	1.2058	7.40	0.386	2.5596	2.2403	2.2403
	25	7.22	0.534	3.5411	1.2588	1.2588	7.42	0.378	2.5066	2.2933	2.2933
	30	7.30	0.524	3.4748	1.3252	1.3252	7.45	0.370	2.4535	2.3464	2.3464

* *Amount of Adsorbent = 0.2 g, Amount of Adsorbate = 20 Cm^3, Particle Size= 150-180 µm, Initial Concentration of AO-10 (D_o) = 4.8× 10^{-5}mol.dm^{-3}, pH of D_o Before Adsorption = 6.20*


400 °C regenerated carbon
Dφ (mol. g-1 × 10-6)
Time (s)
•10 °C
▪45 °C


500 °C regenerated carbon
Dφ (mol. g-1 × 10-6)
Time (s)
•10 °C
▪45 °C


600 °C regenerated carbon
Dφ (mol. g-1 × 10-6)
Time (s)
•10 °C
▪45 °C

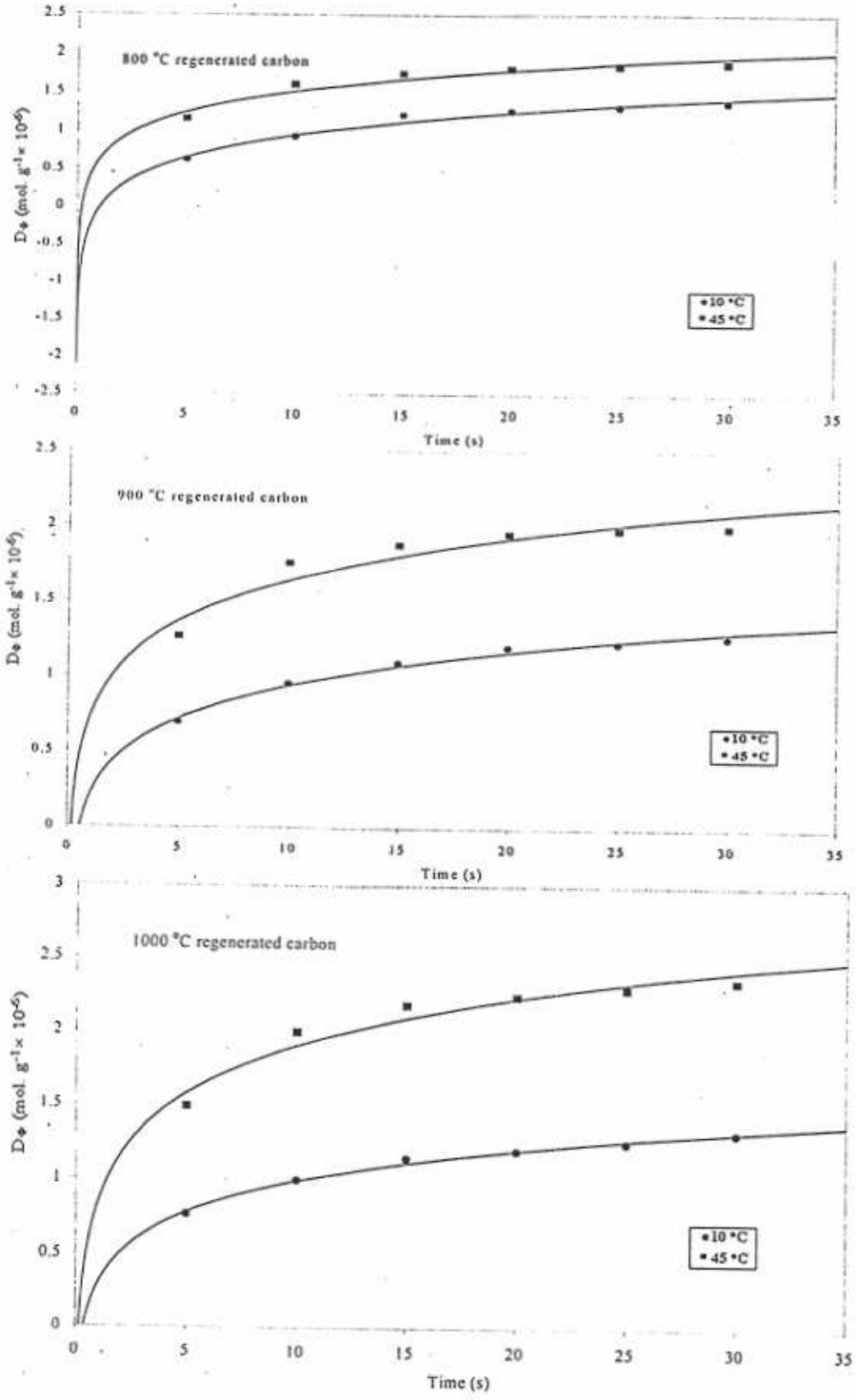


Figure 4.56 Adsorption kinetics of acid orange 10 on regenerated (RG) carbon samples

Table 4.48 Thermodynamic parameters for the adsorption of dyes on *Paulownia tomentosa* (PT) carbon

Dye	Sample	k_{ad} (s^{-1})		ΔE_a ($kJ.mol^{-1}$)	$\Delta H^{\#}$ ($kJ.mol^{-1}$)		$\Delta S^{\#}$ ($J.mol^{-1}K^{-1}$)	
		10 °C	45 °C		10 °C	45 °C	10 °C	45 °C
ACID BLUE 1	Raw	0.00850	0.00900	0.1470000	-2.2059000	-2.496900	-291.9098	-292.461
	400°C	0.01090	0.01140	0.1153000	-2.565900	-2.528500	-289.954	-290.595
	800°C	0.02600	0.02680	0.0780000	-2.2749000	-2.565900	-282.8583	-283.606
BRILLIANT BLUE R	Raw	0.00940	0.01370	8.05257860	5.6997180	5.4087260	-263.1379	-265.0718
	400°C	0.01280	0.01680	5.81324174	3.4603810	3.1693890	-268.4839	-270.4178
	800°C	0.01450	0.01700	3.40039307	1.0475330	0.7565410	-275.9732	-277.9071
ACID YELLOW 29	Raw	0.01190	0.01240	21.3774200	19.024561	18.733569	-214.0929	-223.9988
	400°C	0.03540	0.08230	18.0352600	15.682400	15.391408	-216.8390	-218.7729
	800°C	0.06350	0.12220	13.9940000	11.641210	11.350218	-226.2600	-228.1947
ACID YELLOW 34	Raw	0.00540	0.01520	22.12341845	19.7705584	19.4795664	-218.02622	-218.99570
	400°C	0.01170	0.02080	12.29980201	9.94694201	9.65595001	-246.31032	-247.27980
	800°C	0.02630	0.04510	11.77437841	9.42151841	9.13052641	-241.43277	-242.49762
ACID ORANGE 7	RAW	0.00360	0.00440	4.289822100	1.93696210	1.6459701	-284.41349	-285.38295
	400°C	0.00470	0.00520	2.161174332	-0.1916856	-0.4826776	-289.71847	-290.68793
	800°C	0.00570	0.00630	2.139526308	-0.2133337	-0.5043256	-288.19116	-289.16062
ACID ORANGE 10	Raw	0.00490	0.00640	5.709113807	3.35625381	3.06526181	-276.83511	-277.80459
	400°C	0.00580	0.00720	4.622292593	2.26943259	1.97844059	-279.27354	-280.24300
	800°C	0.00709	0.00870	4.374626111	2.02176611	1.73077411	-278.47901	-279.44847

Table 4.49 Thermodynamic parameters for the adsorption of dyes on *Populus caspica* (PC) carbon

Dye	Sample	k_{ad} (s^{-1})		ΔE_a ($kJ.mol^{-1}$)	$\Delta H^{\#}$ ($kJ.mol^{-1}$)		$\Delta S^{\#}$ ($J.mol^{-1}K^{-1}$)	
		10 °C	45 °C		10 °C	45 °C	10 °C	45 °C
ACID BLUE 1	Raw	0.00420	0.00800	1.65680000	-0.696010	-0.986980	-292.4350	-288.6920
	400°C	0.01680	0.01810	0.19160000	-2.161210	-2.452200	-286.0870	-286.5120
	800°C	0.01860	0.01950	0.12151000	-2.2314000	-2.522350	-285.4890	-286.1130
BRILLIANT BLUE R	Raw	0.00530	0.00990	39.9310000	37.578140	37.287140	-155.2570	-167.5259
	400°C	0.01450	0.01530	22.5560000	20.203140	19.912150	-207.8390	-217.5810
	800°C	0.00780	0.01050	20.7770000	18.424140	18.133150	-219.72660	-226.3052
ACID YELLOW 29	Raw	0.01020	0.01230	4.00210000	1.6492400	1.3582480	-276.77150	-278.7050
	400°C	0.01210	0.01440	3.72015700	1.3672970	1.0763050	-276.34760	-278.28150
	800°C	0.01450	0.01680	3.14740200	0.7945420	0.5035500	-274.40920	-278.80100
ACID YELLOW 34	Raw	0.00840	0.01380	10.61254071	8.25968071	7.96868871	-255.02728	-255.99676
	400°C	0.01670	0.02630	9.708774583	7.35591458	7.06492258	-252.50761	-253.47709
	800°C	0.01870	0.02630	7.290671696	4.93781169	4.64681969	-260.11172	-261.08119
ACID ORANGE 7	RAW	0.00180	0.00420	18.11304375	1.57601838	15.4691918	-241.33097	-242.30047
	400°C	0.00450	0.00730	10.34233149	7.98947149	7.69847949	-261.17131	-262.14078
	800°C	0.00630	0.00790	7.385934362	5.03307436	4.74208236	-268.82052	-270.78084
ACID ORANGE 10	Raw	0.00690	0.00790	2.893249080	0.54038908	0.24939708	-283.93940	-284.90886
	400°C	0.00750	0.00830	2.166655020	-0.1862049	-0.4771969	-285.81364	-286.78309
	800°C	0.01160	0.01270	1.936728045	-0.4161319	-0.7071239	-283.00035	-283.96980

Table 4.50 Thermodynamic parameters for the adsorption of dyes on *Corncobs* (CC) carbon samples

Dye	Sample	k_{ad} (s^{-1})		ΔE_a ($kJ.mol^{-1}$)	ΔH^o ($kJ.mol^{-1}$)		ΔS^o ($J.mol^{-1}K^{-1}$)	
		10 °C	45 °C		10 °C	45 °C	10 °C	45 °C
ACID BLUE 1	Raw	0.00330	0.01130	3.41011000	-2.349450	-2.640442	-300.2832	-291.0205
	400°C	0.01060	0.01190	0.29746500	-2.3525625	-2.643555	-290.5924	-290.6001
	800°C	0.03110	0.03400	0.22924300	-2.352631	-2.643623	-281.6438	-281.8721
BRILLIANT BLUE R	Raw	0.00620	0.01200	14.1167400	11.763880	11.472888	-245.1699	-247.1030
	400°C	0.00850	0.01270	8.58380000	6.2309400	5.939948	-262.0980	-264.0320
	800°C	0.00890	0.01300	8.09986000	5.7470000	5.456008	-263.4250	-265.3590
ACID YELLOW 29	Raw	0.00800	0.01790	17.21650200	14.863640	14.572650	-232.0970	-234.0310
	400°C	0.02600	0.05750	16.96701000	14.614150	14.323160	-223.1790	-225.1130
	800°C	0.03190	0.06650	15.70376700	13.350910	13.059920	-225.9430	-227.8769
ACID YELLOW 34	Raw	0.00580	0.01520	20.595.81003	18.2429500	17.9519580	-222.82998	-223.79945
	400°C	0.01530	0.03430	17257.83284	14.9049728	14.6139808	-226.56041	-227.52992
	800°C	0.02660	0.04210	9.815155157	7.46229516	7.17130316	-248.26152	-249.23099
ACID ORANGE 7	RAW	0.00420	0.00580	6.900062952	4.54720295	4.25621095	-273.90842	-274.87788
	400°C	0.00550	0.00730	6.052509395	3.69964939	3.40865739	-274.66132	-275.63078
	800°C	0.01810	0.02160	3.779130050	1.42627005	1.13527805	-272.79113	-273.76059
ACID ORANGE 10	Raw	0.00280	0.00640	17.672.25655	15.3193966	15.0284045	-239.21513	-240.18463
	400°C	0.00700	0.00870	4.647726768	2.29486677	2.00387477	-277.62020	-278.58966
	800°C	0.01810	0.02090	3.074868937	0.72200893	0.43101693	-275.27969	-276.24915

Table 4.51Thermodynamic parameters for the adsorption of dyes on *Ailanthus altissima* (AA) carbon

Dye	Sample	k_{ad} (s^{-1})		ΔE_a ($kJ.mol^{-1}$)	ΔH^o ($kJ.mol^{-1}$)		ΔS^o ($J.mol^{-1}K^{-1}$)	
		10 °C	45 °C		10 °C	45 °C	10 °C	45 °C
ACID BLUE 1	Raw	0.00700	0.00950	0.78524000	-1.567620	-1.858600	-291.26900	-290.00400
	400°C	0.00710	0.00790	0.27450000	-2.078360	-2.369350	-285.61130	-293.14400
	800°C	0.01310	0.01450	0.26110000	-2.091750	-2.382750	-287.91010	-288.13700
BRILLIANT BLUE R	Raw	0.00220	0.01460	40.4581000	38.10524	35.461388	-160.7073	-169.07130
	400°C	0.00820	0.01400	11.4353000	9.082440	8.7914480	-252.3200	-253.29000
	800°C	0.01140	0.01710	8.66780000	6.314940	6.0239480	-259.3600	-260.32900
ACID YELLOW 29	Raw	0.00640	0.00920	7.75800376	5.40514376	5.11415176	-267.37485	-268.34433
	400°C	0.01200	0.01800	8.66779864	6.31493864	6.02394664	-258.93377	-259.90325
	800°C	0.01750	0.02590	8.38084907	6.02799707	5.73699707	-256.81088	-257.78036
ACID YELLOW 34	Raw	0.00410	0.01090	20.90232603	18.5494660	18.2584740	-224.63076	-225.60026
	400°C	0.01520	0.03480	17.70738790	15.3545279	15.0635359	-225.02640	-225.99589
	800°C	0.01830	0.03960	16.50183170	14.1489717	13.8579797	-227.74319	-228.71269
ACID ORANGE 7	RAW	0.00440	0.00580	5.905584956	3.55272495	3.26173296	-277.03571	-278.00517
	400°C	0.00400	0.00490	4.338352022	1.98549202	1.69450002	-283.36604	-284.33551
	800°C	0.00490	0.00560	2.854556903	0.50169690	0.21070490	-286.92189	-287.89135
ACID ORANGE 10	Raw	0.00380	0.01510	2.949429369	27.1414337	26.8504417	-194.90217	-195.87169
	400°C	0.02060	0.02340	2.724444379	0.37158437	0.08059237	-275.44228	-276.41174
	800°C	0.02950	0.03340	2.654341187	0.30148118	0.01048918	-272.70445	-273.67391

Table 4.52 Thermodynamic parameters for the adsorption of dyes on *Salvadora oleoides* (SO) carbon samples

Dye	Sample	k_{ad} (s^{-1})		ΔE ($kJ.mol^{-1}$)	$\Delta H^{\#}$ ($kJ.mol^{-1}$)		$\Delta S^{\#}$ ($J.mol^{-1}K^{-1}$)	
		10 °C	45 °C		10 °C	45 °C	10 °C	45 °C
ACID BLUE 1	Raw	0.01210	0.01350	2340.49060	-12.369400	-303.36140	-281.22277	-282.19223
	400°C	0.01290	0.01390	1596.07090	-756.88910	-1047.7811	-283.13030	-284.29041
	600°C	0.01390	0.01490	1485.14020	-867.71980	-1158.7118	-283.09220	-284.06166
	800°C	0.01520	0.01600	1096.51830	-1256.3417	-1547.3337	-283.72210	-284.69155
	900°C	0.01580	0.01650	926.720650	-1426.1394	-1717.1314	-284.00022	-284.96967
	1000°C	0.01620	0.01680	777.446460	-1575.4136	-1866.4056	-284.31983	-285.28928
BRILLIANT BLUE R	Raw	0.00230	0.00730	24.6901780	6.2958220	3.942962	3.651970	-285.3664
	400°C	0.00980	0.01230	4.85731100	2.504451	2.213459	-282.9085	-282.9696
	600°C	0.01100	0.01320	3.89756480	1.544704	1.253713	-281.9660	-282.3856
	800°C	0.01290	0.01540	3.78680000	1.433940	1.142948	-280.6417	-281.1043
	900°C	0.01400	0.01620	3.12011830	0.767258	0.476266	-279.9637	-280.6853
	1000°C	0.01470	0.01700	3.10754700	0.754687	0.463695	-279.5581	-280.2846
ACID YELLOW 39	Raw	0.00102	0.00100	40.0103450	29.635399	27.282539	26991.547	-205.5027
	400°C	0.00320	0.00830	20.3921000	18.022061	17.731069	-228.5548	-230.48882
	600°C	0.00550	0.01240	17.3787400	15.025880	14.734888	-234.63927	-236.57326
	800°C	0.00770	0.01570	15.23013800	12.877278	12.586286	-239.43409	-241.36805
	900°C	0.00890	0.01780	14.81769900	12.464839	12.173847	-239.68734	-241.62125
	1000°C	0.01020	0.01980	14.17952020	11.826660	11.535668	-240.80889	-242.74280
ACID YELLOW 34	Raw	0.00540	0.01520	22.12341845	19.7705584	17.1267065	-218.02616	-226.39466
	400°C	0.00700	0.01870	21.00574058	18.6528806	18.3618886	-181.48804	-220.78749
	600°C	0.01410	0.02930	15.63571819	13.2828582	12.9918662	-232.97134	-233.94083
	800°C	0.02560	0.05310	15.59663723	13.2437772	12.9527852	-228.15082	-229.12032
	900°C	0.02460	0.04470	12.76717474	10.4143147	10.1233227	-238.48026	-239.44969
	1000°C	0.02730	0.04870	12.37308772	10.0202277	9.72923572	-239.00695	-239.97641
ACID ORANGE 7	Raw	0.00100	0.00810	44.71866039	42.3658004	42074.8084	-152.20486	-153.17453
	400°C	0.00130	0.00930	42.06328690	39.7104269	39.4194349	-159.40664	-160.37627
	600°C	0.00230	0.01040	32.25632085	29.9034608	29.6124688	-189.31674	-190.28629
	800°C	0.00310	0.01600	35.08433843	32.7314784	32.4404864	-176.84206	-177.81162
	900°C	0.00450	0.01810	29.75383407	27.4009741	27.1099821	-192.57936	-193.54890
	1000°C	0.00640	0.01900	23.26164889	20.9087889	20.6177968	-212.59160	-213.56114
ACID ORANGE 10	Raw	0.00180	0.00320	12.29980201	9.94694201	9.65595001	-261.87253	-262.84196
	400°C	0.00200	0.00340	11.34346394	8.99060394	8.69961194	-264.37580	-265.34528
	600°C	0.00218	0.00360	10.72310650	8.3702465	8.0792545	-265.85140	-266.82088
	800°C	0.00579	0.00870	8.704688076	6.35182807	6.06083607	-267.86245	-268.83192
	900°C	0.01050	0.01340	5.213513866	2.86065386	2.56966186	-272.24992	-273.21938
	1000°C	0.01650	0.02060	4.744306075	2.39144608	2.10045407	-270.15009	-271.11955

Table 4.53 Thermodynamic parameters for the adsorption of dyes on animal bones charcoal (ABC) samples

Dye	Sample	k_{ad} (s^{-1})		ΔE ($kJ.mol^{-1}$)	ΔH° ($kJ.mol^{-1}$)		ΔS° ($J.mol^{-1}.K^{-1}$)	
		10 °C	45 °C		10 °C	45 °C	10 °C	45 °C
ACID BLUE 1	600°C	0.04130	0.04310	0.10969000	-2.24320	-2.53420	-278.890	-279.550
	800°C	0.09060	0.09650	0.16222000	-2.19060	-2.48160	-272.180	-272.690
	900°C	0.09380	0.10380	0.26045000	-2.09240	-2.38240	-271.540	-271.770
	1000°C	0.12730	0.14550	0.43610000	-1.91680	-2.20580	-268.390	-268.410
BRILLIANT BLUE R	600°C	0.00060	0.00120	14.8176900	12.46483	12.173840	-262.109	-264.043
	800°C	0.00400	0.00520	5.60867100	3.255811	2.9648190	-278.877	-280.811
	900°C	0.00550	0.00670	4.21903000	1.866170	1.5751780	-281.140	-283.073
	1000°C	0.00640	0.00770	3.95316000	1.600300	1.3093080	-280.819	-282.753
ACID YELLOW 29	600°C	0.01080	0.02090	14.1134385	11.7605785	11.4695865	-240.56718	-241.53667
	800°C	0.01490	0.02480	10.8914210	8.538.561	8.247.569	-249.27687	-250.24629
	900°C	0.01600	0.02500	9.54046764	6.89661564	6.89661564	-253.45835	-254.42780
	1000°C	0.01740	0.02670	9.15367005	6.80081005	6.50981805	-254.12776	-255.09721
ACID -YELLOW 34	600°C	0.00660	0.00850	5.40841000	3.0555500	2.7645580	-275.421	-277.355
	800°C	0.01880	0.02900	0.92658000	-1.4262800	-1.7172720	-282.555	-281.245
	1000°C	0.03800	0.05370	0.73928000	-1.6135800	-1.9045720	-277.366	-276.7125
ACID ORANGE 7	600°C	0.02480	0.03560	7.727980408	5.3751204	5.08412840	-256.21929	-257.18868
	800°C	0.03490	0.03900	2.324493212	-0.0283667	-0.2693587	-272.47243	-273.26521
	900°C	0.04520	0.04900	1.725654136	-0.6272058	-0.9181978	-272.43837	-273.40784
	1000°C	0.05450	0.05700	0.958789470	-1.3940705	-1.6850625	-273.59257	-274.56203
ACID ORANGE 10	600°C	0.00640	0.00850	6.066231930	3.71337193	3.42237993	-273.35291	-274.32231
	800°C	0.03200	0.03630	2.695304642	0.34244464	0.05145264	-271.88339	-272.85285
	900°C	0.06250	0.06640	1.293986024	-1.0588739	-1.3498659	-262.95540	-272.23886
	1000°C	0.11450	0.11690	0.443454210	-1.9094057	-2.2003977	-269.24145	-270.21090

Table 4.54 Thermodynamic parameters for the adsorption of dyes on regenerated (RG) carbon samples

Dye	Sample	k_{ad} (s^{-1})		ΔE ($kJ.mol^{-1}$)	$\Delta H^{\#}$ ($kJ.mol^{-1}$)		$\Delta S^{\#}$ ($J.mol^{-1}.K^{-1}$)	
		10 °C	45 °C		10 °C	45 °C	10 °C	45 °C
ACID BLUE 1	400°C	0.01000	0.01500	8.667798000	6.3149380	6.0239460	-31.3266	-31.5592
	600°C	0.01900	0.02400	4.994080000	2.6412200	2.3502280	-32.2461	-32.4788
	800°C	0.02610	0.03150	4.020071000	1.6672110	1.3762190	-32.3426	-32.5752
	900°C	0.02890	0.03390	3.411268000	1.0584080	0.7674160	-32.4995	-32.7320
	1000°C	0.03300	0.03650	2.154940000	0.5020800	0.2110880	-32.6032	-32.8686
BRILLIANT BLUE R	400°C	0.00130	0.00250	13.97926192	11.6264019	11.3354099	-258.64356	-259.61304
	600°C	0.00280	0.00400	7.624790722	5.27193072	4.98093872	-274.02348	-275.68804
	800°C	0.00390	0.00530	6.557102306	4.20424230	3.91325030	-275.73646	-276.70590
	900°C	0.00406	0.00540	6.097182308	3.74432230	3.45333030	-277.02732	-277.99680
	1000°C	0.00510	0.00620	4.175197579	1.53134557	1.53134557	-281.92271	-282.89217
ACID YELLOW 29	400°C	0.01040	0.03250	24.35816728	22.0053072	21.7143152	-204.68045	-205.64998
	600°C	0.02770	0.06490	18.20106208	15.8482020	15.5572100	-219.26185	-219.26192
	800°C	0.02880	0.05140	12.38314489	10.0302848	9.73929289	-238.52666	-239.49618
	900°C	0.03750	0.06470	11.65967913	9.30681913	9.01582713	-238.88849	-239.85797
	1000°C	0.04560	0.075580	10.80166880	8.44880880	8.1578168	-240.29445	-241.26386
ACID YELLOW 34	400°C	0.00240	0.00260	1.711106724	-0.6417532	-0.9327452	-296.89660	-297.86607
	600°C	0.02510	0.02640	1.079477797	-1.2733822	-1.5643742	-279.61224	-280.58169
	800°C	0.02570	0.02690	0.975564943	-1.3772950	-1.6682870	-270.04947	-280.75247
	900°C	0.02690	0.02760	0.549174980	-1.8036850	-2.0946770	-280.91029	-281.87973
	1000°C	0.02840	0.02900	0.446931019	-1.9059289	-2.1969209	-280.82042	-281.78987
ACID ORANGE 7	400°C	0.00180	0.00560	24.26294476	21.9100847	21.6190927	-219.59986	-220.56937
	600°C	0.00330	0.00600	12.78021373	10.4273537	7.78350173	-255.13550	-263.50392
	800°C	0.00720	0.00980	6.590688207	4.23782820	3.94683620	-270.52039	-271.48986
	900°C	0.00680	0.00960	4.994083212	2.64122321	2.35023121	-276.63732	-276.68208
	1000°C	0.00860	0.01020	3.647533647	1.29467364	1.00368164	-279.44300	-280.41246
ACID ORANGE 10	400°C	0.00190	0.00510	21.10778097	18.7549209	18.4639289	-230.29934	-231.26887
	600°C	0.00530	0.00690	5.639675790	3.28681579	2.99582379	-276.42806	-277.39753
	800°C	0.01510	0.01770	3.396228773	1.04336877	0.75237677	-275.65078	-276.62024
	900°C	0.01610	0.01810	2.703139316	0.35027931	0.59287316	-277.56673	-278.61397
	1000°C	0.01750	0.01930	2.092939699	-0.2599203	-0.5509123	-279.02968	-279.99914

Table 4.55 Bangham constants for the adsorption of dyes on carbon samples

Dye	Sample	constants	PT carbon		PC carbon		CC carbon		AA carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid blue 1	Raw	α	0.42310	0.36660	0.35660	0.50010	0.49370	0.26370	0.32730	0.28140
		k_o	0.15300	0.20120	0.12270	0.10540	0.06910	0.07370	0.21900	0.32920
	400 °C	α	0.22840	0.22140	0.34070	0.34070	0.49370	0.26370	0.26740	0.18610
		k_o	0.45920	0.47690	0.33290	0.39870	0.17420	0.41390	0.34160	0.46160
	800 °C	α	0.20920	0.19360	0.30000	0.74990	0.46630	0.29840	0.26340	0.18010
		k_o	0.67200	0.83290	0.25740	0.32050	0.28780	0.57330	0.43120	0.59520
Brilliant blue R	Raw	α	0.56530	0.39990	0.36920	0.38980	0.32540	0.34460	1.23220	0.80430
		k_o	0.09870	0.24760	0.13660	0.19390	0.21710	0.29690	0.00229	0.04920
	400 °C	α	0.43720	0.32800	0.39240	0.30780	0.21390	0.24900	0.24520	0.29610
		k_o	0.20620	0.37390	0.25320	0.41630	0.44460	0.45850	0.37030	0.39250
	800 °C	α	0.17050	0.18680	0.15770	0.17920	0.18440	0.22890	0.20440	0.24520
		k_o	0.61530	0.67320	0.58180	0.62300	0.53490	0.55780	0.54060	0.53230
Acid yellow 29	Raw	α	0.28010	0.13910	0.23610	0.21320	0.25370	0.23930	0.19560	0.20330
		k_o	0.36760	0.68690	0.44770	0.38100	0.38770	0.54040	0.38130	0.47540
	400 °C	α	0.30160	0.47550	0.30800	0.34570	0.23000	0.31300	0.22040	0.15370
		k_o	0.42360	0.40190	0.43380	0.52170	0.69160	0.61840	0.50500	0.86410
	800 °C	α	0.20050	0.29660	0.22910	0.15920	0.16080	0.17130	0.15080	0.16580
		k_o	0.76320	0.75590	0.67840	0.93560	0.98670	1.08660	0.86810	0.92830
Acid yellow 34	Raw	α	0.45560	0.48240	0.65950	0.43400	0.29330	0.38870	0.36870	0.25650
		k_o	0.02860	0.05480	0.01860	0.06760	0.06240	0.07940	0.05710	0.12290
	400 °C	α	0.18740	0.16820	0.30010	0.29150	0.32130	0.28700	0.24730	0.22820
		k_o	0.16670	1.26490	0.12010	0.16500	0.11030	0.17380	0.14560	0.15350
	800 °C	α	0.18970	0.21310	0.29290	0.24110	0.38180	0.18140	0.18160	0.15730
		k_o	0.24960	0.29260	0.13130	0.20350	0.10840	0.24480	0.18470	0.25160
Acid orange 7	Raw	α	0.28340	0.24990	0.70070	0.34470	0.88670	0.38920	1.22250	0.83350
		k_o	0.15500	0.20720	0.04150	0.17040	0.01930	0.12640	0.00508	0.02490
	400 °C	α	0.26850	0.21080	0.22150	0.25830	0.18880	0.15390	0.23360	0.15990
		k_o	0.28180	0.36670	0.24740	0.29470	0.36410	0.38220	0.24260	0.34570
	800 °C	α	0.17270	0.14840	0.19000	0.13670	0.08470	0.02640	0.15410	0.11680
		k_o	0.70950	0.95030	0.39470	0.51850	0.79170	0.67960	0.47140	0.55370
Acid orange 10	Raw	α	1.00430	0.80340	0.87620	0.44130	1.38000	0.89280	0.88280	0.50080
		k_o	0.00931	0.05950	0.02300	0.11970	0.00264	0.08480	0.10510	0.16330
	400 °C	α	0.49380	0.20540	0.35590	0.26590	0.26350	0.25200	0.43660	0.25100
		k_o	0.38290	0.41450	0.19630	0.31510	0.28330	0.36190	0.24380	0.47110
	800 °C	α	0.17070	0.11740	0.19380	0.10850	0.24630	0.17180	0.38620	0.14650
		k_o	0.62680	1.12220	0.50690	0.55480	0.47160	0.68210	0.35890	0.46230

Table 4.56 Bangham constants for the adsorption of dyes on carbon samples

Dye	Sample	constants	SO carbon		AB charcoal		RG. carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid blue 1	Raw	α	0.23950	0.18730	xxxx	xxxx	xxxx	xxxx
		k_o	0.46360	0.55750	xxxx	xxxx	xxxx	xxxx
	400 °C	α	0.20200	0.19740	xxxx	xxxx	0.35160	0.30960
		k_o	0.58170	0.70350	xxxx	xxxx	0.31810	0.35690
	600 °C	α	0.17670	0.16160	0.2260	0.18960	0.32890	0.32170
		k_o	0.91620	0.99600	0.81020	1.04660	0.46910	0.57830
	800 °C	α	0.12240	0.10170	0.1910	0.12040	0.28150	0.24360
		k_o	1.26470	1.41540	1.00340	1.13570	0.60470	0.79450
	900 °C	α	0.09410	0.08480	0.08420	0.07740	0.3150	0.23020
		k_o	1.44900	1.52820	1.03960	1.33160	0.53520	0.84080
	1000 °C	α	0.07260	0.07350	0.0780	0.07030	0.21080	0.16480
		k_o	1.52710	1.57250	1.56380	1.61060	0.78790	1.03410
Brilliant blue R	Raw	α	0.52490	0.36260	xxxx	xxxx	xxxx	xxxx
		k_o	0.17880	0.36940	xxxx	xxxx	xxxx	xxxx
	400 °C	α	0.26850	0.26080	xxxx	xxxx	1.05150	1.13230
		k_o	0.44590	0.53820	xxxx	xxxx	0.02170	0.02620
	600 °C	α	0.22990	0.19870	0.98240	0.26380	0.44410	0.44500
		k_o	0.52610	0.70410	0.04160	0.50540	0.16500	0.22600
	800 °C	α	0.23320	0.20750	0.76890	0.24220	0.53810	0.42060
		k_o	0.55920	0.80220	0.09080	0.62480	0.12890	0.27610
	900 °C	α	0.21700	0.20420	0.59890	0.21970	0.72020	0.38580
		k_o	0.63570	0.88000	0.16080	0.72640	0.09330	0.32010
	1000 °C	α	0.26230	0.29160	0.48360	0.35840	0.51130	0.38820
		k_o	0.51970	0.63370	0.23810	0.50460	0.09770	0.20870
Acid yellow 29	Raw	α	1.01270	0.45130	xxxx	xxxx	xxxx	xxxx
		k_o	0.00384	0.04750	xxxx	xxxx	xxxx	xxxx
	400 °C	α	0.72140	0.40840	xxxx	xxxx	0.98300	0.25860
		k_o	0.04770	0.13180	xxxx	xxxx	0.02430	0.65370
	600 °C	α	0.76730	0.44360	0.54770	0.28890	0.57440	0.43080
		k_o	0.03450	0.16420	1.16670	4.25390	0.18820	0.43540
	800 °C	α	0.29980	0.37730	0.40800	0.31920	0.36810	0.30440
		k_o	0.24030	0.22270	2.44110	5.27220	0.46010	0.65780
	900 °C	α	0.24880	0.22420	0.34260	0.26440	0.21010	0.27070
		k_o	0.33110	0.40160	3.04360	6.30220	0.78410	0.76610
	1000 °C	α	0.30980	0.35860	0.27560	0.24500	0.21530	0.24100
		k_o	0.35990	0.35720	3.92540	7.10380	0.86590	0.89220

Table 4.57 Bangham constants for the adsorption of dyes on carbon samples

Dye	Sample	constants	SO carbon		AB charcoal		RG. carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid yellow 34	Raw	α	0.77560	0.68350	xxxx	xxxx	xxxx	xxxx
		k_o	0.01230	0.02030	xxxx	xxxx	xxxx	xxxx
	400 °C	α	0.76830	0.67340	xxxx	xxxx	0.55720	0.54480
		k_o	0.01070	0.07590	xxxx	xxxx	0.11060	0.11680
	600 °C	α	0.48020	0.29210	0.57590	0.36640	0.36920	0.34310
		k_o	0.21420	0.56220	0.14160	0.33070	0.24510	0.23660
	800 °C	α	0.25730	0.21250	0.29310	0.22430	0.25390	0.19670
		k_o	0.62710	0.62340	0.52790	0.78900	0.52190	0.68890
	900 °C	α	0.17380	0.14570	0.22430	0.14170	0.18720	0.11790
		k_o	0.90480	1.14100	0.78750	0.77940	0.81200	0.77740
	1000 °C	α	0.12320	0.10270	0.11180	0.10950	0.04990	0.04324
		k_o	1.03940	0.96470	0.81280	0.77870	0.15400	0.23120
Acid orange 7	Raw	α	2.60230	1.12410	xxxx	xxxx	xxxx	xxxx
		k_o	0.00005	0.00074	xxxx	xxxx	xxxx	xxxx
	400 °C	α	0.49720	0.35070	xxxx	xxxx	0.29440	0.19340
		k_o	0.09580	0.42640	xxxx	xxxx	0.27750	0.48220
	600 °C	α	0.26620	0.21390	0.48980	0.32610	0.17760	0.11330
		k_o	0.21260	0.44710	0.38050	0.45110	0.45500	0.69990
	800 °C	α	0.19650	0.19180	0.24730	0.18760	0.16320	0.14210
		k_o	0.47350	0.76270	0.70790	0.96400	0.52190	0.50220
	900 °C	α	0.19010	0.1580	0.14190	0.10160	0.12670	0.11180
		k_o	0.62440	0.87550	0.48920	1.04880	0.52370	0.50370
	1000 °C	α	0.18570	0.12160	0.10730	0.06470	0.10640	0.05270
		k_o	0.66580	1.12170	0.97270	1.14760	0.51400	0.52620
Acid orange 10	Raw	α	0.92050	0.48790	xxxx	xxxx	xxxx	xxxx
		k_o	0.00669	0.03400	xxxx	xxxx	xxxx	xxxx
	400 °C	α	0.42620	0.35030	xxxx	xxxx	0.70370	0.60780
		k_o	0.01080	0.07630	xxxx	xxxx	0.01420	0.04200
	600 °C	α	0.36270	0.22760	0.42170	0.37360	0.46360	0.28110
		k_o	0.12640	0.21050	0.11590	0.19820	0.07310	0.20800
	800 °C	α	0.19200	0.16770	0.24370	0.23910	0.43330	0.25480
		k_o	0.41480	0.41550	0.53450	0.63540	0.13840	0.34410
	900 °C	α	0.18350	0.13030	0.15590	0.10910	0.33150	0.24340
		k_o	0.36840	0.60530	0.61260	0.72870	0.17720	0.38400
	1000 °C	α	0.10310	0.21590	0.06410	0.03720	0.29500	0.24120
		k_o	0.53300	0.70300	0.77960	0.88950	0.20640	0.44930

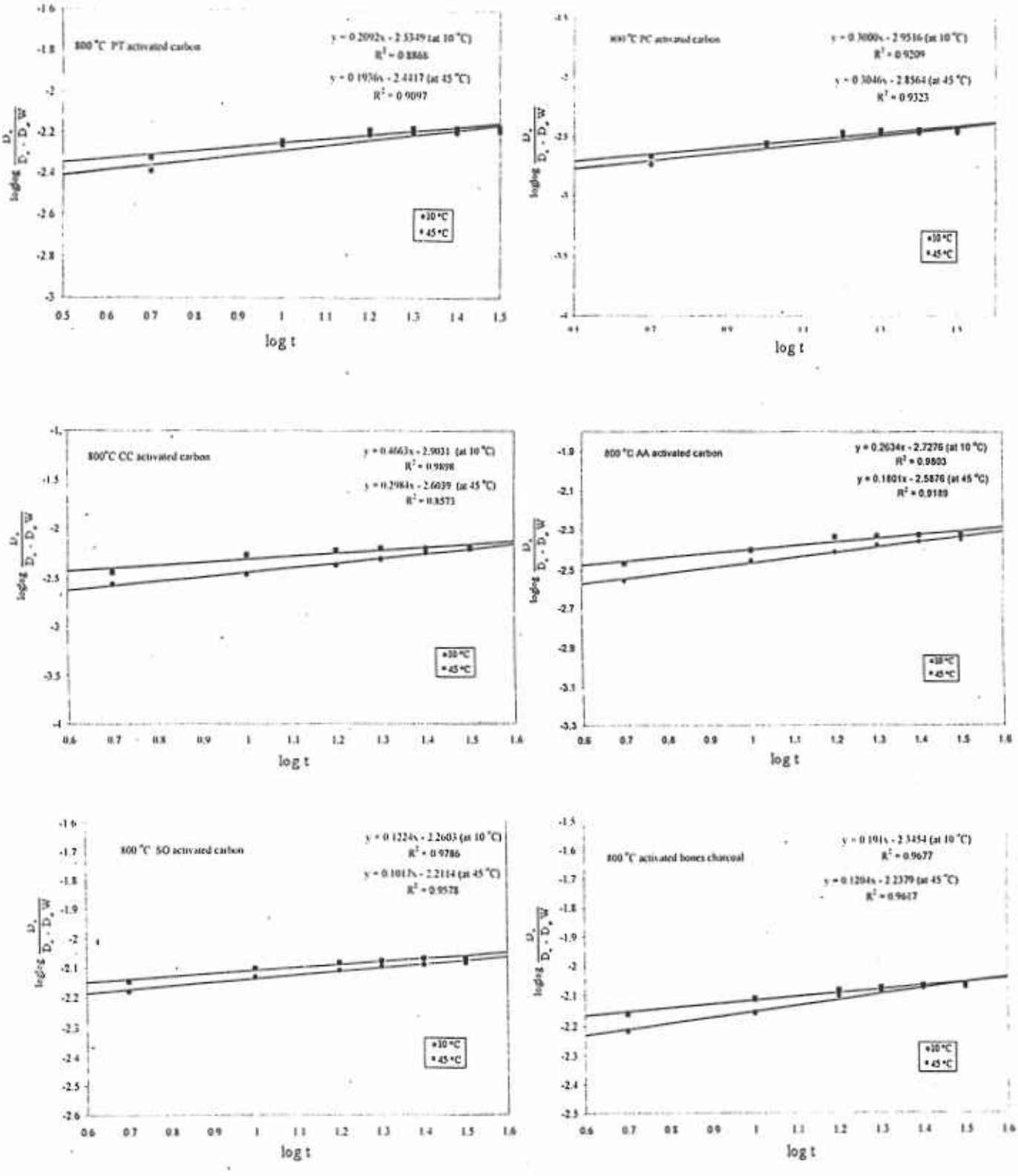


Figure 4.57 Bangham plots for the acid blue 1 adsorption on 800 °C activated carbon samples

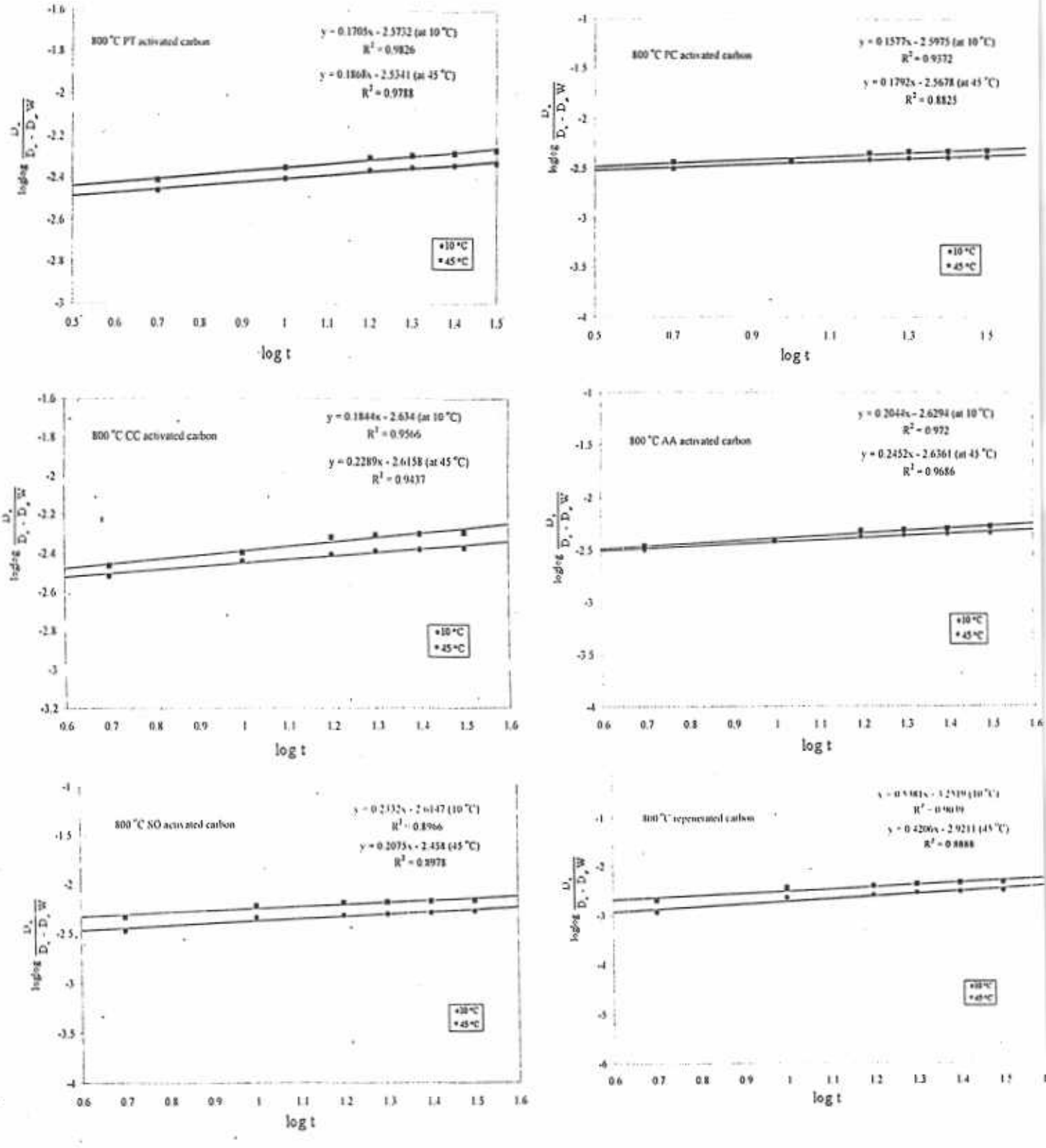


Figure 4.58 Bangham plots for the brilliant blue R adsorption on 800 °C activated carbon samples

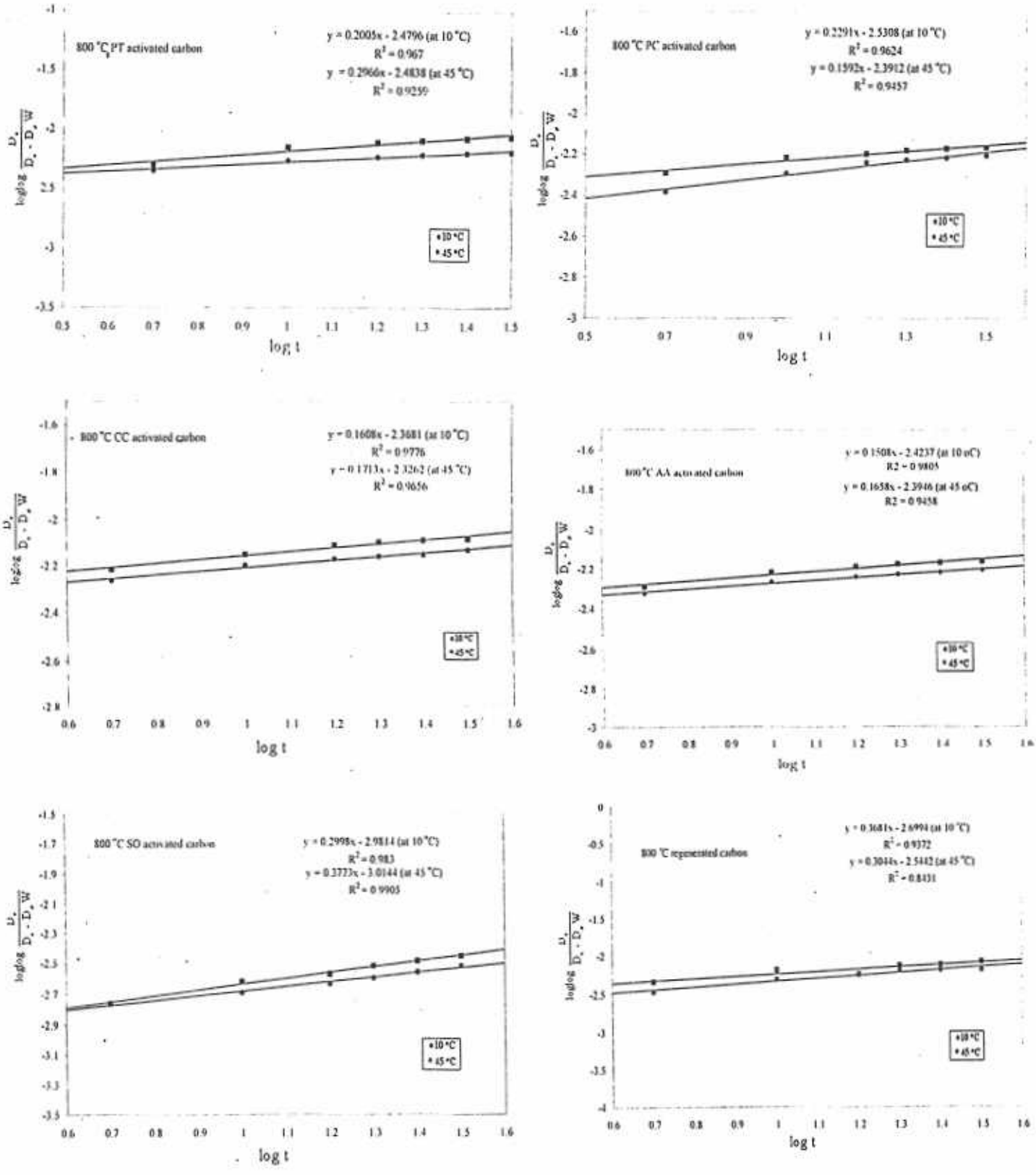


Figure 4.59 Bangham plots for the acid yellow 29 adsorption on 800 °C activated carbon samples

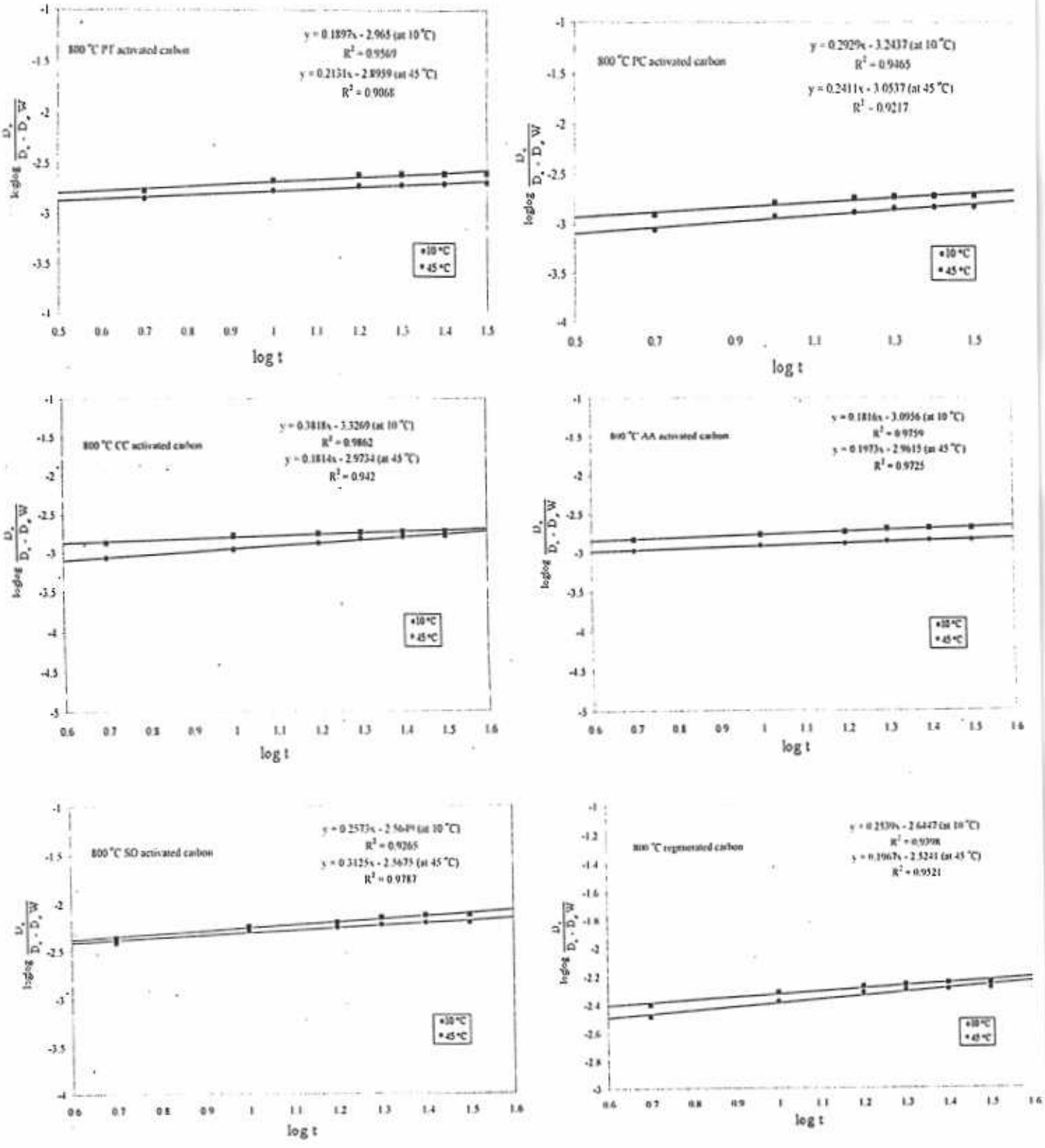


Figure 4.60 Bangham plots for the acid yellow 34 adsorption on 800 °C activated carbon samples

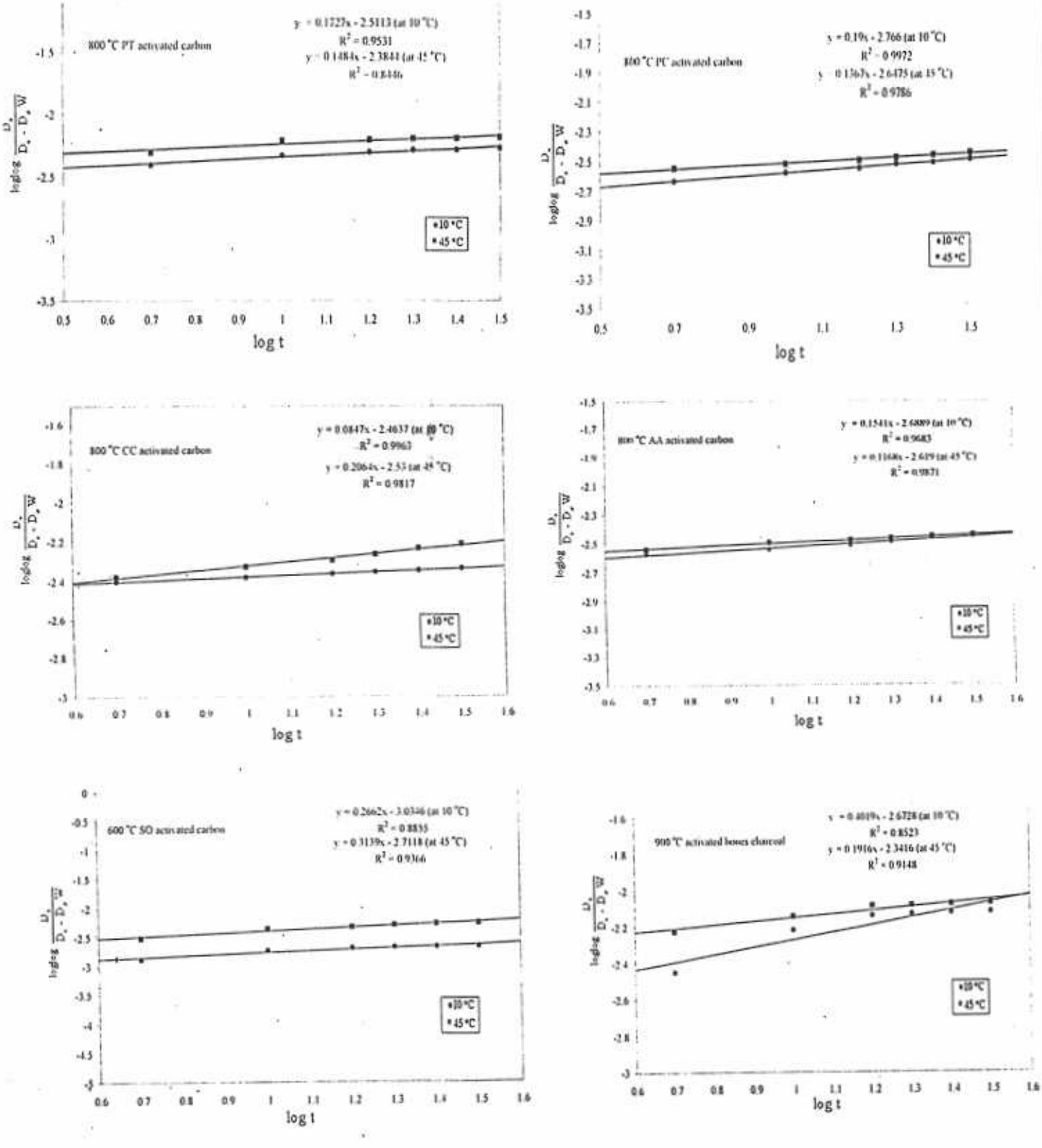


Figure 4.61 Bangham plots for the acid orange 7 adsorption on 800 °C activated carbon samples

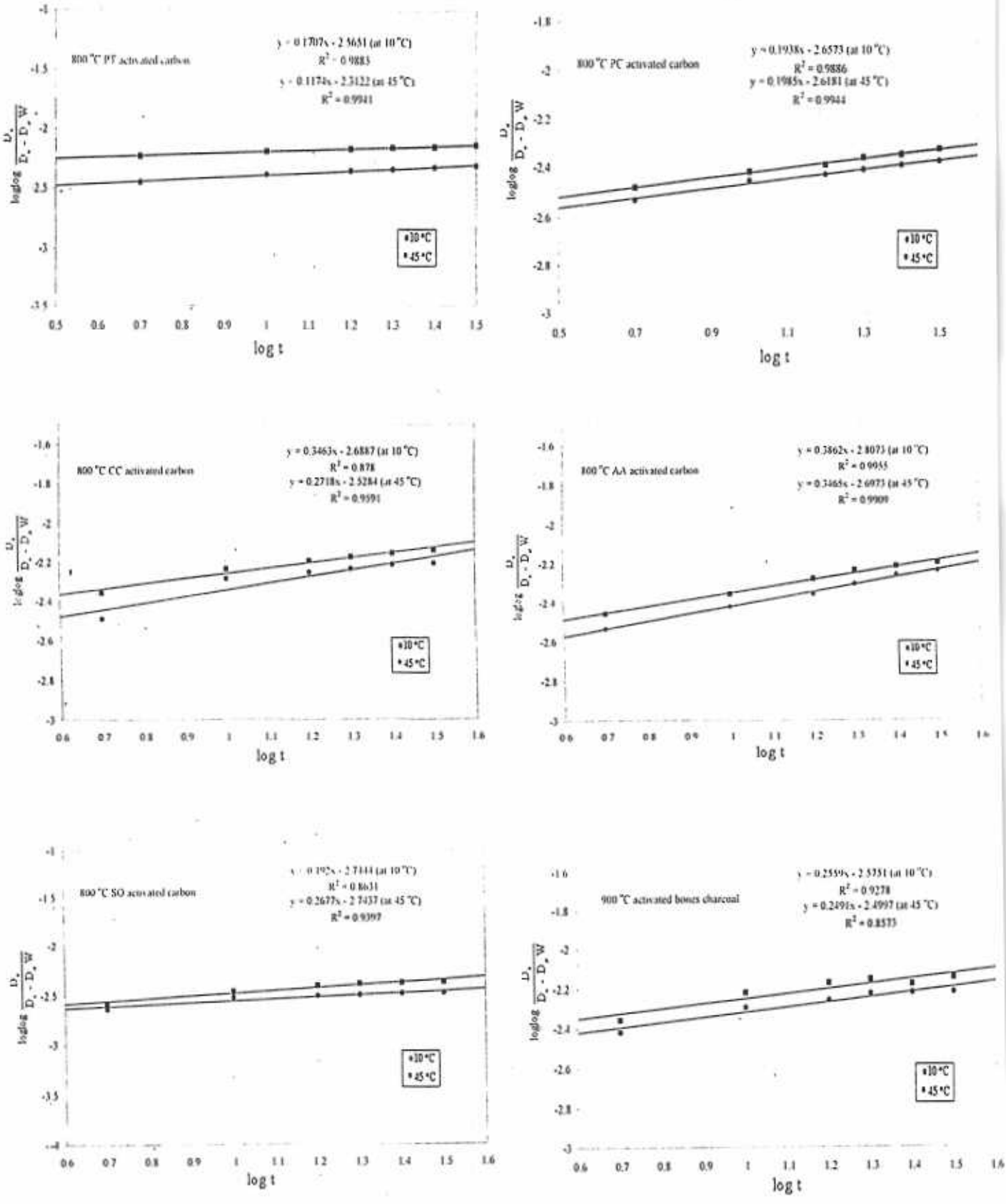


Figure 4.62 Bangham plots for the acid orange 10 adsorption on 800 °C activated carbon samples

able 4.58 Parabolic diffusion constants for the adsorption of dyes on carbon samples

Dye	Sample	Constants	PT carbon		PC carbon		CC carbon		AA carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid blue 1	Raw	B	0.0235	0.0215	0.0129	0.0233	0.0108	0.0315	0.0192	0.0220
		K_{ad}	0.3017	0.3779	0.2119	0.2328	0.1399	0.2013	0.3807	0.5319
	400 °C	B	0.025	0.0245	0.0248	0.0352	0.0332	0.0249	0.0162	0.0167
		K_{ad}	0.6500	0.6707	0.5328	0.6099	0.4187	0.6479	0.5923	0.6282
	800 °C	B	0.0359	0.0304	0.0352	0.0319	0.0523	0.0408	0.0271	0.0285
		K_{ad}	1.0296	1.1538	0.6099	0.6670	0.6000	0.9643	0.6604	0.7824
Brilliant blue R	Raw	B	0.042	0.0483	0.0233	0.0386	0.0361	0.0425	0.0117	0.0592
		K_{ad}	0.3762	0.7269	0.378	0.5383	0.5979	0.8039	0.0236	0.2388
	400 °C	B	0.0477	0.0508	0.0474	0.0456	0.0289	0.0389	0.0297	0.0440
		K_{ad}	0.6508	0.9647	0.7361	1.0902	0.9548	1.0771	0.8427	0.9654
	800 °C	B	0.0298	0.0367	0.0247	0.0288	0.0282	0.0407	0.0336	0.0448
		K_{ad}	1.2196	1.3725	1.1337	1.3102	1.0923	1.2262	1.1367	1.1912
Acid yellow 29	Raw	B	0.0393	0.0261	0.0260	0.0354	0.0342	0.0457	0.0233	0.0298
		K_{ad}	0.8662	1.2680	0.8090	0.9884	0.8837	1.1842	0.7828	0.9951
	400 °C	B	0.0469	0.1099	0.0554	0.0761	0.0517	0.0800	0.0357	0.0346
		K_{ad}	1.0702	1.3529	1.0626	1.3995	1.5205	1.5281	1.0875	1.6787
	800 °C	B	0.0450	0.0829	0.0494	0.0397	0.0426	0.0509	0.0339	0.0416
		K_{ad}	1.5959	1.8683	1.4911	1.8328	1.9349	2.1674	1.6773	1.834
Acid yellow 34	Raw	B	0.0249	0.054	0.0374	0.0501	0.024	0.0511	0.0327	0.0368
		K_{ad}	0.305	0.6048	0.2909	0.7198	0.5041	0.7474	0.5245	0.9414
	400 °C	B	0.0353	0.0213	0.0461	0.0591	0.0478	0.0654	0.0405	0.0708
		K_{ad}	1.0880	1.8765	0.9938	1.3570	0.9461	1.3773	1.1021	1.3187
	800 °C	B	0.0458	0.0618	0.0482	0.0540	0.0684	0.0419	0.033	0.0505
		K_{ad}	1.7172	2.1114	1.0756	1.5247	1.0007	1.6639	1.2466	1.7418
Acid orange 7	Raw	B	0.0165	0.0186	0.0305	0.0254	0.0280	0.0253	0.0270	0.0240
		K_{ad}	0.3720	0.4641	0.1992	0.4536	0.1339	0.3496	0.0474	0.1541
	400 °C	B	0.0265	0.0242	0.0185	0.0276	0.0208	0.0255	0.0199	0.0157
		K_{ad}	0.6627	0.7786	0.5284	0.6707	0.7426	0.7900	0.5267	0.6718
	800 °C	B	0.0344	0.0356	0.0229	0.0194	0.0156	0.0460	0.0208	0.0161
		K_{ad}	1.4183	1.8314	0.8050	0.9660	1.3590	1.4057	0.9022	1.0048
Acid orange 10	Raw	B	0.0162	0.0124	0.0225	0.0196	0.0164	0.0179	0.0202	0.0361
		K_{ad}	0.0314	0.1390	0.0953	0.2479	0.0109	0.1880	0.2371	0.3624
	400 °C	B	0.0147	0.0172	0.0204	0.0195	0.0182	0.0208	0.0404	0.0269
		K_{ad}	0.5287	0.5841	0.3557	0.4931	0.4345	0.5507	0.4877	0.7135
	800 °C	B	0.0202	0.0218	0.0199	0.0229	0.0446	0.0440	0.0473	0.0477
		K_{ad}	0.8292	1.3539	0.6949	0.7629	0.8583	1.0708	0.6538	0.8069

Table 4.59 Parabolic diffusion constants for the adsorption of dyes on carbon samples

Dye	Sample	Constants	SO carbon		AB charcoal		RG carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid blue 1	Raw	B	0.0138	0.0111	xxxx	xxxx	xxxx	xxxx
		K_{ad}	0.3725	0.4164	xxxx	xxxx	xxxx	xxxx
	400 °C	B	0.0166	0.0165	xxxx	xxxx	0.0263	0.0274
		K_{ad}	0.4799	0.5195	xxxx	xxxx	0.4309	0.4777
	600 °C	B	0.0167	0.0157	0.0616	0.0459	0.0362	0.0391
		K_{ad}	0.6723	0.7156	1.8552	2.1604	0.6148	0.7607
	800 °C	B	0.0141	0.0122	0.0609	0.0407	0.0335	0.0340
		K_{ad}	0.8444	0.9150	2.2465	2.5581	0.7344	0.9127
	900 °C	B	0.0117	0.0103	0.0297	0.0278	0.0373	0.0329
		K_{ad}	0.9206	0.9612	2.7296	2.7617	0.6750	0.9432
	1000 °C	B	0.0087	0.0089	0.0276	0.0251	0.0278	0.0247
		K_{ad}	0.9395	0.9707	2.7833	2.8403	0.8511	1.0433
Brilliant blue R	Raw	B	0.1463	0.1423	xxxx	xxxx	xxxx	xxxx
		K_{ad}	1.5920	2.4483	xxxx	xxxx	xxxx	xxxx
	400 °C	B	0.1034	0.1196	xxxx	xxxx	0.1258	0.1698
		K_{ad}	2.4964	2.9681	xxxx	xxxx	0.4060	0.8480
	600 °C	B	0.0940	0.0983	0.2003	0.1116	0.0905	0.1147
		K_{ad}	2.7703	3.5373	0.8373	2.8246	1.0959	1.5911
	800 °C	B	0.0998	0.1172	0.1971	0.1177	0.1015	0.1254
		K_{ad}	2.9852	4.1051	1.2627	3.3870	1.0528	1.8512
	900 °C	B	0.1012	0.1282	0.1754	0.1195	0.0930	0.1222
		K_{ad}	3.2947	4.449	1.6654	3.7642	1.1585	2.0201
	1000 °C	B	0.1111	0.1611	0.1606	0.1959	0.0704	0.0825
		K_{ad}	2.9182	3.7391	1.9744	3.258	0.7457	1.3108
Acid yellow 29	Raw	B	0.0255	0.0364	xxxx	xxxx	xxxx	xxxx
		K_{ad}	0.0690	0.3701	xxxx	xxxx	xxxx	xxxx
	400 °C	B	0.0979	0.0737	xxxx	xxxx	0.4298	0.5184
		K_{ad}	0.6648	1.0295	xxxx	xxxx	1.7288	12.940
	600 °C	B	0.0881	0.1107	0.2893	0.2676	0.7146	0.8524
		K_{ad}	0.4891	1.3432	2.8826	6.8108	6.3355	11.631
	800 °C	B	0.0813	0.0854	0.3364	0.3950	0.6545	0.7042
		K_{ad}	1.5262	1.9046	4.5314	8.7086	11.125	14.581
	900 °C	B	0.0838	0.0810	0.2984	0.3375	0.4092	0.6092
		K_{ad}	1.9317	2.2965	5.0943	9.4600	14.675	15.982
	1000 °C	B	0.1202	0.1504	0.2512	0.3430	0.4581	0.7181
		K_{ad}	2.3853	2.6055	5.9794	10.179	16.415	16.151

Table 4.60 Parabolic diffusion constants for the adsorption of dyes on carbon samples

Dye	Sample	Constants	SO carbon		AB charcoal		RG carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid yellow 34	Raw	B	0.0187	0.0187	xxxx	xxxx	xxxx	xxxx
		K_{ad}	0.1555	0.3167	xxxx	xxxx	xxxx	xxxx
	400 °C	B	0.2405	0.2403	xxxx	xxxx	0.0267	0.0264
		K_{ad}	0.8038	1.5243	xxxx	xxxx	0.6760	0.6966
	600 °C	B	0.2095	0.2048	0.1849	0.1712	0.1020	0.1164
		K_{ad}	2.3527	4.5719	2.0563	3.1481	1.8861	1.8553
	800 °C	B	0.1823	0.2626	0.1911	0.1925	0.1179	0.1056
		K_{ad}	4.8290	5.1759	4.3232	5.6696	3.2083	3.8282
	900 °C	B	0.1404	0.1410	0.1481	0.2090	0.1135	0.1395
		K_{ad}	6.0775	7.2634	5.4194	5.8012	4.4550	4.4705
	1000 °C	B	0.1625	0.1783	0.1739	0.2155	0.1260	0.1451
		K_{ad}	5.7101	6.6476	5.7868	5.6935	1.4452	1.8771
Acid orange 7	Raw	B	0.0558	0.0802	xxxx	xxxx	xxxx	xxxx
		K_{ad}	0.0158	0.1182	xxxx	xxxx	xxxx	xxxx
	400 °C	B	0.1198	0.0129	xxxx	xxxx	0.1676	0.1656
		K_{ad}	0.4632	1.8950	xxxx	xxxx	4.2561	5.9866
	600 °C	B	0.0522	0.1507	0.1365	0.1683	0.1449	0.2444
		K_{ad}	1.3846	3.1044	3.0936	3.1120	6.1178	6.7561
	800 °C	B	0.0706	0.1176	0.2016	0.1726	0.1338	0.1960
		K_{ad}	2.7356	4.2902	5.2835	6.5791	5.8980	6.7615
	900 °C	B	0.0957	0.0983	0.2967	0.1891	0.1629	0.2693
		K_{ad}	3.5755	4.6858	4.9995	7.2023	6.2751	7.0716
	1000 °C	B	0.0931	0.0886	0.1716	0.1640	0.1995	0.2606
		K_{ad}	3.7537	5.6314	6.6515	7.5602	6.4872	7.3156
Acid orange 10	Raw	B	0.0184	0.0159	xxxx	xxxx	xxxx	xxxx
		K_{ad}	0.0700	0.1878	xxxx	xxxx	xxxx	xxxx
	400 °C	B	0.0197	0.0193	xxxx	xxxx	0.0176	0.0313
		K_{ad}	0.2632	0.3218	xxxx	xxxx	0.1038	0.2982
	600 °C	B	0.0312	0.0243	0.0551	0.0685	0.0331	0.0338
		K_{ad}	0.5785	0.7410	0.6683	1.1070	0.3654	0.8019
	800 °C	B	0.0351	0.0617	0.0853	0.0989	0.0507	0.0461
		K_{ad}	1.3955	1.5663	2.4155	2.8431	0.6892	1.2804
	900 °C	B	0.0581	0.0695	0.1052	0.1155	0.0388	0.0475
		K_{ad}	1.4486	2.1506	2.8289	3.3632	0.7438	1.4036
	1000 °C	B	0.0505	0.0795	0.1387	0.1362	0.0374	0.0557
		K_{ad}	1.8079	2.3613	3.6621	3.9600	0.8049	1.6248

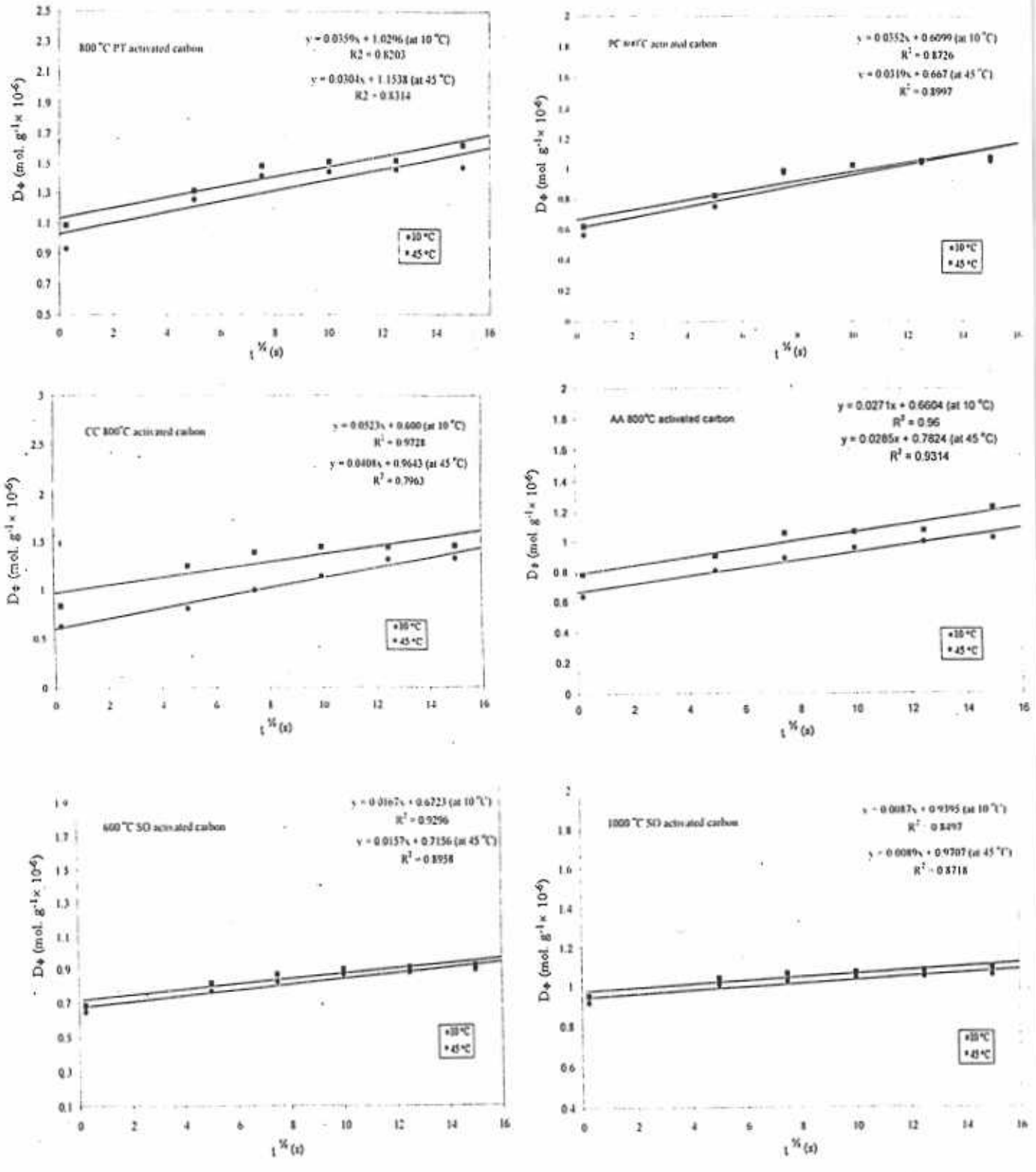


Figure 4.63 Parabolic diffusion plots for the acid blue 1 adsorption on 800 °C activated carbon samples

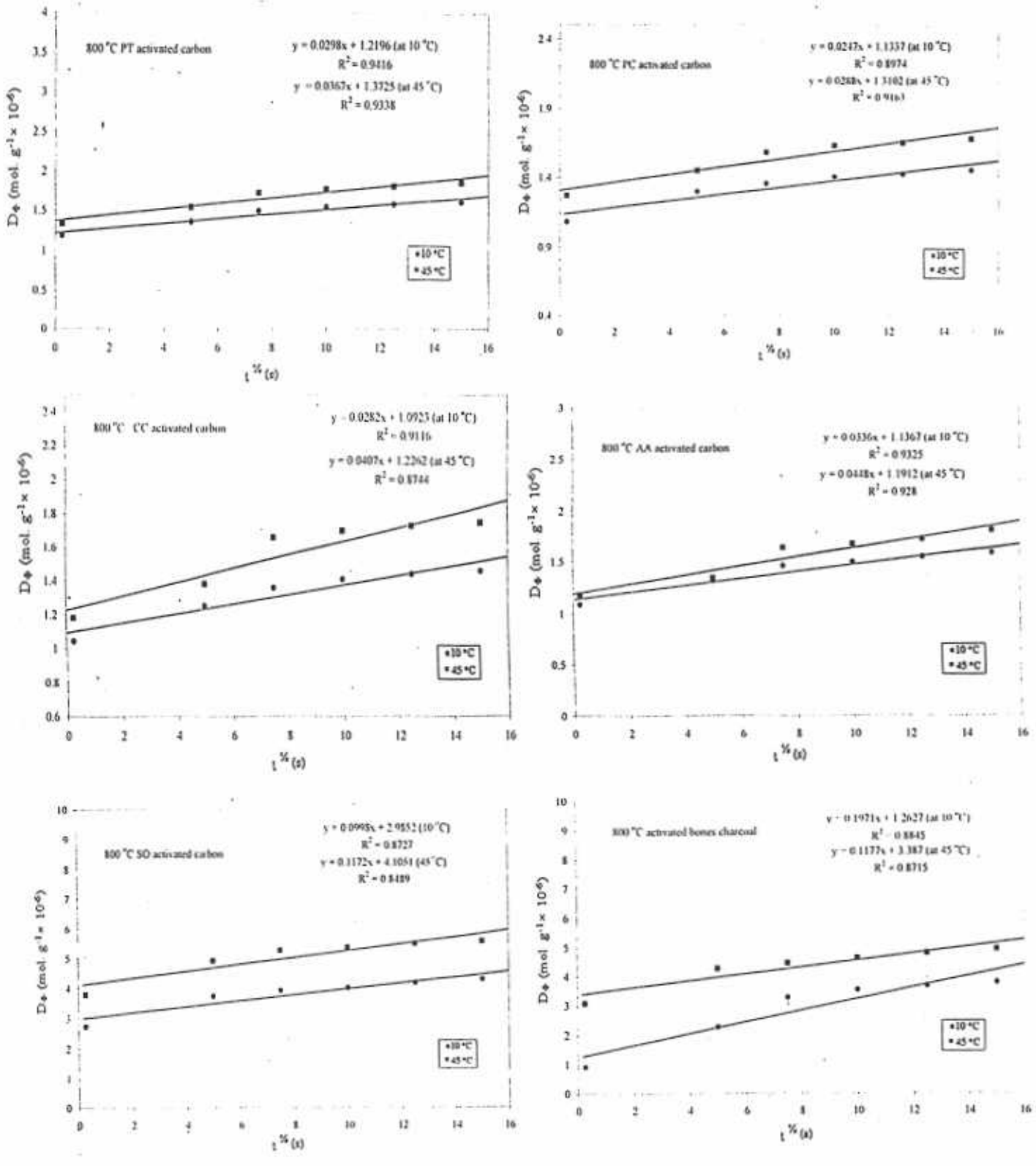


Figure 4.64 Parabolic diffusion plots for the brilliant blue R adsorption on 800 °C activated carbon samples

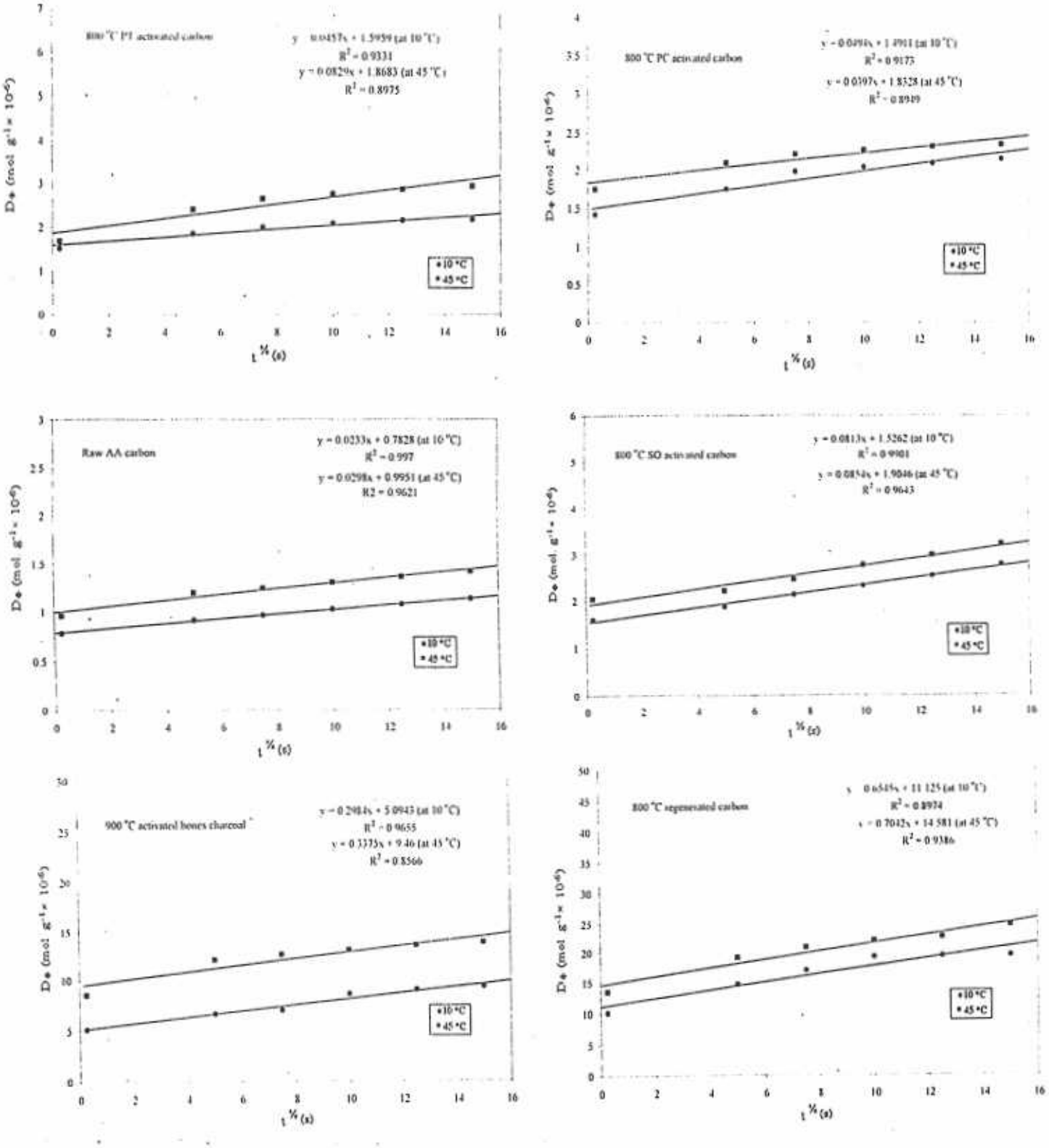


Figure 4.65 Parabolic diffusion plots for the acid yellow 29 adsorption on 800 °C activated carbon samples

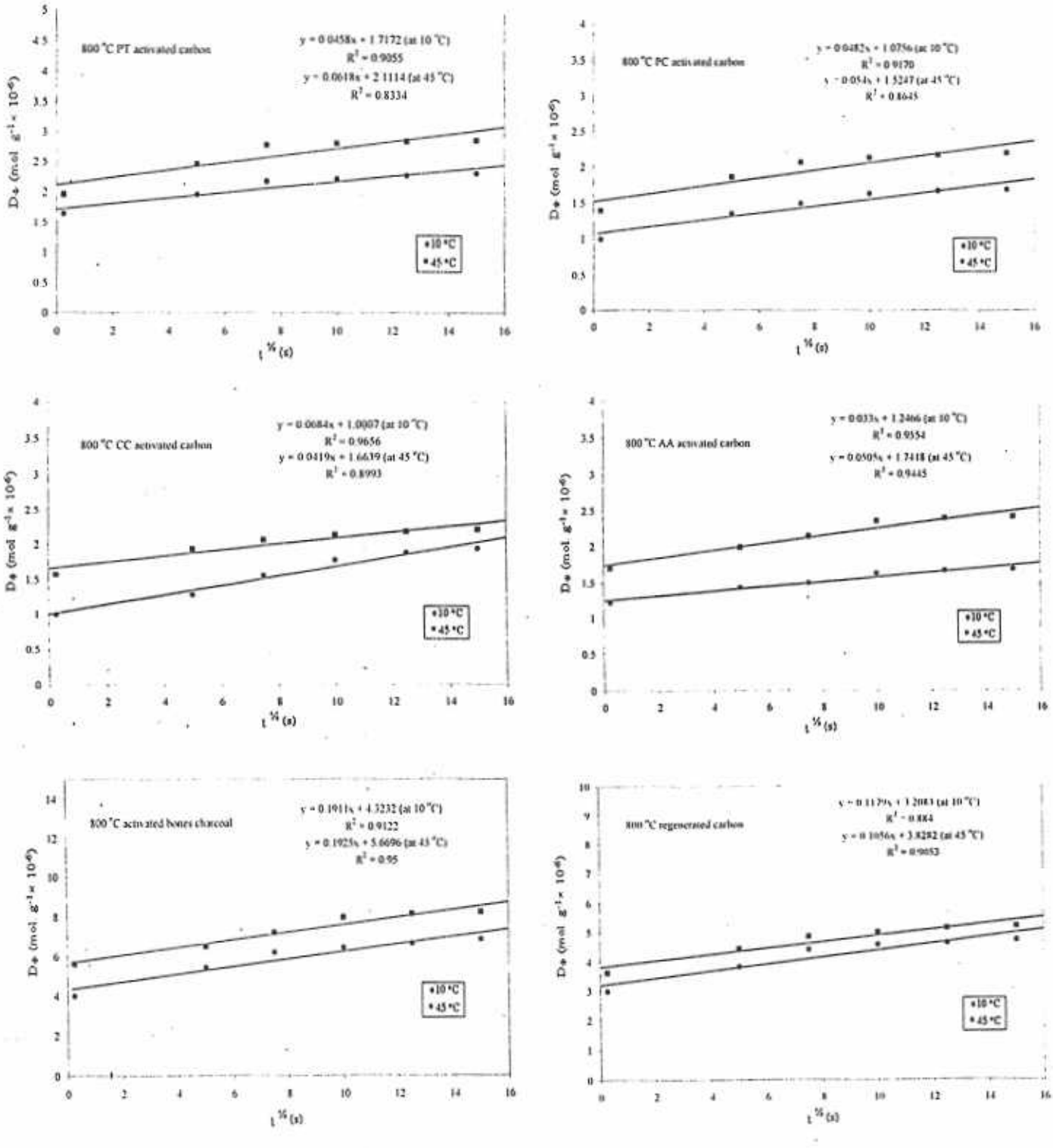


Figure 4.66 Parabolic diffusion plots for the acid yellow 34 adsorption on 800 °C activated carbon samples

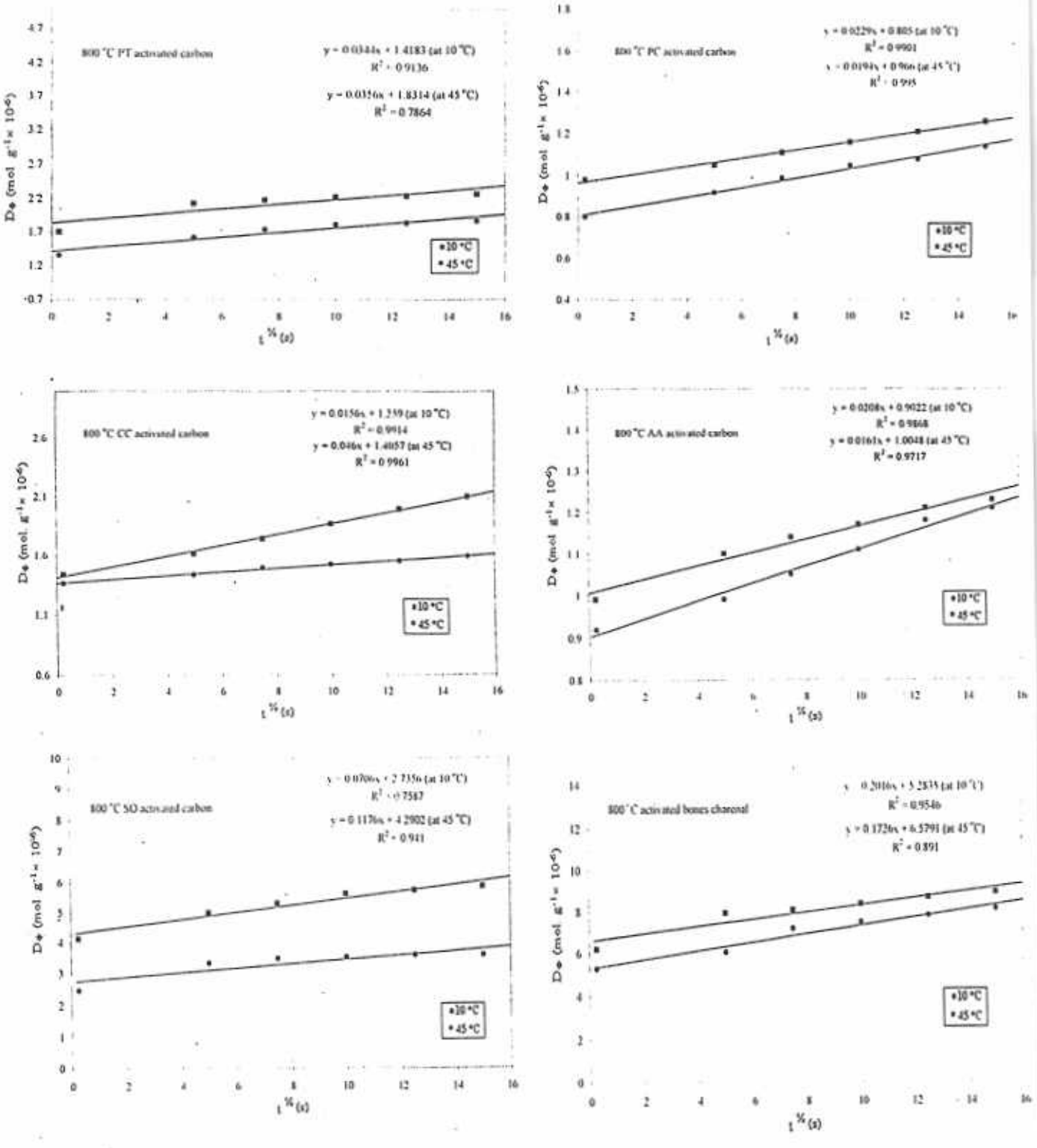


Figure 4.67 Parabolic diffusion plots for the acid orange 7 adsorption on 800 °C activated carbon samples

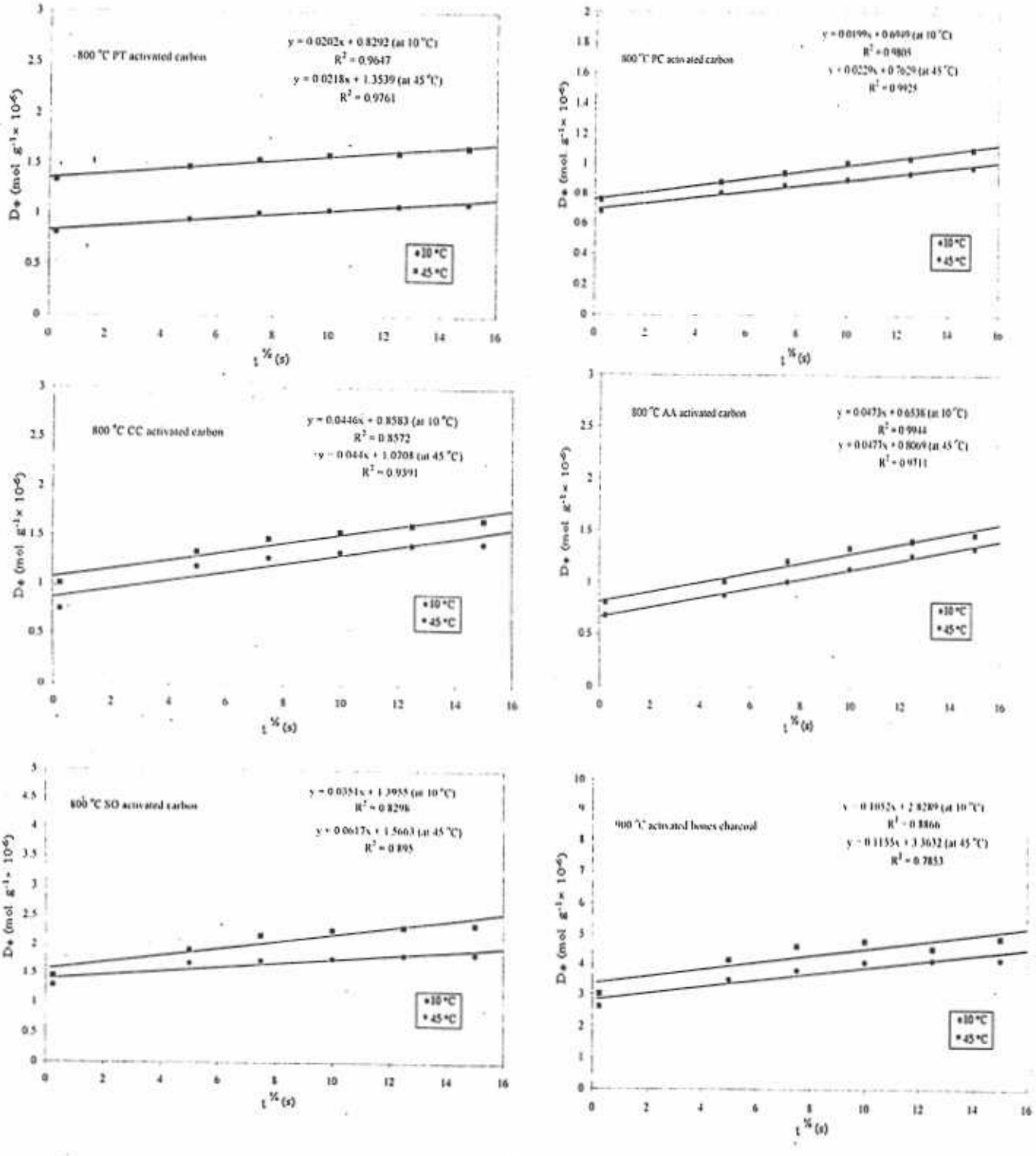


Figure 4.68 Parabolic diffusion plots for the acid orange 10 adsorption on 800 °C activated carbon samples

Table 4.61 Equilibration time for the adsorption of acid blue 1 on carbon samples

	Time (h)	3.0×10^{-5} mol/L					6.0×10^{-5} mol/L				
		pH_M	Ab_M	D_m (mol/L × 10^{-5})	$D_e - D_m$ (mol/L × 10^{-5})	D_e (mol/g × 10^{-6})	pH_M	Ab_M	D_m (mol/L × 10^{-5})	$D_e - D_m$ (mol/L × 10^{-5})	D_e (mol/g × 10^{-6})
Paulownia tomentosa (PT)	½	8.95	1.570	2.175	0.825	0.825	9.16	2.940	4.073	1.930	1.930
	1	9.32	1.130	1.565	1.430	1.430	9.26	2.520	3.490	2.510	2.510
	2	9.63	1.120	1.551	1.450	1.450	9.59	2.400	3.320	2.680	2.680
	4	9.64	1.120	1.551	1.450	1.450	9.59	2.400	3.320	2.680	2.680
	6	9.64	1.120	1.551	1.450	1.450	9.59	2.400	3.320	2.680	2.680
	8	9.64	1.120	1.551	1.450	1.450	9.59	2.400	3.320	2.680	2.680
		pH before adsorption = 6.80					pH before Adsorption = 6.80				
Populus caspica (PC)	Time (h)	3.0×10^{-5} mol/L					6.0×10^{-5} mol/L				
	½	9.670	1.62	2.24	0.756	0.756	10.03	3.020	4.180	1.810	1.810
	1	10.23	1.28	1.77	1.23	1.23	10.12	2.840	3.930	2.070	2.070
	2	10.29	1.26	1.74	1.26	1.26	10.22	2.800	3.880	2.120	2.120
	4	10.32	1.26	1.74	1.26	1.26	10.25	2.800	3.880	2.120	2.120
	6	10.32	1.26	1.74	1.26	1.26	10.25	2.800	3.880	2.120	2.120
	8	10.32	1.26	1.74	1.26	1.26	10.25	2.800	3.880	2.120	2.120
		pH before adsorption = 6.80					pH before adsorption = 6.32				
Corncobs (CC)	Time (h)	3.0×10^{-5} mol/L					6.0×10^{-5} mol/L				
	½	8.29	1.95	2.700	0.298	0.298	6.28	3.560	5.000	1.000	1.000
	1	7.19	1.70	2.350	0.645	0.645	6.35	3.480	4.820	1.180	1.180
	2	6.03	1.65	2.280	0.714	0.714	6.43	3.400	4.710	1.290	1.290
	4	6.00	1.65	2.280	0.714	0.714	6.45	3.400	4.710	1.290	1.290
	6	5.98	1.65	2.280	0.714	0.714	6.45	3.400	4.710	1.290	1.290
	8	5.98	1.65	2.280	0.714	0.714	6.45	3.400	4.710	1.290	1.290
		pH before adsorption = 6.80					pH before adsorption = 6.32				
Ailanthus altissima (AA)	Time (h)	3.0×10^{-5} mol/L					6.0×10^{-5} mol/L				
	½	9.13	1.74	2.410	0.600	0.600	9.41	3.74	5.180	0.820	0.820
	1	9.39	1.68	2.330	0.670	0.670	9.37	3.64	5.040	0.960	0.960
	2	9.39	1.64	2.270	0.730	0.730	9.42	3.60	4.980	1.020	1.020
	4	9.27	1.64	2.270	0.730	0.730	9.50	3.56	4.930	1.070	1.070
	6	9.27	1.64	2.270	0.730	0.730	9.50	3.56	4.930	1.070	1.070
	8	9.27	1.64	2.270	0.730	0.730	9.50	3.56	4.930	1.070	1.070
		pH before adsorption =6.80					pH before adsorption = 6.32				
Salvadora oleoides (SO)	Time (h)	3.0×10^{-5} mol/L					6.0×10^{-5} mol/L				
	½	7.190	1.91	2.646	1.8542	1.8542	7.82	3.90	5.4020	3.5980	3.5980
	1	7.260	1.10	1.5237	2.9763	2.9763	7.51	3.00	4.1557	4.8443	4.8443
	2	7.320	0.84	1.164	3.336	3.336	7.50	2.80	3.8780	5.1220	5.1220
	4	7.460	0.80	1.108	3.3392	3.3392	7.49	2.76	3.8230	5.1770	5.1770
	6	7.480	0.76	1.052	3.4480	3.4480	7.48	2.74	3.7960	5.2040	5.2040
	8	7.480	0.76	1.052	3.4480	3.4480	7.48	2.74	3.7960	5.2040	5.2040
		pH before adsorption=6.44					pH before adsorption =6.24				

Table 4.62 Equilibration time for the adsorption of acid blue 1 on carbon samples

	Time (h)	4.5×10^{-5} mol/L					9.0×10^{-5} mol/L				
		pH_{st}	Ab_{st}	D_e (mo/L $\times 10^{-5}$)	$D_o - D_e$ (mo/L$\times 10^{-5}$)	D_q (mol/g $\times 10^{-6}$)	pH_{st}	Ab_{st}	D_e (mo/L $\times 10^{-5}$)	$D_o - D_e$ (mo/L$\times 10^{-5}$)	D_q (mol/g $\times 10^{-6}$)
Animal bones (ABC)	½	7.11	1.520	0.4557	2.1055	2.3944	7.51	1.6420	2.2745	6.7254	6.7254
	1	7.40	0.200	0.2770	4.2230	4.2230	7.45	0.6420	0.8893	8.1107	8.1107
	2	7.45	0.180	0.2493	4.2507	4.2507	7.44	0.5360	0.7425	8.2575	8.2575
	4	7.53	0.120	0.1662	4.3338	4.3338	7.41	0.4160	0.5762	8.4238	8.4238
	6	7.58	0.115	0.1593	4.3407	4.3407	7.41	0.4100	0.5679	8.4321	8.4321
	8	7.58	0.115	0.1593	4.3407	4.3407	7.41	0.4030	0.5582	8.4418	8.4418
		pH before adsorption = 6.44					pH before adsorption = 6.24				
	Time (h)	4.5×10^{-5} mol/L					9.0×10^{-5} mol/L				
Regenerated (RG)	½	6.82	0.823	1.1400	3.3599	3.3599	6.70	1.130	1.5653	7.4340	7.4340
	1	6.62	0.289	0.4003	4.0997	4.0997	6.64	0.610	0.8450	8.1550	8.1550
	2	6.58	0.285	0.3948	4.1052	4.1052	6.63	0.400	0.5541	8.4460	8.4460
	4	6.52	0.276	0.3830	4.1170	4.1170	6.61	0.398	0.5513	8.4487	8.4487
	6	6.52	0.276	0.3823	4.1177	4.1177	6.60	0.398	0.5513	8.4487	8.4487
	8	6.52	0.276	0.3823	4.1177	4.1177	6.60	0.397	0.5510	8.4500	8.4500
		pH before adsorption = 6.44					pH before adsorption = 6.24				

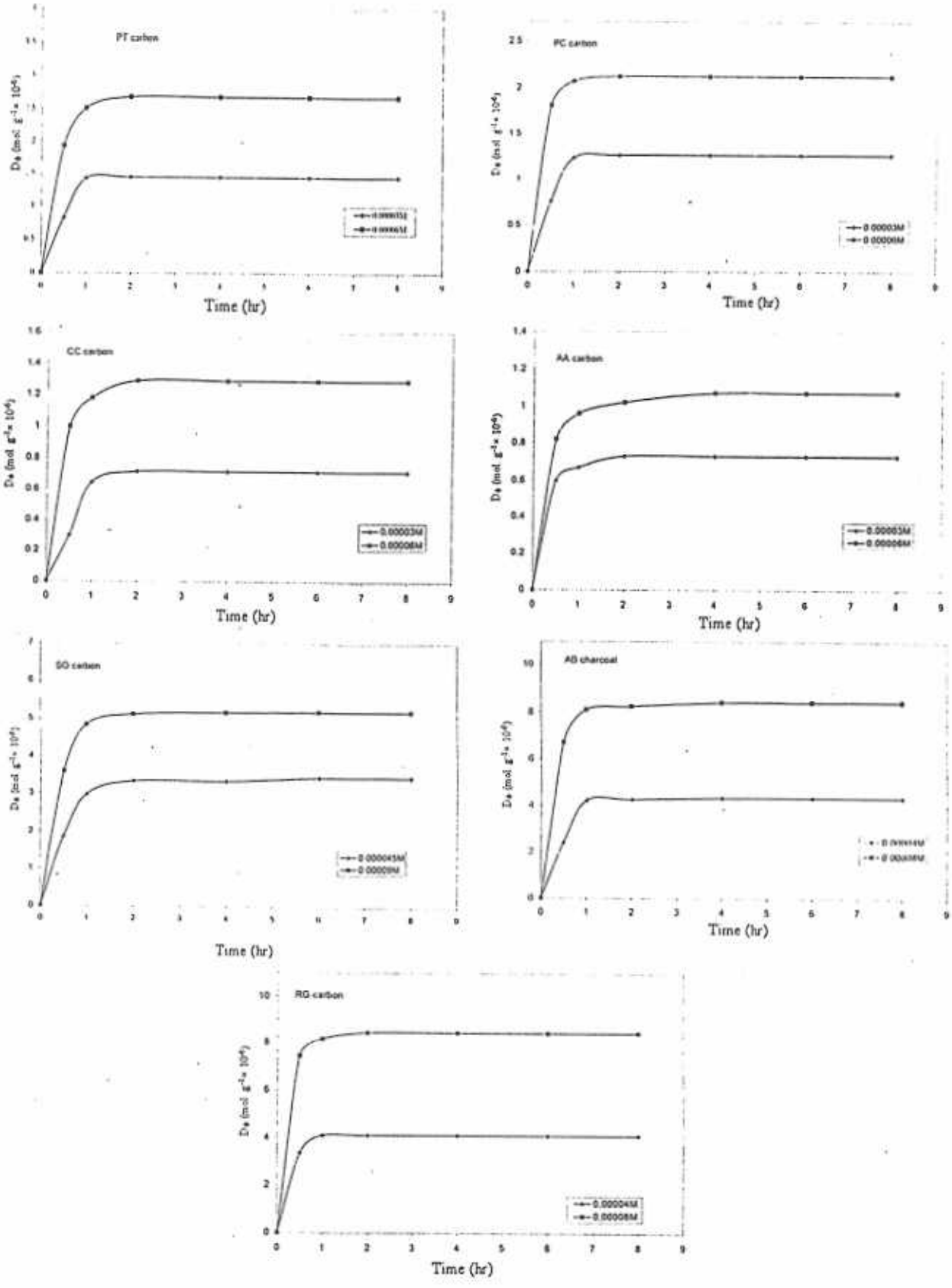


Figure 4.69 Equilibration time for the adsorption of acid blue 1 on carbon samples at 25 °C

Table 4.63 Equilibration time for the adsorption of brilliant blue R on carbon samples

	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
		pH_M	Ab_M	D_a (mo/L × 10^{-5})	D_a- D_a (mo/L×10^{-5})	D_ϕ (mol/g × 10^{-6})	pH_M	Ab_M	D_a (mo/L × 10^{-5})	D_a- D_a (mo/L×10^{-5})	D_ϕ (mol/g × 10^{-6})
Paulownia tomentosa (PT)	½	8.04	0.172	1.560	0.440	0.440	9.23	0.352	3.200	0.800	0.800
	1	8.71	0.113	1.030	0.970	0.970	9.24	0.336	3.050	0.950	0.950
	2	9.13	0.100	0.910	1.090	1.090	9.56	0.270	2.450	1.550	1.550
	4	9.16	0.090	0.820	1.180	1.180	9.60	0.265	2.410	1.590	1.590
	6	9.20	0.088	0.810	1.190	1.190	9.61	0.264	2.400	1.600	1.600
	8	9.30	0.089	0.810	1.190	1.190	9.61	0.263	2.390	1.610	1.610
		pH before adsorption = 6.90					pH before Adsorption = 6.65				
Populus caspica (PC)	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
	½	09.62	0.167	1.520	0.480	0.480	10.09	0.188	1.710	2.290	2.290
	1	09.97	0.075	0.680	1.320	1.320	10.22	0.163	1.480	2.520	2.520
	2	10.11	0.010	0.100	1.900	1.900	10.30	0.138	1.250	2.750	2.750
	4	10.10	0.008	0.072	1.930	1.930	10.30	0.135	1.220	2.780	2.780
	6	10.10	0.008	0.072	1.930	1.930	10.30	0.134	1.210	2.790	2.790
	8	10.10	0.008	0.072	1.930	1.930	10.30	0.133	1.200	2.800	2.800
		pH before adsorption = 6.90					pH before Adsorption = 6.65				
Corncobs (CC)	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
	½	4.21	0.392	3.560	0.440	0.440	09.06	0.183	1.660	0.340	0.340
	1	3.54	0.330	3.000	1.000	1.000	09.95	0.075	0.680	1.320	1.320
	2	3.39	0.286	2.600	1.400	1.400	10.13	0.050	0.450	1.550	1.550
	4	3.31	0.270	2.400	1.600	1.600	10.22	0.040	0.360	1.640	1.640
	6	3.30	0.270	2.400	1.600	1.600	10.20	0.039	0.355	1.640	1.640
	8	3.30	0.270	2.400	1.600	1.600	10.20	0.039	0.355	1.645	1.645
		pH before adsorption = 6.90					pH before Adsorption = 6.65				
Ailanthus altissima (AA)	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
	½	10.11	0.392	3.560	0.440	0.440	09.06	0.183	1.660	0.340	0.340
	1	10.23	0.330	3.000	1.000	1.000	09.95	0.075	0.680	1.320	1.320
	2	10.30	0.286	2.600	1.400	1.400	10.13	0.050	0.450	1.550	1.550
	4	10.35	0.270	2.400	1.600	1.600	10.22	0.040	0.360	1.640	1.640
	6	1.36	0.270	2.400	1.600	1.600	10.20	0.039	0.355	1.640	1.640
	8	10.38	0.270	2.400	1.600	1.600	10.20	0.039	0.355	1.645	1.645
		pH before adsorption = 6.90					pH before Adsorption = 6.65				
Salvadora oleoides (SO)	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
	½	9.08	0.900	8.182	4.068	4.068	8.80	1.800	16.36	8.136	8.136
	1	8.50	0.630	5.730	6.520	6.520	8.60	1.250	11.36	13.14	13.14
	2	8.90	0.570	5.180	7.070	7.070	8.75	1.150	10.45	14.05	14.05
	4	8.81	0.455	4.130	8.120	8.120	8.95	1.000	9.09	15.41	15.41
	6	9.11	0.415	3.770	8.480	8.480	8.72	0.865	7.86	16.64	16.64
	8	9.13	0.350	3.180	9.070	9.070	8.96	0.870	7.91	16.59	16.59
		pH before adsorption = 6.90					pH before Adsorption = 6.65				

Table 4.64 Equilibration time for the adsorption of brilliant blue R on carbon samples

	Time (h)	10×10^{-5} mol/L					20×10^{-5} mol/L				
		pH_M	Ab_M	D_e (mo/L × 10^{-5})	D_o- D_e (mo/L×10^{-5})	D_ϕ (mol/g × 10^{-6})	pH_M	Ab_M	D_e (mo/L × 10^{-5})	D_o- D_e (mo/L×10^{-5})	D_ϕ (mol/g × 10
Animal bones (ABC)	½	7.53	0.520	4.700	5.300	5.300	7.44	1.100	1.0580	9.420	9.420
	1	7.58	0.395	3.590	6.410	6.410	7.63	0.950	0.8500	11.150	11.150
	2	7.76	0.225	2.100	7.900	7.900	7.60	0.900	0.8000	12.000	12.000
	4	8.06	0.185	1.700	8.300	8.300	7.73	0.825	0.7500	12.500	12.500
	6	7.63	0.175	1.600	8.400	8.400	7.67	0.725	0.6600	13.400	13.400
	8	7.67	0.165	1.500	8.500	8.500	7.67	0.700	0.6250	13.750	13.750
		pH before adsorption = 8.13					pH before adsorption = 6.99				
	Time (h)	8.25×10^{-5} mol/L					16.5×10^{-5} mol/L				
Regenerated (RG)	½	7.47	0.485	4.410	3.840	3.840	7.52	0.973	8.850	7.650	7.650
	1	7.47	0.368	3.300	4.950	4.950	7.50	0.830	7.540	8.960	8.960
	2	7.44	0.304	2.750	5.500	5.500	7.49	0.735	6.680	9.820	9.820
	4	7.60	0.249	2.300	5.900	5.900	7.65	0.592	5.380	11.12	11.120
	6	7.61	0.207	1.850	6.400	6.400	7.59	0.539	4.900	11.60	11.60
	8	7.69	0.187	1.750	6.500	6.500	7.53	0.514	4.670	11.83	11.83
		pH before Adsorption = 7.70					pH before adsorption = 7.05				

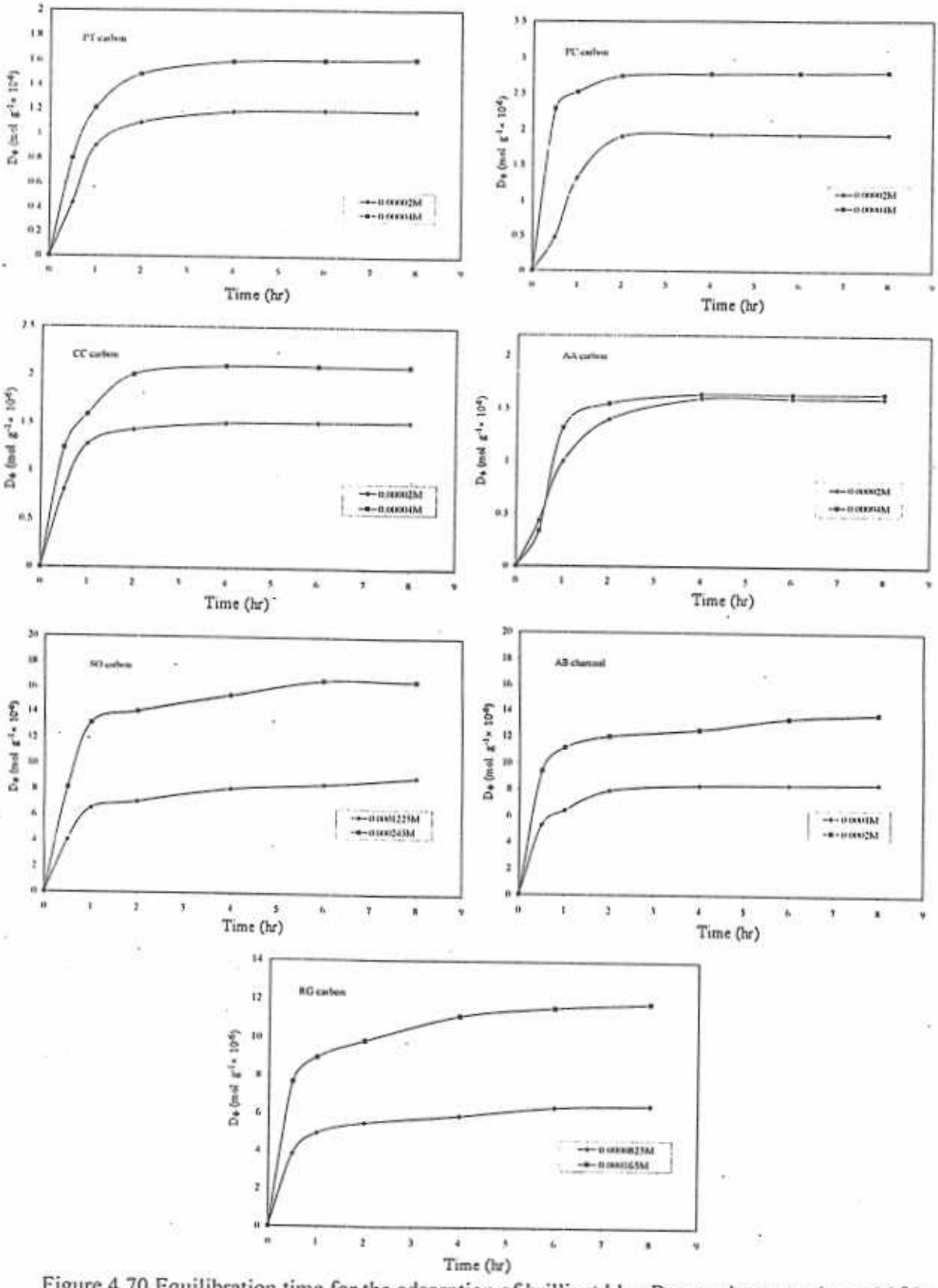


Figure 4.70 Equilibration time for the adsorption of brilliant blue R on carbon samples at 25 °C

Table 4.65 Equilibration time for the adsorption of acid yellow 29 on carbon samples

	Time (h)	4.0×10^{-5} mol/L					8.0×10^{-5} mol/L				
		pH_{ss}	Ab_{ss}	D_n (mol/L × 10^{-5})	$D_e - D_n$ (mol/L × 10^{-5})	D_e (mol/g × 10^{-4})	pH_{ss}	Ab_{ss}	D_n (mol/L × 10^{-5})	$D_e - D_n$ (mol/L × 10^{-5})	D_e (mol/g × 10^{-4})
Paulownia tomentosa (PT)	½	8.36	0.204	2.310	1.690	1.690	8.12	0.580	6.570	1.430	1.430
	1	8.35	0.182	2.060	1.940	1.940	8.14	0.518	5.870	2.130	2.130
	2	8.87	0.175	1.980	2.010	2.010	8.40	0.500	5.670	2.330	2.330
	4	8.90	0.172	1.950	2.050	2.050	8.42	0.500	5.670	2.330	2.330
	6	8.92	0.170	1.920	2.080	2.080	8.45	0.500	5.670	2.330	2.330
	8	8.94	0.170	1.920	2.080	2.080	8.45	0.500	5.670	2.330	2.330
		pH before adsorption = 5.75					pH before adsorption = 5.90				
Populus caspica (PC)	Time (h)	4.0×10^{-5} mol/L					8.0×10^{-5} mol/L				
	½	9.57	0.331	3.75	0.250	0.250	9.75	0.658	7.460	0.540	0.540
	1	9.63	0.313	3.54	0.460	0.460	9.93	0.610	6.920	1.080	1.080
	2	9.91	0.302	3.42	0.580	0.580	10.15	0.600	6.800	1.200	1.200
	4	9.99	0.298	3.37	0.630	0.630	10.20	0.598	6.780	1.220	1.220
	6	10.0	0.296	3.35	0.650	0.650	10.22	0.596	6.750	1.250	1.250
	8	10.0	0.296	3.35	0.650	0.650	10.22	0.596	6.750	1.250	1.250
		pH before adsorption = 5.75					pH before adsorption = 5.90				
Corncobs (CC)	Time (h)	4.0×10^{-5} mol/L					8.0×10^{-5} mol/L				
	½	9.57	0.181	2.050	1.950	1.950	3.34	0.490	5.550	2.440	2.440
	1	9.63	0.150	1.700	2.300	2.300	3.27	0.417	4.720	3.280	3.280
	2	9.91	0.140	1.600	2.400	2.400	3.26	0.400	4.530	3.470	3.470
	4	9.99	0.130	1.470	2.530	2.530	3.23	0.392	4.440	3.560	3.560
	6	10.0	0.127	1.430	2.570	2.570	3.22	0.390	4.420	3.580	3.580
	8	10.0	0.126	1.430	2.570	2.570	3.21	0.390	4.420	3.580	3.580
		pH before adsorption = 5.75					pH before adsorption = 5.90				
Allanthus altissima (AA)	Time (h)	4.0×10^{-5} mol/L					8.0×10^{-5} mol/L				
	½	09.72	0.298	3.380	0.620	0.620	10.35	0.598	6.780	1.220	1.220
	1	10.13	0.274	3.100	0.900	0.900	10.44	0.570	6.460	1.540	1.540
	2	10.20	0.263	2.980	1.020	1.020	10.61	0.560	6.350	1.650	1.650
	4	10.22	0.260	2.940	1.060	1.060	10.64	0.550	6.230	1.770	1.770
	6	10.24	0.258	2.920	1.060	1.060	10.64	0.545	6.180	1.820	1.820
	8	10.25	0.254	2.870	1.130	1.130	10.66	0.542	6.140	1.860	1.860
		pH before adsorption = 5.75					pH before adsorption = 5.90				
Salvadora oleoides (SO)	Time (h)	20×10^{-5} mol/L					40×10^{-5} mol/L				
	½	7.75	1.24	14.060	5.940	5.940	7.52	3.040	34.46	5.540	5.540
	1	7.62	1.17	13.150	6.850	6.850	7.47	2.900	32.88	7.120	7.120
	2	7.56	1.14	13.040	6.960	6.960	7.45	2.800	31.75	8.250	8.250
	4	7.52	1.15	13.040	6.960	6.960	7.45	2.760	31.29	8.710	8.710
	6	7.50	1.15	13.040	6.960	6.960	7.45	2.760	31.29	8.710	8.710
	8	7.50	1.15	13.040	6.960	6.960	7.45	2.740	31.00	8.820	8.820
		pH before adsorption = 7.70					pH before adsorption = 7.98				

Table 4.66 Equilibration time for the adsorption of acid yellow 29 on carbon samples

	Time (h)	20×10^{-5} mol/L					40×10^{-5} mol/L				
		pH_M	Ab_M	D_n (mo/L × 10^{-5})	D_e- D_n (mo/L×10^{-5})	D_t (mol/g × 10^{-6})	pH_M	Ab_M	D_n (mo/L × 10^{-5})	D_e- D_n (mo/L×10^{-5})	D_t (mol/g × 10
Animal bones (ABC)	½	8.47	0.930	10.540	09.450	09.45	8.65	1.820	20.640	19.360	19.360
	1	8.27	0.592	6.7120	13.28	13.28	8.74	0.993	11.250	28.740	28.740
	2	8.25	0.086	0.9860	19.01	19.01	8.27	0.385	7.3650	35.630	35.630
	4	8.20	0.086	0.9750	19.02	19.02	865	0.277	3.1410	36.860	36.860
	6	8.20	0.086	0.9630	19.03	19.03	8.64	0.275	3.1200	36.880	36.880
	8	8.20	0.085	0.9630	19.03	19.03	8.64	0.274	3.1100	36.890	36.890
		pH before adsorption = 7.70					pH before adsorption = 7.98				
	Time (h)	20×10^{-5} mol/L					40×10^{-5} mol/L				
Regenerated (RG)	½	7.77	0.834	9.4550	10.540	10.540	7.50	1.185	13.435	26.500	26.500
	1	7.73	0.473	5.3630	14.640	14.640	7.42	0.768	8.7070	31.300	31.300
	2	7.63	0.270	3.0610	16.930	16.930	7.40	0.612	6.9380	33.100	33.100
	4	7.56	0.200	2.2670	17.730	17.730	7.37	0.512	5.7820	34.210	34.210
	6	7.55	0.200	2.2670	17.730	17.730	7.35	0.500	5.6680	34.330	34.330
	8	7.55	0.198	2.2500	17.750	17.750	7.34	0.495	5.6120	34.380	34.380
		pH before adsorption = 7.70					pH before adsorption = 7.98				

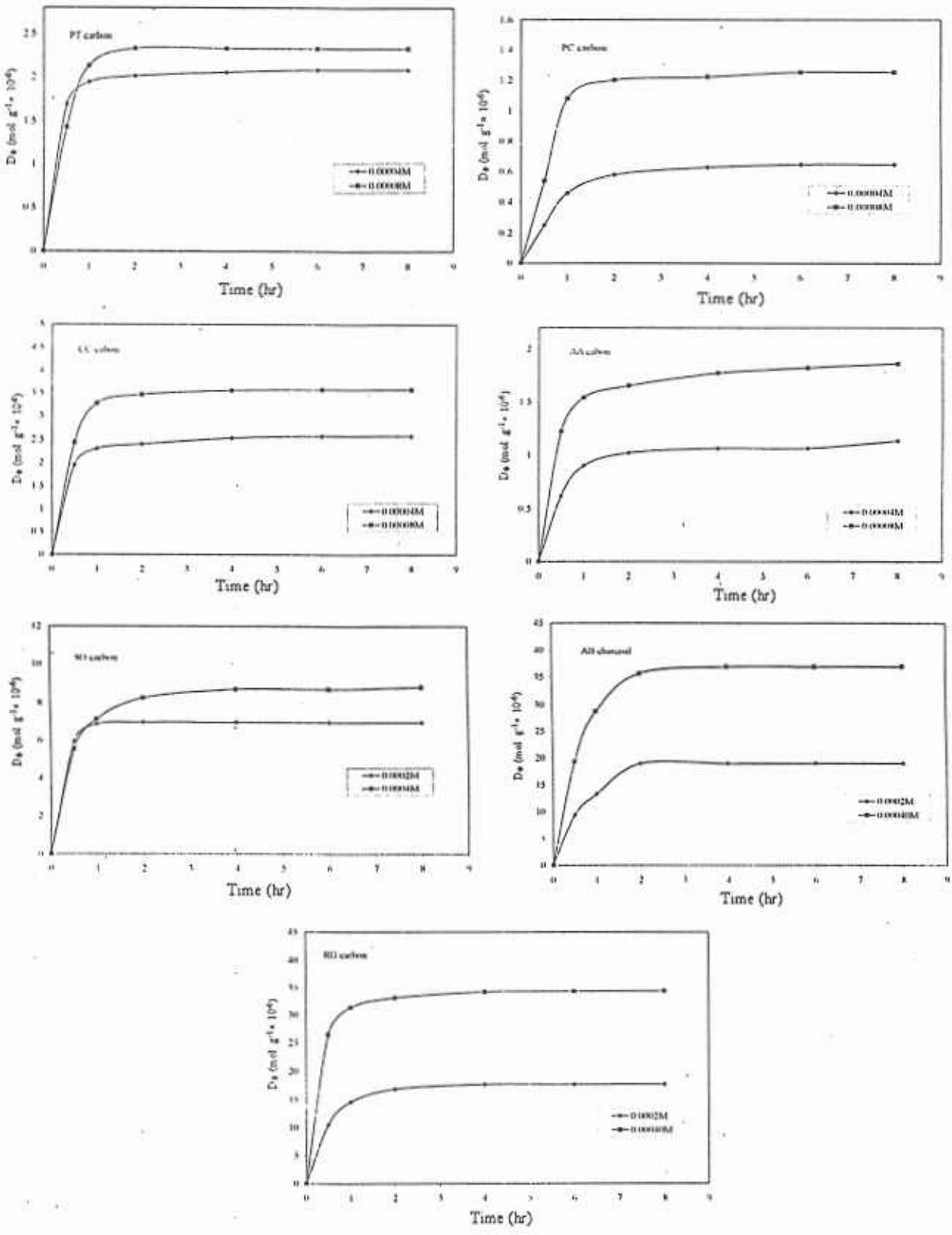


Figure-4.71: Equilibration time for the adsorption of acid yellow 29 on carbon samples at 25 °C

Table 4.67 Equilibration time for the adsorption of acid yellow 34 on carbon samples

	Time (h)	3.0×10^{-5} mol/L					6.0×10^{-5} mol/L				
		pH_M	Ab_M	D_n (mol/L $\times 10^{-5}$)	$D_e - D_n$ (mol/L $\times 10^{-5}$)	D_e (mol/g $\times 10^{-4}$)	pH_M	Ab_M	D_n (mol/L $\times 10^{-5}$)	$D_e - D_n$ (mol/L $\times 10^{-5}$)	D_e (mol/g $\times 10^{-4}$)
Paulownia tomentosa (PT)	½	8.95	1.570	2.175	0.825	0.825	9.16	2.940	4.073	1.930	1.930
	1	9.32	1.130	1.565	1.430	1.430	9.26	2.520	3.490	2.510	2.510
	2	9.63	1.120	1.551	1.450	1.450	9.59	2.400	3.320	2.680	2.680
	4	9.64	1.120	1.551	1.450	1.450	9.59	2.400	3.320	2.680	2.680
	6	9.64	1.120	1.551	1.450	1.450	9.59	2.400	3.320	2.680	2.680
	8	9.64	1.120	1.551	1.450	1.450	9.59	2.400	3.320	2.680	2.680
		pH before adsorption = 6.80					pH before adsorption = 6.32				
Populus caspica (PC)	Time (h)	3.0×10^{-5} mol/L					6.0×10^{-5} mol/L				
	½	9.670	1.62	2.24	0.756	0.756	10.03	3.020	4.180	1.810	1.810
	1	10.23	1.28	1.77	1.23	1.23	10.12	2.840	3.930	2.070	2.070
	2	10.29	1.26	1.74	1.26	1.26	10.22	2.800	3.880	2.120	2.120
	4	10.32	1.26	1.74	1.26	1.26	10.25	2.800	3.880	2.120	2.120
	6	10.32	1.26	1.74	1.26	1.26	10.25	2.800	3.880	2.120	2.120
	8	10.32	1.26	1.74	1.26	1.26	10.25	2.800	3.880	2.120	2.120
		pH before adsorption = 6.80					pH before adsorption = 6.32				
Corncobs (CC)	Time (h)	3.0×10^{-5} mol/L					6.0×10^{-5} mol/L				
	½	8.29	1.95	2.700	0.298	0.298	6.28	3.560	5.000	1.000	1.000
	1	7.19	1.70	2.350	0.645	0.645	6.35	3.480	4.820	1.180	1.180
	2	6.03	1.65	2.280	0.714	0.714	6.43	3.400	4.710	1.290	1.290
	4	6.00	1.65	2.280	0.714	0.714	6.45	3.400	4.710	1.290	1.290
	6	5.98	1.65	2.280	0.714	0.714	6.45	3.400	4.710	1.290	1.290
	8	5.98	1.65	2.280	0.714	0.714	6.45	3.400	4.710	1.290	1.290
		pH before adsorption = 6.80					pH before adsorption = 6.32				
Ailanthus altissima (AA)	Time (h)	4.0×10^{-5} mol/L					8.0×10^{-5} mol/L				
	½	9.300	0.425	3.030	0.964	0.964	9.710	0.840	6.000	2.000	2.000
	1	9.650	0.329	2.350	1.650	1.650	10.10	0.710	5.070	2.920	2.920
	2	10.06	0.300	2.140	1.860	1.860	10.17	0.595	4.250	3.750	3.750
	4	10.20	0.290	2.070	1.930	1.930	10.20	0.590	4.210	3.790	3.790
	6	10.22	0.290	2.070	1.930	1.930	10.22	0.588	4.200	3.800	3.800
	8	10.22	0.290	2.070	1.930	1.930	10.23	0.586	4.180	3.820	3.820
		pH before adsorption = 5.58					pH before adsorption = 5.48				
Salvadora oleoides (SO)	Time (h)	15×10^{-5} mol/L					30×10^{-5} mol/L				
	½	7.57	1.88	13.420	1.5700	1.5700	7.34	3.800	27.14	2.860	2.860
	1	7.42	1.60	11.430	3.5700	3.5700	7.54	3.350	23.93	6.070	6.070
	2	7.44	1.38	9.8570	5.1430	5.1430	7.61	3.120	22.28	7.720	7.720
	4	7.44	1.36	9.7140	5.2860	5.2860	7.70	3.080	22.00	8.000	8.000
	6	7.44	1.36	9.7140	5.2860	5.2860	7.70	3.060	21.85	8.140	8.140
	8	7.44	1.36	9.7140	5.2860	5.2860	7.70	3.040	21.71	8.290	8.290
		pH before adsorption = 5.70					pH before adsorption = 5.48				

Table 4.68 Equilibration time for the adsorption of acid yellow 34 on carbon samples

	Time (h)	20×10^{-5} mol/L					40×10^{-5} mol/L				
		pH_M	Ab_M	D_n (mo/L × 10^{-5})	D_e- D_n (mo/L×10^{-5})	D_t (mol/g × 10^{-4})	pH_M	Ab_M	D_n (mo/L × 10^{-5})	D_e- D_n (mo/L×10^{-5})	D_t (mol/g × 10^{-4})
Animal bones (ABC)	½	7.77	0.741	5.2930	14.710	14.710	7.58	1.640	11.710	28.30	28.30
	1	7.81	0.322	2.3000	17.700	17.700	7.80	1.140	8.1430	31.85	31.85
	2	7.60	0.272	1.9430	18.060	18.060	7.56	0.980	7.0000	33.00	33.00
	4	7.60	0.256	1.8285	18.172	18.172	7.56	0.817	5.8400	34.16	34.16
	6	7.60	0.235	1.6785	18.322	18.322	7.55	0.656	4.6850	35.32	35.32
	8	7.60	0.236	1.6857	18.314	18.314	7.55	0.692	4.9400	35.06	35.06
		pH before adsorption =5.60					pH before adsorption = 5.00				
	Time (h)	30×10^{-5} mol/L					60×10^{-5} mol/L				
Regenerated (RG)	½	7.10	0.709	5.0640	24.360	24.360	7.15	2.720	19.430	40.570	40.570
	1	7.06	0.375	2.6780	27.322	27.322	7.11	1.845	13.180	46.820	46.820
	2	7.02	0.270	1.9280	28.072	28.072	7.07	1.310	9.3570	50.820	50.820
	4	7.01	0.264	1.8850	28.115	28.115	7.02	0.749	5.3500	54.650	54.650
	6	7.00	0.261	1.8640	28.136	28.136	7.02	0.637	4.5500	55.450	55.450
	8	7.00	0.260	1.8570	28.143	28.143	7.01	0.640	4.5700	55.430	55.430
		pH before adsorption = 5.13					pH before adsorption = 5.91				

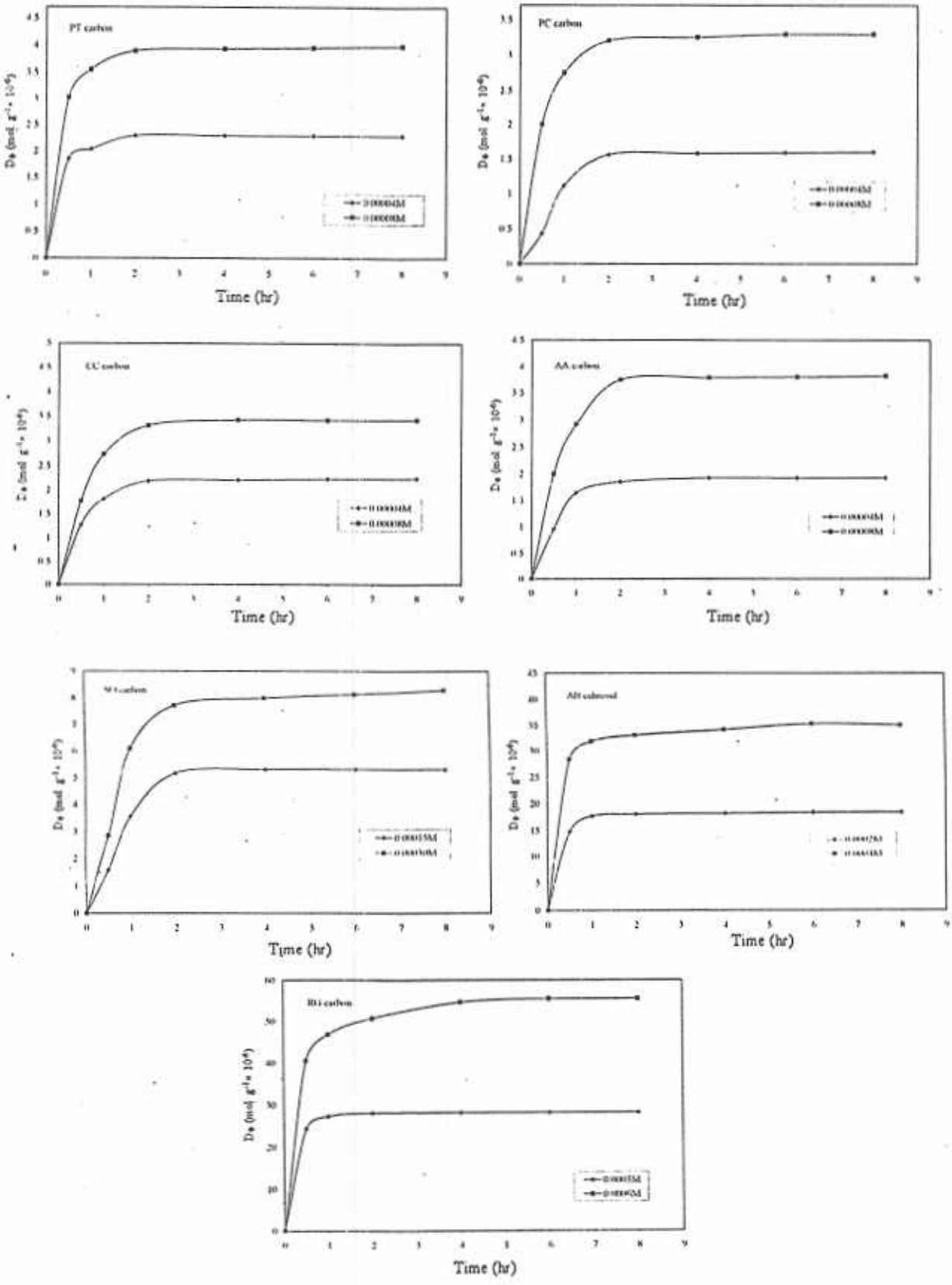


Figure 4.72 Equilibration time for the adsorption of acid yellow 34 on carbon samples at 25 °C

Table 4.69 Equilibration time for the adsorption of acid orange 7 on carbon samples

	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
		pH_{si}	Ab_{si}	D_e (mol/L $\times 10^{-5}$)	$D_e - D_e$ (mol/L $\times 10^{-5}$)	D_ϕ (mol/g $\times 10^{-5}$)	pH_{si}	Ab_{si}	D_e (mol/L $\times 10^{-5}$)	$D_e - D_e$ (mol/L $\times 10^{-5}$)	D_ϕ (mol/g $\times 10^{-5}$)
Paulownia tomentosa (PT)	½	8.16	0.160	1.0080	0.991	0.991	8.70	0.446	2.810	1.190	1.190
	1	8.71	0.130	0.8190	1.180	1.180	8.84	0.433	2.730	1.270	1.270
	2	9.02	0.115	0.7250	1.280	1.280	9.18	0.430	2.710	1.290	1.290
	4	9.09	0.115	0.7250	1.280	1.280	9.20	0.430	2.710	1.290	1.290
	6	9.11	0.115	0.7250	1.280	1.280	9.21	0.430	2.710	1.290	1.290
	8	9.13	0.115	0.7250	1.280	1.280	9.21	0.430	2.710	1.290	1.290
		pH before adsorption = 6.92					pH before adsorption = 6.75				
Populus caspica (PC)	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
	½	9.41	0.185	1.1660	0.8330	0.833	9.72	0.380	2.396	1.6040	1.6040
	1	9.98	0.153	0.9640	1.0360	1.036	9.88	0.340	2.1437	1.8562	1.8562
	2	10.11	0.148	0.9330	1.0670	1.067	10.02	0.335	2.1122	1.8877	1.8877
	4	10.12	0.151	0.9500	1.0500	1.050	10.14	0.332	2.0933	1.9066	1.9066
	6	10.13	0.150	0.9400	1.0600	1.060	10.16	0.331	2.0870	1.9129	1.9129
	8	10.15	0.150	0.9400	1.0600	1.060	10.17	0.331	2.0870	1.9130	1.9130
		pH before adsorption = 6.92					pH before adsorption = 6.75				
Corncobs (CC)	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
	½	3.69	0.104	0.656	1.340	1.340	3.32	0.292	1.840	2.160	2.160
	1	3.34	0.070	0.440	1.560	1.560	3.30	0.260	1640	2.360	2.360
	2	3.30	0.068	0.428	1.570	1.570	3.20	0.250	1.570	2.430	2.430
	4	3.27	0.067	0.420	1.580	1.580	3.18	0.248	1.560	2.440	2.440
	6	3.26	0.067	0.420	1.580	1.580	3.17	0.247	1.550	2.450	2.450
	8	3.26	0.067	0.420	1.580	1.580	3.16	0.247	1.550	2.450	2.450
		pH before adsorption = 6.92					pH before adsorption = 6.75				
Ailanthus altissima (AA)	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
	½	09.47	0.160	1.010	0.990	0.990	09.81	0.461	2.906	1.093	1.093
	1	09.82	0.150	0.940	1.060	1.060	09.97	0.432	2.724	1.276	1.276
	2	10.04	0.140	0.880	1.120	1.120	09.99	0.431	2.717	1.282	1.282
	4	10.07	0.140	0.880	1.120	1.120	10.02	0.430	2.710	1.290	1.290
	6	10.10	0.140	0.880	1.120	1.120	10.04	0.428	2.690	1.310	1.310
	8	10.12	0.140	0.880	1.120	1.120	10.06	0.427	2.680	1.320	1.320
		pH before adsorption = 6.92					pH before adsorption = 6.75				
Salvadora oleoides (SO)	Time (h)	20×10^{-5} mol/L					40×10^{-5} mol/L				
	½	7.24	3.00	18.915	1.0844	1.0844	7.30	3.860	24.330	15.67	15.67
	1	7.29	2.80	17.654	2.3455	2.3455	7.31	3.000	13.556	26.44	26.44
	2	7.35	2.70	17.040	2.9760	2.9760	7.32	2.150	12.610	27.38	27.38
	4	7.42	2.65	16.710	3.2913	3.2913	7.35	2.110	13.304	26.69	26.69
	6	7.40	2.64	16.645	3.3543	3.3543	7.33	2.108	13.291	26.70	26.70
	8	7.40	2.63	16.583	3.4174	3.4174	7.33	2.106	13.278	26.72	26.72
		pH before adsorption = 6.92					pH before adsorption = 6.35				

Table 4.70 Equilibration time for the adsorption of acid orange 7 on carbon samples

	Time (h)	20×10^{-5} mol/L					40×10^{-5} mol/L				
		pH_M	Ab_M	D_m (mo/L × 10^{-5})	D_e- D_m (mo/L×10^{-5})	D_f (mol/g × 10^{-6})	pH_M	Ab_M	D_m (mo/L × 10^{-5})	D_e- D_m (mo/L×10^{-5})	D_f (mol/g × 10^{-6})
Animal bones (ABC)	½	8.16	3.860	24.337	4.3379	4.3379	8.28	5.320	33.543	6.4564	6.4564
	1	8.06	1.250	7.8814	12.110	12.110	8.34	1.940	12.230	27.767	27.767
	2	8.28	0.070	0.4413	19.559	19.559	8.30	0.137	0.8638	39.136	39.136
	4	8.39	0.068	0.4287	19.571	19.571	8.38	0.099	0.6242	39.376	39.376
	6	8.39	0.068	0.4287	19.571	19.571	8.37	0.096	0.6053	39.395	39.395
	8	8.39	0.068	0.4287	19.571	19.571	8.37	0.096	0.6053	39.397	39.397
		pH before adsorption = 6.90					pH before adsorption = 6.35				
	Time (h)	30×10^{-5} mol/L					60×10^{-5} mol/L				
Regenerated (RG)	½	7.41	0.840	5.2963	14.703	14.703	7.27	1.510	9.521	30.479	30.479
	1	7.32	0.297	1.8730	18.127	18.127	7.26	0.873	5.507	34.493	34.493
	2	7.30	0.290	1.8280	18.172	18.172	7.25	0.594	3.745	36.255	36.255
	4	7.28	0.285	1.7969	18.203	18.203	7.24	0.546	3.443	36.557	36.557
	6	7.28	0.285	1.7969	18.203	18.203	7.24	0.540	3.405	36.595	36.595
	8	7.28	0.285	1.7969	18.203	18.203	7.24	0.540	3.405	36.595	36.595
		pH before adsorption = 6.90					pH before adsorption = 6.35				

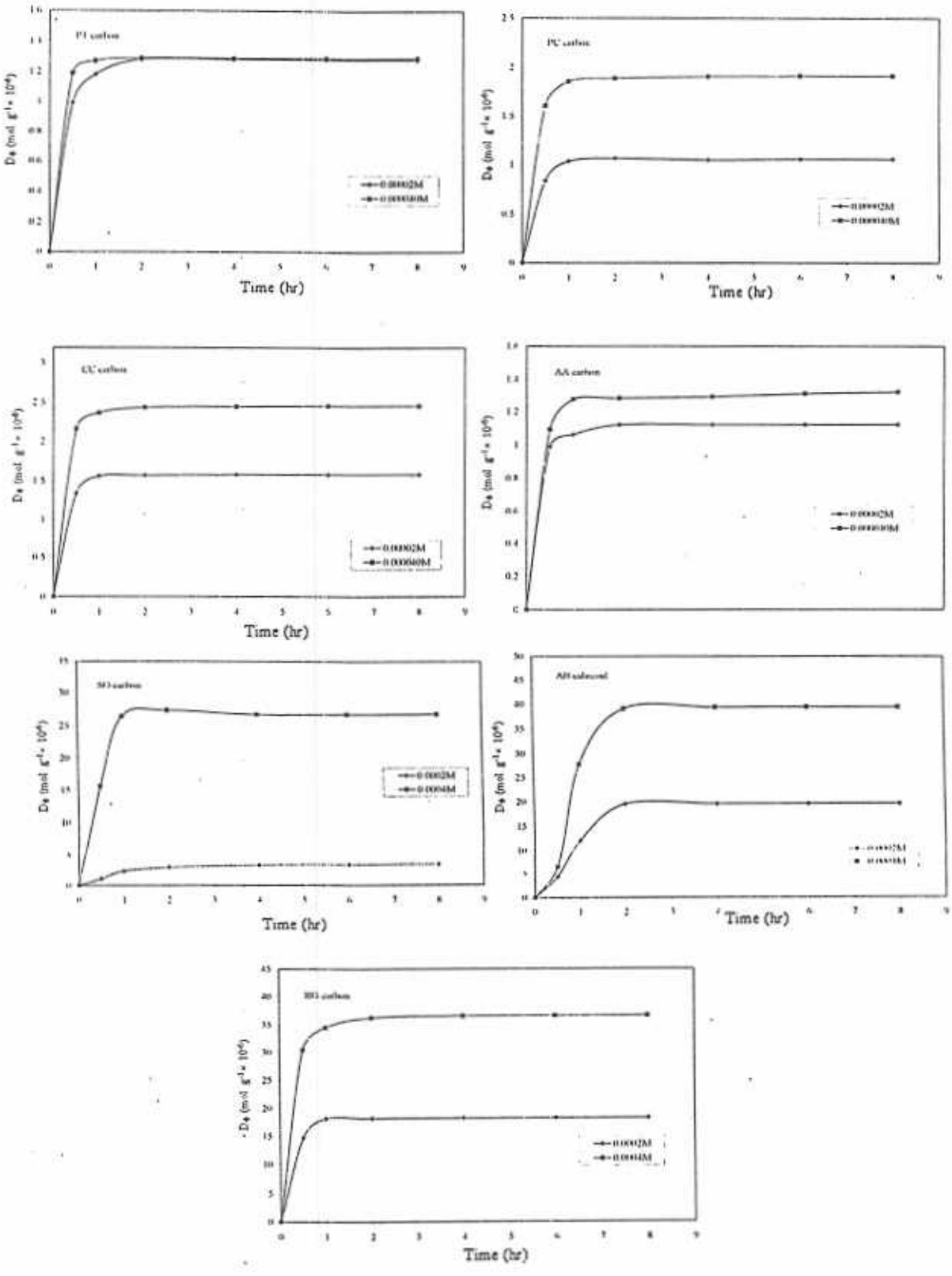


Figure 4.73 Equilibration time for the adsorption of acid orange 7 on carbon samples at 25 °C

Table 4.71 Equilibration time for the adsorption of acid orange 10 on carbon samples

	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
		pH_M	Ab_M	D_e (mol/L $\times 10^{-5}$)	$D_e - D_e$ (mol/L$\times 10^{-5}$)	D_ϕ (mol/g $\times 10^{-5}$)	pH_M	Ab_M	D_e (mol/L $\times 10^{-5}$)	$D_e - D_e$ (mol/L$\times 10^{-5}$)	D_ϕ (mol/g $\times 10^{-5}$)
Paulownia tomentosa (PT)	½	9.13	0.594	3.930	0.060	0.060	8.68	0.230	1.5200	0.480	0.480
	1	9.30	0.590	3.910	0.090	0.090	8.99	0.220	1.4600	0.540	0.540
	2	9.55	0.587	3.890	0.110	0.110	9.17	0.215	1.4200	0.580	0.580
	4	9.60	0.586	3.880	0.120	0.120	9.20	0.214	1.4190	0.581	0.581
	6	9.63	0.586	3.880	0.120	0.120	9.25	0.212	1.4100	0.590	0.590
	8	9.64	0.586	3.880	0.120	0.120	9.30	0.211	1.3990	0.601	0.601
		pH before adsorption = 6.62					pH before adsorption = 6.10				
Populus caspica (PC)	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
	½	09.60	0.249	1.650	0.350	0.350	09.68	0.502	3.320	0.680	0.680
	1	09.87	0.230	1.520	0.480	0.480	09.89	0.495	3.280	0.720	0.720
	2	10.14	0.220	1.460	0.540	0.540	10.14	0.480	3.180	0.820	0.820
	4	10.19	0.220	1.460	0.540	0.540	10.19	0.480	3.180	0.820	0.820
	6	10.20	0.220	1.460	0.540	0.540	10.21	0.480	3.160	0.840	0.840
	8	10.22	0.220	1.460	0.540	0.540	10.22	0.480	6.140	0.860	0.860
		pH before adsorption = 6.62					pH before adsorption = 6.10				
Corncobs (CC)	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
	½	3.51	0.270	1.790	0.210	0.210	3.32	0.540	3.580	0.420	0.420
	1	3.34	0.250	1.650	0.350	0.350	3.27	0.510	3.380	0.620	0.620
	2	3.24	0.245	1.620	0.390	0.390	3.16	0.505	3.340	0.660	0.660
	4	3.20	0.243	1.610	0.390	0.390	3.13	0.503	3.330	0.670	0.670
	6	3.19	0.242	1.600	0.390	0.390	3.10	0.503	3.330	0.670	0.670
	8	3.16	0.242	1.600	0.390	0.390	3.10	0.503	3.330	0.670	0.670
		pH before adsorption = 6.62					pH before adsorption = 6.10				
Allanthus altissima (AA)	Time (h)	2.0×10^{-5} mol/L					4.0×10^{-5} mol/L				
	½	09.17	0.266	1.760	0.240	0.240	09.71	0.430	2.850	1.150	1.150
	1	10.01	0.197	1.300	0.700	0.700	09.99	0.385	2.550	1.470	1.470
	2	10.10	0.192	1.270	0.730	0.730	10.08	0.286	1.900	2.100	2.100
	4	10.22	0.190	1.260	0.740	0.740	10.16	0.280	1.850	2.150	2.150
	6	10.22	0.190	1.260	0.740	0.740	10.20	0.280	1.850	2.150	2.150
	8	10.23	0.190	1.260	0.740	0.740	10.21	0.280	1.850	2.150	2.150
		pH before adsorption = 6.62					pH before adsorption = 6.10				
Salvadora oleoides (SO)	Time (h)	10×10^{-5} mol/L					20×10^{-5} mol/L				
	½	7.58	1.48	9.81	0.190	0.190	7.48	2.90	19.23	0.770	0.770
	1	7.61	1.40	9.28	0.720	0.720	7.37	2.80	18.57	1.430	1.430
	2	7.62	1.35	8.95	1.050	1.050	7.49	2.76	18.30	1.700	1.700
	4	7.93	1.30	8.62	1.380	1.380	7.53	2.74	18.16	1.840	1.840
	6	7.95	1.30	8.62	1.380	1.380	7.53	2.74	18.16	1.840	1.840
	8	7.95	1.30	8.62	1.380	1.380	7.53	2.74	18.16	1.840	1.840
		pH before adsorption = 6.80					pH before adsorption = 7.17				

Table 4.72 Equilibration time for the adsorption of acid orange 10 on activated carbon

	Time (h)	20×10^{-5} mol/L					40×10^{-5} mol/L				
		pH_M	Ab_M	D_n (mo/L × 10^{-5})	D_o- D_n (mo/L×10^{-5})	D_k (mol/g × 10^{-6})	pH_M	Ab_M	D_n (mo/L × 10^{-5})	D_o- D_n (mo/L×10^{-5})	D_k (mol/g × 10^{-6})
Animal bones (ABC)	½	8.11	1.700	11.27	8.7300	8.7300	7.81	3.80	25.190	14.810	14.810
	1	7.84	1.400	9.280	10.720	10.720	7.87	3.60	23.870	16.130	16.130
	2	7.93	1.200	7.960	12.040	12.040	7.95	3.36	22.280	17.720	17.720
	4	7.89	1.100	7.290	12.710	12.710	7.99	3.34	22.140	17.860	17.860
	6	7.89	1.095	7.250	12.750	12.750	7.98	3.34	22.140	17.860	17.860
	8	7.88	1.095	7.250	12.750	12.750	7.98	3.34	22.140	17.860	17.860
		pH before adsorption = 7.17					pH before adsorption = 6.80				
	Time (h)	20×10^{-5} mol/L					40×10^{-5} mol/L				
Regenerated (RG)	½	7.29	1.950	12.930	7.0700	7.0700	7.11	1.90	12.600	27.400	27.400
	1	7.31	1.401	9.3500	10.650	10.650	7.17	1.63	10.740	29.260	29.260
	2	7.20	1.300	8.6200	11.380	11.380	7.18	1.46	9.6800	30.320	30.320
	4	7.21	1.046	6.9400	13.060	13.060	7.18	1.30	8.6200	31.380	31.380
	6	7.21	1.044	6.9200	13.080	13.080	7.18	1.30	8.6200	31.380	31.380
	8	7.21	1.043	6.9200	13.080	13.080	7.18	1.30	8.6200	31.380	31.380
		pH before adsorption = 7.17					pH before adsorption = 6.80				

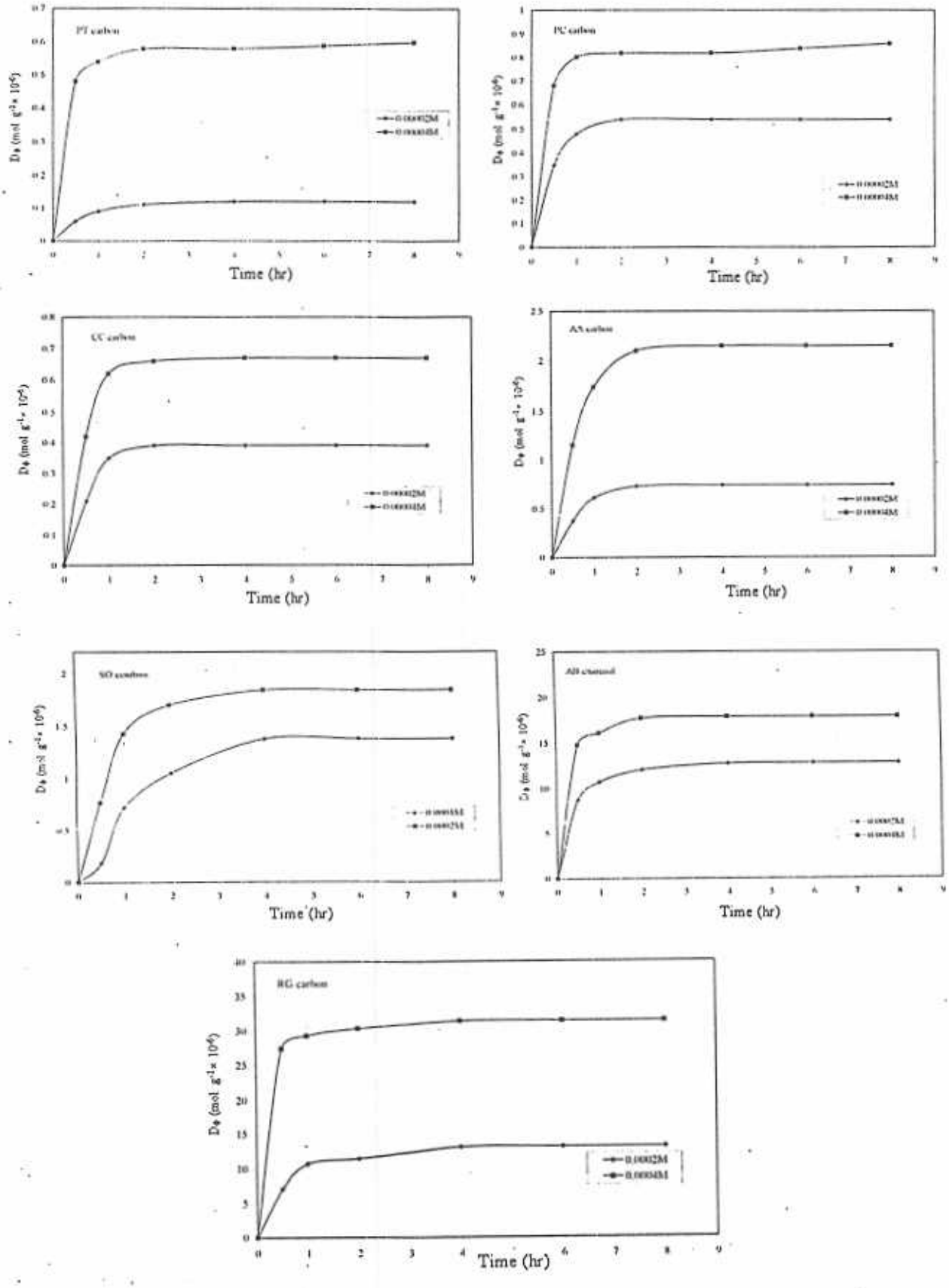


Figure 4.74 Equilibration time for the adsorption of acid orange 10 on carbon samples at 25 °C

Table 4.73 Adsorption isotherm of acid blue 1 on carbon samples

Sample		D_o ($mol/L \times 10^{-4}$)	at 10°C				D_o ($mol/L \times 10^{-4}$)	at 45°C			
			Ab_M	D_e ($mol/L \times 10^{-5}$)	D_o-D_e ($mol/L \times 10^{-5}$)	D_ϕ ($mol/g \times 10^{-4}$)		Ab_M	D_e ($mol/L \times 10^{-5}$)	D_o-D_e ($mol/L \times 10^{-5}$)	D_ϕ ($mol/g \times 10^{-4}$)
Paulownia tomentosa (PT)	Raw	3.00	0.090	0.125	0.175	0.175	3.00	0.050	0.069	0.231	0.231
		6.00	0.120	0.166	0.434	0.434	6.00	0.100	0.138	0.462	0.462
		9.00	0.182	0.252	0.648	0.648	9.00	0.160	0.222	0.678	0.678
		12.0	0.250	0.346	0.854	0.854	12.0	0.240	0.332	0.867	0.867
		15.0	0.360	0.498	1.001	1.001	15.0	0.332	0.459	1.040	1.040
		18.0	0.499	0.691	1.108	1.108	18.0	0.490	0.678	1.121	1.121
		21.0	0.650	0.900	1.190	1.190	21.0	0.635	0.879	1.220	1.220
		23.0	0.780	1.080	1.219	1.219	23.0	0.745	1.032	1.268	1.268
	400 °C	3.00	0.071	0.097	0.203	0.203	3.00	0.058	0.080	0.220	0.220
		6.00	0.141	0.195	0.404	0.404	6.00	0.097	0.134	0.466	0.466
		9.00	0.185	0.256	0.643	0.643	9.00	0.174	0.241	0.658	0.658
		12.0	0.270	0.374	0.826	0.826	12.0	0.248	0.343	0.857	0.857
		15.0	0.368	0.511	0.989	0.989	15.0	0.349	0.483	1.017	1.017
		18.0	0.490	0.678	1.121	1.121	18.0	0.470	0.651	1.148	1.148
		21.0	0.655	0.907	1.192	1.192	21.0	0.620	0.858	1.241	1.241
		23.0	0.800	1.108	1.192	1.192	23.0	0.750	1.038	1.261	1.261
	800 °C	3.00	0.022	0.03047	0.26953	0.26953	3.00	0.010	0.0138	0.2861	0.2861
		6.00	0.033	0.04571	0.55430	0.55430	6.00	0.021	0.0291	0.5709	0.5709
		9.00	0.046	0.06372	0.83630	0.83630	9.00	0.034	0.0471	0.8529	0.8529
		12.0	0.057	0.07896	1.12104	1.12104	12.0	0.045	0.0623	1.1376	1.1376
		15.0	0.073	0.10112	1.39887	1.39887	15.0	0.060	0.0831	1.4168	1.4168
		18.0	0.092	0.12744	1.67255	1.67255	18.0	0.081	0.1120	1.6880	1.6880
		21.0	0.127	0.17592	1.92407	1.92407	21.0	0.115	0.1593	1.9410	1.9410
		23.0	0.178	0.24657	2.05343	2.05343	23.0	0.165	0.2285	2.0714	2.0714
Populus caspica (PC)	Raw	3.00	0.120	0.166	0.133	0.133	3.00	0.120	0.166	0.134	0.134
		6.00	0.205	0.284	0.316	0.316	6.00	0.220	0.300	0.300	0.300
		9.00	0.350	0.430	0.414	0.414	9.00	0.311	0.430	0.470	0.470
		12.0	0.502	0.620	0.505	0.505	12.0	0.451	0.620	0.580	0.580
		15.0	0.644	0.892	0.608	0.608	15.0	0.570	0.790	0.710	0.710
		18.0	0.860	1.19	0.608	0.608	18.0	0.750	1.039	0.761	0.761
		21.0	1.077	1.492	0.608	0.608	21.0	0.967	1.334	0.760	0.760
		23.0	1.220	1.169	0.610	0.610	23.0	1.09	1.510	0.791	0.791
	400 °C	3.00	0.090	0.124	0.176	0.176	3.00	0.071	0.098	0.202	0.202
		6.00	0.145	0.200	0.400	0.400	6.00	0.124	0.171	0.429	0.429
		9.00	0.235	0.325	0.575	0.575	9.00	0.211	0.292	0.608	0.608
		12.0	0.371	0.514	0.686	0.686	12.0	0.341	0.472	0.728	0.728
		15.0	0.569	0.788	0.711	0.711	15.0	0.481	0.666	0.834	0.834
		18.0	0.781	1.082	0.718	0.718	18.0	0.680	0.942	0.858	0.858
		21.0	0.991	1.372	0.727	0.727	21.0	0.889	1.231	0.868	0.868
		23.0	1.140	1.580	0.721	0.721	23.0	1.042	1.443	0.856	0.856
	800 °C	3.00	0.070	0.097	0.203	0.203	3.00	0.051	0.070	0.230	0.230
		6.00	0.130	0.180	0.420	0.420	6.00	0.108	0.150	0.450	0.450
		9.00	0.222	0.307	0.593	0.593	9.00	0.203	0.281	0.619	0.619
		12.0	0.360	0.498	0.702	0.702	12.0	0.300	0.415	0.784	0.784
		15.0	0.492	0.681	0.819	0.819	15.0	0.400	0.554	0.946	0.946
		18.0	0.692	0.958	0.841	0.841	18.0	0.565	0.782	1.018	1.018
		21.0	0.920	1.274	0.830	0.830	21.0	0.779	1.079	1.021	1.021
		23.0	1.050	1.454	0.845	0.845	23.0	0.929	1.287	1.013	1.013

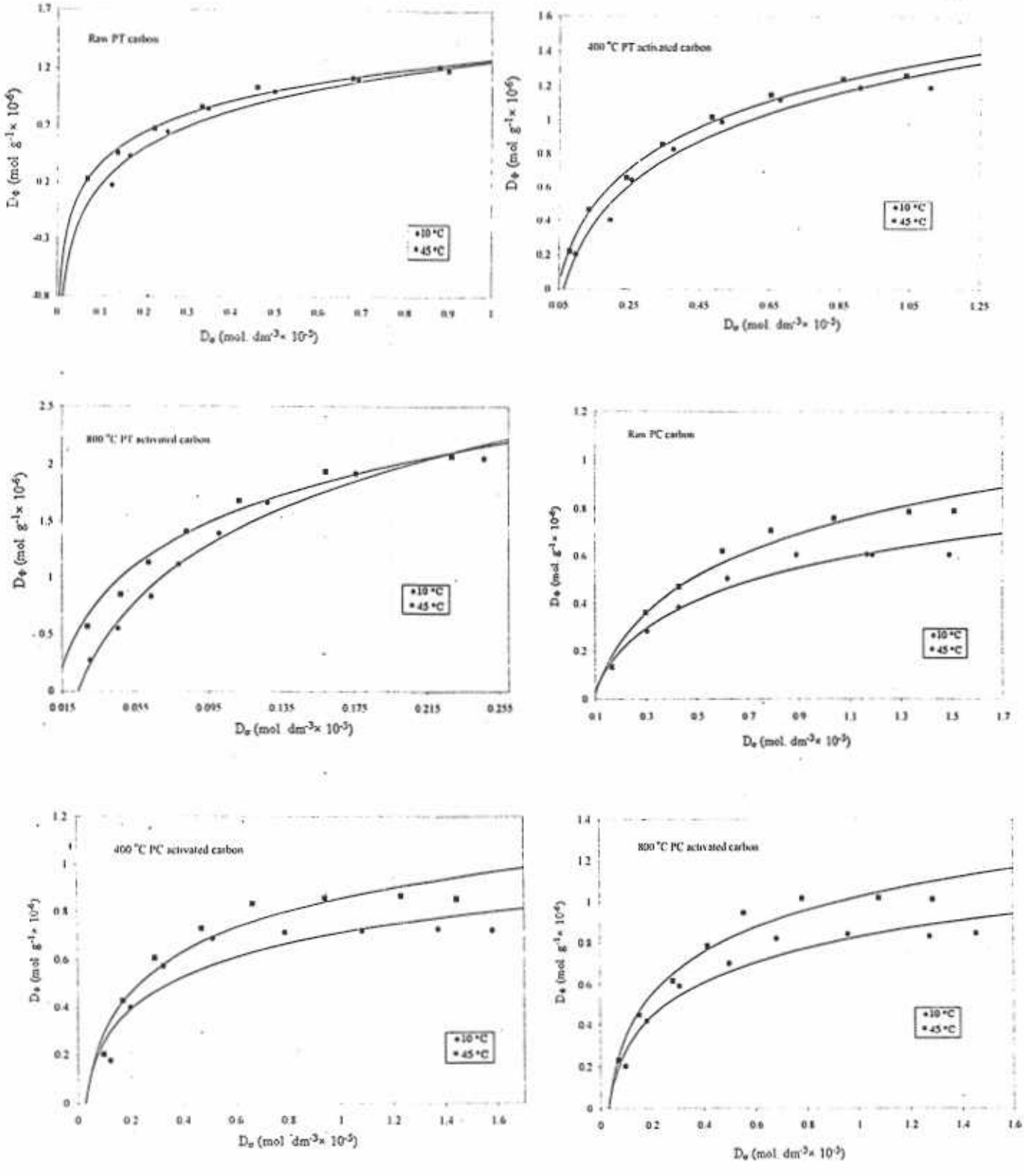


Figure 4.75 Adsorption isotherms of acid blue 1 on *Paulownia tomentosa* (PT) and *Populus caspica* (PC) carbon samples.

Table 4.74 Adsorption isotherm of acid blue 1 on carbon samples

Sample		D_o ($mol/L \times 10^{-6}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-6}$)	at 45°C			
			Ab_M	D_e (mol./L × 10^{-5})	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_s ($mol.g^{-1} \times 10^{-6}$)		Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_s ($mol.g^{-1} \times 10^{-6}$)
Corncobs (CC)	Raw	3.00	0.101	0.134	0.161	0.161	3.00	0.100	0.13850	0.16470	0.1647
		6.00	0.200	0.277	0.322	0.322	6.00	0.170	0.23548	0.36450	0.3645
		9.00	0.290	0.401	0.499	0.499	9.00	0.250	0.34630	0.55370	0.5537
		12.0	0.421	0.583	0.620	0.620	12.0	0.341	0.47200	0.72800	0.7280
		15.0	0.595	0.824	0.675	0.675	15.0	0.520	0.72000	0.77900	0.7790
		18.0	0.808	1.120	0.680	0.680	18.0	0.738	1.02200	0.77800	0.7780
		21.0	1.045	1.447	0.652	0.652	21.0	0.966	1.33800	0.76200	0.7620
		23.0	1.180	1.634	0.665	0.665	23.0	1.111	1.53800	0.76100	0.7610
	400 °C	3.00	0.075	0.104	0.196	0.196	3.00	0.044	0.061	0.239	0.239
		6.00	0.13	0.180	0.420	0.420	6.00	0.110	0.152	0.448	0.448
		9.00	0.176	0.243	0.657	0.657	9.00	0.155	0.215	0.685	0.685
		12.0	0.281	0.389	0.811	0.811	12.0	0.262	0.363	0.837	0.837
		15.0	0.468	0.648	0.851	0.851	15.0	0.423	0.586	0.914	0.914
		18.0	0.670	0.928	0.872	0.872	18.0	0.599	0.829	0.970	0.970
		21.0	0.875	1.212	0.888	0.888	21.0	0.810	1.122	0.978	0.978
		23.0	1.020	1.413	0.888	0.888	23.0	0.958	1.327	0.973	0.973
	800 °C	3.00	0.024	0.033	0.2660	0.2660	3.00	0.002	0.0027	0.2970	0.2970
		6.00	0.084	0.116	0.4840	0.4840	6.00	0.020	0.0277	0.5723	0.5723
		9.00	0.175	0.2424	0.6576	0.6576	9.00	0.090	0.1250	0.7750	0.7750
		12.0	0.260	0.3602	0.8398	0.8398	12.0	0.184	0.255	0.9450	0.9450
		15.0	0.404	0.559	0.9440	0.9440	15.0	0.314	0.4350	1.0650	1.0650
		18.0	0.540	0.748	1.0000	1.0000	18.0	0.470	0.6511	1.1489	1.1489
		21.0	0.780	1.080	1.0100	1.0100	21.0	0.650	0.9000	1.1990	1.1990
		23.0	0.900	1.246	1.0500	1.0500	23.0	0.810	1.1220	1.1780	1.1780
Ailanthus altissima (AA)	Raw	3.00	0.130	0.1801	0.1199	0.1199	3.00	0.065	0.0900	0.20995	0.20995
		6.00	0.210	0.2909	0.3091	0.3091	6.00	0.126	0.17454	0.42546	0.42546
		9.00	0.355	0.4920	0.408	0.408	9.00	0.242	0.33522	0.56470	0.56470
		12.0	0.500	0.6926	0.507	0.507	12.0	0.381	0.52700	0.67300	0.67300
		15.0	0.680	0.9420	0.558	0.558	15.0	0.555	0.76880	0.73120	0.73120
		18.0	0.885	1.2260	0.574	0.574	18.0	0.770	1.06660	0.73330	0.73330
		21.0	1.100	1.5237	0.576	0.576	21.0	0.985	1.36440	0.73550	0.73550
		23.0	1.250	1.7315	0.568	0.568	23.0	1.127	1.56110	0.73880	0.73880
	400 °C	3.00	0.100	0.1385	0.162	0.162	3.00	0.080	0.111	0.1892	0.1892
		6.00	0.173	0.2400	0.360	0.360	6.00	0.150	0.207	0.3922	0.3922
		9.00	0.273	0.3780	0.522	0.522	9.00	0.242	0.335	0.5647	0.5647
		12.0	0.416	0.5760	0.624	0.624	12.0	0.361	0.500	0.6999	0.6999
		15.0	0.540	0.7480	0.752	0.752	15.0	0.500	0.693	0.8074	0.8074
		18.0	0.702	0.9724	0.827	0.827	18.0	0.672	0.931	0.8691	0.8691
		21.0	0.910	1.2600	0.839	0.839	21.0	0.880	1.220	0.8810	0.8810
		23.0	1.060	1.4680	0.832	0.832	23.0	1.010	1.399	0.9009	0.9009
	800 °C	3.00	0.042	0.058	0.2420	0.2420	3.00	0.010	0.0138	0.2861	0.2861
		6.00	0.090	0.125	0.4753	0.4753	6.00	0.031	0.0430	0.5570	0.5570
		9.00	0.145	0.201	0.6991	0.6991	9.00	0.110	0.1523	0.7476	0.7476
		12.0	0.252	0.349	0.8510	0.8510	12.0	0.227	0.3144	0.8855	0.8855
		15.0	0.402	0.557	0.9430	0.9430	15.0	0.365	0.5056	0.9943	0.9943
		18.0	0.598	0.828	0.9716	0.9716	18.0	0.504	0.6981	1.1018	1.1018
		21.0	0.800	1.108	0.9918	0.9918	21.0	0.650	0.9004	1.1995	1.1995
		23.0	0.940	1.302	0.9978	0.9978	23.0	0.785	1.0874	1.2126	1.2126

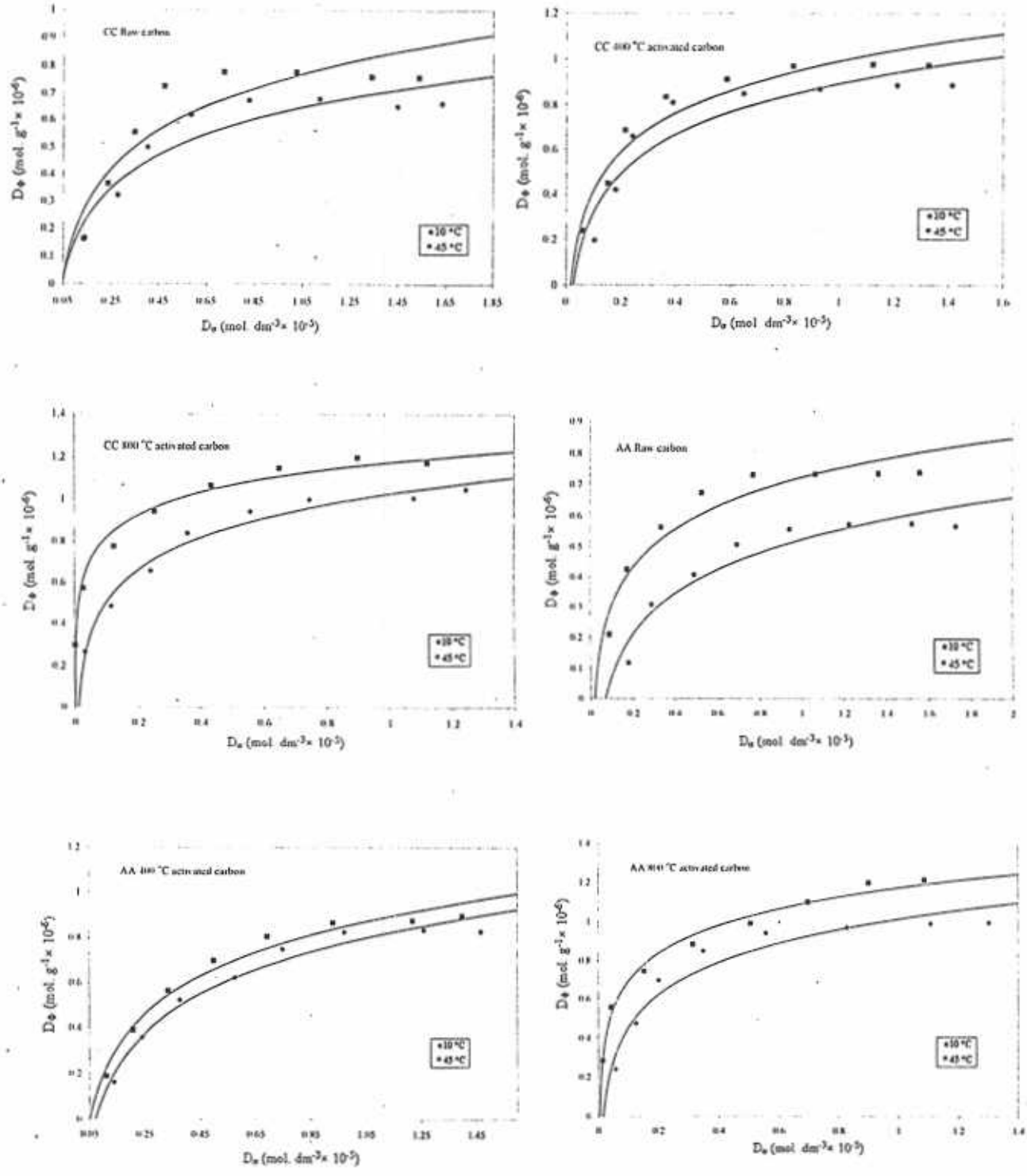


Figure 4.76 Adsorption isotherms of acid blue 1on *Corncobs* (CC) and *Ailanthus altissima* (AA) carbon samples.

Table 4.75 Adsorption isotherm of acid blue 1 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_t ($mol.g^{-1} \times 10^{-4}$)		Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e $mol.dm^{-3} \times 10^{-5}$)	D_t ($mol.g^{-1} \times 10^{-4}$)
Salvadora Oleoides (SO)	Raw	1.00	0.600	0.8311	0.1688	0.1688	1.00	0.450	0.623	0.376	0.376
		2.00	1.075	1.4891	0.5108	0.5108	2.00	0.920	1.274	0.726	0.726
		3.00	1.560	2.1609	0.8390	0.8390	3.00	1.250	1.731	1.268	1.268
		4.00	1.910	2.6457	1.3542	1.3542	4.00	1.600	2.216	1.784	1.784
		5.00	2.260	3.1306	1.8693	1.8693	5.00	1.950	2.701	2.299	2.299
		6.00	2.750	3.8100	2.1906	2.1906	6.00	2.400	3.324	2.676	2.676
		8.00	4.000	5.5409	2.4590	2.4590	8.00	3.600	4.986	3.014	3.014
		1.00	5.380	7.4525	2.5470	2.5470	1.00	4.990	6.912	3.087	3.087
	400 °C	1.00	0.335	0.4640	0.5359	0.5359	1.00	0.225	0.3117	0.6883	0.6883
		2.00	0.740	1.0250	0.9749	0.9749	2.00	0.600	0.8311	1.1688	1.1688
		3.00	1.090	1.5099	1.4900	1.4900	3.00	0.920	1.2744	1.7256	1.7256
		4.00	1.300	1.8000	2.1992	2.1992	4.00	1.220	1.6899	2.3100	2.3100
		5.00	1.700	2.3548	2.6451	2.6451	5.00	1.600	2.2163	2.7836	2.7836
		6.00	2.000	2.7705	3.2295	3.2295	6.00	1.900	2.6319	3.3680	3.3680
		8.00	3.340	4.6266	3.3733	3.3733	8.00	3.200	4.4327	3.5670	3.5670
		10.0	4.700	6.5106	3.4894	3.4894	10.0	4.550	6.3028	3.6972	3.6972
	600 °C	1.00	0.152	0.21055	0.7894	0.7894	1.00	0.124	0.1717	0.8282	0.8282
		2.00	0.385	0.53330	1.4666	1.4666	2.00	0.359	0.4973	1.5027	1.5027
		3.00	0.752	1.0417	1.9583	1.9583	3.00	0.700	0.9696	2.0303	2.0303
		4.00	1.100	1.52375	2.4762	2.4762	4.00	1.152	1.5957	2.4042	2.4042
		5.00	1.402	1.94209	3.0579	3.0579	5.00	1.540	2.1332	2.8667	2.8667
		6.00	1.930	2.67350	3.3265	3.3265	6.00	1.850	2.5626	3.4370	3.4370
		8.00	3.000	4.15570	3.8443	3.8443	8.00	2.800	3.8786	4.1213	4.1213
		10.0	4.400	6.09502	3.9049	3.9049	10.0	4.200	5.8179	4.1820	4.1820
	800 °C	1.00	0.0400	0.05541	0.94459	0.94459	1.00	0.010	0.01385	0.9861	0.9861
		2.00	0.1150	0.15930	1.84069	1.84069	2.00	0.030	0.04155	1.9584	1.9584
		3.00	0.3220	0.44604	2.55395	2.55395	3.00	0.036	0.04986	2.9501	2.9501
		4.00	0.6800	0.94195	3.05804	3.05804	4.00	0.161	0.22302	3.7769	3.7769
		5.00	1.1600	1.60687	3.39313	3.39313	5.00	0.262	0.36293	4.6370	4.6370
		6.00	1.8200	2.52113	3.47887	3.47887	6.00	0.692	0.95858	5.0414	5.0414
		8.00	3.200	4.43274	3.56725	3.56725	8.00	1.600	2.21637	5.7836	5.7836
		10.0	4.620	6.39977	3.60022	3.60022	10.0	2.860	3.96176	6.0382	6.0382
	900 °C	1.00	0.0220	0.03047	0.96952	0.96952	1.00	0.005	0.0069	0.99307	0.99307
		2.00	0.0200	0.02770	1.97229	1.97229	2.00	0.012	0.0166	1.98337	1.98337
		3.00	0.0290	0.04017	2.95983	2.95983	3.00	0.043	0.0595	2.94043	2.94043
		4.00	0.1000	0.13852	3.86147	3.86147	4.00	0.117	0.1621	3.83792	3.83792
		5.00	0.2100	0.29089	4.70910	4.70910	5.00	0.169	0.2341	4.76580	4.76580
		6.00	0.6720	0.93087	5.06912	5.06912	6.00	0.300	0.4155	5.58440	5.58440
		8.00	2.1000	2.90899	5.09100	5.09100	8.00	1.500	2.07785	5.92214	5.92214
		10.0	3.5200	4.87602	5.12397	5.12397	10.0	2.800	3.8786	6.12130	6.12130
	1000 °C	1.00	0.0320	0.044327	0.95567	0.95567	1.00	0.021	0.02908	0.97091	0.97091
		2.00	0.0400	0.055409	1.94459	1.94459	2.00	0.028	0.03878	1.96121	1.96121
		3.00	0.0590	0.081728	2.91827	2.91827	3.00	0.032	0.04432	2.95570	2.95570
		4.00	0.1900	0.263194	3.73680	3.73680	4.00	0.043	0.0595	3.94043	3.94043
		5.00	0.3100	0.429422	4.57057	4.57057	5.00	0.150	0.20778	4.79221	4.79221
		6.00	0.7520	1.041690	4.95830	4.95830	6.00	0.280	0.3878	5.61212	5.61212
		8.00	2.1400	2.964399	5.03560	5.03560	8.00	1.300	1.80080	6.19919	6.19919
		10.0	3.5200	4.876021	5.12397	5.12397	10.0	2.550	3.53245	6.46765	6.46765

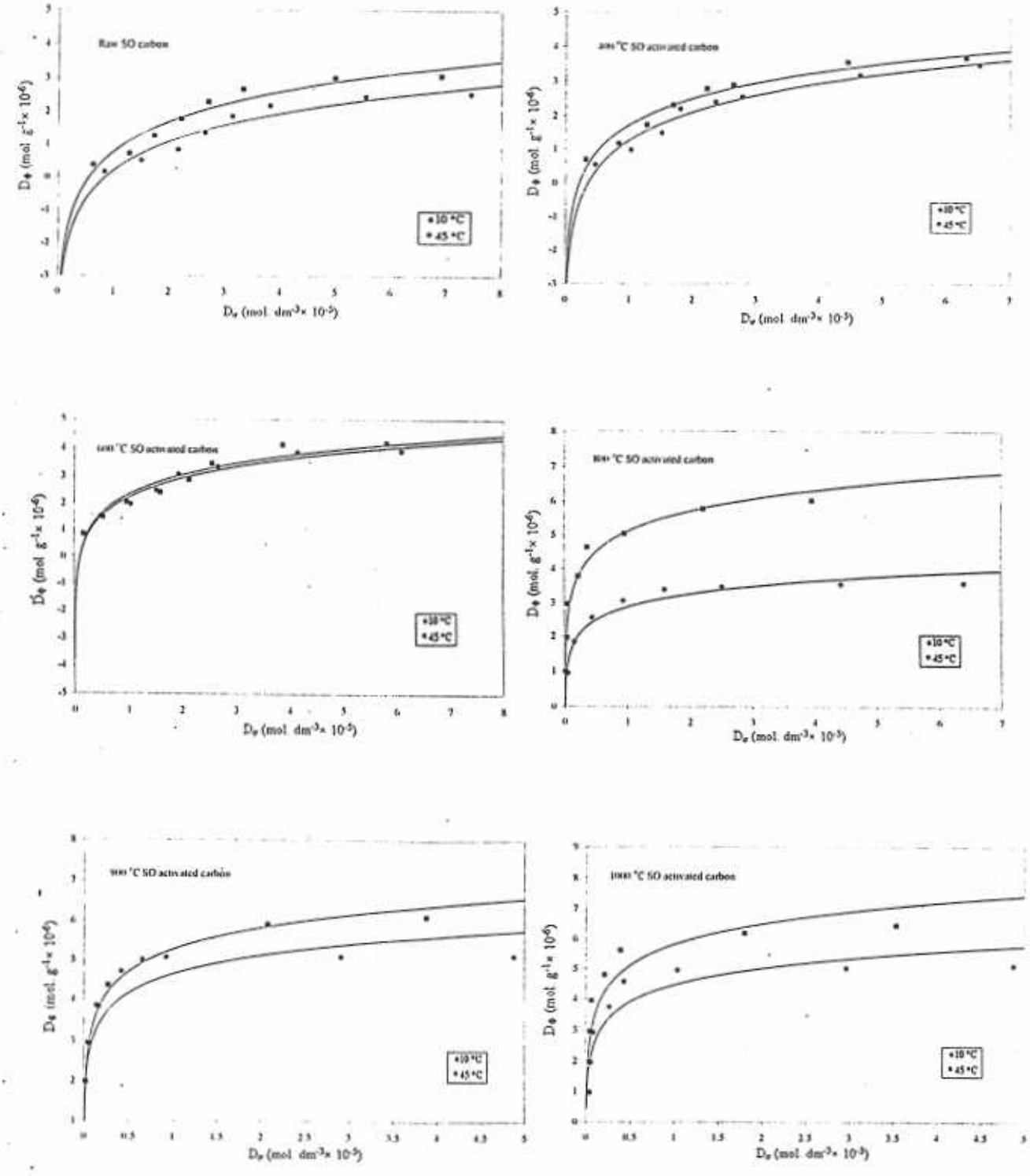


Figure 4.77 Adsorption isotherms of acid blue 1 on *Salvadora oleoides* (SO) carbon samples

Table 4.76 Adsorption isotherm of acid blue 1 on animal bones based carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Abs_t	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_t ($mol.g^{-1} \times 10^{-2}$)		Abs_t	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_t ($mol.g^{-1} \times 10^{-2}$)
Animal bones (ABC)	600 °C	4.00	0.540	0.74802	3.2519	3.2519	4.00	0.220	0.30475	3.69520	3.69520
		6.00	0.688	0.95304	5.0469	5.0469	6.00	0.376	0.52084	5.47915	5.47915
		8.00	0.822	1.13866	6.8613	6.8613	8.00	0.510	0.70646	7.29353	7.29353
		10.0	1.046	1.44895	8.5510	8.5510	10.0	0.734	1.01676	8.98320	8.98320
		12.0	1.432	1.98365	10.016	10.016	12.0	1.120	1.55140	10.4480	10.4480
		14.0	2.140	2.96440	11.035	11.035	14.0	1.700	2.35480	11.6451	11.6451
		16.0	3.062	4.24160	11.758	11.758	16.0	2.750	3.80940	12.1906	12.1906
		18.0	4.112	5.69610	12.304	12.304	18.0	3.800	5.26380	12.7360	12.7360
	700 °C	4.00	0.400	0.55409	3.4459	3.4459	4.00	0.140	0.19393	3.8061	3.8061
		6.00	0.572	0.79235	5.2076	5.2076	6.00	0.286	0.39620	5.6038	5.6038
		8.00	0.740	1.02507	6.9749	6.9749	8.00	0.420	0.58179	7.4182	7.4182
		10.0	0.994	1.37692	8.6321	8.6321	10.0	0.644	0.89210	9.1079	9.1079
		12.0	1.360	1.88390	10.116	10.116	12.0	1.040	1.44064	10.559	10.559
		14.0	2.060	2.85358	11.146	11.146	14.0	1.620	2.24407	11.756	11.756
		16.0	2.960	4.10029	11.899	11.899	16.0	2.660	3.68472	12.315	12.315
		18.0	4.014	5.56039	12.439	12.439	18.0	3.710	5.13921	12.861	12.861
	800 °C	4.00	0.328	0.45435	3.5456	3.5456	4.00	0.100	0.13852	3.86147	3.86147
		6.00	0.462	0.63997	5.3600	5.3600	6.00	0.175	0.24241	5.75760	5.75760
		8.00	0.630	0.87269	7.1273	7.1273	8.00	0.310	0.42942	7.57057	7.57057
		10.0	0.884	1.22454	8.7754	8.7754	10.0	0.533	0.73833	9.26160	9.26160
		12.0	1.250	1.73154	10.268	10.268	12.0	0.983	1.36168	10.6383	10.6383
		14.0	1.830	2.53490	11.465	11.465	14.0	1.510	2.09170	11.9083	11.9083
		16.0	2.940	4.07250	11.927	11.927	16.0	2.548	3.52957	12.4704	12.4704
		18.0	3.310	4.58510	13.415	13.415	18.0	3.604	4.99238	13.0076	13.0076
	900 °C	4.00	0.217	0.30059	3.6994	3.6994	4.00	0.060	0.083110	3.916880	3.916880
		6.00	0.351	0.48621	5.5138	5.5138	6.00	0.084	0.116350	5.883640	5.883640
		8.00	0.514	0.71201	7.2879	7.2879	8.00	0.218	0.301980	7.698010	7.698010
		10.0	0.772	1.06940	8.9305	8.9305	10.0	0.442	0.612270	9.387727	9.387727
		12.0	1.140	1.57916	10.421	10.421	12.0	0.892	1.235630	10.76437	10.76437
		14.0	1.720	2.38260	11.617	11.617	14.0	1.420	1.967030	12.03290	12.03290
		16.0	2.830	3.92020	12.0797	12.0797	16.0	2.457	3.403520	12.59648	12.59648
		18.0	3.900	5.42410	12.5975	12.5975	18.0	3.513	4.866320	13.1336	13.1336
	1000 °C	4.00	0.105	0.14545	3.8545	3.8545	4.00	0.040	0.05541	3.94459	3.94459
		6.00	0.240	0.3324	5.6675	5.6675	6.00	0.064	0.08865	5.91134	5.91134
		8.00	0.402	0.5568	7.4431	7.4431	8.00	0.118	0.16345	7.83654	7.83654
		10.0	0.660	0.9142	9.0857	9.0857	10.0	0.262	0.36293	9.63706	9.63706
		12.0	1.030	1.4267	10.573	10.573	12.0	0.622	0.86162	11.1384	11.1384
		14.0	1.612	2.2330	11.767	11.767	14.0	1.220	1.68998	12.3100	12.3100
		16.0	2.711	3.7554	12.244	12.244	16.0	2.257	3.12647	12.8735	12.8735
		18.0	3.801	5.2652	12.734	12.734	18.0	3.413	4.7278	13.2722	13.2722

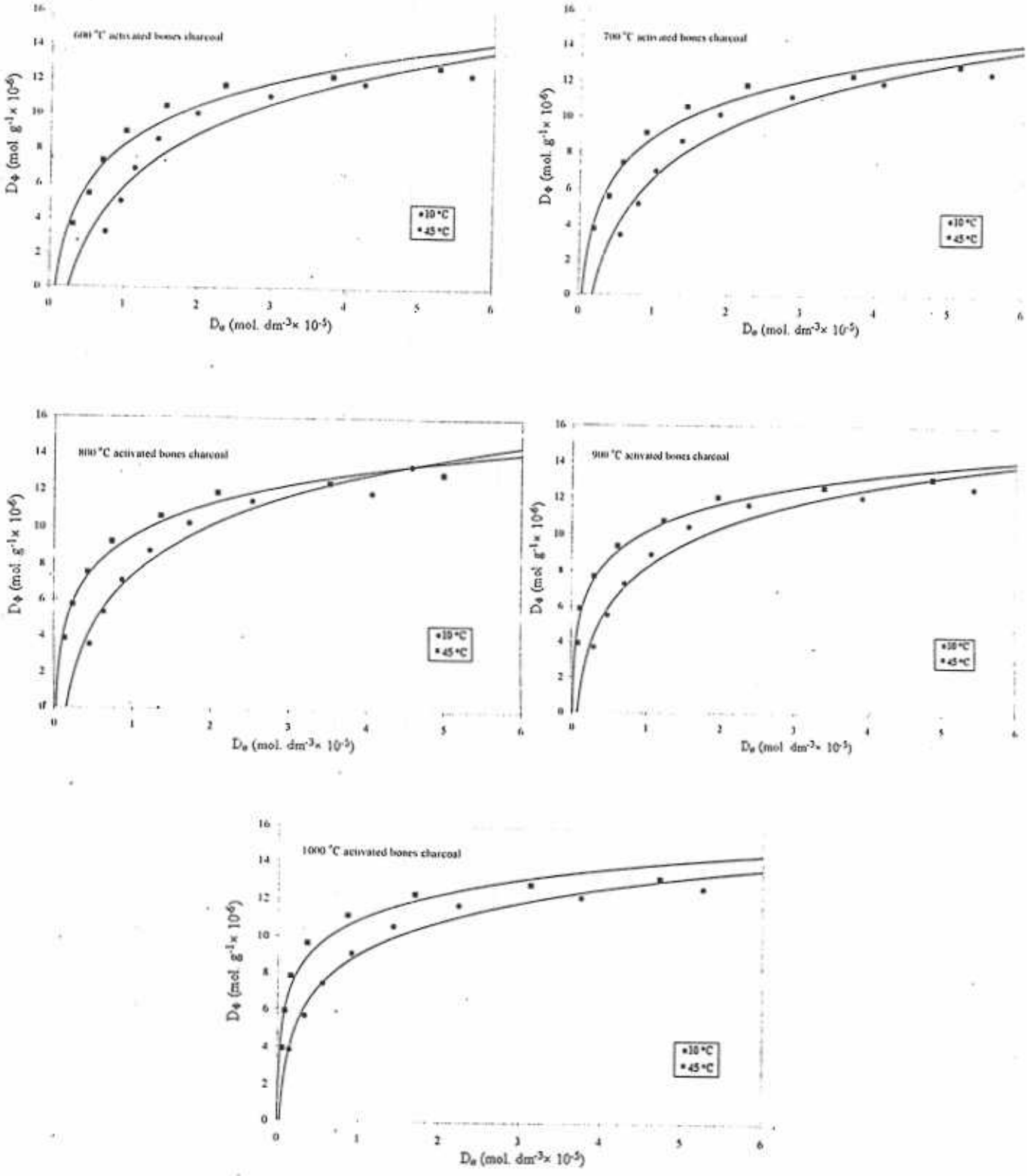


Figure 4.78 Adsorption isotherms of acid blue 1 on animal bones based charcoal samples

Table 4.77 Adsorption isotherm of acid blue 1 on regenerated carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_ϕ ($mol.g^{-1} \times 10^{-2}$)		Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_ϕ ($mol.g^{-1} \times 10^{-2}$)
Regenerated (RG)	400 °C	10.00	1.526	2.11380	7.88613	7.88613	10.00	0.636	0.8810	9.1189	9.1189
		12.00	1.770	2.45180	9.54810	9.54810	12.00	0.880	1.2190	10.781	10.781
		14.00	2.200	3.04750	10.9520	10.9520	14.00	1.310	1.8146	12.185	12.185
		16.00	2.570	3.56000	12.4390	12.4390	16.00	1.660	2.2994	13.700	13.700
		18.00	3.040	4.21110	13.7880	13.7880	18.00	2.150	2.9782	15.022	15.022
		20.00	4.000	5.54100	14.4590	14.4590	20.00	3.080	4.2665	15.733	15.733
		22.00	5.402	7.48300	14.5160	14.5160	22.00	4.500	6.2335	15.766	15.766
		24.00	6.760	9.36410	14.6350	14.6350	24.00	5.850	8.1036	15.896	15.896
	600 °C	10.00	0.492	0.68153	9.31846	9.31846	10.00	0.280	0.3878	9.6121	9.6121
		12.00	0.531	0.73555	11.2644	11.2644	12.00	0.320	0.4432	11.556	11.556
		14.00	0.611	0.84637	13.1536	13.1536	14.00	0.400	0.5541	13.440	13.440
		16.00	0.681	0.94334	15.0566	15.0566	16.00	0.470	0.6150	15.348	15.348
		18.00	0.799	1.10680	16.8931	16.8931	18.00	0.592	0.8200	17.179	17.179
		20.00	0.969	1.34229	18.6577	18.6577	20.00	0.758	1.0500	18.949	18.949
		22.00	1.211	1.67751	20.3224	20.3224	22.00	1.000	1.3852	20.615	20.615
		24.00	1.957	2.71090	21.2890	21.2890	24.00	1.746	2.4186	21.580	21.580
	800 °C	10.00	0.260	0.36016	9.63980	9.63980	10.00	0.100	0.13852	9.86150	9.86150
		12.00	0.300	0.41557	11.5840	11.5840	12.00	0.130	0.18010	11.8200	11.8200
		14.00	0.401	0.55547	13.4440	13.4440	14.00	0.202	0.27980	13.7200	13.7200
		16.00	0.460	0.63720	15.3630	15.3630	16.00	0.261	0.36150	15.6380	15.6380
		18.00	0.578	0.80066	17.1993	17.1993	18.00	0.382	0.52912	17.4710	17.4710
		20.00	0.697	0.96551	19.0345	19.0345	20.00	0.548	0.75910	19.2410	19.2410
		22.00	1.008	1.39631	20.6036	20.6036	22.00	0.800	1.10818	20.8918	20.8918
		24.00	1.622	2.24684	21.5315	21.5315	24.00	1.456	2.01680	21.9830	21.9830
	900 °C	10.00	0.152	0.21055	9.78944	9.78944	10.00	0.060	0.08311	9.91680	9.91680
		12.00	0.198	0.27427	11.72570	11.72570	12.00	0.080	0.11081	11.8890	11.8890
		14.00	0.311	0.43080	13.56900	13.56900	14.00	0.122	0.16890	13.8310	13.8310
		16.00	0.350	0.48483	15.51500	15.51500	16.00	0.159	0.22020	15.7790	15.7790
		18.00	0.468	0.64828	17.35200	17.35200	18.00	0.290	0.40170	17.5980	17.5980
		20.00	0.567	0.78542	19.21457	19.21457	20.00	0.452	0.62610	19.3740	19.3740
		22.00	0.940	1.30219	20.69780	20.69780	22.00	0.992	1.37410	21.6250	21.6250
		24.00	1.502	2.08062	21.91930	21.91930	24.00	1.260	1.74540	22.2540	22.2540
	1000 °C	10.00	0.070	0.09696	9.90303	9.90303	10.00	0.030	0.04155	9.95840	9.95840
		12.00	0.110	0.15237	11.8476	11.8476	12.00	0.072	0.09973	11.9002	11.9002
		14.00	0.165	0.22856	13.7714	13.7714	14.00	0.088	0.12190	13.8780	13.8780
		16.00	0.245	0.33938	15.6606	15.6606	16.00	0.139	0.19254	15.8070	15.8070
		18.00	0.365	0.50561	17.4943	17.4943	18.00	0.189	0.26181	17.7380	17.7380
		20.00	0.520	0.72032	19.2796	19.2796	20.00	0.342	0.47370	19.5260	19.5260
		22.00	0.930	1.28826	20.7117	20.7117	22.00	0.882	1.22170	20.7780	20.7780
		24.00	1.520	2.10555	21.8944	21.8944	24.00	1.252	1.73431	22.2656	22.2656

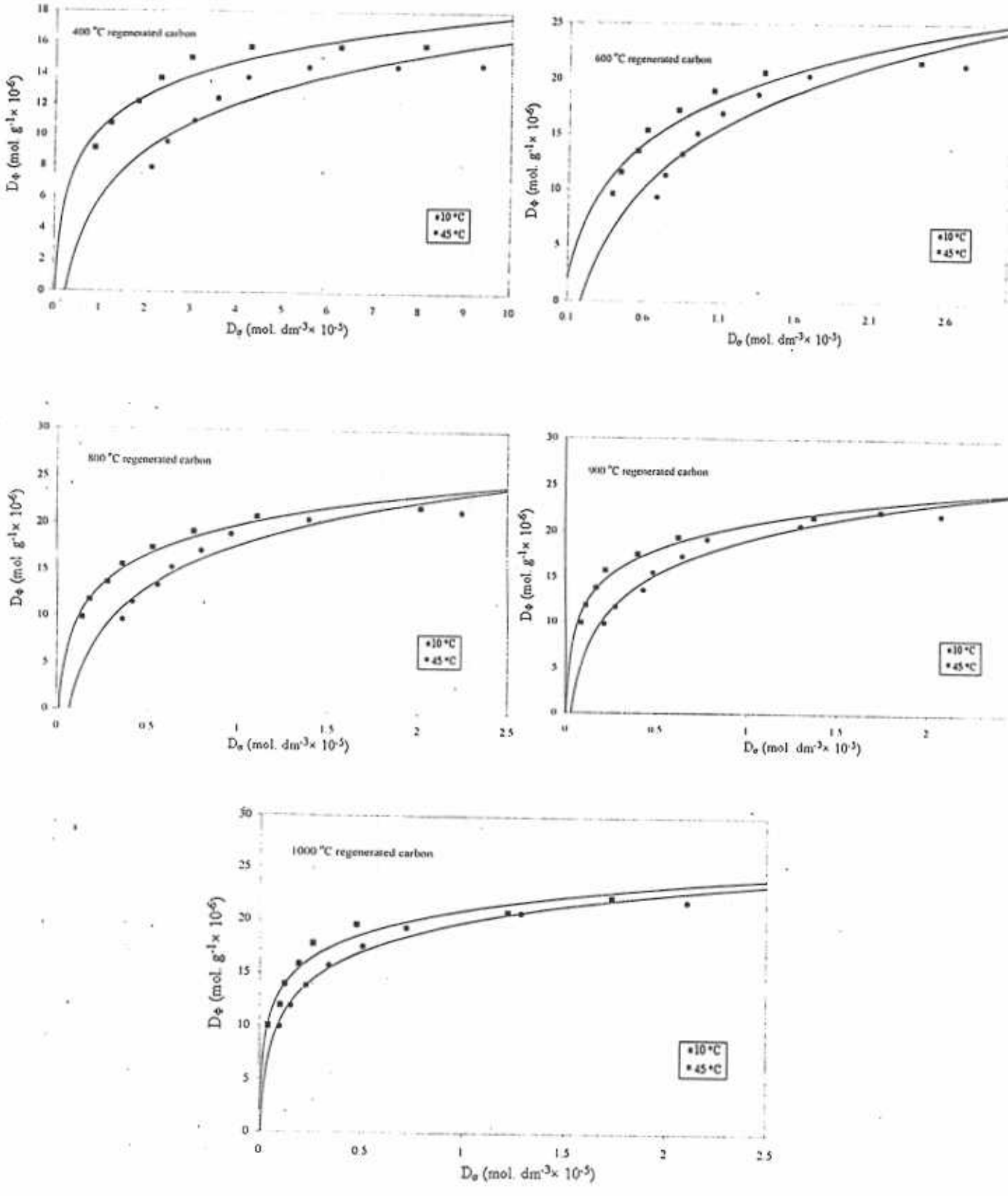


Figure 4.79 Adsorption isotherms of acid blue 1 on regenerated carbon samples

Table 4.78 Adsorption isotherm of brilliant blue R on carbon samples

Sample		D_u ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_u ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Ab_M	D_n ($mol.dm^{-3} \times 10^{-5}$)	D_u-D_n ($mol.dm^{-3} \times 10^{-5}$)	D_f ($mol.g^{-1} \times 10^{-4}$)		Ab_M	D_n ($mol.dm^{-3} \times 10^{-5}$)	D_u-D_n ($mol.dm^{-3} \times 10^{-5}$)	D_f ($mol.g^{-1} \times 10^{-4}$)
Paulownia tomentosa (PT)	Raw	1.00	0.070	0.636	0.364	0.364	1.00	0.060	0.545	0.455	0.455
		1.50	0.105	0.954	0.546	0.546	1.50	0.095	0.863	0.637	0.637
		2.00	0.140	1.272	0.728	0.728	2.00	0.122	1.110	0.890	0.890
		2.50	0.175	1.590	0.910	0.910	2.50	0.157	1.430	1.070	1.070
		3.00	0.211	1.910	1.090	1.090	3.00	0.191	1.730	1.270	1.270
		3.50	0.260	2.360	1.140	1.140	3.50	0.239	2.170	1.330	1.330
		4.00	0.310	2.810	1.190	1.190	4.00	0.286	2.600	1.400	1.400
		4.50	0.358	3.250	1.250	1.250	4.50	0.332	3.010	1.490	1.490
	400 °C	1.00	0.051	0.463	0.537	0.537	1.00	0.040	0.364	0.636	0.636
		1.50	0.083	0.754	0.746	0.746	1.50	0.068	0.618	0.882	0.882
		2.00	0.115	1.045	0.955	0.955	2.00	0.097	0.880	1.120	1.120
		2.50	0.146	1.327	1.173	1.173	2.50	0.124	1.127	1.370	1.370
		3.00	0.185	1.681	1.320	1.320	3.00	0.162	1.472	1.530	1.530
		3.50	0.230	2.090	1.410	1.410	3.50	0.195	1.773	1.727	1.727
		4.00	0.284	2.582	1.418	1.418	4.00	0.249	2.260	1.740	1.740
		4.50	0.338	3.073	1.427	1.427	4.50	0.295	2.680	1.820	1.820
	800 °C	1.00	0.030	0.272	0.727	0.727	1.00	0.022	0.200	0.800	0.800
		1.50	0.058	0.527	0.973	0.973	1.50	0.048	0.436	1.063	1.063
		2.00	0.087	0.791	1.210	1.210	2.00	0.077	0.700	1.300	1.300
		2.50	0.114	1.036	1.464	1.464	2.50	0.104	0.945	1.554	1.554
		3.00	0.152	1.382	1.620	1.620	3.00	0.142	1.291	1.710	1.710
		3.50	0.200	1.820	1.682	1.682	3.50	0.192	1.745	1.754	1.754
		4.00	0.239	2.173	1.830	1.830	4.00	0.232	2.110	1.891	1.891
		4.50	0.285	2.591	1.910	1.910	4.50	0.280	2.545	1.954	1.954
Populus caspica (PC)	Raw	1.00	0.085	0.773	0.227	0.227	1.00	0.070	0.636	0.364	0.364
		1.50	0.120	1.091	0.409	0.409	1.50	0.100	0.909	0.510	0.510
		2.00	0.160	1.450	0.550	0.550	2.00	0.132	1.200	0.800	0.800
		2.50	0.199	1.809	0.691	0.691	2.50	0.165	1.500	1.000	1.000
		3.00	0.248	2.254	0.745	0.745	3.00	0.210	1.910	1.090	1.090
		3.50	0.300	2.730	0.770	0.770	3.50	0.265	2.410	1.090	1.090
		4.00	0.354	3.218	0.782	0.782	4.00	0.320	2.910	1.090	1.090
		4.50	0.410	3.727	0.773	0.773	4.50	0.380	3.450	1.080	1.080
	400 °C	1.00	0.065	0.591	0.409	0.409	1.00	0.059	0.536	0.464	0.464
		1.50	0.095	0.863	0.636	0.636	1.50	0.080	0.727	0.773	0.773
		2.00	0.128	1.163	0.836	0.836	2.00	0.111	1.009	0.990	0.990
		2.50	0.165	1.500	1.000	1.000	2.50	0.141	1.280	1.220	1.220
		3.00	0.210	1.909	1.091	1.091	3.00	0.182	1.650	1.350	1.350
		3.50	0.265	2.410	1.091	1.091	3.50	0.220	2.000	1.500	1.500
		4.00	0.315	2.863	1.136	1.136	4.00	0.270	2.450	1.550	1.550
		4.50	0.362	3.291	1.210	1.210	4.50	0.325	2.950	1.550	1.550
	800 °C	2.00	0.048	0.4363	0.5636	0.5636	2.00	0.049	0.4454	1.554	1.554
		2.50	0.071	0.6454	0.8545	0.8545	2.50	0.065	0.5909	1.909	1.909
		3.00	0.100	0.9090	1.0910	1.0910	3.00	0.084	0.7636	2.236	2.236
		3.50	0.132	1.2000	1.3000	1.3000	3.50	0.112	1.0182	2.482	2.482
		4.00	0.171	1.5540	1.4450	1.4450	4.00	0.150	1.3636	2.636	2.636
		4.50	0.210	1.9090	1.5910	1.5910	4.50	0.189	1.7182	2.782	2.782
		5.00	0.262	2.3810	1.6180	1.6180	5.00	0.242	2.2000	2.800	2.800
		5.50	0.314	2.8540	1.6450	1.6450	5.50	0.294	2.6727	2.827	2.827

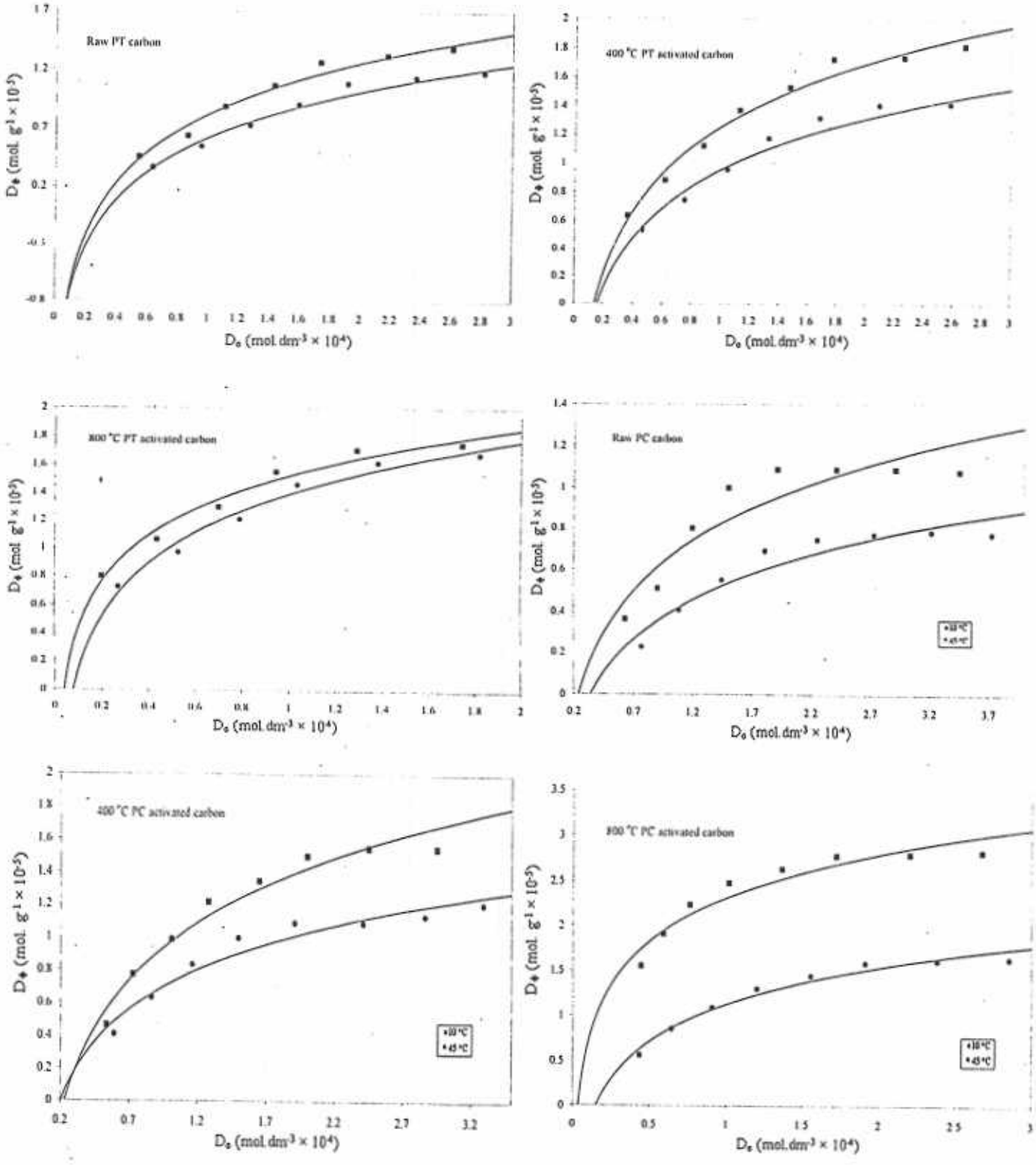


Figure 4.80 Adsorption isotherms of brilliant blue R on *Paulownia tomentosa* (PT) and *Populus caspica* (PC) carbon samples

Table 4.79 Adsorption isotherm of brilliant blue R on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_t ($mol.g^{-1} \times 10^{-2}$)		Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_t ($mol.g^{-1} \times 10^{-2}$)
Corncobs (CC)	Raw	1.00	0.065	0.591	0.409	0.409	1.00	0.042	0.380	0.610	0.610
		1.50	0.080	0.820	0.680	0.680	1.50	0.073	0.660	0.840	0.840
		2.00	0.130	1.182	0.820	0.820	2.00	0.100	0.910	1.090	1.090
		2.50	0.160	1.450	1.050	1.050	2.50	0.140	1.270	1.230	1.230
		3.00	0.200	1.820	1.180	1.180	3.00	0.178	1.618	1.382	1.382
		3.50	0.246	2.230	1.270	1.270	3.50	0.230	2.091	1.409	1.409
		4.00	0.300	2.727	1.273	1.273	4.00	0.275	2.500	1.500	1.500
		4.50	0.354	3.218	1.282	1.282	4.50	0.325	2.954	1.545	1.545
	400 °C	1.00	0.038	0.3454	0.654	0.654	1.00	0.026	0.2363	0.7636	0.7636
		1.50	0.063	0.5730	0.927	0.927	1.50	0.047	0.4272	1.0727	1.0727
		2.00	0.090	0.8182	1.182	1.182	2.00	0.071	0.6454	1.3540	1.3540
		2.50	0.120	1.0909	1.409	1.409	2.50	0.100	0.9091	1.5910	1.5910
		3.00	0.158	1.4364	1.564	1.564	3.00	0.137	1.2454	1.7540	1.7540
		3.50	0.210	1.9091	1.591	1.591	3.50	0.187	1.7000	1.8000	1.8000
		4.00	0.265	2.409	1.591	1.591	4.00	0.238	2.1636	1.8363	1.8363
		4.50	0.319	2.900	1.600	1.600	4.50	0.287	2.6090	1.8909	1.8909
	800 °C	2.00	0.020	0.1818	1.8181	1.8181	2.00	0.018	0.1636	1.8363	1.8363
		2.50	0.035	0.3182	2.182	2.182	2.50	0.029	0.2636	2.2363	2.2363
		3.00	0.055	0.5000	2.500	2.500	3.00	0.043	0.3909	2.6091	2.6091
		3.50	0.081	0.7364	2.764	2.764	3.50	0.063	0.5757	2.9273	2.9273
		4.00	0.115	1.0454	2.954	2.954	4.00	0.092	0.8364	3.1636	3.1636
		4.50	0.155	1.4091	3.090	3.090	4.50	0.137	1.2454	3.2545	3.2545
		5.00	0.200	1.8181	3.182	3.182	5.00	0.182	1.6545	3.3454	3.3454
		5.50	0.250	2.272	3.227	3.227	5.50	0.232	2.1091	3.3910	3.3910
Ailanthus altissima (AA)	Raw	1.00	0.070	0.636	0.364	0.364	1.00	0.055	0.500	0.500	0.500
		1.50	0.100	0.910	0.590	0.590	1.50	0.081	0.736	0.764	0.764
		2.00	0.135	1.230	0.770	0.770	2.00	0.112	1.020	0.980	0.980
		2.50	0.168	1.530	0.970	0.970	2.50	0.144	1.310	1.190	1.190
		3.00	0.203	1.840	1.160	1.160	3.00	0.185	1.680	1.320	1.320
		3.50	0.247	2.250	1.250	1.250	3.50	0.240	2.180	1.320	1.320
		4.00	0.303	2.750	1.250	1.250	4.00	0.295	2.680	1.320	1.320
		4.50	0.358	3.250	1.250	1.250	4.50	0.347	3.150	1.320	1.320
	400 °C	1.00	0.052	0.472	0.528	0.528	1.00	0.049	0.445	0.555	0.555
		1.50	0.085	0.773	0.730	0.730	1.50	0.077	0.700	0.800	0.800
		2.00	0.119	1.082	0.920	0.920	2.00	0.104	0.945	1.055	1.055
		2.50	0.158	1.430	1.070	1.070	2.50	0.145	1.320	1.180	1.180
		3.00	0.199	1.810	1.190	1.190	3.00	0.189	1.720	1.280	1.280
		3.50	0.243	2.210	1.290	1.290	3.50	0.235	2.140	1.360	1.360
		4.00	0.295	2.680	1.320	1.320	4.00	0.288	2.610	1.390	1.390
		4.50	0.350	3.180	1.320	1.320	4.50	0.340	3.100	1.400	1.400
	800 °C	0.052	0.4727	1.5273	1.5273	2.00	0.048	0.4363	1.5636	1.5636	0.052
		0.074	0.6727	1.8273	1.8273	2.50	0.065	0.5909	1.9091	1.9091	0.074
		0.099	0.9000	2.1000	2.1000	3.00	0.079	0.7182	2.2820	2.2820	0.099
		0.124	1.1272	2.3730	2.3730	3.50	0.104	0.9454	2.5545	2.5545	0.124
		0.168	1.5273	2.4730	2.4730	4.00	0.148	1.3454	2.6545	2.6545	0.168
		0.210	1.9091	2.5910	2.5910	4.50	0.190	1.7273	2.773	2.773	0.210
		0.260	2.3636	2.6363	2.6363	5.00	0.232	2.1091	2.891	2.891	0.260
		0.300	2.7272	2.7727	2.7727	5.50	0.278	2.5270	2.973	2.973	0.300

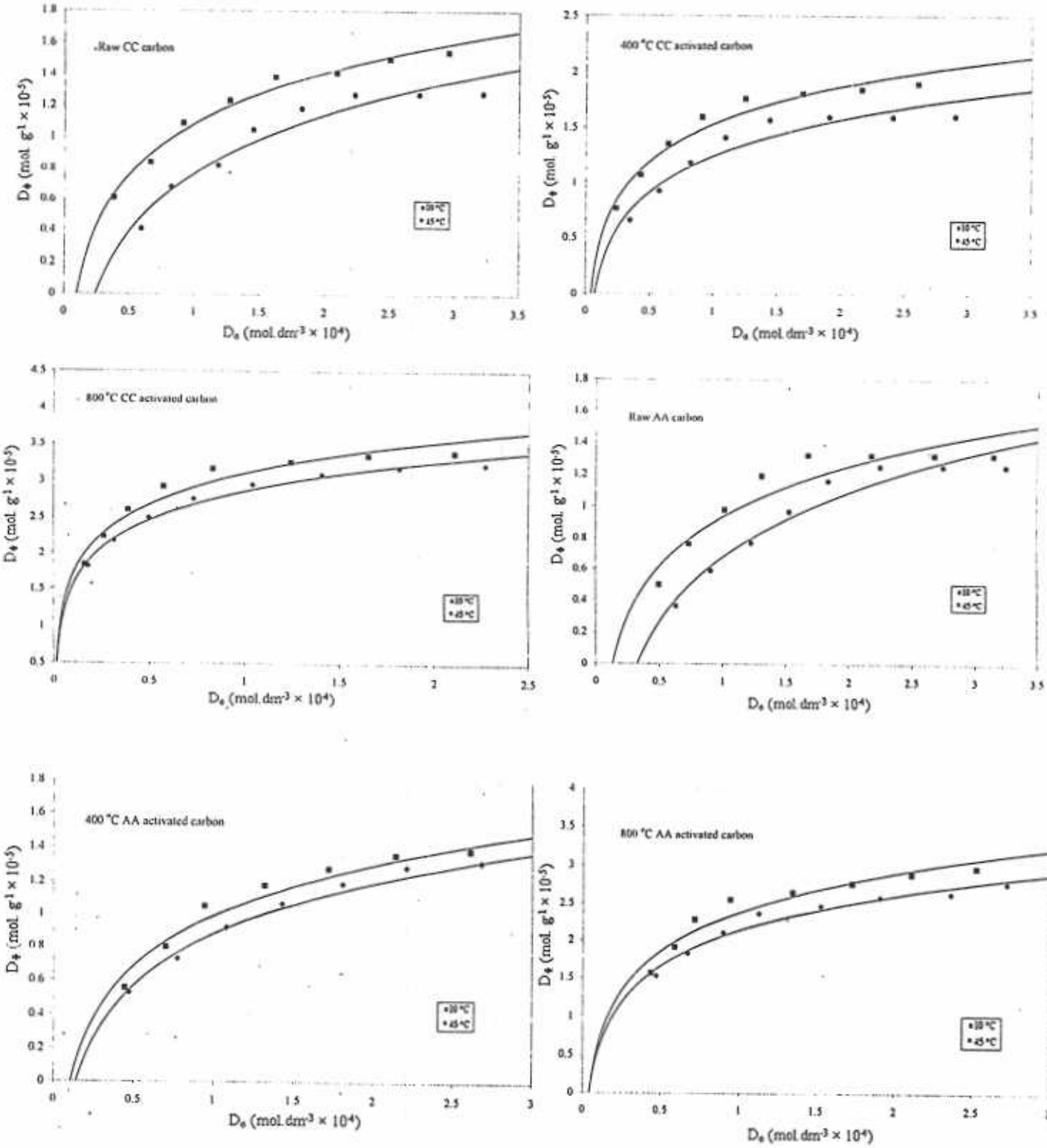


Figure 4.81 Adsorption isotherms of brilliant blue R on *Corncobs* (CC) and *Ailanthus altissima* (AA) carbon samples

Table 4.80 Adsorption isotherm of brilliant blue R on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	Adsorption isotherm at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	Adsorption isotherm at 45°C			
			Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_q ($mol.g^{-1} \times 10^{-4}$)		Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_q ($mol.g^{-1} \times 10^{-4}$)
Salvadora oleoides (SO)	Raw	24.0	1.1280	10.25454	13.7454	13.7454	24.0	0.702	6.38200	17.6200	17.6200
		28.0	1.3850	12.59091	15.4091	15.4091	28.0	0.889	8.08200	19.9180	19.9180
		32.0	1.5230	13.8454	18.1545	18.1545	32.0	1.100	10.0000	22.0000	22.0000
		36.0	1.7300	15.7273	20.2727	20.2727	36.0	1.308	11.8910	24.1090	24.1090
		40.0	1.9880	18.0727	21.9273	21.9273	40.0	1.560	14.1820	25.8200	25.8200
		44.0	2.3720	21.5636	22.4364	22.4364	44.0	1.950	17.7273	26.2730	26.2730
		48.0	2.7420	24.9273	23.0730	23.0730	48.0	2.320	21.0910	26.9090	26.9090
		52.0	3.1720	28.8364	23.1640	23.1640	52.0	2.750	25.0000	27.0000	27.0000
	400 °C	24.0	0.923	8.39091	15.60901	15.60901	24.0	0.590	5.36400	18.6364	18.6364
		28.0	1.109	10.0818	17.9182	17.9182	28.0	0.776	7.05450	20.9450	20.9450
		32.0	1.322	12.0182	19.9820	19.9820	32.0	0.989	8.99100	23.0100	23.0100
		36.0	1.529	13.9000	22.1000	22.1000	36.0	1.195	10.8640	25.1364	25.1364
		40.0	1.781	16.19091	23.8091	23.8091	40.0	1.448	13.1640	26.8400	26.8400
		44.0	2.171	19.7364	24.2636	24.2636	44.0	1.838	16.7100	27.2910	27.2910
		48.0	2.541	23.1000	24.9000	24.9000	48.0	2.208	20.0730	27.9300	27.9300
		52.0	2.971	27.0091	24.9909	24.9909	52.0	2.638	23.9820	28.0820	28.0820
	600 °C	24.0	0.588	5.34545	18.6545	18.6545	24.0	0.310	2.81820	21.1820	21.1820
		28.0	0.778	7.07273	20.9273	20.9273	28.0	0.4230	3.84540	24.1540	24.1540
		32.0	0.978	8.89091	23.1091	23.1091	32.0	0.6380	5.80000	26.2000	26.2000
		36.0	1.190	10.8182	25.1820	25.1820	36.0	0.8420	7.65450	28.3450	28.3450
		40.0	1.448	13.1636	26.8364	26.8364	40.0	1.0950	9.95450	30.0450	30.0450
		44.0	1.837	16.7000	27.3000	27.3000	44.0	1.4850	13.5000	30.5000	30.5000
		48.0	2.207	20.0636	27.9364	27.9364	48.0	1.8550	16.8636	31.1360	31.1360
		52.0	2.637	23.9727	28.0273	28.0273	52.0	2.3070	20.9730	31.1600	31.1600
	800 °C	24.0	0.394	3.58182	20.4182	20.4182	24.0	0.1580	1.43636	22.5640	22.5640
		28.0	0.544	4.94545	23.0545	23.0545	28.0	0.3220	2.9273	25.0727	25.0727
		32.0	0.699	6.35454	25.6454	25.6454	32.0	0.4170	3.79100	28.2100	28.2100
		36.0	0.927	8.42730	27.5727	27.5727	36.0	0.6230	5.66400	30.3360	30.3360
		40.0	1.213	11.0273	28.9730	28.9730	40.0	0.8780	7.98200	32.0182	32.0182
		44.0	1.603	14.5730	29.4273	29.4273	44.0	1.2680	11.5273	32.4720	32.4720
		48.0	1.973	17.9364	30.0640	30.0640	48.0	1.6380	14.8910	33.1091	33.1091
		52.0	2.403	21.8454	30.1545	30.1545	52.0	2.0600	18.7273	33.1730	33.1730
	900 °C	24.0	0.305	2.77273	21.2273	21.2273	24.0	0.1800	1.63640	22.3636	22.3636
		28.0	0.423	3.89091	24.1091	24.1091	28.0	0.2660	2.41820	25.5820	25.5820
		32.0	0.578	5.25454	26.7454	26.7454	32.0	0.4120	3.74540	28.2540	28.2540
		36.0	0.806	7.32727	28.6727	28.6727	36.0	0.6180	5.61820	30.3820	30.3820
		40.0	1.090	9.90910	30.0910	30.0910	40.0	0.8730	7.93640	32.0636	32.0636
		44.0	1.480	13.4545	30.5454	30.5454	44.0	1.2630	11.4820	32.5200	32.5200
		48.0	1.851	16.8273	31.1727	31.1727	48.0	1.6330	14.8454	33.1540	33.1540
		52.0	2.280	20.7273	31.2730	31.2730	52.0	2.0720	18.8364	33.1640	33.1640
	1000 °C	24.0	0.139	1.26363	22.7364	22.7364	B24.0	0.124	1.1273	22.8730	22.8730
		28.0	0.243	2.20910	25.7910	25.7910	28.0	0.226	2.0545	25.9454	25.9454
		32.0	0.358	3.25454	28.7454	28.7454	32.0	0.310	2.82000	29.1820	29.1820
		36.0	0.586	5.32727	30.6727	30.6727	36.0	0.513	4.66360	31.3364	31.3364
		40.0	0.870	7.90910	32.0910	32.0910	40.0	0.775	7.04550	32.9540	32.9540
		44.0	1.260	11.4545	32.5454	32.5454	44.0	1.160	10.5454	33.4540	33.4540
		48.0	1.631	14.8273	33.1727	33.1727	48.0	1.530	13.9091	34.0910	34.0910
		52.0	2.060	18.7273	33.2727	33.2727	52.0	1.000	17.0910	34.9100	34.9100

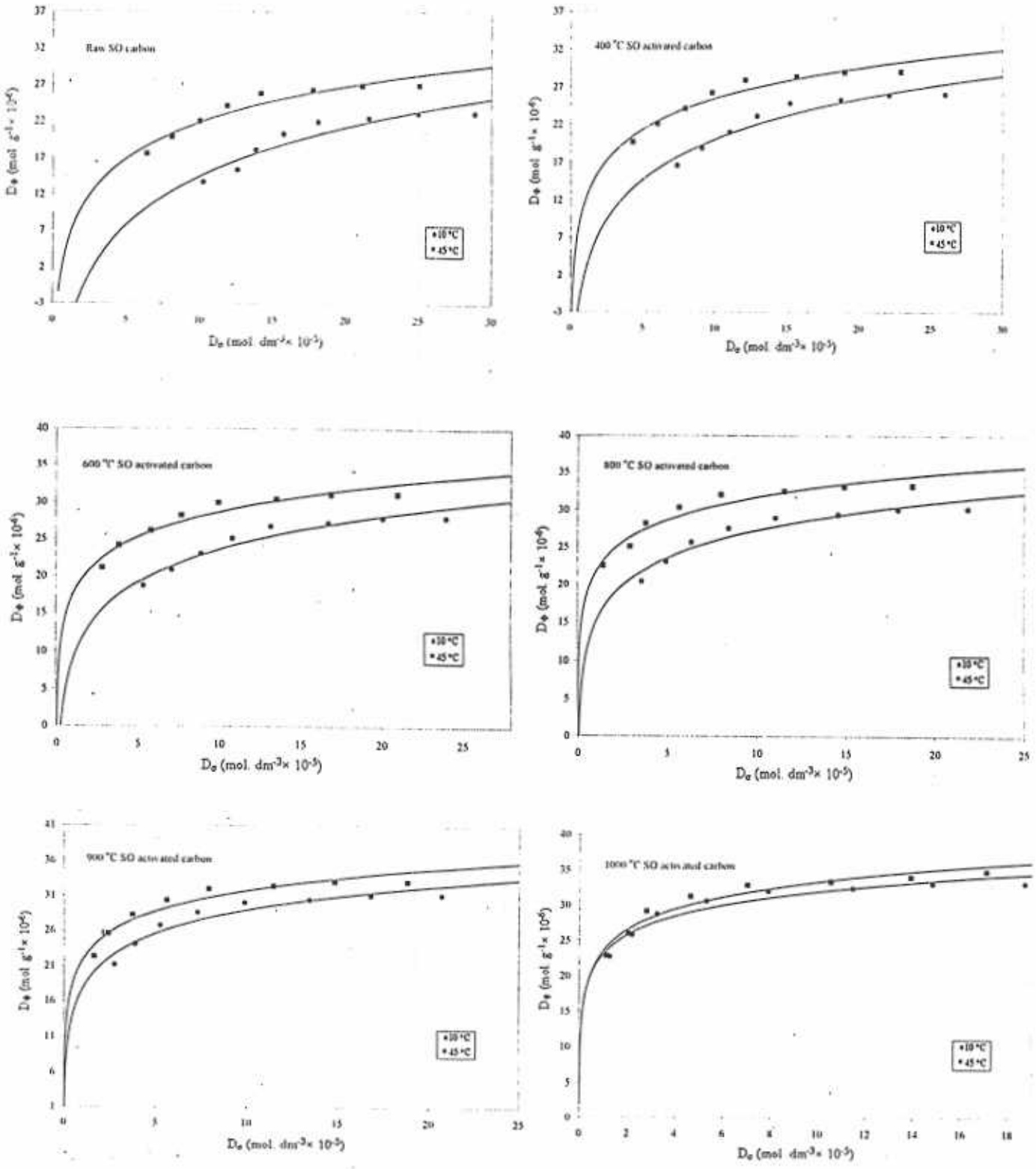


Figure 4.82 Adsorption isotherms of brilliant blue R on *Salvadora oleoides* (SO) carbon samples

Table 4.81 Adsorption isotherm of brilliant blue R on charcoal samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_ϕ ($mol.g^{-1} \times 10^{-4}$)		Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_ϕ ($mol.g^{-1} \times 10^{-4}$)
Animal bones charcoal (ABC)	600 °C	5.00	0.310	2.81820	2.18182	2.18182	5.00	0.123	1.1182	3.8820	3.8820
		8.00	0.468	4.25454	3.74545	3.74545	8.00	0.147	1.3364	6.6640	6.6640
		11.0	0.641	5.82727	5.17273	5.17273	11.0	0.300	2.7273	8.2727	8.2727
		14.0	0.861	7.82727	6.17273	6.17273	14.0	0.520	4.7273	9.2727	9.2727
		17.0	1.156	10.5091	6.49091	6.49091	17.0	0.845	7.6820	9.3182	9.3182
		20.0	1.461	13.2818	6.71820	6.71820	20.0	1.150	10.454	9.5450	9.5450
		23.0	1.781	16.1910	6.80910	6.80910	23.0	1.470	13.364	9.6364	9.6364
		26.0	2.101	19.1000	6.90000	6.90000	26.0	1.790	16.273	9.7273	9.7273
	700 °C	5.00	0.200	1.81818	3.18182	3.18182	5.00	0.104	0.77273	4.22730	4.22730
		8.00	0.357	3.24545	4.75455	4.75455	8.00	0.130	1.18200	6.81820	6.81820
		11.0	0.530	4.81818	6.18182	6.18182	11.0	0.169	1.53640	9.46360	9.46360
		14.0	0.750	6.81820	7.18182	7.18182	14.0	0.237	2.15450	11.8450	11.8450
		17.0	1.045	9.50000	7.50000	7.50000	17.0	0.420	3.81820	13.1820	13.1820
		20.0	1.351	12.2818	7.71820	7.71820	20.0	0.635	5.77270	14.2300	14.2300
		23.0	1.671	15.1909	7.80909	7.80909	23.0	0.955	8.68200	14.3200	14.3200
		26.0	2.000	18.1818	7.81818	7.81818	26.0	1.270	11.5450	14.4540	14.4540
	800 °C	5.00	0.100	0.909091	4.09091	4.09091	5.00	0.078	0.70910	4.29100	4.29100
		8.00	0.247	2.245450	5.75454	5.75454	8.00	0.110	1.00000	7.00000	7.00000
		11.0	0.420	3.818180	7.18182	7.18182	11.0	0.150	1.36360	9.63600	9.63600
		14.0	0.640	5.818180	8.18181	8.18181	14.0	0.200	1.81820	12.1820	12.1820
		17.0	0.935	8.500000	8.50000	8.50000	17.0	0.300	2.72730	14.2730	14.2730
		20.0	1.241	11.28182	8.71818	8.71818	20.0	0.458	4.16360	15.8360	15.8360
		23.0	1.561	14.19091	8.80909	8.80909	23.0	0.770	7.00000	16.0000	16.0000
		26.0	1.870	17.00000	9.00000	9.00000	26.0	0.970	8.81820	17.1820	17.1820
	900 °C	5.00	0.068	0.618182	4.381820	4.381820	5.00	0.050	0.45450	4.54540	4.54540
		8.00	0.138	1.254545	6.745454	6.745454	8.00	0.100	0.90910	7.09100	7.09100
		11.0	0.314	2.854545	8.145450	8.145450	11.0	0.140	1.27300	9.73000	9.73000
		14.0	0.533	4.845454	9.154545	9.154545	14.0	0.190	1.72730	12.2730	12.2730
		17.0	0.826	7.509100	9.490910	9.490910	17.0	0.290	2.63640	14.3640	14.3640
		20.0	1.133	10.30000	9.700000	9.700000	20.0	0.405	3.68200	16.3200	16.3200
		23.0	1.452	13.20000	9.800000	9.800000	23.0	0.668	6.07300	16.9270	16.9270
		26.0	1.762	16.01820	9.981820	9.981820	26.0	0.950	8.63640	17.3630	17.3630
	1000 °C	5.00	0.0580	0.527273	4.472730	4.472730	5.00	0.025	0.22730	4.77270	4.77270
		8.00	0.1000	0.909100	7.090910	7.090910	8.00	0.050	0.45450	7.54540	7.54540
		11.0	0.2000	1.818180	9.181818	9.181818	11.0	0.090	0.81820	10.1818	10.1818
		14.0	0.4200	3.818182	10.18182	10.18182	14.0	0.140	1.27270	12.7270	12.7270
		17.0	0.7100	6.454545	10.54544	10.54544	17.0	0.240	2.18180	14.8182	14.8182
		20.0	1.0200	9.272730	10.72730	10.72730	20.0	0.370	3.36360	16.6364	16.6364
		23.0	1.3400	12.18182	10.81818	10.81818	23.0	0.600	5.45450	17.5450	17.5450
		26.0	1.6500	15.00000	11.00000	11.00000	26.0	0.910	8.27270	17.7270	17.7270

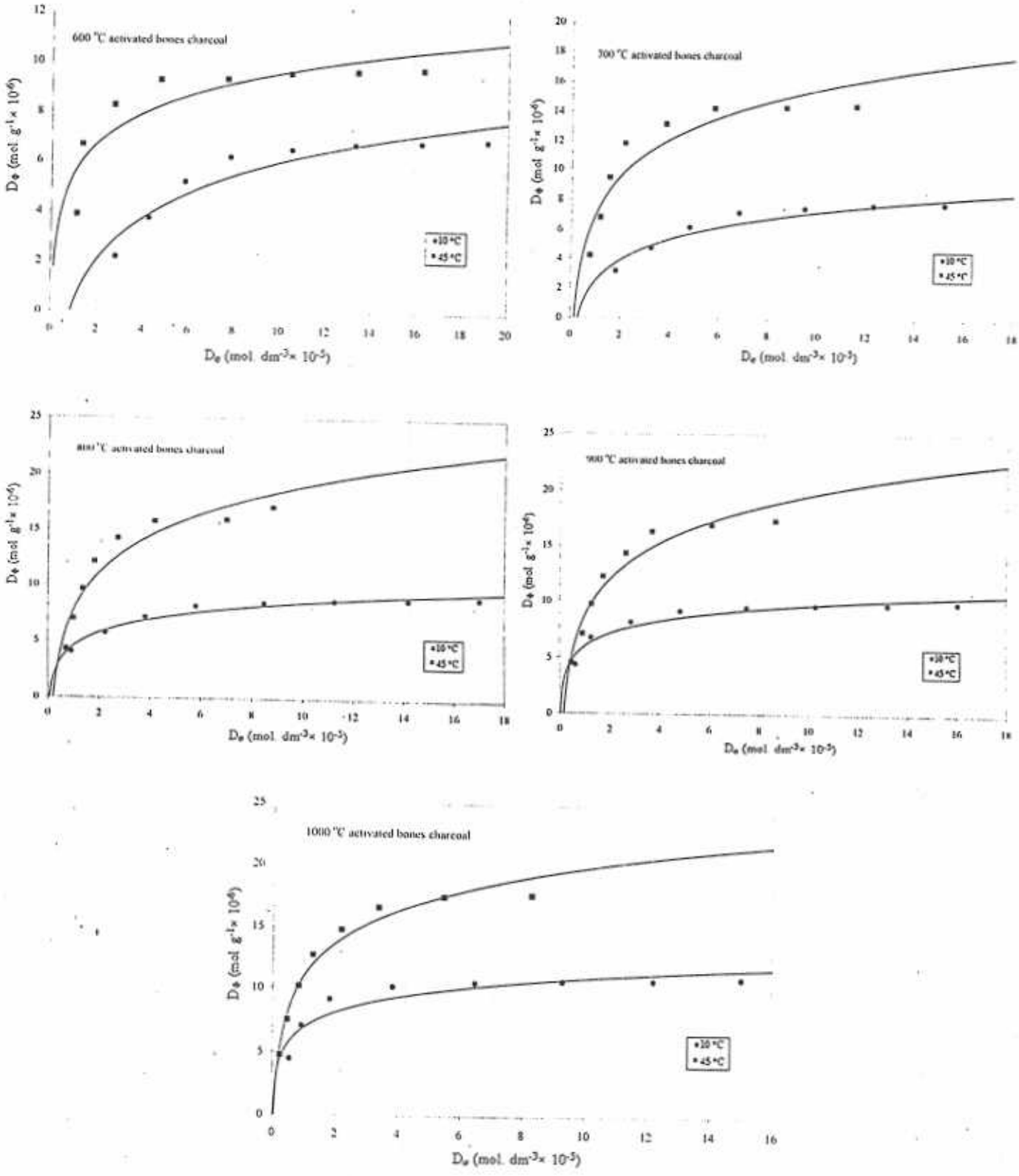


Figure 4.83 Adsorption isotherms of brilliant blue R on animal bones based charcoal samples

Table 4.82 Adsorption isotherm of brilliant blue R on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Abs1	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_f ($mol.g^{-1} \times 10^{-5}$)		Abs1	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_f ($mol.g^{-1} \times 10^{-5}$)
Regenerated (RG)	400 °C	11.0	1.010	9.181820	1.82820	1.82820	11.0	0.790	7.1818	3.8182	3.8182
		14.0	1.285	11.68182	2.31818	2.31818	14.0	1.040	9.4545	4.5454	4.5454
		17.0	1.579	14.35450	2.64545	2.64545	17.0	1.300	11.8182	5.1820	5.1820
		20.0	1.887	17.15450	2.84545	2.84545	20.0	1.590	14.454	5.5450	5.5450
		23.0	2.200	20.00000	3.00000	3.00000	23.0	1.900	17.273	5.7273	5.7273
		26.0	2.520	22.90900	3.09091	3.09091	26.0	2.230	20.273	5.7273	5.7273
		29.0	2.850	25.90910	3.09091	3.09091	29.0	2.560	23.273	5.7273	5.7273
		34.0	3.399	30.90000	3.10000	3.10000	34.0	3.100	28.182	5.8120	5.8120
	600 °C	11.0	0.769	6.99090	4.00909	4.00909	11.0	0.600	5.45450	5.5454	5.5454
		14.0	1.049	9.53636	4.46364	4.46364	14.0	0.740	6.72730	7.2730	7.2730
		17.0	1.339	12.1727	4.82727	4.82727	17.0	0.990	9.00000	8.0000	8.0000
		20.0	1.640	14.9091	5.09091	5.09091	20.0	1.255	11.4091	8.5910	8.5910
		23.0	1.950	17.7273	5.27273	5.27273	23.0	1.550	14.0910	8.9100	8.9100
		26.0	2.272	20.6545	5.34545	5.34545	26.0	1.840	16.7273	9.2730	9.2730
		29.0	2.602	23.6545	5.34545	5.34545	29.0	2.140	19.4545	9.5454	9.5454
		34.0	3.151	28.6454	5.35454	5.35454	34.0	2.680	24.3636	9.6364	9.6364
	800 °C	11.0	0.570	5.181818	5.818182	5.818182	11.0	0.340	3.09100	7.90910	7.90910
		14.0	0.811	7.372730	6.627270	6.627270	14.0	0.520	4.72730	9.27300	9.27300
		17.0	1.091	9.918182	7.081818	7.081818	17.0	0.770	7.00000	10.0000	10.0000
		20.0	1.390	12.63636	7.363636	7.363636	20.0	1.030	9.36400	10.6363	10.6363
		23.0	1.735	15.77273	7.227273	7.227273	23.0	1.332	12.1091	10.8910	10.8910
		26.0	2.056	18.69090	7.309091	7.309091	26.0	1.621	14.7364	11.2640	11.2640
		29.0	2.350	21.36364	7.636360	7.636360	29.0	1.940	17.6364	11.3640	11.3640
		34.0	2.895	26.31818	7.681810	7.681810	34.0	2.480	22.5450	11.4540	11.4540
	900 °C	11.0	0.480	4.363640	6.636360	6.636360	11.0	0.238	2.1636	8.83640	8.83640
		14.0	0.715	6.500000	7.500000	7.500000	14.0	0.410	3.7273	10.2730	10.2730
		17.0	0.970	8.818180	8.181820	8.181820	17.0	0.659	5.9910	11.0090	11.0090
		20.0	1.270	11.54540	8.454545	8.454545	20.0	0.919	8.3540	11.6450	11.6450
		23.0	1.585	14.40910	8.590910	8.590910	23.0	1.220	11.091	11.9100	11.9100
		26.0	1.905	17.31830	8.681820	8.681820	26.0	1.516	13.752	12.2200	12.2200
		29.0	2.202	20.01820	8.981820	8.981820	29.0	1.830	16.636	12.3640	12.3640
		34.0	2.744	24.94545	9.05454	9.05454	34.0	2.370	21.545	12.4540	12.4540
	1000 °C	11.0	0.525	4.77273	6.22727	6.22727	11.0	0.207	1.88182	9.118200	9.118200
		14.0	0.704	6.40000	7.60000	7.60000	14.0	0.370	3.36363	10.63640	10.63640
		17.0	0.922	8.38182	8.61820	8.61820	17.0	0.538	4.89100	12.11000	12.11000
		20.0	1.130	10.2727	9.72727	9.72727	20.0	0.801	7.28200	12.71820	12.71820
		23.0	1.385	12.5909	10.4091	10.4091	23.0	1.100	10.0000	13.00000	13.00000
		26.0	1.705	15.5000	10.5000	10.5000	26.0	1.402	12.7455	13.25400	13.25400
		29.0	2.002	18.2000	10.8000	10.8000	29.0	1.708	15.5273	13.47300	13.47300
		34.0	2.544	23.1272	10.8727	10.8727	34.0	2.252	20.4730	13.53000	13.53000

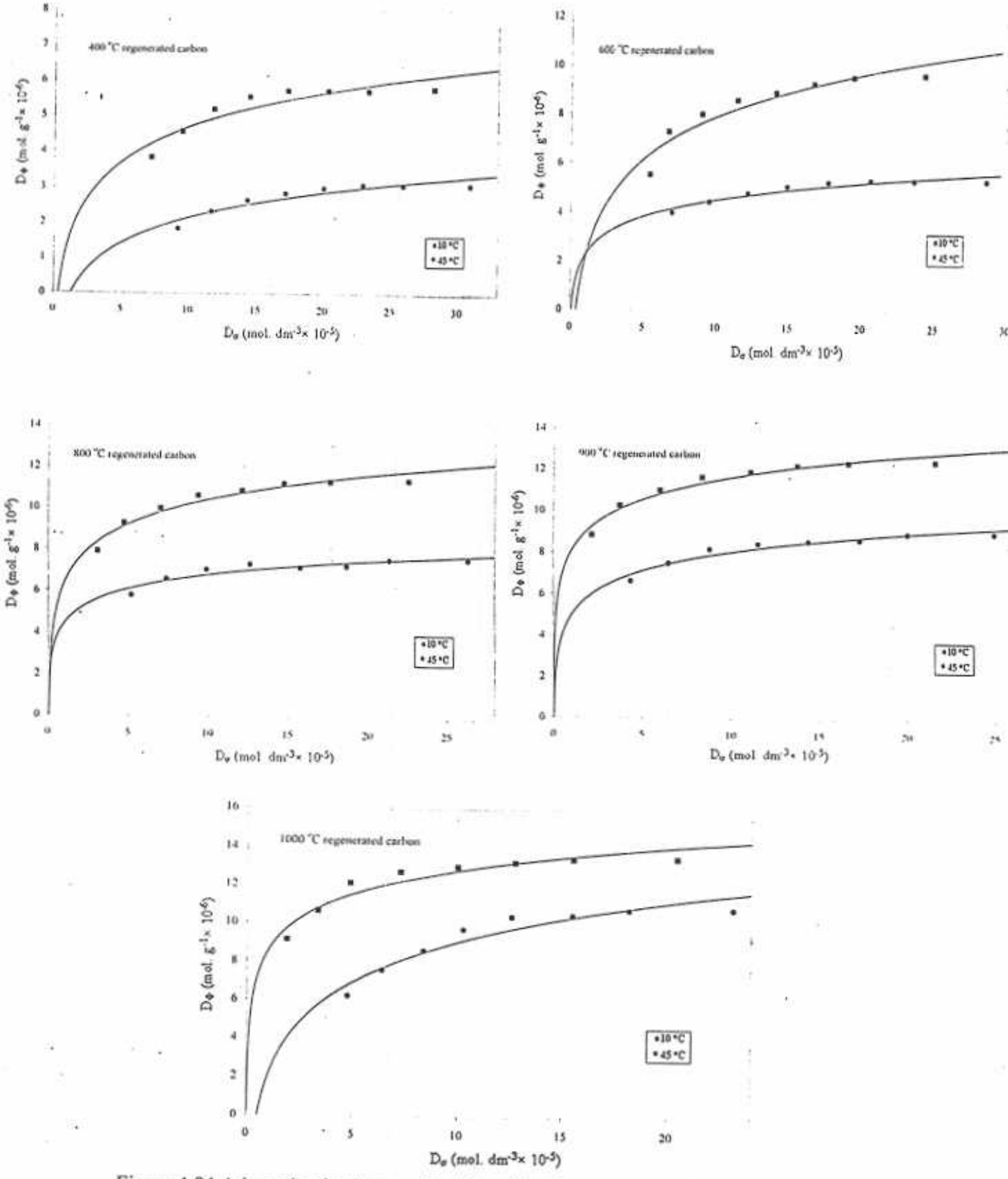


Figure 4.84 Adsorption isotherms of brilliant blue R on regenerated carbon samples

Table 4.83 Adsorption isotherm of acid yellow 29 on carbon samples

Sample		D_e ($mol.dm^{-3} \times 10^{-4}$)	at 10 °C				D_e ($mol.dm^{-3} \times 10^{-4}$)	at 45°C			
			Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_w-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_ϕ ($mol.g^{-1} \times 10^{-5}$)		Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_w-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_ϕ ($mol.g^{-1} \times 10^{-5}$)
Paulownia tomentosa (PT)	Raw	1.00	0.100	1.130	0.887	0.887	1.00	0.010	0.110	0.989	0.989
		1.30	0.120	1.360	1.164	1.164	1.30	0.030	0.340	1.266	1.266
		1.60	0.160	1.810	1.420	1.420	1.60	0.060	0.680	1.532	1.532
		1.90	0.220	2.490	1.650	1.650	1.90	0.110	1.240	1.776	1.776
		2.20	0.550	3.960	1.800	1.800	2.20	0.200	2.260	1.974	1.974
		2.50	0.615	6.973	1.802	1.802	2.50	0.315	3.570	2.143	2.143
		2.80	0.800	9.070	1.893	1.893	2.80	0.429	4.860	2.314	2.314
		3.10	0.940	10.65	2.034	2.034	3.10	0.550	6.230	2.477	2.477
	400 °C	2.00	0.220	2.490	1.750	1.750	2.00	0.100	1.130	1.880	1.880
		2.30	0.253	2.860	2.010	2.010	2.30	0.121	1.370	2.160	2.160
		2.60	0.295	3.340	2.270	2.270	2.60	0.202	2.290	2.370	2.370
		2.90	0.356	4.030	2.500	2.500	2.90	0.243	2.750	2.620	2.620
		3.20	0.470	5.320	2.670	2.670	3.20	0.350	3.960	2.800	2.800
		3.50	0.590	6.680	2.830	2.830	3.50	0.468	5.300	3.000	3.000
		3.80	0.688	7.800	3.019	3.019	3.80	0.592	6.712	3.128	3.128
		4.10	0.800	9.071	3.193	3.193	4.10	0.730	8.276	3.272	3.272
	800 °C	2.60	0.220	2.490	2.350	2.350	2.60	0.150	1.700	2.430	2.430
		2.90	0.263	2.980	2.600	2.600	2.90	0.190	2.150	2.680	2.680
		3.20	0.300	3.400	2.860	2.860	3.20	0.230	2.600	2.940	2.940
		3.50	0.375	4.250	3.070	3.070	3.50	0.300	3.400	3.160	3.160
		3.80	0.440	4.980	3.300	3.300	3.80	0.370	4.200	3.380	3.380
		4.10	0.570	6.460	3.450	3.450	4.10	0.468	5.300	3.570	3.570
		4.30	0.688	7.800	3.520	3.520	4.30	0.573	6.490	3.650	3.650
		4.60	0.790	8.950	3.700	3.700	4.60	0.669	7.580	3.840	3.840
Populus caspica (PC)	Raw	1.00	0.150	1.701	0.8299	0.8299	1.00	0.100	1.130	0.887	0.887
		1.30	0.180	2.041	1.0959	1.0959	1.30	0.130	1.470	1.153	1.153
		1.60	0.230	2.607	1.3393	1.3393	1.60	0.170	1.920	1.410	1.410
		1.90	0.270	3.061	1.5959	1.5959	1.90	0.220	2.490	1.650	1.650
		2.20	0.360	4.082	1.7918	1.7918	2.20	0.300	3.400	1.860	1.860
		2.50	0.480	5.442	1.9558	1.9558	2.50	0.420	4.760	2.020	2.020
		2.80	0.610	6.916	2.1084	2.1084	2.80	0.550	6.230	2.170	2.170
		3.10	0.770	8.730	2.2270	2.2270	3.10	0.710	8.049	2.295	2.295
	400 °C	2.00	0.280	3.170	1.680	1.680	2.00	0.200	2.26	1.77	1.77
		2.30	0.303	3.430	1.960	1.960	2.30	0.228	2.58	2.04	2.04
		2.60	0.510	3.980	2.200	2.200	2.60	0.282	3.19	2.28	2.28
		2.90	0.385	4.365	2.463	2.463	2.90	0.360	4.08	2.49	2.49
		3.20	0.502	5.691	2.631	2.631	3.20	0.482	5.47	2.66	2.66
		3.50	0.660	7.483	2.752	2.752	3.50	0.610	6.91	2.81	2.81
		3.80	0.810	9.180	2.880	2.880	3.80	0.730	8.27	2.97	2.97
		4.10	0.980	11.11	2.980	2.980	4.10	0.860	9.75	3.12	3.12
	800 °C	2.60	0.219	2.483	2.352	2.352	2.60	0.150	1.700	2.430	2.430
		2.90	0.270	3.060	2.590	2.590	2.90	0.180	2.040	2.690	2.690
		3.20	0.319	3.610	2.840	2.840	3.20	0.230	2.600	2.940	2.940
		3.50	0.424	4.780	3.020	3.020	3.50	0.355	4.020	3.100	3.100
		3.80	0.569	6.480	3.320	3.320	3.80	0.479	5.430	3.260	3.260
		4.10	0.624	7.075	3.392	3.392	4.10	0.599	6.790	3.420	3.420
		4.30	0.780	8.843	3.415	3.415	4.30	0.750	8.500	3.580	3.580
		4.60	0.949	10.75	3.524	3.524	4.60	0.890	10.09	3.590	3.590

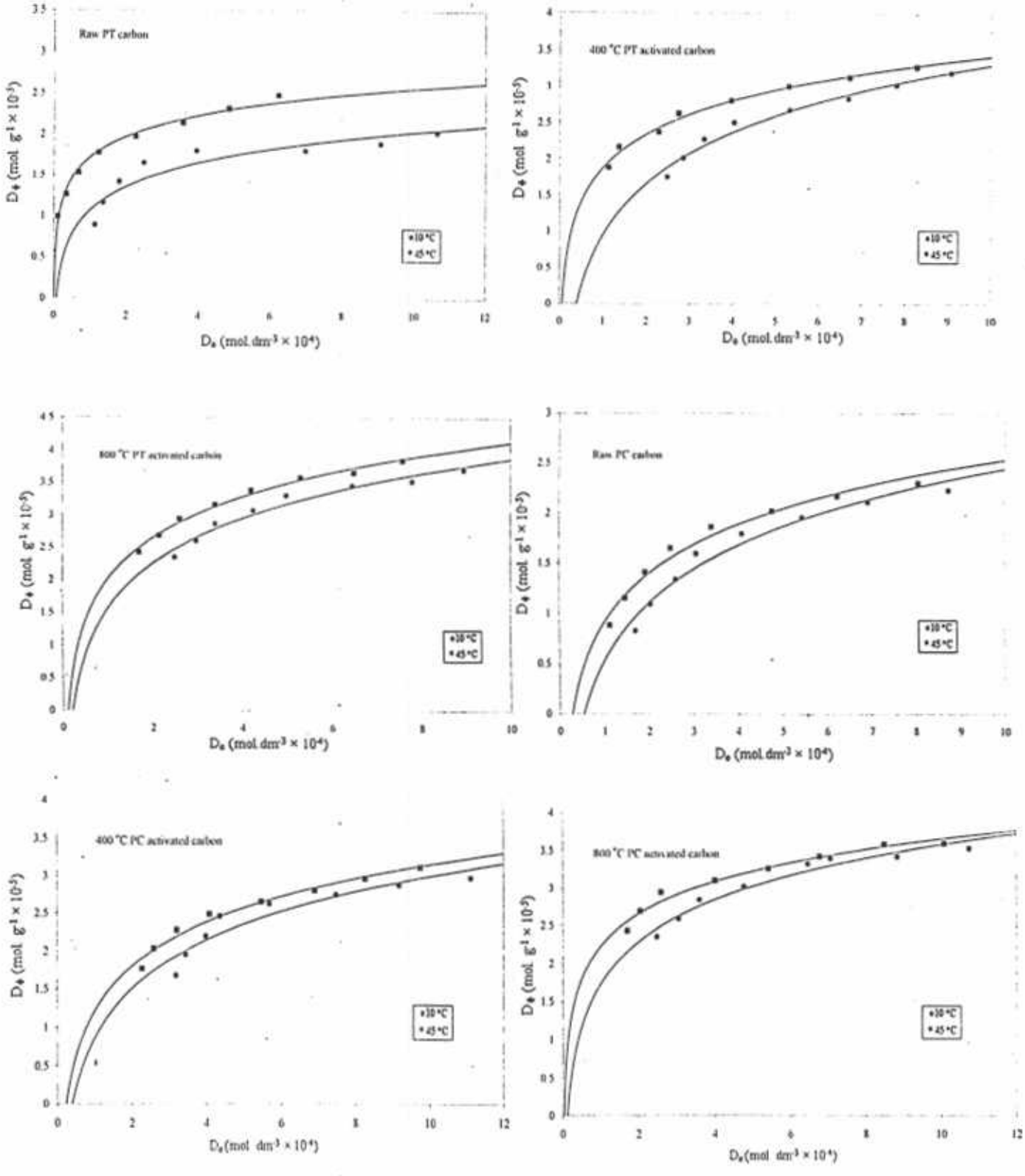


Figure 4.85 Adsorption isotherms of acid yellow 29on *Paulownia tomentosa* (PT) and *Populus caspica* (PC) carbon samples

Table 4.84 Adsorption isotherm of acid yellow 29 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-4}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-4}$)	at 45°C			
			Ab_{31}	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_f ($mol.g^{-1} \times 10^{-5}$)		Ab_{31}	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_f ($mol.g^{-1} \times 10^{-5}$)
Corncobs (CC)	Raw	1.00	0.129	1.462	0.853	0.853	1.00	0.040	0.450	0.950	0.950
		1.30	0.163	1.848	1.115	1.115	1.30	0.090	1.020	1.198	1.198
		1.60	0.199	2.256	1.374	1.374	1.60	0.130	1.470	1.450	1.450
		1.90	0.263	2.982	1.601	1.601	1.90	0.179	2.020	1.690	1.690
		2.20	0.368	4.172	1.782	1.782	2.20	0.250	2.830	1.910	1.910
		2.50	0.498	5.640	1.970	1.970	2.50	0.370	4.190	2.080	2.080
		2.80	0.640	7.256	2.074	2.074	2.80	0.489	5.550	2.240	2.240
		3.10	0.795	9.013	2.198	2.198	3.10	0.654	7.415	2.360	2.360
	400 °C	2.00	0.300	3.400	1.660	1.660	2.00	0.140	1.580	1.840	1.840
		2.30	0.339	3.840	1.920	1.920	2.30	0.193	2.180	2.080	2.080
		2.60	0.383	4.340	2.160	2.160	2.60	0.243	2.750	2.320	2.320
		2.90	0.460	5.210	2.380	2.380	2.90	0.300	3.400	2.560	2.560
		3.20	0.600	6.800	2.520	2.520	3.20	0.413	4.680	2.730	2.730
		3.50	0.760	8.610	2.640	2.640	3.50	0.570	6.460	2.850	2.850
		3.80	0.910	10.30	2.770	2.770	3.80	0.733	8.310	2.970	2.970
		4.10	1.200	13.60	2.740	2.740	4.10	0.890	10.09	3.100	3.100
	800 °C	2.60	0.250	2.830	2.320	2.320	2.60	0.190	2.150	2.380	2.380
		2.90	0.280	3.170	2.580	2.580	2.90	0.234	2.650	2.630	2.630
		3.20	0.335	3.790	2.820	2.820	3.20	0.282	3.190	2.880	2.880
		3.50	0.390	4.420	3.060	3.060	3.50	0.350	3.960	3.100	3.100
		3.80	0.520	5.890	3.210	3.210	3.80	0.479	5.430	3.250	3.250
		4.10	0.699	7.920	3.310	3.310	4.10	0.620	7.020	3.390	3.390
		4.30	0.820	9.290	3.370	3.370	4.30	0.750	8.500	3.450	3.450
		4.60	1.100	12.47	3.350	3.350	4.60	0.950	10.71	3.520	3.520
Ailanthus altissima (AA)	Raw	1.00	0.150	1.700	0.830	0.830	1.00	0.080	0.900	0.910	0.910
		1.30	0.189	2.140	1.080	1.080	1.30	0.120	1.360	1.160	1.160
		1.60	0.245	2.770	1.320	1.320	1.60	0.150	1.700	1.430	1.430
		1.90	0.300	3.400	1.560	1.560	1.90	0.200	2.260	1.670	1.670
		2.20	0.390	4.420	1.760	1.760	2.20	0.280	3.170	1.880	1.880
		2.50	0.499	5.650	1.930	1.930	2.50	0.390	4.420	2.060	2.060
		2.80	0.710	8.040	1.990	1.990	2.80	0.610	6.910	2.110	2.110
		3.10	0.930	10.54	2.050	2.050	3.10	0.750	8.500	2.250	2.250
	400 °C	2.00	0.250	2.830	1.720	1.720	2.00	0.160	1.810	1.820	1.820
		2.30	0.289	3.270	1.970	1.970	2.30	0.190	2.150	2.080	2.080
		2.60	0.350	3.960	2.200	2.200	2.60	0.240	2.720	2.330	2.330
		2.90	0.480	5.440	2.350	2.350	2.90	0.310	3.510	2.550	2.550
		3.20	0.610	6.910	2.510	2.510	3.20	0.420	4.760	2.720	2.720
		3.50	0.800	9.070	2.600	2.600	3.50	0.540	6.120	2.890	2.890
		3.80	0.990	11.22	2.680	2.680	3.80	0.690	7.820	3.010	3.010
		4.10	1.200	13.60	2.740	2.740	4.10	0.820	9.290	3.170	3.170
	800 °C	2.60	0.260	3.010	2.300	2.300	2.60	0.200	2.260	2.3700	2.3700
		2.90	0.290	3.280	2.570	2.570	2.90	0.240	2.720	2.6300	2.6300
		3.20	0.350	3.960	2.800	2.800	3.20	0.275	3.110	2.8900	2.8900
		3.50	0.400	4.530	3.040	3.040	3.50	0.368	4.170	3.0800	3.0800
		3.80	0.570	6.460	3.150	3.150	3.80	0.499	5.650	3.2300	3.2300
		4.10	0.730	8.270	3.270	3.270	4.10	0.596	6.750	3.4200	3.4200
		4.30	0.890	10.10	3.290	3.290	4.30	0.730	8.270	3.4700	3.4700
		4.60	1.000	11.34	3.460	3.460	4.60	0.999	11.32	3.4768	3.4768

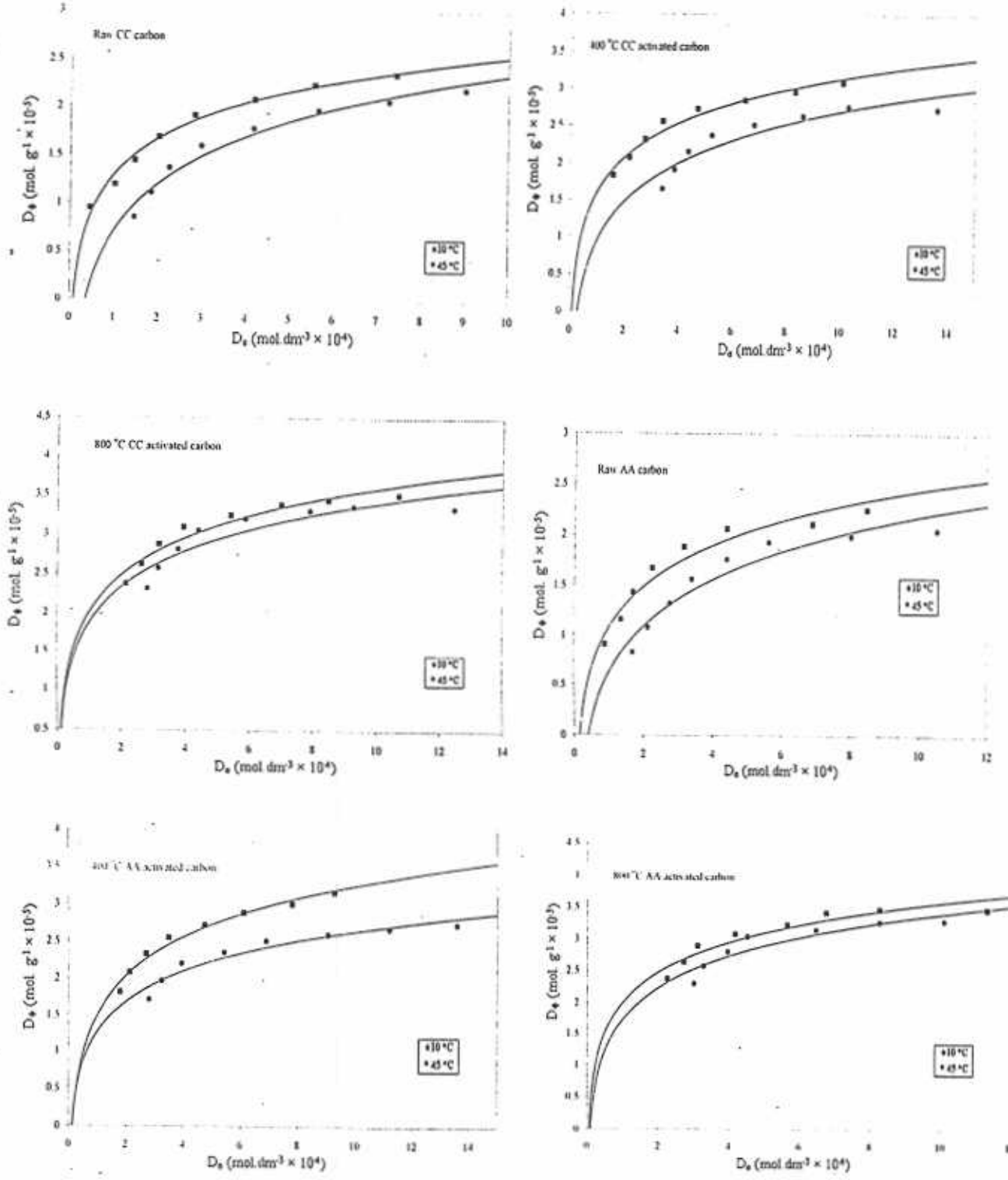


Figure 4.86 Adsorption isotherms of acid yellow 29 on *Corncobs* (CC) and *Ailanthus altissima* (AA) carbon samples

Table 4.85 Adsorption isotherm of acid yellow 29 on carbon samples

Sample		D_e ($mol.dm^{-3} \times 10^{-5}$)	Adsorption isotherm at 10 °C				D_e ($mol.dm^{-3} \times 10^{-5}$)	Adsorption isotherm at 45°C			
			Ab_M	D_o ($mol.dm^{-3} \times 10^{-5}$)	D_e-D_o ($mol.dm^{-3} \times 10^{-3}$)	D_ϕ ($mol.g^{-1} \times 10^{-2}$)		Ab_M	D_o ($mol.dm^{-3} \times 10^{-5}$)	D_e-D_o ($mol.dm^{-3} \times 10^{-5}$)	D_ϕ ($mol.g^{-1} \times 10^{-2}$)
Salvadora oleoides (SO)	Raw	8.00	0.669	7.58503	0.414965	0.414965	8.00	0.610	6.916099	1.083900	1.083900
		10.0	0.800	9.52381	0.476190	0.476190	10.0	0.760	8.616780	1.383219	1.383219
		12.0	0.990	11.36054	0.639456	0.639456	12.0	0.920	10.43084	1.569161	1.569161
		14.0	1.152	13.06122	0.938775	0.938775	14.0	1.080	12.24489	1.755103	1.755103
		16.0	1.302	14.76190	1.238095	1.238095	16.0	1.250	14.17233	1.827665	1.827665
		18.0	1.472	16.68934	1.310657	1.310657	18.0	1.420	16.09977	1.900226	1.900226
		22.0	1.816	20.58956	1.410430	1.410430	22.0	1.765	20.01134	1.988663	1.988663
		26.0	2.168	24.58049	1.419501	1.419501	26.0	2.117	24.00226	1.997733	1.997733
	400 °C	8.00	0.620	7.029470	0.970521	0.970521	8.00	0.550	6.235827	1.764172	1.764172
		10.0	0.770	8.730158	1.269841	1.269841	10.0	0.679	7.698412	2.301587	2.301587
		12.0	0.900	10.20408	1.795918	1.795918	12.0	0.815	9.240363	2.759637	2.759637
		14.0	1.050	11.90476	2.095238	2.095238	14.0	0.975	11.08442	2.945578	2.945578
		16.0	1.200	13.60544	2.394558	2.394558	16.0	1.130	12.81179	3.188208	3.188208
		18.0	1.374	15.57823	2.421768	2.421768	18.0	1.300	14.73923	3.260771	3.260771
		22.0	1.720	19.50113	2.498866	2.498866	22.0	1.650	18.70748	3.292517	3.292517
		26.0	2.060	23.35601	2.643991	2.643991	26.0	2.000	22.67574	3.324630	3.324630
	600 °C	8.00	0.452	5.124716	2.875280	2.875280	8.00	0.369	4.183673	3.816326	3.816326
		10.0	0.580	6.575963	3.424036	3.424036	10.0	0.490	5.555555	4.444444	4.444444
		12.0	0.698	7.913832	4.086168	4.086168	12.0	0.600	6.802721	5.197279	5.197279
		14.0	0.800	9.070295	4.929705	4.929705	14.0	0.705	7.993197	6.006802	6.006802
		16.0	0.940	10.65759	5.342403	5.342403	16.0	0.850	9.637188	6.362811	6.362811
		18.0	1.100	12.47165	5.528344	5.528344	18.0	1.000	11.33786	6.662132	6.662132
		22.0	1.440	16.32653	5.673469	5.673469	22.0	1.350	15.30612	6.693877	6.693877
		26.0	1.790	20.29478	5.705215	5.705215	26.0	1.700	19.27437	6.725623	6.725623
	800 °C	8.00	0.399	4.523809	3.476190	3.476190	8.00	0.298	3.378684	4.621315	4.621315
		10.0	0.491	5.566893	4.433106	4.433106	10.0	0.390	4.421768	5.578231	5.578231
		12.0	0.601	6.814058	5.185941	5.185941	12.0	0.500	5.668934	6.331065	6.331065
		14.0	0.751	8.514739	5.48526	5.48526	14.0	0.650	7.369614	6.630385	6.630385
		16.0	0.901	10.21542	5.784580	5.784580	16.0	0.800	9.070294	6.929705	6.929705
		18.0	1.051	11.91609	6.083900	6.083900	18.0	0.950	10.77097	7.229025	7.229025
		22.0	1.381	15.65759	6.342400	6.342400	22.0	1.250	14.17233	7.827664	7.827664
		26.0	1.710	19.38775	6.612244	6.612244	26.0	1.599	18.12925	7.870748	7.870748
	900 °C	8.00	0.088	0.997733	7.002267	7.002267	8.00	0.033	0.374149	7.625851	7.625851
		10.0	0.110	1.247165	8.752834	8.752834	10.0	0.072	0.816326	9.183673	9.183673
		12.0	0.196	2.222222	9.777778	9.777778	12.0	0.158	1.791383	10.20862	10.20862
		14.0	0.328	3.718820	10.28118	10.28118	14.0	0.285	3.231293	10.76871	10.76871
		16.0	0.436	4.943310	11.05668	11.05668	16.0	0.398	4.512472	11.48753	11.48753
		18.0	0.576	6.530612	11.46938	11.46938	18.0	0.528	5.986395	12.01361	12.01361
		22.0	0.858	9.727891	12.27211	12.27211	22.0	0.804	9.115646	12.88435	12.88435
		26.0	1.178	13.35601	12.64399	12.64399	26.0	1.130	12.81179	13.18821	13.18821
	1000 °C	8.00	0.153	1.734690	6.265306	6.265306	8.00	0.023	0.260771	7.739229	7.739229
		10.0	0.222	2.517006	7.482993	7.482993	10.0	0.072	0.816326	9.183673	9.183673
		12.0	0.302	3.424036	8.575963	8.575963	12.0	0.182	2.063492	9.936507	9.936507
		14.0	0.410	4.648526	9.351474	9.351474	14.0	0.300	3.401361	10.59864	10.59864
		16.0	0.556	6.303854	9.696145	9.696145	16.0	0.406	4.603174	11.39683	11.39683
		18.0	0.696	7.891156	10.10884	10.10884	18.0	0.526	5.963718	12.03628	12.03628
		22.0	1.028	11.65533	10.34467	10.34467	22.0	0.875	9.920635	12.07936	12.07936
		26.0	1.384	15.69161	10.30839	10.30839	26.0	1.170	13.26530	12.73469	12.73469

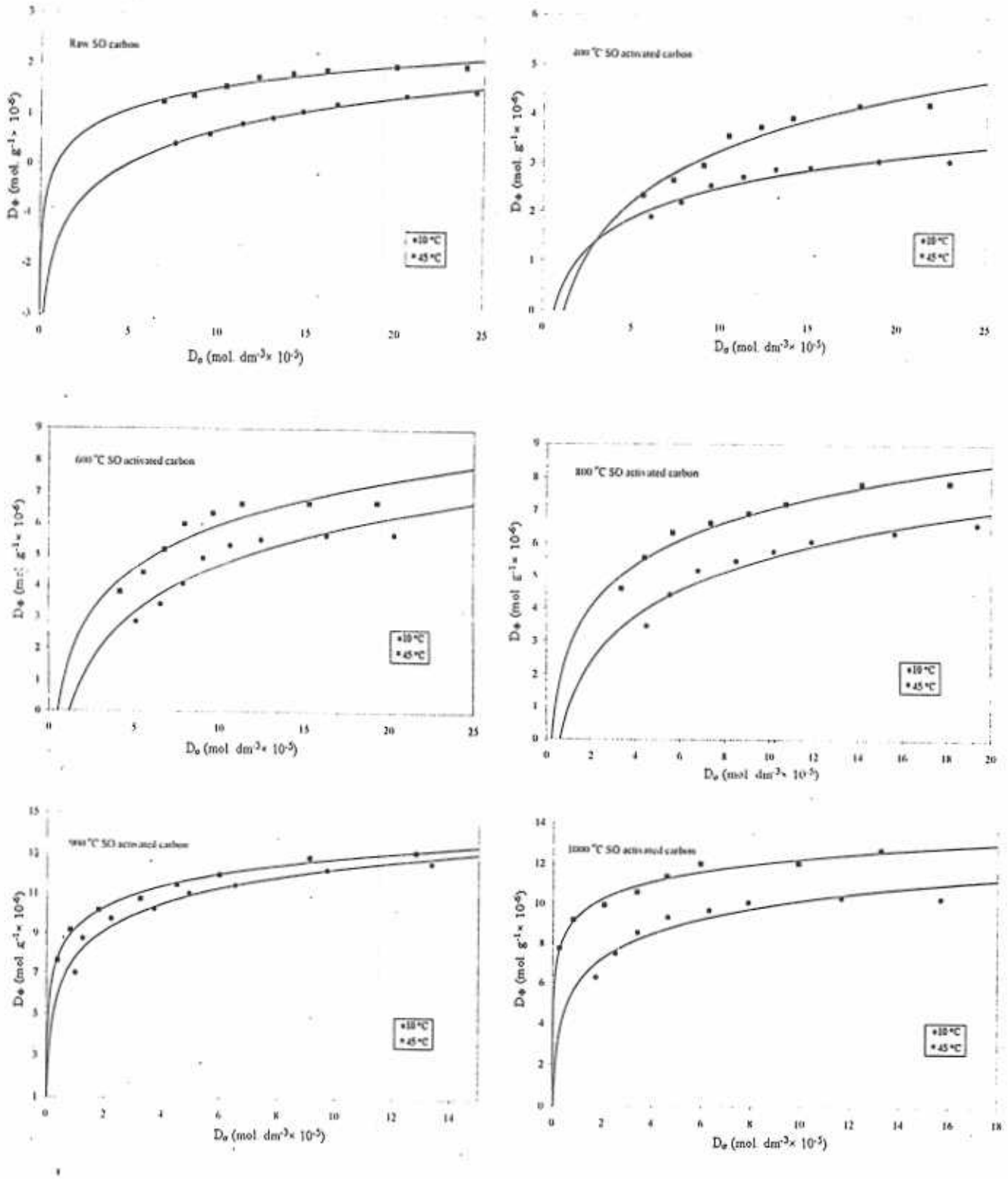


Figure 4.87 Adsorption isotherms of acid yellow 29on *Salvadora oleoides* (SO) carbon samples

Table 4.86 Adsorption isotherm of acid yellow 29 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Ab_{31}	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_f ($mol.g^{-1} \times 10^{-2}$)		Ab_{31}	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_f ($mol.g^{-1} \times 10^{-2}$)
Animal bones (ABC)	600 °C	32.0	0.355	4.024943	27.97505	27.97505	32.0	0.166	1.882086	30.11791	30.11791
		36.0	0.412	4.671202	31.32879	31.32879	36.0	0.223	2.528345	33.47165	33.47165
		40.0	0.467	5.294785	34.70522	34.70522	40.0	0.278	3.151927	36.84807	36.84807
		44.0	0.532	6.031746	37.96825	37.96825	44.0	0.313	3.548753	40.45125	40.45125
		48.0	0.702	7.959183	40.04082	40.04082	48.0	0.500	5.668934	42.33106	42.33106
		52.0	0.784	8.888889	43.11112	43.11112	52.0	0.593	6.723356	45.27665	45.27665
		56.0	0.943	10.69161	45.30839	45.30839	56.0	0.732	8.299319	47.70068	47.70068
		60.0	1.159	13.14059	46.85941	46.85941	60.0	0.948	10.74829	49.25170	49.25170
	700 °C	32.0	0.174	1.972789	30.02721	30.02721	32.0	0.091	1.031746	30.96825	30.96825
		36.0	0.202	2.290249	33.70975	33.70975	36.0	0.120	1.360544	34.63945	34.63945
		40.0	0.262	2.970522	37.02947	37.02947	40.0	0.190	2.154195	37.84580	37.84580
		44.0	0.331	3.752834	40.24716	40.24716	44.0	0.250	2.834467	41.16553	41.16553
		48.0	0.502	5.691609	42.30839	42.30839	48.0	0.420	4.761904	43.23809	43.23809
		52.0	0.602	6.825397	45.17460	45.17460	52.0	0.520	5.895692	46.10431	46.10431
		56.0	0.748	8.480726	47.51927	47.51927	56.0	0.595	6.746032	49.25396	49.25396
		60.0	0.886	10.04535	49.95465	49.95465	60.0	0.680	7.709750	52.29025	52.29025
	800 °C	32.0	0.240	2.721088	29.27891	29.27891	32.0	0.130	1.473923	30.52607	30.52607
		36.0	0.290	3.287982	32.71202	32.71202	36.0	0.180	2.040816	33.95918	33.95918
		40.0	0.360	4.081632	35.91836	35.91836	40.0	0.250	2.834467	37.16553	37.16553
		44.0	0.404	4.580498	39.41950	39.41950	44.0	0.300	3.401360	40.59864	40.59864
		48.0	0.516	5.850340	42.14965	42.14965	48.0	0.410	4.648526	43.35147	43.35147
		52.0	0.598	6.780045	45.21995	45.21995	52.0	0.495	5.612245	46.38775	46.38775
		56.0	0.836	9.478458	46.52154	46.52154	56.0	0.630	7.142857	48.85714	48.85714
		60.0	0.924	10.47619	49.52381	49.52381	60.0	0.720	8.163265	51.83673	51.83673
	900 °C	32.0	0.142	1.609977	30.39002	30.39002	32.0	0.060	0.680272	31.31973	31.31973
		36.0	0.192	2.176871	33.82313	33.82313	36.0	0.080	0.907029	35.09297	35.09297
		40.0	0.244	2.766439	37.23356	37.23356	40.0	0.130	1.473923	38.52607	38.52607
		44.0	0.316	3.582766	40.41723	40.41723	44.0	0.200	2.267573	41.73243	41.73243
		48.0	0.414	4.693877	43.30612	43.30612	48.0	0.302	3.424036	44.57596	44.57596
		52.0	0.489	5.544217	46.45578	46.45578	52.0	0.395	4.478458	47.52154	47.52154
		56.0	0.584	6.621315	49.37868	49.37868	56.0	0.470	5.328798	50.67120	50.67120
		60.0	0.740	8.390023	51.60997	51.60997	60.0	0.580	6.575963	53.42404	53.42404
	1000 °C	32.0	0.028	0.317460	31.68254	31.68254	32.0	0.007	0.079365	31.92063	31.92063
		36.0	0.042	0.476190	35.52381	35.52381	36.0	0.020	0.226757	35.77324	35.77324
		40.0	0.078	0.884354	39.1156	39.1156	40.0	0.055	0.623583	39.37642	39.37642
		44.0	0.117	1.326531	42.6735	42.6735	44.0	0.098	1.111112	42.88889	42.88889
		48.0	0.189	2.142857	45.8514	45.8514	48.0	0.147	1.666667	46.33334	46.33334
		52.0	0.254	2.879818	49.1202	49.1202	52.0	0.210	2.380953	49.61905	49.61905
		56.0	0.354	4.013605	51.9864	51.9864	56.0	0.301	3.412698	52.58730	52.58730
		60.0	0.568	6.439909	53.5601	53.5601	60.0	0.446	5.056689	54.94331	54.94331

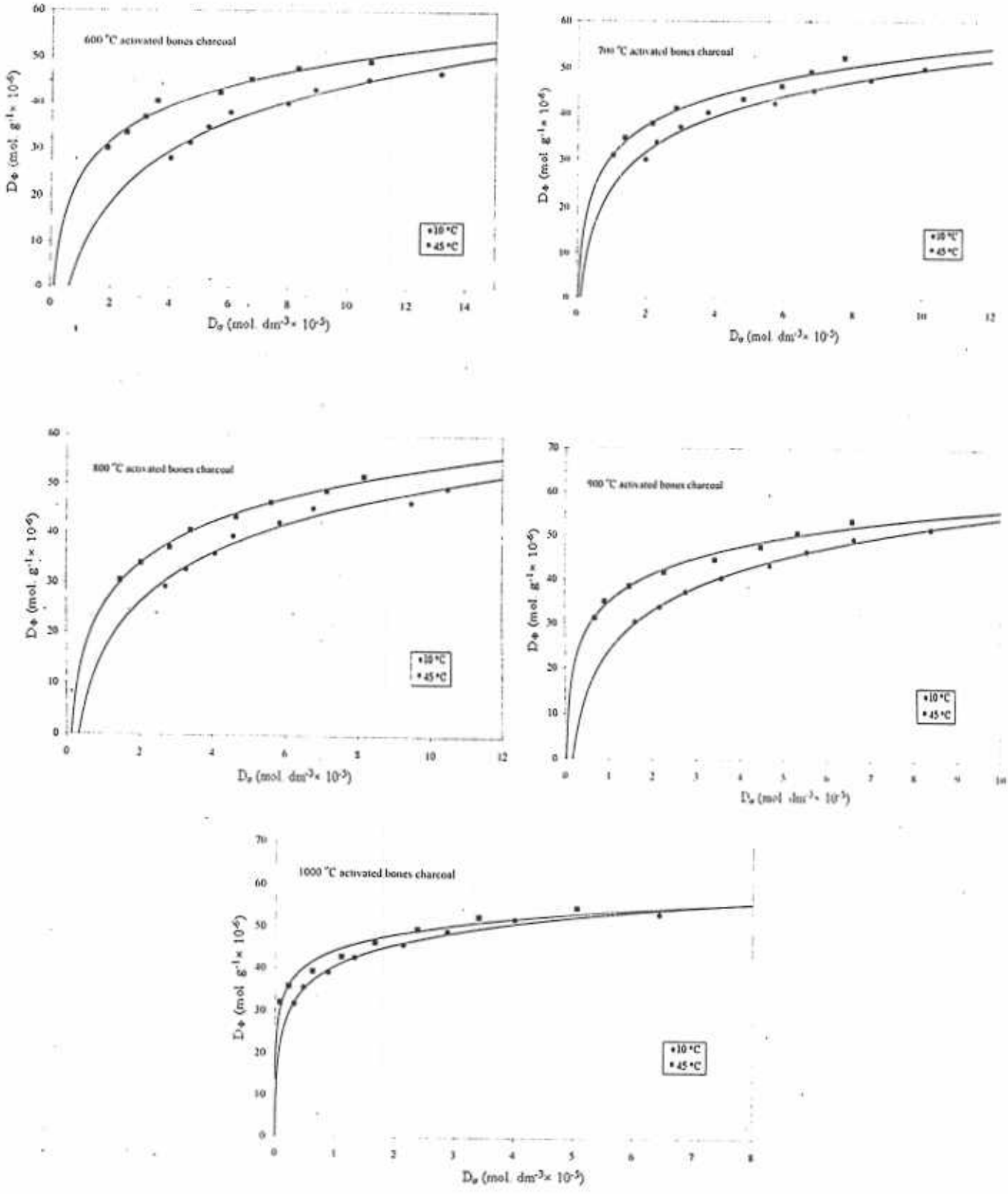


Figure 4.88 Adsorption isotherms of acid yellow 29on animal bones based charcoal samples

Table 4.87 Adsorption isotherm of acid yellow 29 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_q ($mol.g^{-1} \times 10^{-2}$)		Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_q ($mol.g^{-1} \times 10^{-2}$)
Regenerated (RG)	400 °C	32.0	0.804	9.115646	22.88435	22.88435	32.0	0.610	6.916099	25.08390	25.08390
		36.0	0.915	10.37415	25.62585	25.62585	36.0	0.722	8.185941	27.81405	27.81405
		40.0	1.010	11.45125	28.54875	28.54875	40.0	0.820	9.297052	30.70294	30.70294
		44.0	1.206	13.67647	30.32653	30.32653	44.0	0.915	10.37414	33.62585	33.62585
		48.0	1.422	16.12245	31.87755	31.87755	48.0	1.130	12.81179	35.18821	35.18821
		52.0	1.684	19.09297	32.90703	32.90703	52.0	1.460	16.55328	35.44671	35.44671
		56.0	1.976	22.40363	33.59637	33.59637	56.0	1.760	19.95465	36.04535	36.04535
		60.0	2.288	25.94104	34.05895	34.05895	60.0	2.076	23.53742	36.46258	36.46258
	600 °C	36.0	0.334	3.786848	32.21315	32.21315	36.0	0.264	2.993197	33.00681	33.00681
		40.0	0.405	4.591836	35.40816	35.40816	40.0	0.326	3.696145	36.30385	36.30385
		44.0	0.460	5.215420	38.78458	38.78458	44.0	0.360	4.081632	39.91836	39.91836
		48.0	0.600	6.802721	41.19728	41.19728	48.0	0.500	5.668934	42.33106	42.33106
		52.0	0.707	8.015873	43.98413	43.98413	52.0	0.628	7.120181	44.87981	44.87981
		56.0	0.950	10.77097	45.22902	45.22902	56.0	0.880	9.977324	46.02267	46.02267
		60.0	1.300	14.73923	45.26077	45.26077	60.0	1.200	13.60544	46.39455	46.39455
		68.0	1.770	20.06803	47.93197	47.93197	68.0	1.610	18.25396	49.74603	49.74603
	800 °C	36.0	0.212	2.403628	33.59637	33.59637	36.0	0.100	1.133786	34.86621	34.86621
		40.0	0.263	2.981859	37.01814	37.01814	40.0	0.150	1.700681	38.29932	38.29932
		44.0	0.323	3.662132	40.33786	40.33786	44.0	0.210	2.380952	41.61904	41.61904
		48.0	0.372	4.217687	43.78231	43.78231	48.0	0.260	2.947845	45.05215	45.05215
		52.0	0.442	5.011337	46.98866	46.98866	52.0	0.330	3.741496	48.25851	48.25851
		56.0	0.599	6.791383	49.20862	49.20862	56.0	0.450	5.102141	50.89796	50.89796
		60.0	0.786	8.911564	51.08843	51.08843	60.0	0.730	8.276644	51.72335	51.72335
		68.0	1.527	17.31293	50.68707	50.68707	68.0	1.400	15.87301	52.12698	52.12698
	900 °C	36.0	0.200	2.267573	33.73243	33.73243	36.0	0.110	1.247165	34.75283	34.75283
		40.0	0.220	2.494331	37.50567	37.50567	40.0	0.140	1.587301	38.41269	38.41269
		44.0	0.278	3.151927	40.84807	40.84807	44.0	0.200	2.26757	41.73246	41.73246
		48.0	0.330	3.741496	44.25850	44.25850	48.0	0.250	2.834467	45.16553	45.16553
		52.0	0.398	4.512472	47.48753	47.48753	52.0	0.300	3.401361	48.59863	48.59863
		56.0	0.496	5.623582	50.37642	50.37642	56.0	0.400	4.535147	51.46485	51.46485
		60.0	0.704	7.981859	52.01814	52.01814	60.0	0.600	6.802721	53.19727	53.19727
		68.0	1.110	12.58503	55.41496	55.41496	68.0	0.820	9.297052	58.70295	58.70295
	1000 °C	36.0	0.155	1.757369	34.24260	34.24260	36.0	0.025	0.283446	35.71655	35.71655
		40.0	0.180	2.040816	37.95918	37.95918	40.0	0.050	0.566893	39.43310	39.43310
		44.0	0.230	2.607709	41.39229	41.39229	44.0	0.100	1.133787	42.86621	42.86621
		48.0	0.300	3.401361	44.59863	44.59863	48.0	0.200	2.267574	45.73246	45.73246
		52.0	0.360	4.081632	47.91836	47.91836	52.0	0.280	3.174603	48.82539	48.82539
		56.0	0.496	5.623583	50.37642	50.37642	56.0	0.386	4.376417	51.62358	51.62358
		60.0	0.780	8.843537	51.15646	51.15646	60.0	0.570	6.462585	53.53742	53.53742
		68.0	1.200	13.60544	54.39455	54.39455	68.0	0.830	9.410431	58.58956	58.58956

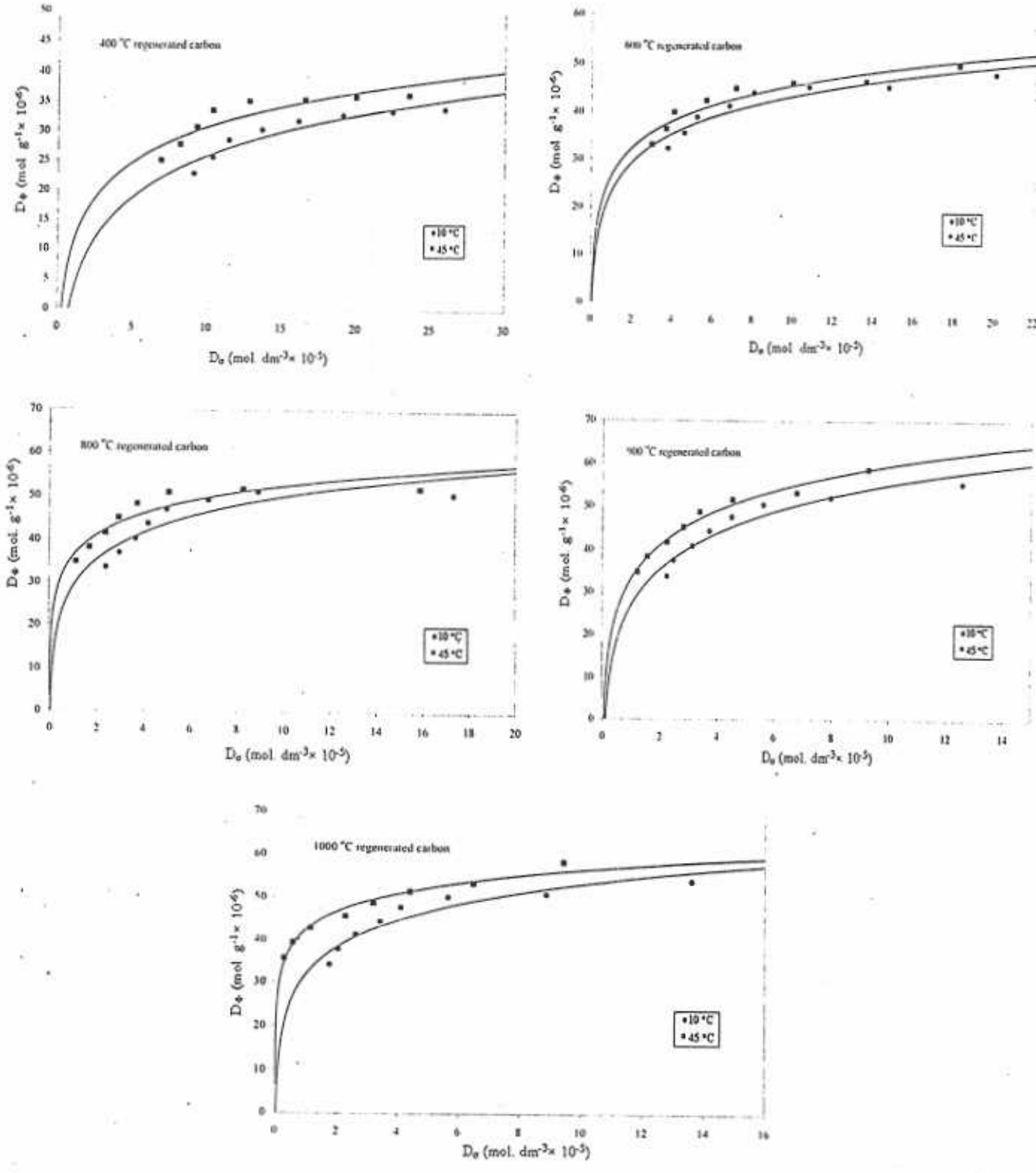


Figure 4.89 Adsorption isotherms of acid yellow 29 on regenerated carbon samples

Table 4.88 Adsorption isotherm of acid yellow 34 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-4}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-4}$)	at 45°C			
			Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_f ($mol.g^{-1} \times 10^{-5}$)		Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_f ($mol.g^{-1} \times 10^{-5}$)
Paulownia tomentosa (PT)	Raw	1.00	0.038	0.2714	0.9728	0.9728	1.00	0.008	0.057	0.994	0.994
		1.30	0.050	0.3570	1.5640	1.5640	1.30	0.020	0.132	1.286	1.286
		1.60	0.080	0.5714	1.5428	1.5428	1.60	0.050	0.357	1.564	1.564
		1.90	0.120	0.8571	1.8142	1.8142	1.90	0.090	0.642	1.835	1.835
		2.20	0.180	1.6363	2.0363	2.0363	2.20	0.150	1.071	2.100	2.100
		2.50	0.290	2.0714	2.2930	2.2930	2.50	0.260	1.850	2.320	2.320
		2.80	0.410	2.9285	2.5071	2.5071	2.80	0.399	2.850	2.520	2.520
		3.10	0.520	3.7142	2.7285	2.7285	3.10	0.490	3.500	2.750	2.750
	400 °C	2.00	0.100	0.714	1.920	1.920	2.00	0.050	0.3572	1.9643	1.9643
		2.30	0.140	1.000	2.200	2.200	2.30	0.085	0.6072	2.2394	2.2394
		2.60	0.180	1.280	2.470	2.470	2.60	0.100	0.7143	2.5928	2.5928
		2.90	0.250	1.780	2.720	2.720	2.90	0.130	0.9280	2.8100	2.8100
		3.20	0.380	2.710	2.930	2.930	3.20	0.200	1.4200	3.0600	3.0600
		3.50	0.459	3.270	3.170	3.170	3.50	0.350	2.5000	3.2500	3.2500
		3.80	0.599	4.270	3.370	3.370	3.80	0.470	3.3500	3.4600	3.4600
		4.10	0.710	5.070	3.590	3.590	4.10	0.599	4.2800	3.6700	3.6700
	800 °C	2.60	0.150	1.070	2.500	2.500	2.60	0.100	0.714	2.520	2.520
		2.90	0.210	1.500	2.750	2.750	2.90	0.143	1.020	2.790	2.790
		3.20	0.270	1.920	3.000	3.000	3.20	0.192	1.370	3.060	3.060
		3.50	0.350	2.500	3.250	3.250	3.50	0.243	1.740	3.320	3.320
		3.80	0.493	3.520	3.450	3.450	3.80	0.370	2.640	3.530	3.530
		4.10	0.599	4.270	3.670	3.670	4.10	0.510	3.640	3.730	3.730
		4.30	0.710	5.070	3.790	3.790	4.30	0.650	4.640	3.830	3.830
		4.60	0.920	6.570	3.940	3.940	4.60	0.830	5.920	4.010	4.010
Populus caspica (PC)	Raw	1.00	0.170	1.210	0.879	0.879	1.00	0.100	0.7143	0.9285	0.9285
		1.30	0.200	1.430	1.120	1.120	1.30	0.130	0.9285	1.2071	1.2071
		1.60	0.240	1.710	1.430	1.430	1.60	0.175	1.2500	1.4750	1.4750
		1.90	0.320	2.280	1.670	1.670	1.90	0.230	1.6428	1.7357	1.7357
		2.20	0.450	3.210	1.880	1.880	2.20	0.320	2.2857	1.9714	1.9714
		2.50	0.590	4.210	2.080	2.080	2.50	0.455	3.2500	2.1750	2.1750
		2.80	0.810	5.785	2.221	2.221	2.80	0.579	4.1357	2.3860	2.3860
		3.10	0.930	6.643	2.435	2.435	3.10	0.680	4.8571	2.6143	2.6143
	400 °C	2.00	0.130	0.930	1.910	1.910	2.00	0.120	0.850	1.920	1.920
		2.30	0.190	1.350	2.160	2.160	2.30	0.150	1.070	2.190	2.190
		2.60	0.320	2.286	2.371	2.371	2.60	0.230	1.640	2.440	2.440
		2.90	0.400	2.857	2.614	2.614	2.90	0.300	2.140	2.680	2.680
		3.20	0.542	3.870	2.810	2.810	3.20	0.458	3.270	2.870	2.870
		3.50	0.710	5.070	2.990	2.990	3.50	0.578	4.120	3.080	3.080
		3.80	0.890	6.350	3.160	3.160	3.80	0.723	5.160	3.280	3.280
		4.10	0.999	7.130	3.380	2.380	4.10	0.843	6.020	3.490	3.490
	800 °C	2.60	0.220	1.570	2.440	2.440	2.60	0.210	1.500	2.450	2.450
		2.90	0.300	2.140	2.680	2.680	2.90	0.241	1.720	2.730	2.730
		3.20	0.380	2.710	2.930	2.930	3.20	0.350	2.500	2.950	2.950
		3.50	0.510	3.640	3.140	3.140	3.50	0.400	2.850	3.220	3.220
		3.80	0.680	4.850	3.310	3.310	3.80	0.553	3.950	3.400	3.400
		4.10	0.735	5.250	3.570	3.570	4.10	0.670	4.780	3.620	3.620
		4.30	0.856	6.110	3.690	3.690	4.30	0.793	5.660	3.730	3.730
		4.60	1.100	7.850	3.820	3.820	4.60	0.999	7.130	3.890	3.890

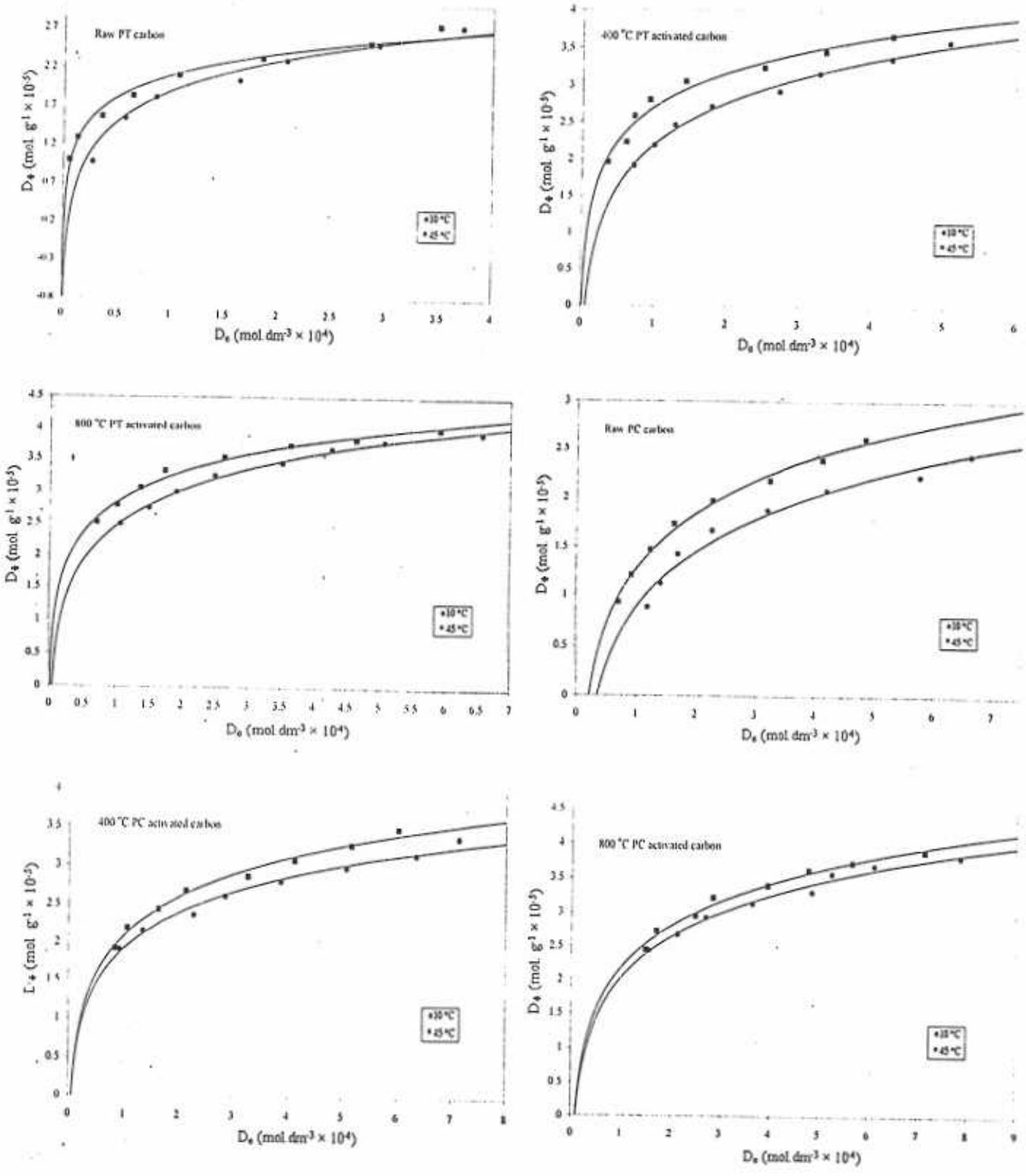


Figure 4.90 Adsorption isotherms of acid yellow 34 on *Paulownia tomentosa* (PT) and *Populus caspica* (PC) carbon samples

Table 4.89 Adsorption isotherm of acid yellow 34 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-4}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-4}$)	at 45°C			
			Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_f ($mol.g^{-1} \times 10^{-5}$)		Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_f ($mol.g^{-1} \times 10^{-5}$)
Corncobs (CC)	Raw	1.00	0.080	0.571	0.940	0.940	1.00	0.050	0.350	0.950	0.950
		1.30	0.110	0.785	1.220	1.220	1.30	0.091	0.640	1.240	1.240
		1.60	0.200	1.420	1.460	1.460	1.60	0.150	1.070	1.500	1.500
		1.90	0.310	2.210	1.680	1.680	1.90	0.210	1.500	1.750	1.750
		2.20	0.440	3.140	1.880	1.880	2.20	0.290	2.070	2.000	2.000
		2.50	0.559	3.990	2.100	2.100	2.50	0.385	2.750	2.220	2.220
		2.80	0.770	5.500	2.250	2.250	2.80	0.599	4.278	2.372	2.372
		3.10	0.913	6.521	2.447	2.447	3.10	0.742	5.300	2.570	2.570
	400 °C	2.00	0.120	0.850	1.930	1.930	2.00	0.100	0.7140	1.920	1.920
		2.30	0.160	1.140	2.160	2.160	2.30	0.130	0.930	2.210	2.210
		2.60	0.220	1.570	2.440	2.440	2.60	0.165	1.170	2.480	2.480
		2.90	0.350	2.500	2.650	2.650	2.90	0.200	1.420	2.750	2.750
		3.20	0.470	3.350	2.860	2.860	3.20	0.290	2.070	3.000	3.000
		3.50	0.600	4.280	3.070	3.070	3.50	0.399	2.850	3.210	3.210
		3.80	0.733	5.230	3.270	3.270	3.80	0.519	3.700	3.430	3.430
		4.10	0.897	6.400	3.460	3.460	4.10	0.698	4.980	3.600	3.600
	800 °C	2.60	0.1500	1.070	2.430	2.430	2.60	0.110	0.785	2.52	2.52
		2.90	0.1930	1.370	2.760	2.760	2.90	0.150	1.070	2.79	2.79
		3.20	0.2810	2.000	3.000	3.000	3.20	0.193	1.370	3.06	3.06
		3.50	0.4300	3.070	3.190	3.190	3.50	0.270	1.920	3.31	3.31
		3.80	0.5800	4.140	3.380	3.380	3.80	0.361	2.570	3.54	3.54
		4.10	0.6890	4.920	3.610	3.610	4.10	0.483	3.450	3.75	3.75
		4.30	0.7910	5.650	3.730	3.730	4.30	0.608	4.340	3.86	3.86
		4.60	0.9930	7.090	3.890	3.890	4.60	0.790	5.640	4.04	4.04
Ailanthus altissima (AA)	Raw	1.00	0.100	0.714	0.930	0.930	1.00	0.070	0.500	0.950	0.950
		1.30	0.140	1.000	1.200	1.200	1.30	0.100	0.710	1.230	1.230
		1.60	0.190	1.350	1.460	1.460	1.60	0.170	1.210	1.470	1.470
		1.90	0.260	1.850	1.710	1.710	1.90	0.240	1.710	1.730	1.730
		2.20	0.400	2.850	1.920	1.920	2.20	0.320	2.280	1.970	1.970
		2.50	0.550	3.920	2.110	2.110	2.50	0.490	3.500	2.150	2.150
		2.80	0.790	5.643	2.235	2.235	2.80	0.693	4.950	2.305	2.305
		3.10	0.990	7.071	2.393	2.393	3.10	0.830	5.928	2.507	2.507
	400 °C	2.00	0.120	0.850	1.920	1.920	2.00	0.100	0.710	1.930	1.930
		2.30	0.170	1.210	2.180	2.180	2.30	0.150	1.070	2.200	2.200
		2.60	0.300	2.140	2.380	2.380	2.60	0.200	1.420	2.460	2.460
		2.90	0.420	3.000	2.600	2.600	2.90	0.245	1.750	2.730	2.730
		3.20	0.590	4.210	2.780	2.780	3.20	0.310	2.210	2.980	2.980
		3.50	0.680	4.850	3.010	3.010	3.50	0.445	3.170	3.180	3.180
		3.80	0.810	5.780	3.220	3.220	3.80	0.590	4.210	3.380	3.380
		4.10	0.950	6.780	3.420	3.420	4.10	0.730	5.210	3.570	3.570
	800 °C	2.60	0.160	1.140	2.480	2.480	2.60	0.120	0.850	2.520	2.520
		2.90	0.250	1.780	2.720	2.720	2.90	0.160	1.140	2.780	2.780
		3.20	0.370	2.640	2.940	2.940	3.20	0.220	1.570	3.040	3.040
		3.50	0.485	3.460	3.150	3.150	3.50	0.310	2.210	3.270	3.270
		3.80	0.558	3.980	3.400	3.400	3.80	0.450	3.210	3.480	3.480
		4.10	0.683	4.870	3.610	3.610	4.10	0.520	3.710	3.730	3.730
		4.30	0.799	5.700	3.730	3.730	4.30	0.680	4.850	3.810	3.810
		4.60	0.910	6.500	3.900	3.900	4.60	0.830	5.920	4.000	4.000

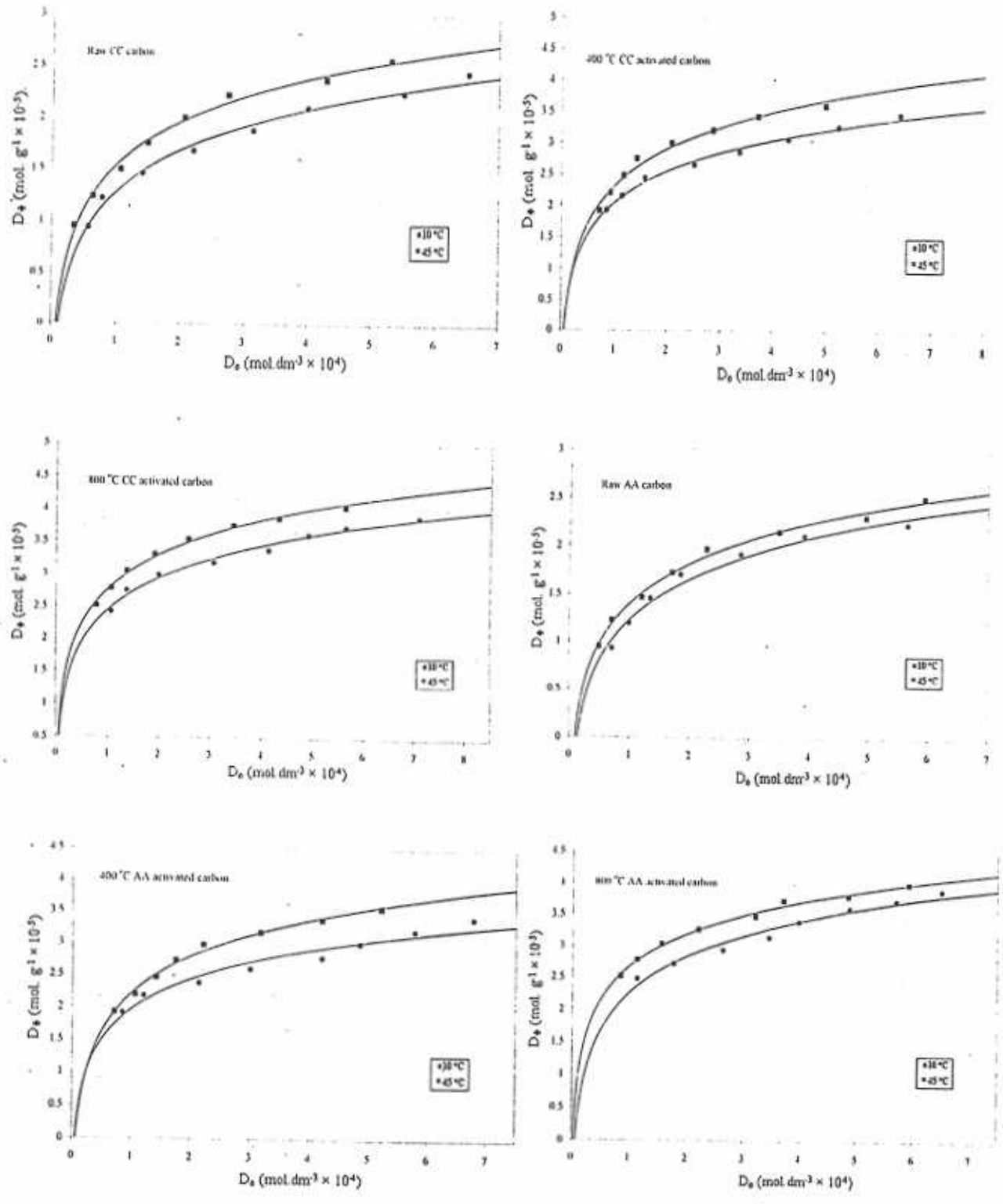


Figure 4.91 Adsorption isotherms of acid yellow 34 on *Corncobs* (CC) and *Ailanthus altissima* (AA) carbon samples

Table 4.90 Adsorption isotherm of acid yellow 34 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_f ($mol.g^{-1} \times 10^{-5}$)		Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_f ($mol.g^{-1} \times 10^{-5}$)
Salvadora Oleoides (SO)	Raw	16.0	1.900	13.57140	2.428570	2.428570	16.0	1.650	11.7857	4.214280	4.214280
		20.0	2.290	16.35714	3.642850	3.642850	20.0	2.000	14.2857	5.714285	5.714285
		24.0	2.790	19.92857	4.071428	4.071428	24.0	2.420	17.2857	6.714280	6.714280
		28.0	3.320	23.71428	4.285714	4.285714	28.0	2.900	20.7143	7.285720	7.285720
		34.0	4.041	28.86428	5.135714	5.135714	34.0	3.600	25.7143	8.285720	8.285720
		40.0	4.850	34.64285	5.357143	5.357143	40.0	4.340	31.0000	9.000000	9.000000
		48.0	5.970	42.64285	5.357143	5.357143	48.0	5.350	38.2143	9.785710	9.785710
		56.0	7.081	50.57857	5.421428	5.421428	56.0	6.450	46.0714	9.928570	9.928570
	400 °C	16.0	1.685	12.03571	3.964285	3.964285	16.0	1.210	8.642857	7.357140	7.357140
		20.0	2.114	15.10000	4.900000	4.900000	20.0	1.600	11.42857	8.571430	8.571430
		24.0	2.530	18.07143	5.928571	5.928571	24.0	2.000	14.28571	9.714280	9.714280
		28.0	3.010	21.50000	6.500000	6.500000	28.0	2.479	17.70710	10.29290	10.29290
		34.0	3.800	27.14283	6.857143	6.857143	34.0	3.210	22.92860	11.07140	11.07140
		40.0	4.640	33.14285	6.857143	6.857143	40.0	4.040	28.85710	11.14285	11.14285
		48.0	5.760	41.14285	6.857143	6.857143	48.0	5.080	36.28570	11.71430	11.71430
		56.0	6.860	49.00000	7.000000	7.000000	56.0	6.210	44.35720	11.64280	11.64280
	600 °C	16.0	1.450	10.35714	5.642850	5.642850	16.0	0.9890	7.06428	8.935710	8.935710
		20.0	1.900	13.57128	6.428571	6.428571	20.0	1.3840	9.88571	10.11430	10.11430
		24.0	2.319	16.56428	7.435714	7.435714	24.0	1.7590	12.5643	11.43571	11.43571
		28.0	2.809	20.06428	7.935714	7.935714	28.0	2.2530	16.0928	11.90714	11.90714
		34.0	3.619	25.85000	8.150000	8.150000	34.0	2.9890	21.3500	12.65000	12.65000
		40.0	4.449	31.77857	8.221428	8.221428	40.0	3.8200	27.2857	12.71428	12.71428
		48.0	5.567	39.76428	8.235714	8.235714	48.0	4.8890	34.9214	13.07857	13.07857
		56.0	6.678	47.70000	8.300000	8.300000	56.0	6.0000	42.8571	13.14285	13.14285
	800 °C	16.0	1.040	7.428571	8.571428	8.571428	16.0	0.800	5.714286	10.28571	10.28571
		20.0	1.379	9.850000	10.15000	10.15000	20.0	1.162	8.30000	11.70000	11.70000
		24.0	1.798	12.84280	11.15710	11.15710	24.0	1.550	11.07143	12.92857	12.92857
		28.0	2.288	16.34285	11.65710	11.65710	28.0	2.031	14.50714	13.4928	13.4928
		34.0	3.098	22.12857	11.87143	11.87143	34.0	2.767	19.76430	14.23570	14.23570
		40.0	3.926	28.04287	11.95714	11.95714	40.0	3.600	25.71428	14.28571	14.28571
		48.0	5.041	36.00714	11.99285	11.99285	48.0	4.669	33.35000	14.65000	14.65000
		56.0	6.145	43.89285	12.10714	12.10714	56.0	5.774	41.24286	14.75142	14.75142
	900 °C	16.0	0.918	6.557140	9.442857	9.442857	16.0	0.700	05.0000	11.00000	11.00000
		20.0	1.246	8.900000	11.10000	11.10000	20.0	1.051	7.507142	12.49280	12.49280
		24.0	1.665	11.89280	12.10714	12.10714	24.0	1.440	10.28571	13.71428	13.71428
		28.0	2.155	15.39285	12.60714	12.60714	28.0	1.880	13.42857	14.57143	14.57143
		34.0	2.965	21.17857	12.82142	12.82142	34.0	2.656	18.97143	15.02847	15.02847
		40.0	3.793	27.09286	12.90714	12.90714	40.0	3.490	24.92857	15.07143	15.07143
		48.0	4.908	35.05714	12.94285	12.94285	48.0	4.558	32.55714	15.44285	15.44285
		56.0	6.012	42.94286	13.05714	13.05714	56.0	5.663	40.45000	15.55000	15.55000
	1000 °C	16.0	0.696	4.971420	11.02857	11.02857	16.0	0.610	04.35714	11.64285	11.64285
		20.0	1.023	7.307142	12.69285	12.69285	20.0	0.938	06.70000	13.30000	13.30000
		24.0	1.442	10.30000	13.70000	13.70000	24.0	1.327	09.47857	14.52143	14.52143
		28.0	1.933	13.80714	14.19285	14.19285	28.0	1.769	12.63571	15.36428	15.36428
		34.0	2.743	19.59285	14.40714	14.40714	34.0	2.543	18.16428	15.83571	15.83571
		40.0	3.571	25.50714	14.49285	14.49285	40.0	3.310	23.64285	16.35714	16.35714
		48.0	4.797	34.26428	13.73571	13.73571	48.0	4.400	31.42857	16.57143	16.57143
		56.0	5.901	42.15000	13.85000	13.85000	56.0	5.500	39.28571	16.71428	16.71428

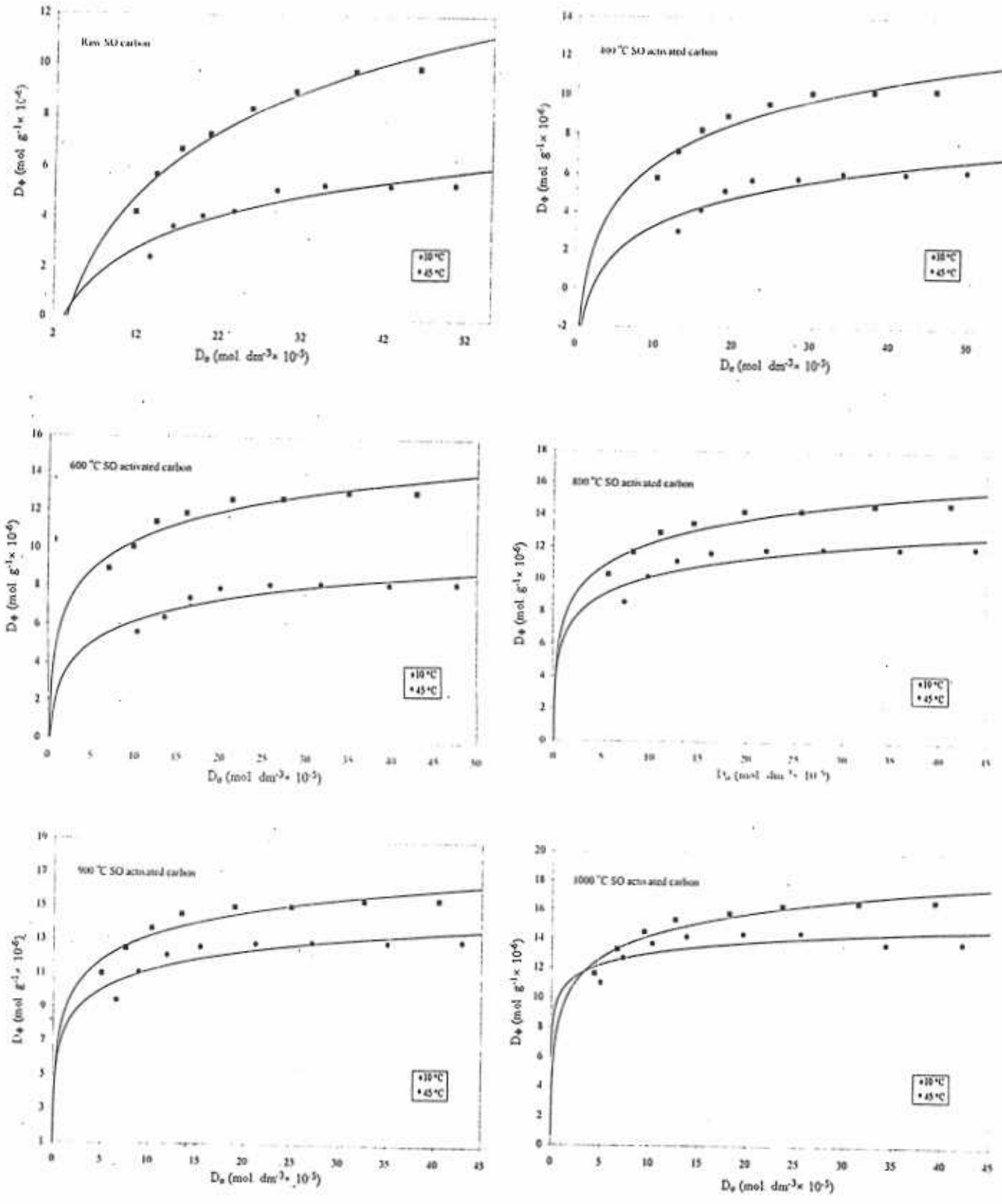


Figure 4.92 Adsorption isotherms of acid yellow 34 on *Salvadora oleoides* (SO) carbon samples

Table 4.91 Adsorption isotherm of acid yellow 34 on charcoal samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_f ($mol.g^{-1} \times 10^{-2}$)		Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_f ($mol.g^{-1} \times 10^{-2}$)
Animal bones charcoal (ABC)	600 °C	50.00	0.582	4.157140	45.84285	45.84285	50.00	0.467	3.335714	46.66428	46.66428
		60.00	0.698	4.985714	55.01428	55.01428	60.00	0.588	4.200000	55.80000	55.80000
		70.00	1.152	8.228571	61.77143	61.77143	70.00	0.820	5.857143	64.14285	64.14285
		80.00	1.543	11.02143	68.97857	68.97857	80.00	1.400	10.00000	70.00000	70.00000
		90.00	2.313	16.52143	73.47570	73.47570	90.00	2.200	15.71428	74.28571	74.28571
		100.0	3.335	23.82143	76.17857	76.17857	100.0	3.224	23.02857	76.97143	76.97143
		110.0	4.725	33.75000	76.25000	76.25000	110.0	4.618	32.98571	77.01428	77.01428
		120.0	6.127	43.7643	76.23571	76.23571	120.0	6.022	43.01428	76.98571	76.98571
	700 °C	10.00	0.311	2.221428	7.778570	7.778570	10.00	0.050	0.357143	9.642857	9.642857
		20.00	0.580	4.142857	15.85714	15.85714	20.00	0.088	0.628571	19.37143	19.37143
		30.00	1.005	7.178571	22.82143	22.82143	30.00	0.164	1.171428	28.82857	28.82857
		40.00	1.430	10.21428	29.78571	29.78571	40.00	0.300	2.142857	37.85714	37.85714
		50.00	2.040	14.57143	35.42857	35.42857	50.00	0.634	4.528571	45.47143	45.47143
		60.00	2.831	20.22142	39.77857	39.77857	60.00	0.955	6.821428	53.17857	53.17857
		70.00	3.999	28.56428	41.43571	41.43571	70.00	1.960	14.00000	56.00000	56.00000
		80.00	5.305	37.89285	42.10714	42.10714	80.00	3.180	22.71428	57.28571	57.28571
	800 °C	30.00	0.245	1.750000	28.25000	28.25000	30.00	0.200	1.428571	28.57143	28.57143
		40.00	0.540	3.857140	36.14285	36.14285	40.00	0.470	3.357140	36.64285	36.64285
		50.00	0.900	6.428571	43.57143	43.57143	50.00	0.680	4.857143	45.14286	45.14286
		60.00	1.320	9.428571	50.57143	50.57143	60.00	1.190	8.500000	51.50000	51.50000
		70.00	1.918	13.70000	56.30000	56.30000	70.00	1.700	12.14285	57.85714	57.85714
		80.00	2.920	20.85714	59.14285	59.14285	80.00	2.729	19.49285	60.50714	60.50714
		90.00	3.990	28.50000	61.50000	61.50000	90.00	3.889	27.77857	62.22143	62.22143
		100.0	5.320	38.00000	62.0000	62.0000	100.0	5.208	37.20000	62.80000	62.80000
	900 °C	30.00	0.138	0.985714	29.01428	29.01428	30.00	0.135	0.964285	29.03570	29.03570
		40.00	0.430	3.071428	36.92857	36.92857	40.00	0.300	2.142857	37.85714	37.85714
		50.00	0.798	5.700000	44.30000	44.30000	50.00	0.630	4.500000	45.50000	45.50000
		60.00	1.380	9.857143	50.14286	50.14286	60.00	0.980	7.000000	53.00000	53.00000
		70.00	1.920	13.71428	56.28572	56.28572	70.00	1.602	11.44285	58.55714	58.55714
		80.00	2.940	21.00000	59.00000	59.00000	80.00	2.822	20.15714	59.84285	59.84285
		90.00	3.980	28.42857	61.57143	61.57143	90.00	3.892	27.80000	62.20000	62.20000
		100.0	5.330	38.07143	61.92857	61.92857	100.0	5.224	37.31428	62.68571	62.68571
	1000 °C	30.00	0.099	0.707143	29.29285	29.29285	30.00	0.054	0.385714	29.61428	29.61428
		40.00	0.320	2.285714	37.71428	37.71428	40.00	0.098	0.700000	39.30000	39.30000
		50.00	0.688	4.914285	45.08571	45.08571	50.00	0.252	1.800000	48.20000	48.20000
		60.00	1.190	8.500000	51.50000	51.50000	60.00	0.346	2.471428	57.52857	57.52857
		70.00	1.810	12.92857	57.07143	57.07143	70.00	0.840	6.000000	64.00000	64.00000
		80.00	2.732	19.51428	60.48571	60.48571	80.00	1.210	8.642857	71.35714	71.35714
		90.00	3.799	27.13571	62.86428	62.86428	90.00	1.850	13.21428	76.78571	76.78571
		100.0	5.145	36.75000	63.25000	63.25000	100.0	2.960	21.14285	78.85714	78.85714

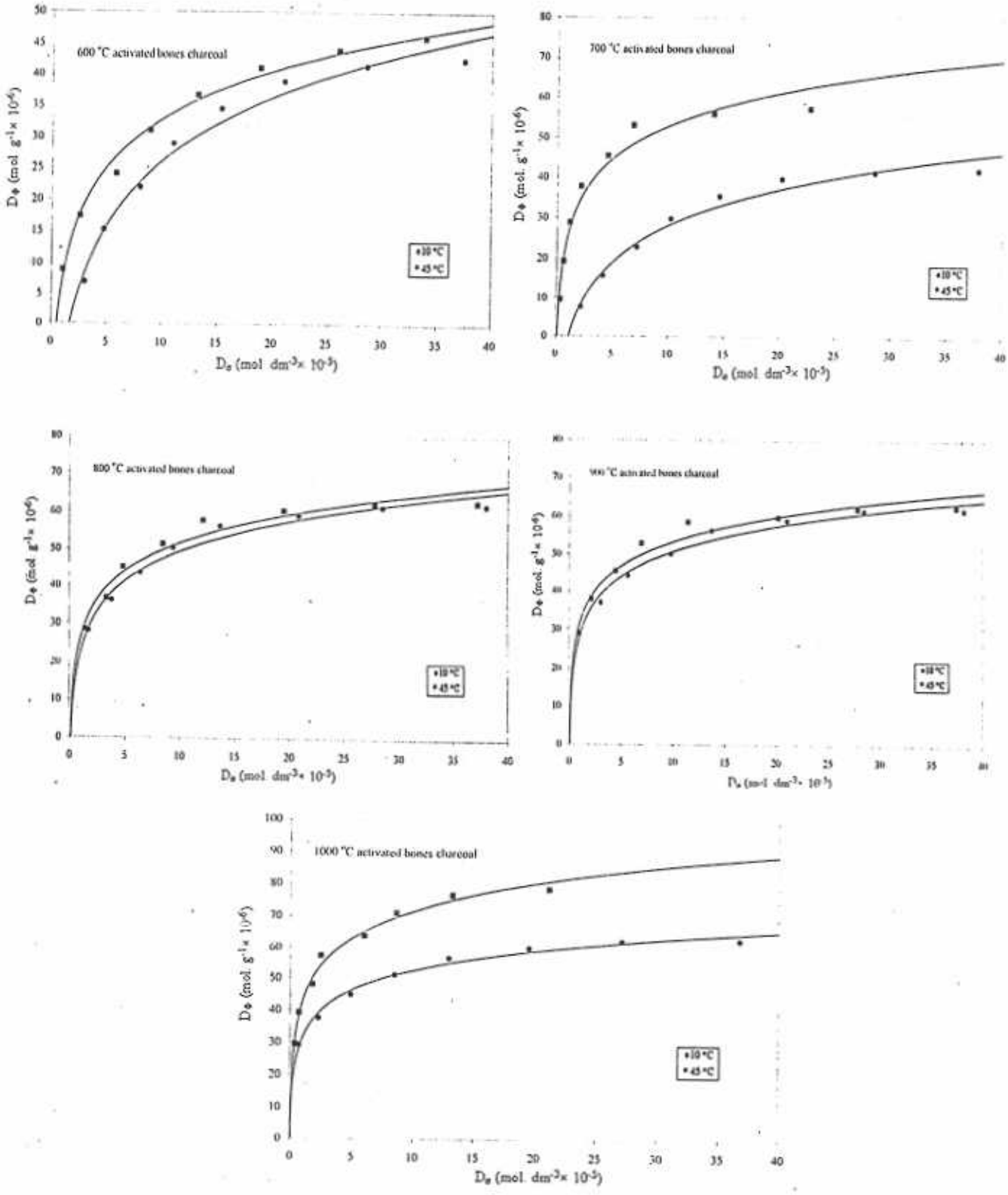


Figure 4.93 Adsorption isotherms of acid yellow 34 on animal bones charcoal (ABC) samples

Table 4.92 Adsorption isotherm of acid yellow 34 on carbon samples

Sample		D_u ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_u ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_u-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_ϕ ($mol.g^{-1} \times 10^{-5}$)		Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_u-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_ϕ ($mol.g^{-1} \times 10^{-5}$)
Regenerated (RG)	400 °C	50.00	4.400	31.42857	18.57143	18.57143	50.00	3.400	24.28571	25.71428	25.71428
		60.00	5.490	39.21428	20.78571	20.78571	60.00	3.960	28.28571	31.71428	31.71428
		70.00	6.500	46.42850	23.57140	23.57140	70.00	4.500	32.14285	37.85714	37.85714
		80.00	7.780	55.57140	24.42857	24.42857	80.00	5.430	38.78571	41.21428	41.21428
		90.00	9.040	64.57143	25.42851	25.42851	90.00	6.240	44.57143	45.42857	45.42857
		100.0	10.20	72.85714	27.14285	27.14285	100.0	7.320	52.28571	47.71428	47.71428
		110.0	11.58	82.71428	27.28571	27.28571	110.0	8.720	62.28571	47.71428	47.71428
		120.0	12.89	92.07142	27.92857	27.92857	120.0	10.10	72.14285	47.85714	47.85714
	600 °C	50.00	0.958	6.842850	43.15714	43.15714	50.00	0.764	5.45714	44.54285	44.54285
		60.00	1.242	8.871430	51.12857	51.12857	60.00	1.040	7.428571	52.57143	52.57143
		70.00	1.742	12.31571	57.68428	57.68428	70.00	1.640	11.71428	58.28571	58.28571
		80.00	2.400	17.14285	62.85714	62.85714	80.00	2.320	16.57143	63.42857	63.42857
		90.00	2.999	21.42142	68.57857	68.57857	90.00	2.800	20.00000	70.00000	70.00000
		100.0	4.010	28.64285	71.35714	71.35714	100.0	3.700	26.42857	73.57143	73.57143
		110.0	5.340	38.14285	71.85714	71.85714	110.0	5.100	36.42857	73.57143	73.57143
		120.0	6.700	47.85714	72.14287	72.14287	120.0	6.500	46.42857	73.57143	73.57143
	800 °C	50.00	0.762	5.442857	44.55714	44.55714	50.00	0.656	4.685714	45.31428	45.31428
		60.00	0.884	6.314285	53.68571	53.68571	60.00	0.772	5.514285	54.48571	54.48571
		70.00	1.352	9.657143	60.34285	60.34285	70.00	0.905	6.464285	63.53571	63.53571
		80.00	1.741	12.43571	67.56428	67.56428	80.00	1.600	11.42857	68.57143	68.57143
		90.00	2.511	17.93571	72.06428	72.06428	90.00	2.400	17.14286	72.85714	72.85714
		100.0	3.533	25.23571	74.76428	74.76428	100.0	3.420	24.42857	75.57143	75.57143
		110.0	4.923	35.16428	74.83571	74.83571	110.0	4.800	34.28571	75.71428	75.71428
		120.0	6.324	45.17142	74.82857	74.82857	120.0	6.200	44.28571	75.71428	75.71428
	900 °C	50.00	0.671	4.792857	45.20714	45.20714	50.00	0.546	3.900000	46.10000	46.10000
		60.00	0.805	5.750000	54.25000	54.25000	60.00	0.662	4.728570	55.27140	55.27140
		70.00	1.261	9.007142	60.99285	60.99285	70.00	0.882	6.300000	63.70000	63.70000
		80.00	1.652	11.80000	68.20000	68.20000	80.00	1.502	10.72857	69.27143	69.27143
		90.00	2.422	17.30000	72.70000	72.70000	90.00	2.302	16.44286	73.55714	73.55714
		100.0	3.444	24.60000	75.40000	75.40000	100.0	3.322	23.72857	76.27143	76.27143
		110.0	4.834	34.52857	75.47143	75.47143	110.0	4.704	33.60000	76.40000	76.40000
		120.0	6.236	44.54285	75.45714	75.45714	120.0	6.102	43.58571	76.41428	76.41428
	1000 °C	50.00	0.582	4.157140	45.84285	45.84285	50.00	0.467	3.335714	46.66428	46.66428
		60.00	0.698	4.985714	55.01428	55.01428	60.00	0.588	4.200000	55.80000	55.80000
		70.00	1.152	8.228571	61.77143	61.77143	70.00	0.820	5.857143	64.14285	64.14285
		80.00	1.543	11.02143	68.97857	68.97857	80.00	1.400	10.00000	70.00000	70.00000
		90.00	2.313	16.52143	73.47570	73.47570	90.00	2.200	15.71428	74.28571	74.28571
		100.0	3.335	23.82143	76.17857	76.17857	100.0	3.224	23.02857	76.97143	76.97143
		110.0	4.725	33.75000	76.25000	76.25000	110.0	4.618	32.98571	77.01428	77.01428
		120.0	6.127	43.7643	76.23571	76.23571	120.0	6.022	43.01428	76.98571	76.98571

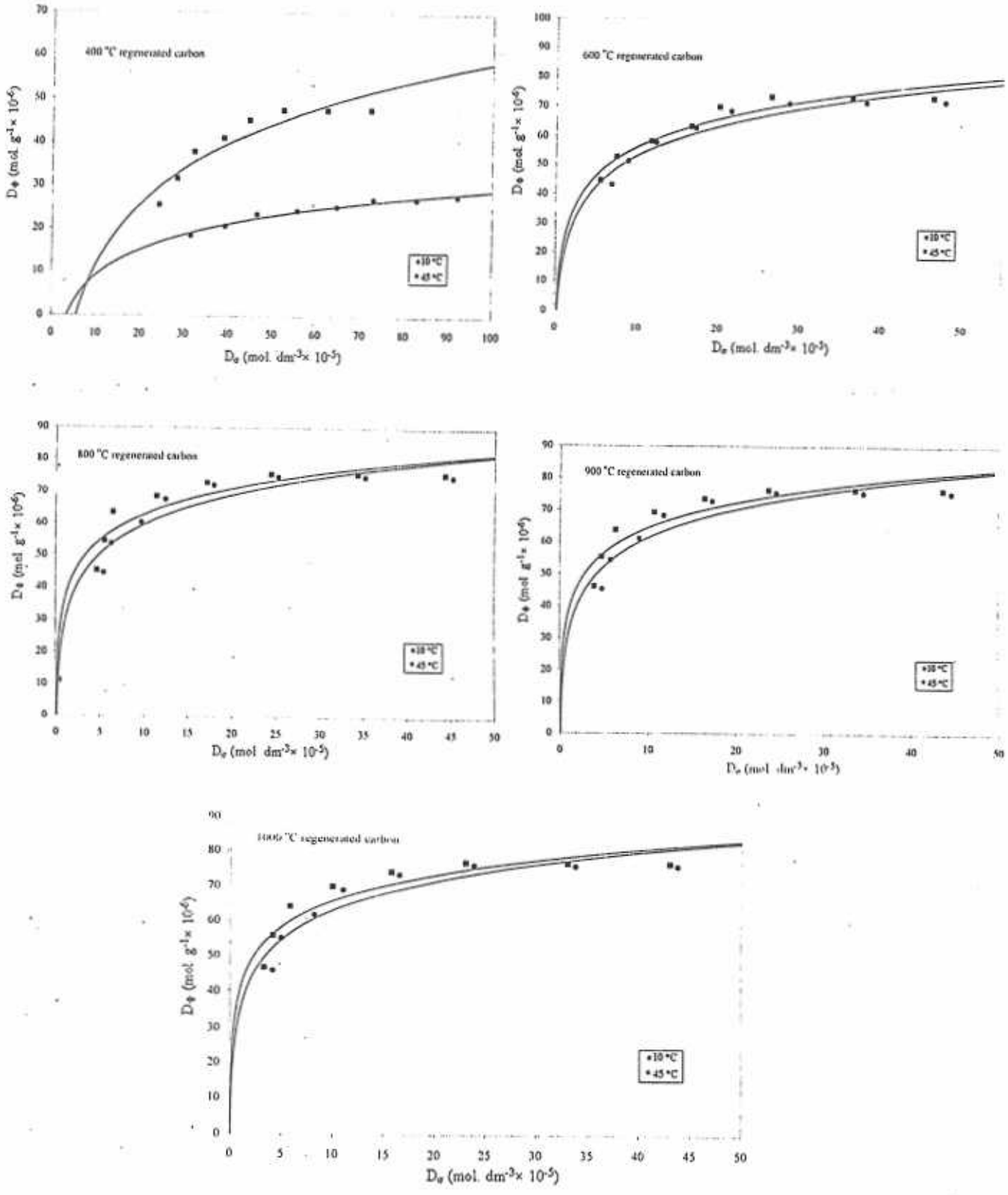


Figure 4.94 Adsorption isotherms of acid yellow 34 on regenerated carbon samples

Table 4.93 Adsorption isotherm of acid orange 7 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-4}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-4}$)	at 45°C			
			Ab_{51}	D_n ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_o ($mol.dm^{-3} \times 10^{-4}$)	D_ϕ ($mol.g^{-1} \times 10^{-5}$)		Ab_{51}	D_n ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_n ($mol.dm^{-3} \times 10^{-4}$)	D_ϕ ($mol.g^{-1} \times 10^{-5}$)
Paulownia tomentosa (PT)	Raw	1.00	0.100	0.630	0.937	0.937	1.00	0.050	0.310	0.969	0.969
		1.30	0.135	0.851	1.220	1.220	1.30	0.070	0.440	1.256	1.256
		1.60	0.183	1.150	1.480	1.480	1.60	0.100	0.630	1.537	1.537
		1.90	0.220	1.380	1.760	1.760	1.90	0.130	0.820	1.820	1.820
		2.20	0.310	1.950	2.000	2.000	2.20	0.200	1.260	2.070	2.070
		2.50	0.409	2.570	2.240	2.240	2.50	0.315	1.980	2.300	2.300
		2.80	0.560	3.530	2.440	2.440	2.80	0.450	2.830	2.520	2.520
		3.10	0.890	5.611	2.538	2.538	3.10	0.690	4.350	2.660	2.660
	400 °C	2.00	0.120	0.757	1.930	1.930	2.00	0.100	0.631	1.937	1.937
		2.30	0.150	0.945	2.200	2.200	2.30	0.120	0.750	2.230	2.230
		2.60	0.195	1.230	2.470	2.470	2.60	0.160	1.000	2.500	2.500
		2.90	0.250	1.577	2.743	2.743	2.90	0.195	1.230	2.770	2.770
		3.20	0.390	2.450	2.960	2.960	3.20	0.250	1.570	3.040	3.040
		3.50	0.525	3.480	3.150	3.150	3.50	0.410	2.580	3.240	3.240
		3.80	0.720	4.530	3.340	3.340	3.80	0.630	3.970	3.400	3.400
		4.10	0.950	5.980	3.500	3.500	4.10	0.820	5.170	3.580	3.580
	800 °C	2.60	0.130	0.820	2.520	2.520	2.60	0.103	0.650	2.560	2.560
		2.90	0.183	1.150	2.780	2.780	2.90	0.132	0.832	2.820	2.820
		3.20	0.240	1.510	3.050	3.050	3.20	0.169	1.060	3.110	3.110
		3.50	0.322	2.030	3.300	3.300	3.50	0.202	1.270	3.370	3.370
		3.80	0.517	3.260	3.4700	3.4700	3.80	0.419	2.640	3.530	3.530
		4.10	0.898	5.660	3.530	3.530	4.10	0.732	4.610	3.640	3.640
		4.30	0.999	6.290	3.670	3.670	4.30	0.865	5.450	3.750	3.750
		4.60	1.300	8.190	3.780	3.780	4.60	1.100	6.935	3.900	3.900
Populus caspica (PC)	Raw	1.00	0.121	0.7629	0.924	0.924	1.00	0.104	0.655	0.934	0.934
		1.30	0.151	0.9521	1.205	1.205	1.30	0.138	0.870	1.210	1.210
		1.60	0.210	1.3240	1.460	1.460	1.60	0.189	1.190	1.480	1.480
		1.90	0.311	1.9600	1.700	1.700	1.90	0.250	1.570	1.770	1.770
		2.20	0.450	2.8300	1.920	1.920	2.20	0.396	2.500	1.950	1.950
		2.50	0.720	4.5300	2.050	2.050	2.50	0.598	3.770	2.120	2.120
		2.80	0.933	5.8823	2.212	2.212	2.80	0.833	5.252	2.270	2.270
		3.10	1.200	7.5662	2.344	2.344	3.10	1.120	7.061	2.393	2.393
	400 °C	2.00	0.110	0.693	1.930	1.930	2.00	0.106	0.630	1.940	1.940
		2.30	0.150	0.945	2.210	2.210	2.30	0.125	0.788	2.220	2.220
		2.60	0.175	1.100	2.490	2.490	2.60	0.151	0.950	2.510	2.510
		2.90	0.273	1.720	2.720	2.720	2.90	0.235	1.480	2.750	2.750
		3.20	0.422	2.660	2.930	2.930	3.20	0.375	2.360	2.960	2.960
		3.50	0.603	3.800	3.120	3.120	3.50	0.495	3.120	3.180	3.180
		3.80	0.790	4.980	3.300	3.300	3.80	0.687	4.330	3.360	3.360
		4.10	1.230	7.750	3.320	3.320	4.10	1.150	7.2509	3.370	3.370
	800 °C	2.60	0.130	0.820	2.520	2.520	2.60	0.120	0.756	2.520	2.520
		2.90	0.153	0.964	2.800	2.800	2.90	0.147	0.926	2.80	2.80
		3.20	0.251	1.580	3.040	3.040	3.20	0.182	1.140	3.10	3.10
		3.50	0.343	2.160	3.280	3.280	3.50	0.215	1.350	3.360	3.360
		3.80	0.485	3.050	3.500	3.500	3.80	0.316	1.990	3.600	3.600
		4.10	0.668	4.210	3.680	3.680	4.10	0.525	3.310	3.770	3.770
		4.30	0.869	5.470	3.750	3.750	4.30	0.717	4.520	3.840	3.840
		4.60	1.350	8.512	3.750	3.750	4.60	1.200	7.566	3.843	3.843

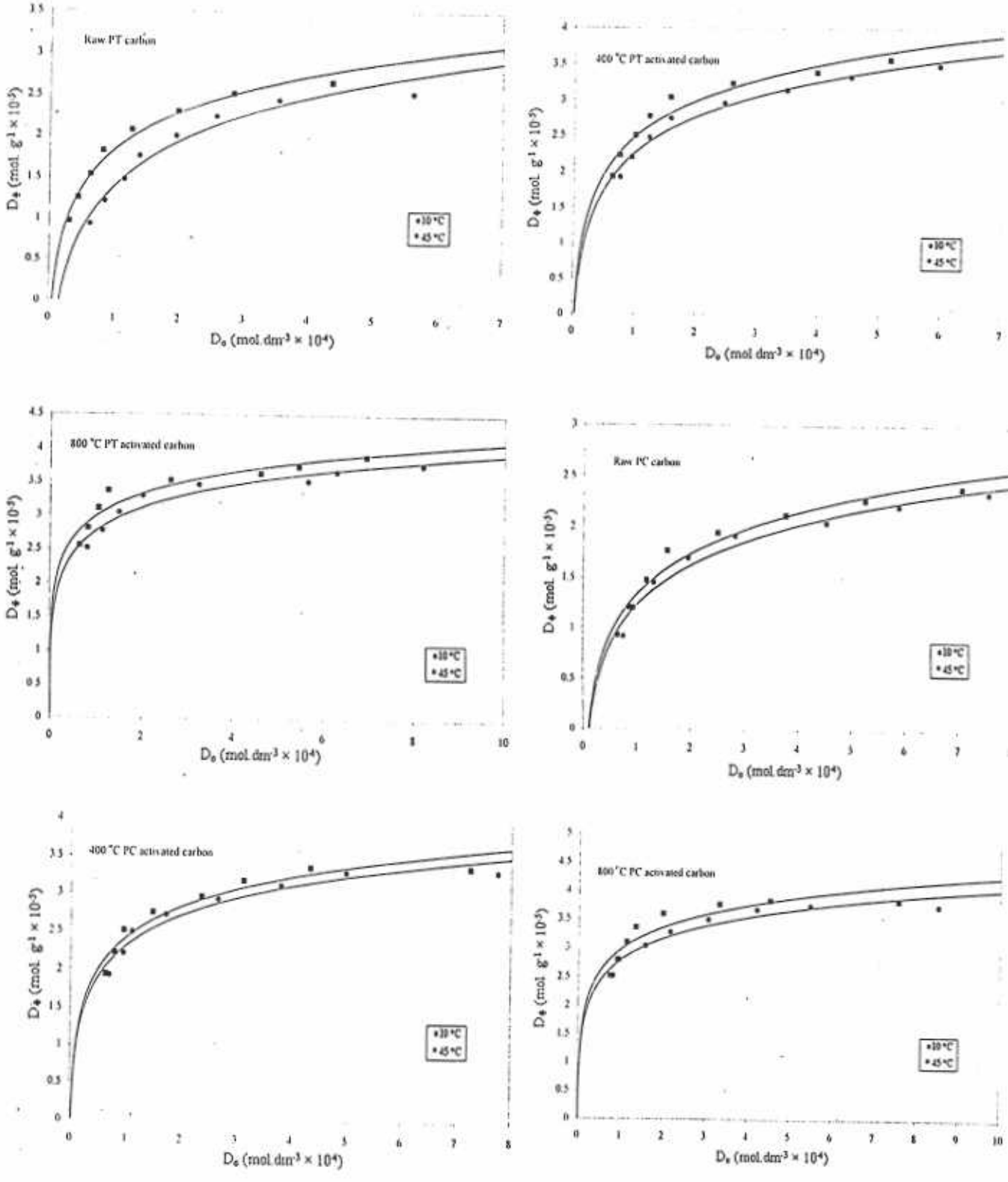


Figure 4.95 Adsorption isotherms of acid orange 7on *Paulownia tomentosa* (PT) and *Populus caspica* (PC) carbon samples.

Table 4.94 Adsorption isotherm of acid orange 7 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-4}$)	Adsorption isotherm at 10 °C				D_o ($mol.dm^{-3} \times 10^{-4}$)	Adsorption isotherm at 45°C			
			Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_f ($mol.g^{-1} \times 10^{-3}$)		Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_f ($mol.g^{-1} \times 10^{-3}$)
Corncobs (CC)	Raw	1.00	0.105	0.662	0.934	0.934	1.00	0.080	0.500	0.950	0.950
		1.30	0.132	0.832	1.220	1.220	1.30	0.110	0.690	1.230	1.230
		1.60	0.154	0.970	1.500	1.500	1.60	0.132	0.830	1.510	1.510
		1.90	0.200	1.260	1.770	1.770	1.90	0.152	0.960	1.800	1.800
		2.20	0.290	1.830	2.010	2.010	2.20	0.176	1.110	2.090	2.090
		2.50	0.395	2.490	2.250	2.250	2.50	0.382	2.400	2.260	2.260
		2.80	0.599	3.770	2.420	2.420	2.80	0.551	3.4700	2.450	2.450
		3.10	1.000	6.305	2.469	2.469	3.10	0.980	6.1790	2.482	2.482
	400 °C	2.00	0.138	0.870	1.910	1.910	2.00	0.124	0.782	1.922	1.922
		2.30	0.160	1.010	2.20	2.20	2.30	0.137	0.863	2.210	2.210
		2.60	0.210	1.320	2.460	2.460	2.60	0.154	0.970	2.510	2.510
		2.90	0.306	1.910	2.710	2.710	2.90	0.199	1.250	2.770	2.770
		3.20	0.411	2.590	2.940	2.940	3.20	0.280	1.760	3.020	3.020
		3.50	0.618	3.840	3.110	3.110	3.50	0.430	2.710	3.230	3.230
		3.80	0.911	5.744	3.225	3.225	3.80	0.616	3.884	3.412	3.412
		4.10	1.310	8.259	3.274	3.274	4.10	0.985	6.211	3.478	3.478
	800 °C	2.60	0.115	0.725	2.520	2.520	2.60	0.118	0.744	2.525	2.525
		2.90	0.149	0.939	2.800	2.800	2.90	0.132	0.832	2.810	2.810
		3.20	0.201	1.267	3.070	3.070	3.20	0.155	0.977	3.100	3.100
		3.50	0.271	1.708	3.330	3.330	3.50	0.197	1.240	3.370	3.370
		3.80	0.389	2.450	3.550	3.550	3.80	0.250	1.570	3.640	3.640
		4.10	0.474	2.980	3.800	3.800	4.10	0.322	2.030	3.896	3.896
		4.30	0.608	3.830	3.920	3.920	4.30	0.540	3.400	3.960	3.960
		4.60	0.919	5.790	4.020	4.020	4.60	0.878	5.530	4.050	4.050
Ailanthus altissima (AA)	Raw	1.00	0.100	0.630	0.937	0.937	1.00	0.090	0.567	0.943	0.943
		1.30	0.150	0.945	1.210	1.210	1.30	0.130	0.819	1.220	1.220
		1.60	0.188	1.180	1.480	1.480	1.60	0.173	1.090	1.500	1.500
		1.90	0.245	1.540	1.750	1.750	1.90	0.199	1.250	1.770	1.770
		2.20	0.370	2.330	1.960	1.960	2.20	0.270	1.700	2.030	2.030
		2.50	0.499	3.146	2.190	2.190	2.50	0.386	2.430	2.260	2.260
		2.80	0.617	3.890	2.410	2.410	2.80	0.591	3.720	2.430	2.430
		3.10	0.992	6.250	2.470	2.470	3.10	0.865	5.450	2.550	2.550
	400 °C	2.00	0.121	0.762	1.920	1.920	2.00	0.109	0.687	1.931	1.931
		2.30	0.182	1.140	2.180	2.180	2.30	0.153	0.964	2.20	2.20
		2.60	0.240	1.576	2.440	2.440	2.60	0.195	1.230	2.470	2.470
		2.90	0.344	2.030	2.700	2.700	2.90	0.250	1.570	2.740	2.740
		3.20	0.499	3.140	2.890	2.890	3.20	0.469	2.950	2.910	2.910
		3.50	0.703	4.430	3.050	3.050	3.50	0.638	4.022	3.097	3.097
		3.80	0.929	5.850	3.210	3.210	3.80	0.818	5.150	3.280	3.280
		4.10	1.300	8.190	3.280	3.280	4.10	0.121	7.620	3.300	3.300
	800 °C	2.60	0.140	0.882	2.510	2.510	2.60	0.101	0.636	2.540	2.540
		2.90	0.195	1.230	2.770	2.770	2.90	0.156	0.983	2.800	2.800
		3.20	0.289	1.820	3.010	3.010	3.20	0.200	1.260	3.070	3.070
		3.50	0.410	2.580	3.240	3.240	3.50	0.250	1.570	3.340	3.340
		3.80	0.550	3.460	3.450	3.450	3.80	0.473	2.980	3.500	3.500
		4.10	0.820	5.170	3.580	3.580	4.10	0.768	4.840	3.610	3.610
		4.30	1.100	6.930	3.610	3.610	4.30	0.991	6.240	3.670	3.670
		4.60	1.500	9.450	3.650	3.650	4.60	1.430	9.010	3.700	3.700

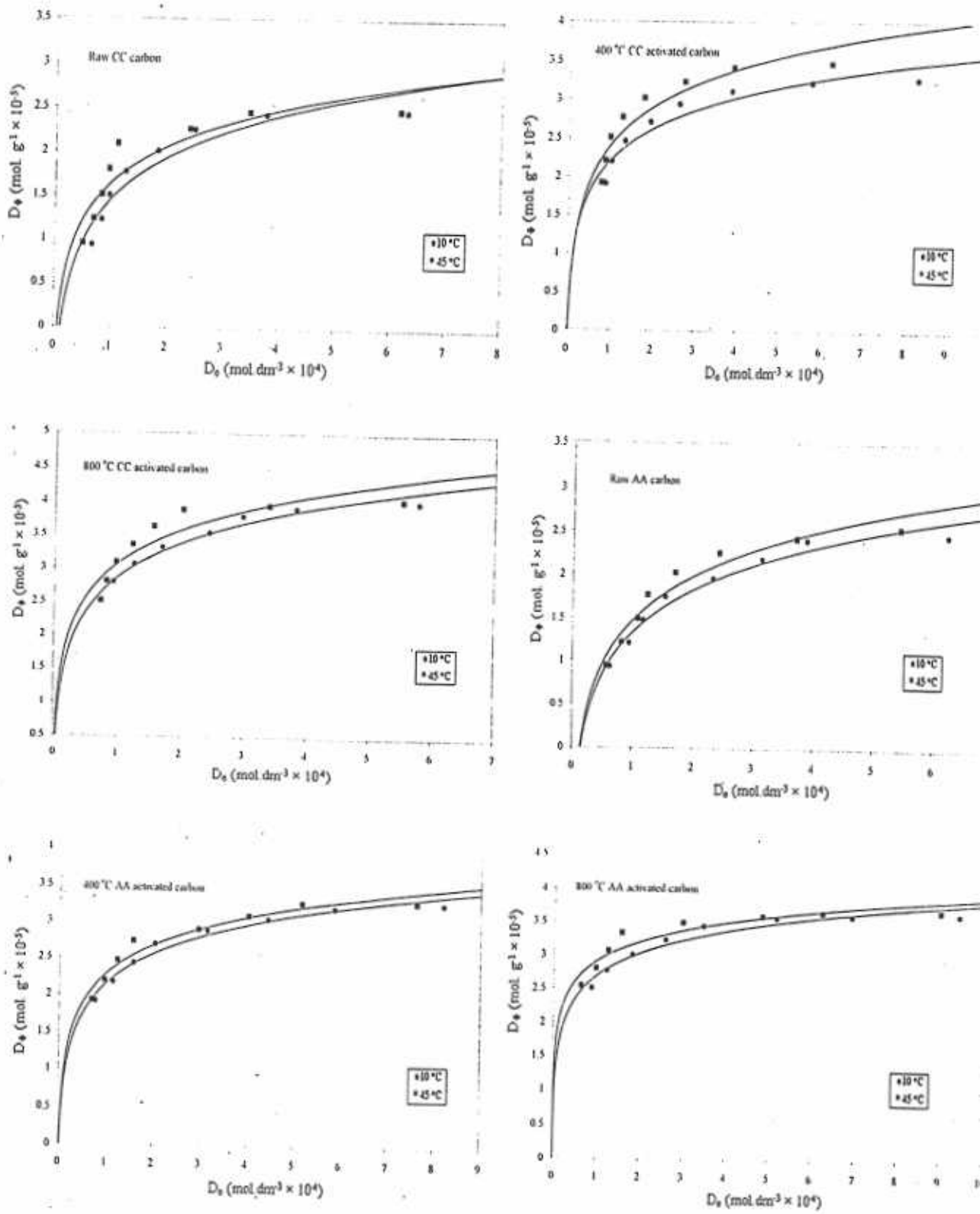


Figure 4.96 Adsorption isotherms of acid orange 7 on *Corncobs* (CC) and *Ailanthus altissima* (AA) carbon samples.

Table 4.95 Adsorption isotherm of acid orange 7 on carbon samples

Sample		D_u ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_q ($mol.g^{-1} \times 10^{-5}$)		Ab_M	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_q ($mol.g^{-1} \times 10^{-5}$)
Salvadora oleoides (SO)	Raw	6.00	0.450	2.837326	3.162673	3.162673	6.00	0.303	1.910466	4.089533	4.089533
		9.00	0.682	4.300126	4.699874	4.699874	9.00	0.432	2.723834	6.276200	6.276200
		12.0	0.902	5.687263	6.312736	6.312736	12.0	0.602	3.795713	8.204287	8.204287
		15.0	1.060	6.683481	8.316519	8.316519	15.0	0.804	5.069356	9.930643	9.930643
		18.0	1.314	8.284994	9.715006	9.715006	18.0	1.100	6.935687	11.06432	11.06432
		21.0	1.742	10.98360	10.01639	10.01639	21.0	1.421	8.956464	12.04035	12.04035
		24.0	2.150	13.55611	10.44388	10.44388	24.0	1.820	11.47541	12.52459	12.52459
		27.0	2.562	16.15384	10.84615	10.84615	27.0	2.231	14.06683	12.93316	12.93316
	400 °C	6.00	0.300	1.891551	4.108448	4.108448	6.00	0.230	1.450189	4.549810	4.549810
		9.00	0.450	2.837327	6.162673	6.162673	9.00	0.380	2.395965	6.604035	6.604035
		12.0	0.642	4.047919	7.952081	7.952081	12.0	0.550	3.467843	8.532156	8.532156
		15.0	0.810	5.107187	9.892812	9.892812	15.0	0.700	4.413619	10.58638	10.58638
		18.0	1.088	6.860025	11.13997	11.13997	18.0	0.932	5.876420	12.12358	12.12358
		21.0	1.441	9.085751	11.91425	11.91425	21.0	1.220	7.692310	13.30769	13.30769
		24.0	1.870	11.79067	12.20933	12.20933	24.0	1.662	10.47919	13.52081	13.52081
		27.0	2.330	14.69105	12.30895	12.30895	27.0	2.120	13.36696	13.63304	13.63304
	600 °C	6.00	0.240	1.513241	4.486759	4.486759	6.00	0.200	1.261034	4.738960	4.738960
		9.00	0.390	2.459016	6.540984	6.540984	9.00	0.320	2.017654	6.982345	6.982345
		12.0	0.560	3.530895	8.469104	8.469104	12.0	0.500	3.152585	8.847415	8.847415
		15.0	0.698	4.401010	10.59899	10.59899	15.0	0.610	3.846154	11.15385	11.15385
		18.0	0.862	5.435056	12.56494	12.56494	18.0	0.780	4.918032	13.08196	13.08196
		21.0	1.220	7.692307	13.30769	13.30769	21.0	1.053	6.639344	14.36065	14.36065
		24.0	1.620	10.21437	13.78563	13.78563	24.0	1.451	9.148802	14.85120	14.85120
		27.0	2.140	13.49306	13.50693	13.50693	27.0	1.920	12.10593	14.89407	14.89407
	800 °C	6.00	0.112	0.706179	5.293821	5.293821	6.00	0.020	0.126103	5.873890	5.873890
		9.00	0.164	1.034079	7.965952	7.965952	9.00	0.033	0.208071	8.919294	8.919294
		12.0	0.222	1.399747	10.60025	10.60025	12.0	0.103	0.649433	11.35056	11.35056
		15.0	0.272	1.715006	13.28499	13.28499	15.0	0.169	1.065573	13.93443	13.93443
		18.0	0.399	2.515763	15.48423	15.48423	18.0	0.294	1.853720	16.14628	16.14628
		21.0	0.532	3.354350	17.64565	17.64565	21.0	0.426	2.686003	18.31399	18.31399
		24.0	0.866	5.460277	18.53972	18.53972	24.0	0.750	4.728877	19.27112	19.27112
		27.0	1.221	7.698613	19.30138	19.30138	27.0	1.100	6.935687	20.06432	20.06432
	900 °C	6.00	0.050	0.315259	5.684742	5.684742	6.00	0.010	0.063052	5.936948	5.936948
		9.00	0.070	0.441362	8.558638	8.558638	9.00	0.022	0.138714	8.861286	8.861286
		12.0	0.046	0.290038	11.70996	11.70996	12.0	0.038	0.239596	11.76041	11.76041
		15.0	0.056	0.353089	14.64691	14.64691	15.0	0.044	0.277427	14.72257	14.72257
		18.0	0.088	0.554855	17.44515	17.44515	18.0	0.072	0.453972	17.54602	17.54602
		21.0	0.232	1.462799	19.53721	19.53721	21.0	0.147	0.926860	20.07313	20.07313
		24.0	0.488	3.076923	20.92307	20.92307	24.0	0.396	2.496847	21.50315	21.50315
		27.0	0.869	5.479193	21.52081	21.52081	27.0	0.774	4.880202	22.11979	22.11979
	1000 °C	6.00	0.014	0.088273	5.911727	5.911727	6.00	0.005	0.031525	5.968470	5.968470
		9.00	0.014	0.088273	8.911727	8.911727	9.00	0.009	0.056746	8.943253	8.943253
		12.0	0.032	0.201765	11.79823	11.79823	12.0	0.020	0.126103	11.87389	11.87389
		15.0	0.184	1.160151	13.83984	13.83984	15.0	0.092	0.580075	14.41993	14.41993
		18.0	0.378	2.383354	15.61665	15.61665	18.0	0.266	1.677175	16.32282	16.32282
		21.0	0.614	3.871375	17.12863	17.12863	21.0	0.500	3.152585	17.84741	17.84741
		24.0	0.886	5.586381	18.41362	18.41362	24.0	0.794	5.006305	18.99369	18.99369
		27.0	1.218	7.679697	19.32030	19.32030	27.0	1.100	6.935687	20.06431	20.06431

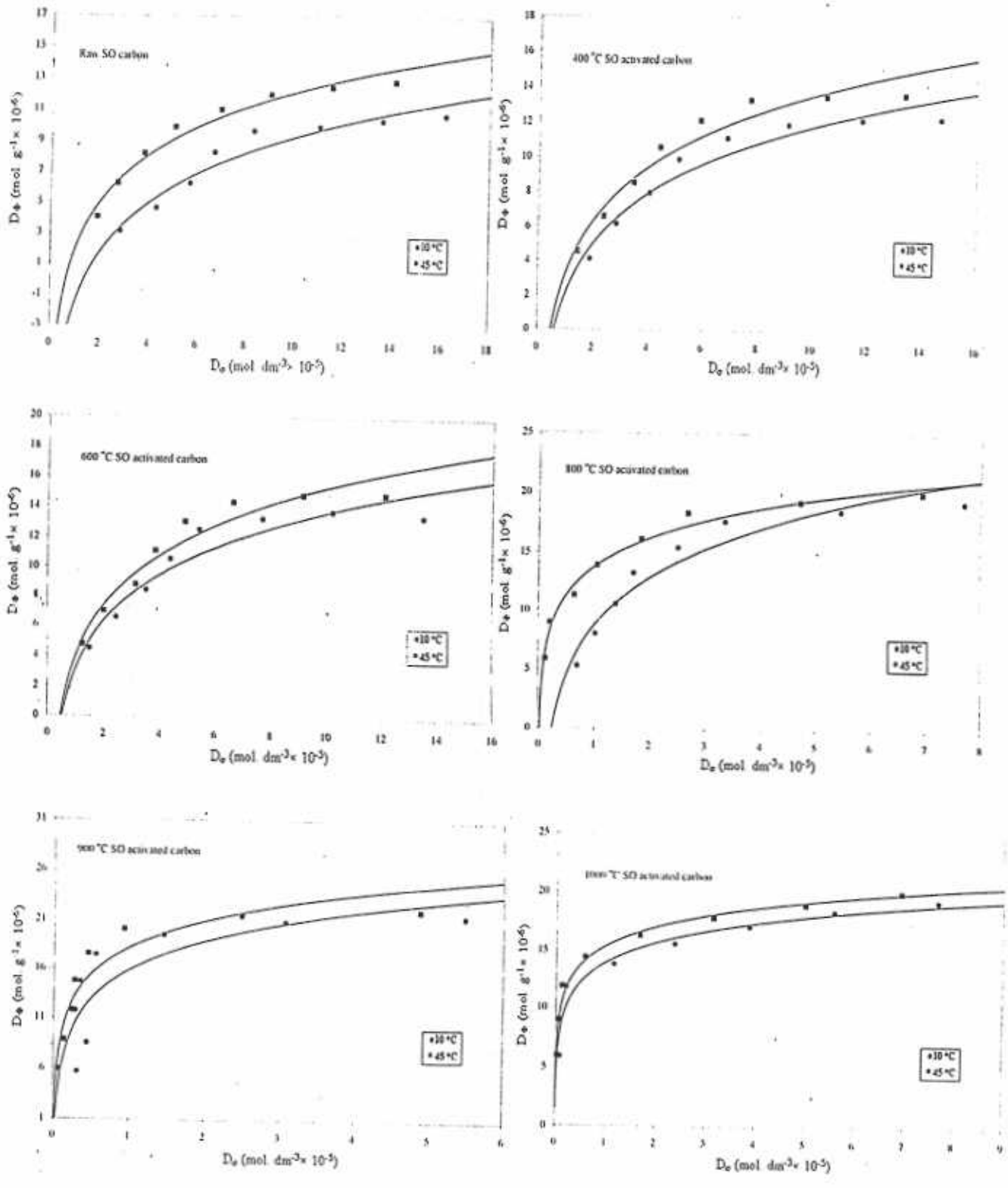


Figure 4.97 Adsorption isotherms of acid orange 7 on *Salvadora oleoides* (SO) carbon samples

Table 4.96 Adsorption isotherm of acid orange 7 on charcoal samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10°C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_f ($mol.g^{-1} \times 10^{-4}$)		Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_f ($mol.g^{-1} \times 10^{-4}$)
Animal bones (ABC)	600 °C	10.0	0.143	0.901639	9.098361	9.098361	10.0	0.055	0.346784	9.653216	9.653216
		20.0	0.207	1.305170	18.69483	18.69483	20.0	0.116	0.731399	19.26860	19.26860
		30.0	0.406	2.559899	27.44010	27.44010	30.0	0.308	1.941993	28.05801	28.05801
		40.0	0.823	5.189155	34.81084	34.81084	40.0	0.734	4.627995	35.37200	35.37200
		50.0	1.438	9.06683	40.93316	40.93316	50.0	1.440	9.079445	40.92055	40.92055
		60.0	2.218	13.98486	46.01513	46.01513	60.0	2.020	12.73644	47.26355	47.26355
		65.0	2.804	17.67969	47.32030	47.32030	65.0	2.600	16.39344	48.60655	48.60655
		70.0	3.358	21.17276	48.82724	48.82724	70.0	3.160	19.92433	50.07566	50.07566
	700 °C	10.0	0.080	0.504414	9.495586	9.495586	10.0	0.035	0.220680	9.779319	9.779319
		20.0	0.128	0.807062	19.19294	19.19294	20.0	0.078	0.491803	19.50819	19.50819
		30.0	0.179	1.128625	28.87137	28.87137	30.0	0.099	0.624212	29.37578	29.37578
		40.0	0.216	1.361917	38.63808	38.63808	40.0	0.129	0.813367	39.18664	39.18664
		50.0	0.281	1.771753	48.22825	48.22825	50.0	0.231	1.456494	48.54350	48.54350
		60.0	0.445	2.805800	57.19419	57.19419	60.0	0.385	2.427490	57.57251	57.57251
		65.0	0.630	3.972258	61.02774	61.02774	65.0	0.577	3.638084	61.36192	61.36192
		70.0	0.883	5.567465	64.43253	64.43253	70.0	0.753	4.747794	65.25221	65.25221
	800 °C	10.0	0.102	0.643127	9.35687	9.35687	10.0	0.030	0.189155	9.810844	9.810844
		20.0	0.149	0.939471	19.06053	19.06053	20.0	0.037	0.233291	19.76671	19.76671
		30.0	0.176	1.109709	28.89029	28.89029	30.0	0.084	0.529634	29.47036	29.47036
		40.0	0.211	1.330391	38.66961	38.66961	40.0	0.092	0.580075	39.41993	39.41993
		50.0	0.239	1.506935	48.49306	48.49306	50.0	0.127	0.800756	49.19924	49.19924
		60.0	0.319	2.011493	57.98865	57.98865	60.0	0.207	1.305171	58.69483	58.69483
		65.0	0.410	2.851200	62.41488	62.41488	65.0	0.310	1.954603	63.04539	63.04539
		70.0	0.500	3.152585	66.84741	66.84741	70.0	0.400	2.522068	67.47793	67.47793
	900 °C	30.0	0.050	0.315258	29.68474	29.68474	30.0	0.010	0.063052	29.93695	29.93695
		40.0	0.070	0.441362	39.55863	39.55863	40.0	0.040	0.252207	39.74779	39.74779
		50.0	0.090	0.567465	49.43253	49.43253	50.0	0.057	0.359395	49.64061	49.64061
		60.0	0.132	0.832282	59.16772	59.16772	60.0	0.081	0.510718	59.48958	59.48958
		65.0	0.182	1.147541	63.85246	63.85246	65.0	0.090	0.567465	64.43253	64.43253
		70.0	0.212	1.336696	68.66330	68.66330	70.0	0.120	0.756621	69.24337	69.24337
		80.0	0.344	2.168978	77.83102	77.83102	80.0	0.235	1.481715	78.51828	78.51828
		90.0	0.482	3.039092	86.96091	86.96091	90.0	0.375	2.364439	87.63556	87.63556
	1000 °C	50.00	0.015	0.094577	49.90542	49.90542	50.00	0.001	0.006305	49.99369	49.99369
		60.00	0.039	0.245902	59.75409	59.75409	60.00	0.002	0.012611	59.98738	59.98738
		65.00	0.060	0.378310	64.62168	64.62168	65.00	0.010	0.063052	64.93695	64.93695
		70.00	0.105	0.662043	69.33795	69.33795	70.00	0.025	0.157629	69.84237	69.84237
		80.00	0.160	1.008827	78.99117	78.99117	80.00	0.040	0.252206	79.74779	79.74779
		90.00	0.220	1.387137	88.61286	88.61286	90.00	0.100	0.630517	89.36948	89.36948
		100.0	0.270	1.702396	98.29760	98.29760	100.0	0.150	0.945775	99.05422	99.05422
		110.0	0.422	2.660782	107.3392	107.3392	110.0	0.340	2.143758	107.8563	107.8563

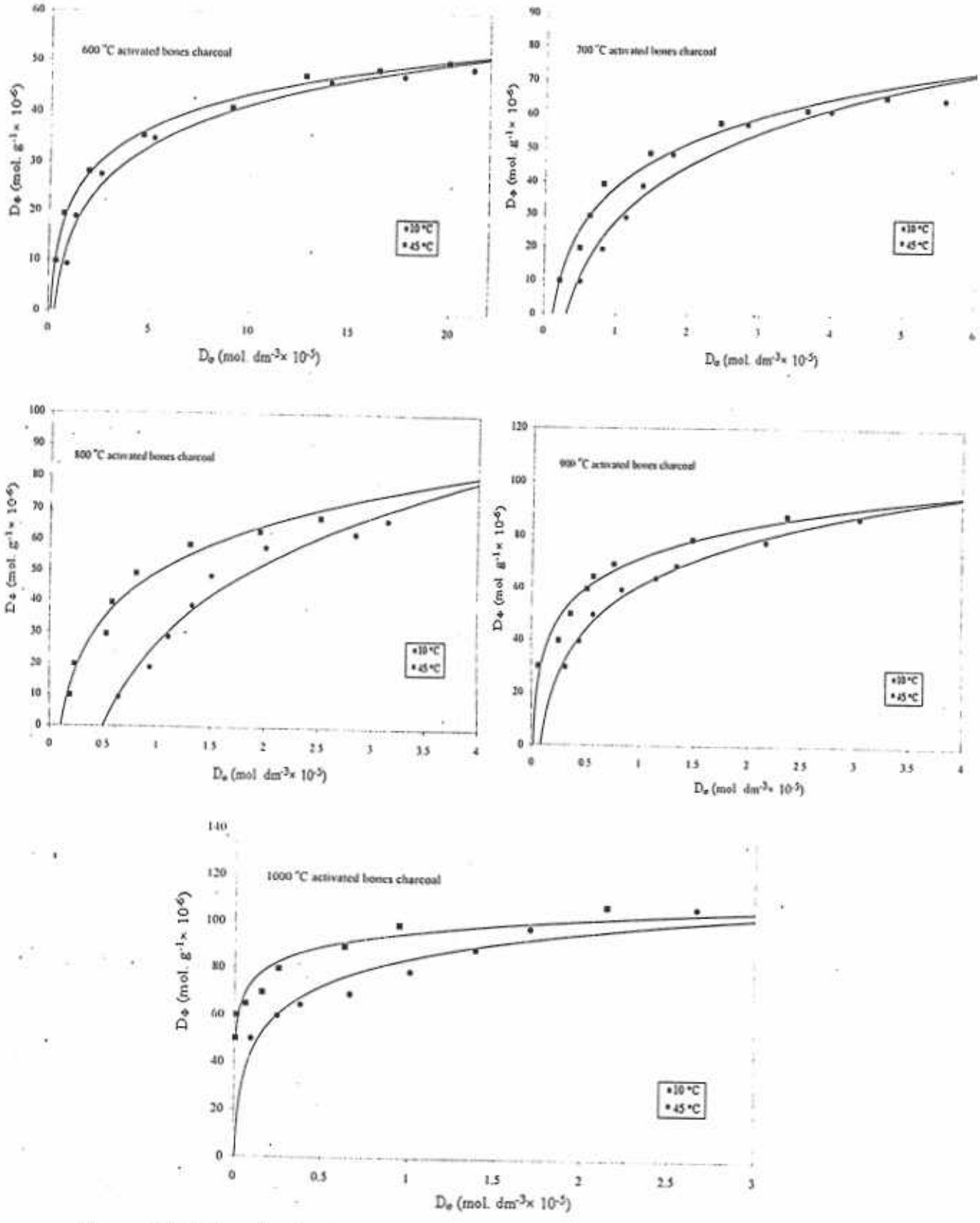


Figure 4.98 Adsorption isotherms of acid orange 7 on animal bones charcoal (ABC) samples.

Table 4.97 Adsorption isotherm of acid orange 7 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Abs1	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_t ($mol.g^{-1} \times 10^{-4}$)		Abs1	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_t ($mol.g^{-1} \times 10^{-4}$)
Regenerated (RG)	400 °C	10.0	0.550	3.467843	6.532156	6.532156	10.0	0.267	1.683480	8.316519	8.316519
		20.0	0.844	5.321564	14.67844	14.67844	20.0	0.544	3.430013	16.56998	16.56998
		30.0	1.664	10.49181	19.50819	19.50819	30.0	1.160	7.313997	22.68600	22.68600
		40.0	3.033	19.12358	20.87642	20.87642	40.0	2.460	15.51072	24.48928	24.48928
		50.0	4.574	28.83985	21.16015	21.16015	50.0	3.930	24.77932	25.22068	25.22068
		60.0	6.073	38.29129	21.70870	21.70870	60.0	5.490	34.61538	25.38461	25.38461
		65.0	6.824	43.02648	21.97352	21.97352	65.0	6.320	39.84867	25.15132	25.15132
		70.0	7.572	47.74275	22.25730	22.25730	70.0	7.200	45.39722	24.60277	24.60277
	600 °C	10.0	0.240	1.513241	8.486759	8.486759	10.0	0.150	0.945775	9.054224	9.054224
		20.0	0.410	2.585119	17.41488	17.41488	20.0	0.240	1.513241	18.48676	18.48676
		30.0	0.570	3.593947	26.40605	26.40605	30.0	0.350	2.206809	27.79319	27.79319
		40.0	0.730	4.602775	35.39723	35.39723	40.0	0.424	2.673392	37.32661	37.32661
		50.0	0.900	5.674653	44.32535	44.32535	50.0	0.615	3.877679	46.12232	46.12232
		60.0	1.500	9.457755	50.54224	50.54224	60.0	1.220	7.692307	52.30769	52.30769
		65.0	2.100	13.24086	51.75914	51.75914	65.0	1.800	11.34931	53.65069	53.65069
		70.0	2.500	15.76292	54.23707	54.23707	70.0	2.260	14.24968	55.75032	55.75032
	800 °C	10.0	0.095	0.598991	9.401008	9.401008	10.0	0.080	0.504414	9.495586	9.495586
		20.0	0.146	0.920555	19.07944	19.07944	20.0	0.114	0.718789	19.28121	19.28121
		30.0	0.190	1.197982	28.80202	28.80202	30.0	0.150	0.945775	29.05422	29.05422
		40.0	0.270	1.702396	38.29761	38.29761	40.0	0.200	1.261034	38.73896	38.73896
		50.0	0.320	2.017655	47.98235	47.98235	50.0	0.260	1.639344	48.36065	48.36065
		60.0	0.480	3.026482	56.97352	56.97352	60.0	0.404	2.547288	57.45271	57.45271
		65.0	0.792	4.993695	60.00630	60.00630	65.0	0.712	4.489281	60.51072	60.51072
		70.0	1.100	6.935687	63.06431	63.06431	70.0	1.000	6.305171	63.69483	63.69483
	900 °C	10.0	0.185	1.166456	8.833543	8.833543	10.0	0.091	0.573771	9.426229	9.426229
		20.0	0.246	1.551072	18.44893	18.44893	20.0	0.134	0.844893	19.15511	19.15511
		30.0	0.304	1.916772	28.08323	28.08323	30.0	0.195	1.229508	28.77049	28.77049
		40.0	0.353	2.225725	37.77427	37.77427	40.0	0.242	1.525851	38.47419	38.47419
		50.0	0.488	3.076923	46.92307	46.92307	50.0	0.379	2.389659	47.61034	47.61034
		60.0	0.702	4.426229	55.57377	55.57377	60.0	0.594	3.745271	56.25473	56.25473
		65.0	0.884	5.573770	59.42622	59.42622	65.0	0.772	4.867592	60.13241	60.13241
		70.0	1.324	8.348045	61.65195	61.65195	70.0	1.210	7.629255	62.37075	62.37075
	1000 °C	10.0	0.160	1.008827	8.991173	8.991173	10.0	0.071	0.447667	9.552333	9.552333
		20.0	0.200	1.261034	18.73897	18.73897	20.0	0.110	0.693568	19.30643	19.30643
		30.0	0.235	1.481715	28.51828	28.51828	30.0	0.145	0.914249	29.08575	29.08575
		40.0	0.300	1.891551	38.10844	38.10844	40.0	0.202	1.273644	38.72635	38.72635
		50.0	0.410	2.585119	47.41488	47.41488	50.0	0.314	1.978235	48.02017	48.02017
		60.0	0.618	3.895952	56.10340	56.10340	60.0	0.520	3.278688	56.72131	56.72131
		65.0	0.804	5.069357	59.93064	59.93064	65.0	0.600	3.783102	61.21689	61.21689
		70.0	1.258	7.931904	62.06809	62.06809	70.0	0.920	5.800757	64.19924	64.19924

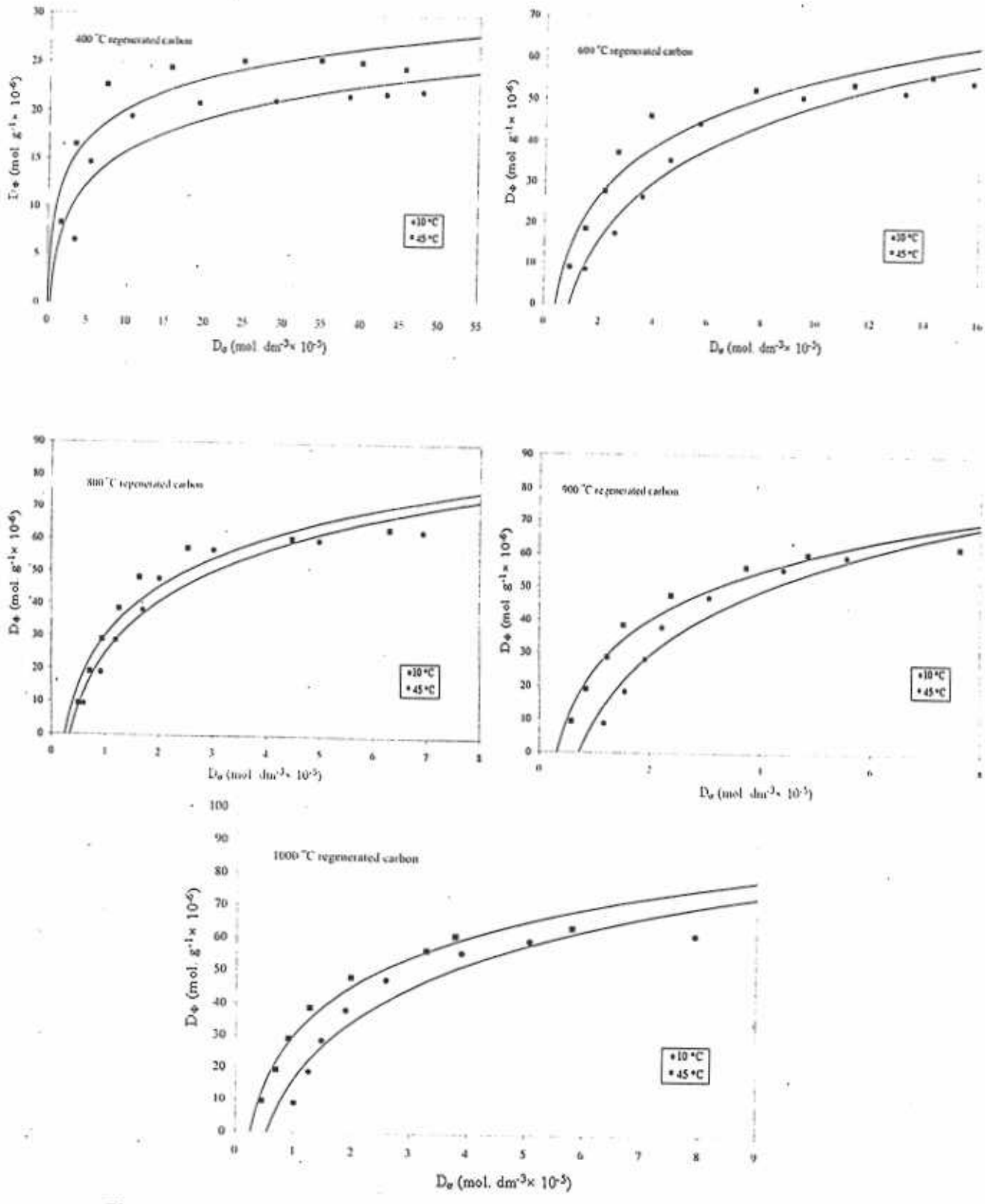


Figure 4.99 Adsorption isotherms of acid orange 7 on regenerated (RG) carbon samples

Table 4.98 Adsorption isotherm of acid orange 10 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-4}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-4}$)	at 45°C			
			Abs_{λ}	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_ϕ ($mol.g^{-1} \times 10^{-3}$)		Abs_{λ}	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_ϕ ($mol.g^{-1} \times 10^{-3}$)
Paulownia tomentosa (PT)	Raw	1.00	0.150	0.994	0.900	0.900	1.00	0.101	0.670	0.933	0.933
		1.30	0.172	1.140	1.186	1.186	1.30	0.122	0.810	1.220	1.220
		1.60	0.199	1.320	1.470	1.470	1.60	0.153	1.010	1.500	1.500
		1.90	0.250	1.650	1.730	1.730	1.90	0.179	1.180	1.780	1.780
		2.20	0.467	3.100	1.890	1.890	2.20	0.220	1.458	2.054	2.054
		2.50	0.737	4.880	2.010	2.010	2.50	0.388	2.570	2.240	2.240
		2.80	0.922	6.110	2.190	2.190	2.80	0.602	3.990	2.400	2.400
		3.10	1.100	7.290	2.370	2.370	3.10	0.833	5.520	2.550	2.550
	400 °C	2.00	0.140	0.928	1.910	1.910	2.00	0.130	0.862	1.920	1.920
		2.30	0.165	1.094	2.20	2.200	2.30	0.154	1.020	2.210	2.210
		2.60	0.210	1.390	2.460	2.460	2.60	0.179	1.180	2.480	2.480
		2.90	0.260	1.720	2.730	2.730	2.90	0.199	1.320	2.770	2.770
		3.20	0.350	2.320	2.970	2.970	3.20	0.280	1.850	3.010	3.010
		3.50	0.510	3.380	3.160	3.160	3.50	0.441	2.920	3.200	3.200
		3.80	0.801	5.310	3.270	3.270	3.80	0.732	4.850	3.310	3.310
		4.10	0.999	6.620	3.440	3.440	4.10	0.930	6.160	3.480	3.480
	800 °C	2.60	0.143	0.948	2.50	2.50	2.60	0.132	0.875	2.520	2.520
		2.90	0.180	1.190	2.78	2.78	2.90	0.152	1.000	2.800	2.800
		3.20	0.238	1.570	3.04	3.04	3.20	0.173	1.140	3.100	3.100
		3.50	0.300	1.980	3.30	3.30	3.50	0.197	1.300	3.380	3.380
		3.80	0.411	2.720	3.53	3.53	3.80	0.273	1.810	3.620	3.620
		4.10	0.653	4.330	3.66	3.66	4.10	0.510	3.380	3.760	3.760
		4.30	0.953	6.320	3.67	3.67	4.30	0.803	5.320	3.770	3.770
		4.60	1.390	9.210	3.68	3.68	4.60	1.040	6.890	3.910	3.910
Populus caspica (PC)	Raw	1.00	0.130	0.862	0.914	0.914	1.00	0.119	0.789	0.9210	0.9210
		1.30	0.169	1.120	1.190	1.190	1.30	0.153	1.010	1.200	1.200
		1.60	0.299	1.980	1.400	1.400	1.60	0.240	1.591	1.440	1.440
		1.90	0.510	3.380	1.560	1.560	1.90	0.443	2.930	1.600	1.600
		2.20	0.773	5.120	1.680	1.680	2.20	0.663	4.390	1.760	1.760
		2.50	0.991	6.571	1.843	1.843	2.50	0.889	5.890	1.910	1.910
		2.80	1.300	8.620	1.938	1.938	2.80	1.200	7.957	2.004	2.004
		3.10	1.600	10.61	2.004	2.004	3.10	1.510	10.01	2.098	2.098
	400 °C	2.00	0.143	0.948	1.900	1.900	2.00	0.140	0.928	1.907	1.907
		2.30	0.210	1.390	2.160	2.160	2.30	0.200	1.320	2.170	2.170
		2.60	0.300	1.980	2.400	2.400	2.60	0.263	1.740	2.430	2.430
		2.90	0.410	2.720	2.630	2.630	2.90	0.350	2.320	2.660	2.660
		3.20	0.589	3.900	2.810	2.810	3.20	0.489	3.240	2.870	2.870
		3.50	0.702	4.655	3.034	3.034	3.50	0.632	4.200	3.080	3.080
		3.80	0.914	6.060	3.200	3.200	3.80	0.850	5.670	3.230	3.230
		4.10	1.200	7.950	3.300	3.300	4.10	1.170	7.758	3.324	3.324
	800 °C	2.60	0.142	0.942	2.505	2.505	2.60	0.120	0.795	2.530	2.530
		2.90	0.200	1.326	2.760	2.760	2.90	0.170	1.120	2.780	2.780
		3.20	0.280	1.850	3.010	3.010	3.20	0.230	1.520	3.050	3.050
		3.50	0.390	2.580	3.240	3.240	3.50	0.293	1.940	3.300	3.300
		3.80	0.599	3.970	3.400	3.400	3.80	0.350	2.320	3.560	3.560
		4.10	0.818	5.420	3.560	3.560	4.10	0.558	3.700	3.730	3.730
		4.30	0.993	6.580	3.640	3.640	4.30	0.789	5.210	3.780	3.780
		4.60	1.400	9.280	3.670	3.670	4.60	0.969	6.420	3.950	3.950

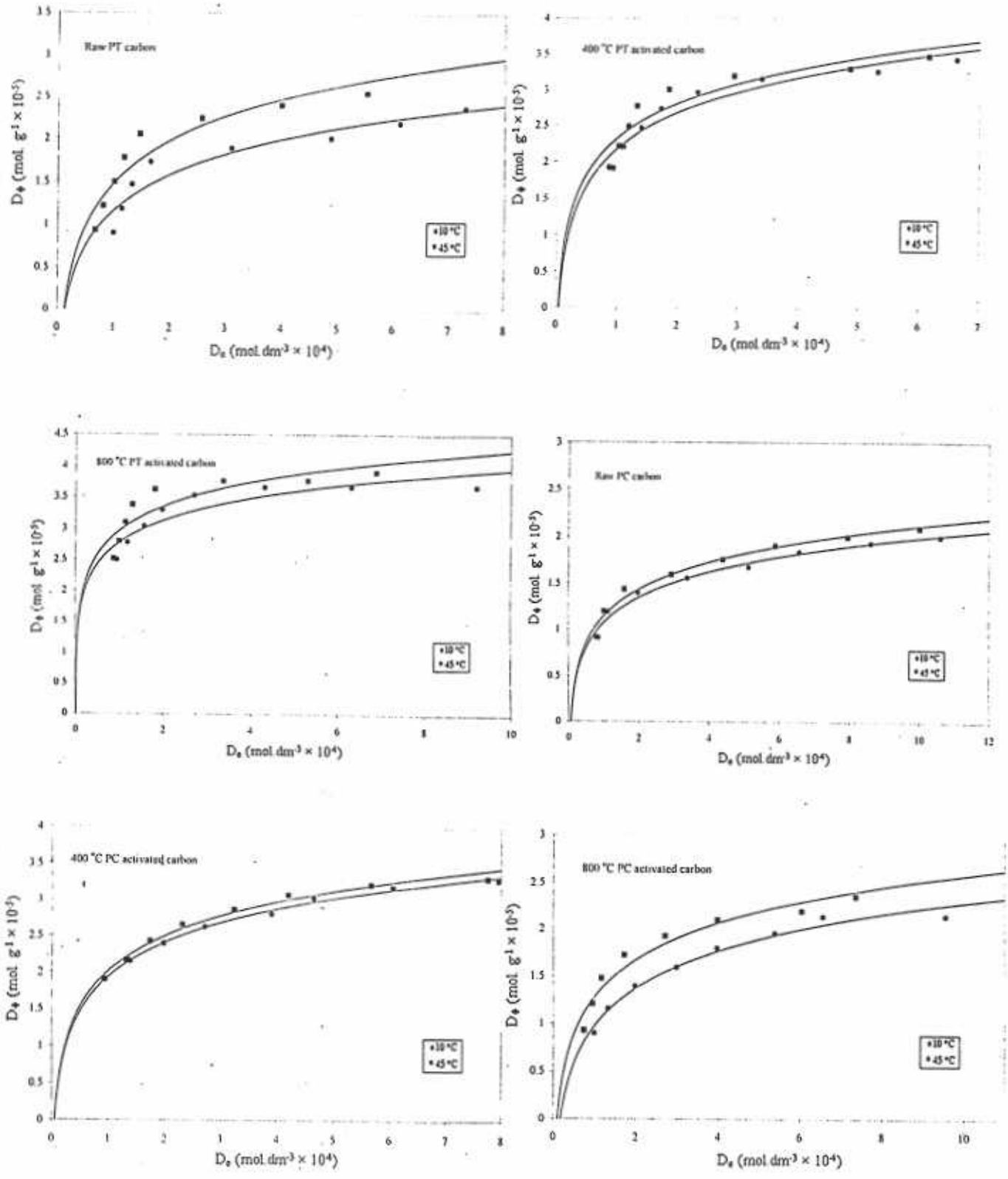


Figure 4.100 Adsorption isotherms of acid orange 10 on *Paulownia tomentosa* (PT) and *Populus caspica* (PC) carbon samples

Table 4.99 Adsorption isotherm of acid orange 10 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-4}$)	at 10°C				D_o ($mol.dm^{-3} \times 10^{-4}$)	at 45°C			
			Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_q ($mol.g^{-1} \times 10^{-3}$)		Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-4}$)	D_q ($mol.g^{-1} \times 10^{-3}$)
Corncobs (CC)	Raw	1.00	0.150	0.9940	0.900	0.900	1.00	0.112	0.742	0.930	0.930
		1.30	0.200	1.3260	1.160	1.160	1.30	0.143	0.950	1.210	1.210
		1.60	0.300	1.9890	1.400	1.400	1.60	0.176	1.167	1.480	1.480
		1.90	0.452	2.9970	1.600	1.600	1.90	0.259	1.720	1.730	1.730
		2.20	0.600	3.9780	1.800	1.800	2.20	0.411	2.720	1.930	1.930
		2.50	0.813	5.3910	1.960	1.960	2.50	0.603	3.990	2.100	2.100
		2.80	0.989	6.5600	2.140	2.140	2.80	0.911	6.040	2.200	2.200
		3.10	1.440	9.549	2.145	2.145	3.10	1.110	7.360	2.360	2.360
	400 °C	2.00	0.120	0.795	1.920	1.920	2.00	0.101	0.670	1.930	1.930
		2.30	0.160	1.060	2.190	2.190	2.30	0.140	0.930	2.210	2.210
		2.60	0.208	1.380	2.460	2.460	2.60	0.180	1.200	2.480	2.480
		2.90	0.311	2.060	2.690	2.690	2.90	0.242	1.604	2.739	2.739
		3.20	0.511	3.380	2.860	2.860	3.20	0.456	3.020	2.890	2.890
		3.50	0.789	5.230	2.970	2.970	3.50	0.703	4.660	3.030	3.030
		3.80	0.981	6.505	3.149	3.149	3.80	0.913	6.050	3.190	3.190
		4.10	0.150	9.950	3.110	3.110	4.10	1.320	8.750	3.220	3.220
	800 °C	2.60	0.114	0.760	2.520	2.520	2.60	0.108	0.716	2.530	2.530
		2.90	0.200	1.330	2.760	2.760	2.90	0.170	1.127	2.790	2.790
		3.20	0.309	2.050	2.990	2.990	3.20	0.250	1.650	3.030	3.030
		3.50	0.415	2.750	3.220	3.220	3.50	0.320	2.120	3.290	3.290
		3.80	0.635	4.210	3.380	3.380	3.80	0.400	2.650	3.530	3.530
		4.10	0.853	5.650	3.530	3.530	4.10	0.613	4.060	3.700	3.700
		4.30	0.962	6.380	3.660	3.660	4.30	0.789	5.230	3.780	3.780
		4.60	1.400	9.280	3.670	3.670	4.60	1.250	8.289	3.771	3.771
Ailanthus altissima (AA)	Raw	1.00	0.125	0.828	0.917	0.917	1.00	0.105	0.696	0.930	0.930
		1.30	0.175	1.160	1.184	1.184	1.30	0.135	0.895	1.210	1.210
		1.60	0.243	1.610	1.440	1.440	1.60	0.162	1.074	1.490	1.490
		1.90	0.316	2.090	1.700	1.700	1.90	0.193	1.280	1.770	1.770
		2.20	0.429	2.840	1.910	1.910	2.20	0.303	2.010	1.990	1.990
		2.50	0.689	4.560	2.040	2.040	2.50	0.516	3.420	2.150	2.150
		2.80	0.989	6.560	2.140	2.140	2.80	0.811	5.370	2.260	2.260
		3.10	1.350	8.950	2.200	2.200	3.10	0.985	6.530	2.440	2.440
	400 °C	2.00	0.131	0.868	1.900	1.900	2.00	0.111	0.730	1.930	1.930
		2.30	0.201	1.330	2.167	2.167	2.30	0.177	1.170	2.184	2.184
		2.60	0.269	1.780	2.420	2.420	2.60	0.239	1.580	2.450	2.450
		2.90	0.490	3.250	2.570	2.570	2.90	0.410	2.720	2.620	2.620
		3.20	0.610	4.050	2.790	2.790	3.20	0.553	3.660	2.840	2.840
		3.50	0.774	5.130	2.980	2.980	3.50	0.693	4.590	3.040	3.040
		3.80	0.992	6.580	3.140	3.140	3.80	0.850	5.630	3.230	3.230
		4.10	1.530	10.14	3.100	3.100	4.10	1.110	7.360	3.360	3.360
	800 °C	2.60	0.160	1.060	2.490	2.490	2.60	0.141	0.935	2.500	2.500
		2.90	0.230	1.520	2.750	2.750	2.90	0.185	1.226	2.780	2.780
		3.20	0.410	2.720	2.920	2.920	3.20	0.243	1.610	3.040	3.040
		3.50	0.603	3.990	3.100	3.100	3.50	0.516	3.420	3.160	3.160
		3.80	0.912	6.040	3.200	3.200	3.80	0.808	5.350	3.270	3.270
		4.10	1.110	7.360	3.360	3.360	4.10	1.010	6.690	3.430	3.430
		4.30	1.400	9.280	3.370	3.370	4.30	1.320	8.750	3.420	3.420
		4.60	1.830	12.13	3.386	3.386	4.60	1.590	10.54	3.540	3.540

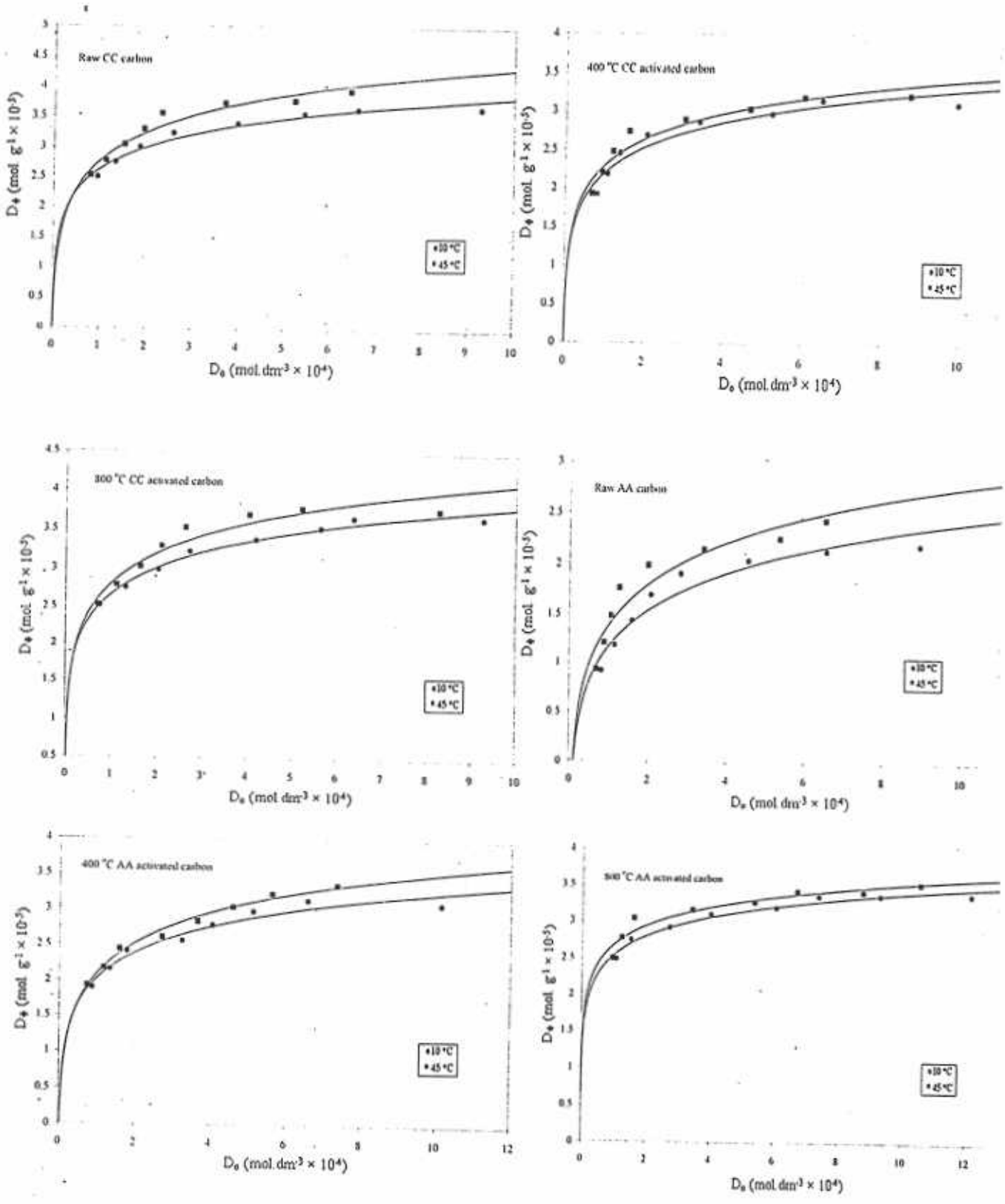


Figure 4.101 Adsorption isotherms of acid orange 10 on *Corncobs* (CC) and *Ailanthus altissima* (AA) carbon samples

Table 4.100 Adsorption isotherm of acid orange 10 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_t ($mol.g^{-1} \times 10^{-2}$)		Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_t ($mol.g^{-1} \times 10^{-2}$)
Salvadora oleoides (SO)	Raw	3.000	0.420	2.785145	0.214854	0.214854	3.000	0.415	2.751989	0.248011	0.248011
		5.000	0.705	4.675066	0.324933	0.324933	5.000	0.695	4.608753	0.391246	0.391246
		7.000	1.000	6.631299	0.368700	0.368700	7.000	0.990	6.564986	0.435013	0.435013
		9.000	1.300	8.620689	0.379310	0.379310	9.000	1.290	8.554376	0.445623	0.445623
		11.00	1.600	10.61008	0.388992	0.388992	11.00	1.590	10.54376	0.456233	0.456233
		13.00	1.900	12.59946	0.400530	0.400530	13.00	1.890	12.53315	0.466843	0.466843
		15.00	2.200	14.58859	0.411114	0.411114	15.00	2.190	14.52255	0.477454	0.477454
		17.00	2.499	16.57162	0.428382	0.428382	17.00	2.490	16.51194	0.488064	0.488064
	400 °C	3.000	0.399	2.645888	0.354111	0.354111	3.000	0.393	2.606100	0.393899	0.393899
		5.000	0.683	4.529177	0.470822	0.470822	5.000	0.662	4.389921	0.610079	0.610079
		7.000	0.978	6.485411	0.514588	0.514588	7.000	0.955	6.332892	0.667108	0.667108
		9.000	1.268	8.408488	0.591512	0.591512	9.000	1.252	8.302387	0.697613	0.697613
		11.00	1.56	10.34483	0.655173	0.655173	11.00	1.547	10.25862	0.741379	0.741379
		13.00	1.858	12.32095	0.679045	0.679045	13.00	1.844	12.22811	0.771883	0.771883
		15.00	2.158	14.31034	0.689655	0.689655	15.00	2.145	14.22414	0.775862	0.775862
		17.00	2.457	16.29311	0.706896	0.706896	17.00	2.444	16.20689	0.793103	0.793103
	600 °C	3.000	0.322	2.135278	0.864721	0.864721	3.000	0.243	1.611405	1.388594	1.388594
		5.000	0.597	3.958886	1.041120	1.041120	5.000	0.500	3.315649	1.684350	1.684350
		7.000	0.871	5.775862	1.224137	1.224137	7.000	0.790	5.238726	1.761273	1.761273
		9.000	1.174	7.785146	1.214854	1.214854	9.000	1.085	7.194960	1.805039	1.805039
		11.00	1.457	9.661804	1.338196	1.338196	11.00	1.378	9.137931	1.862068	1.862068
		13.00	1.745	11.57162	1.428382	1.428382	13.00	1.676	11.11406	1.885942	1.885942
		15.00	2.041	13.53448	1.465517	1.465517	15.00	1.970	13.06366	1.936339	1.936339
		17.00	2.338	15.50397	1.496021	1.496021	17.00	2.269	15.04642	1.953581	1.953581
	800 °C	3.000	0.166	1.100795	1.899204	1.899204	3.000	0.063	0.417772	2.582230	2.582230
		5.000	0.364	2.413793	2.586207	2.586207	5.000	0.071	0.470823	4.529177	4.529177
		7.000	0.576	3.819628	3.180371	3.180371	7.000	0.094	0.623342	6.376658	6.376658
		9.000	0.840	5.570291	3.429708	3.429708	9.000	0.160	1.061008	7.938992	7.938992
		11.00	1.140	7.559682	3.440318	3.440318	11.00	0.376	2.493368	8.506631	8.506631
		13.00	1.420	9.416445	3.583554	3.583554	13.00	0.676	4.482758	8.517241	8.517241
		15.00	1.720	11.40584	3.594164	3.594164	15.00	0.975	6.465517	8.534483	8.534483
		17.00	2.000	13.26259	3.737400	3.737400	17.00	1.250	8.289125	8.710875	8.710875
	900 °C	3.000	0.014	0.092838	2.907162	2.907162	3.000	0.004	0.026525	2.973475	2.973475
		5.000	0.027	0.179045	4.820954	4.820954	5.000	0.017	0.112732	4.887268	4.887268
		7.000	0.037	0.245358	6.754642	6.754642	7.000	0.027	0.179045	6.820955	6.820955
		9.000	0.095	0.629074	8.370026	8.370026	9.000	0.065	0.431035	8.568965	8.568965
		11.00	0.122	0.809018	10.19098	10.19098	11.00	0.012	0.795750	10.92043	10.92043
		13.00	0.299	1.982758	11.01724	11.01724	13.00	0.275	1.823607	11.17639	11.17639
		15.00	0.539	3.574271	11.42573	11.42573	15.00	0.489	3.242705	11.75729	11.75729
		17.00	0.794	5.265252	11.73475	11.73475	17.00	0.759	5.033156	11.96684	11.96684
	1000 °C	3.000	0.021	0.139257	2.860742	2.860742	3.000	0.001	0.006632	2.993368	2.993368
		5.000	0.038	0.251989	4.748011	4.748011	5.000	0.008	0.053051	4.946950	4.946950
		7.000	0.052	0.344827	6.655173	6.655173	7.000	0.020	0.132625	6.867374	6.867374
		9.000	0.096	0.636605	8.363395	8.363395	9.000	0.055	0.364722	8.635278	8.635278
		11.00	0.183	1.213528	9.786472	9.786472	11.00	0.092	0.610079	10.38992	10.38992
		13.00	0.351	2.327586	10.67242	10.67242	13.00	0.200	1.326259	11.67374	11.67374
		15.00	0.523	3.468169	11.53183	11.53183	15.00	0.404	2.679045	12.32095	12.32095
		17.00	0.812	5.384615	11.61538	11.61538	17.00	0.710	4.708223	12.29177	12.29177

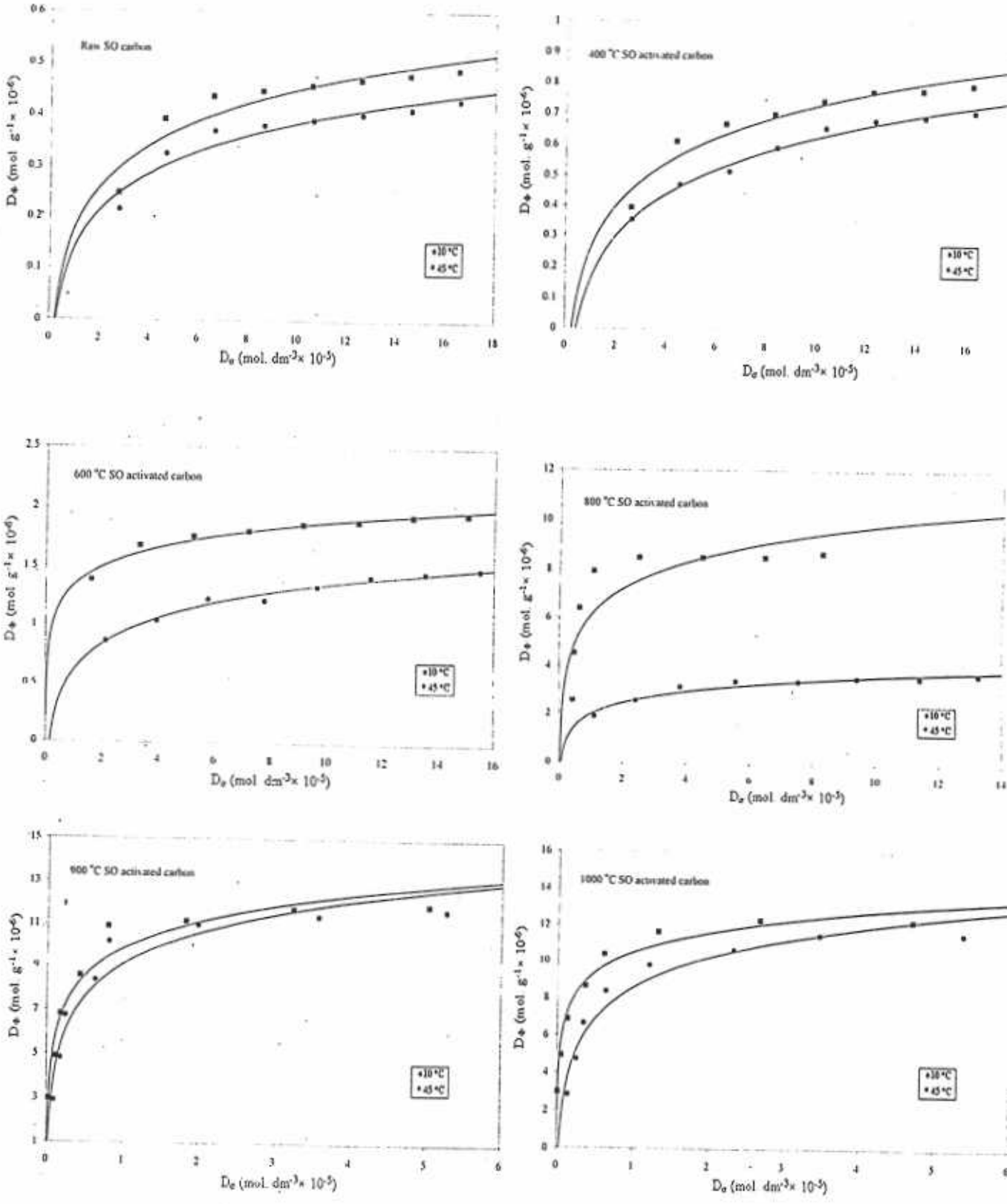


Figure 4.102 Adsorption isotherms of acid orange 10 on *Salvadora oleoides* (SO) carbon samples

Table 4.101 Adsorption isotherm of acid orange 10 on charcoal samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10 °C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_q ($mol.g^{-1} \times 10^{-2}$)		Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_q ($mol.g^{-1} \times 10^{-2}$)
Animal bones (ABC)	600 °C	5.00	0.210	1.392573	3.607427	3.607427	5.00	0.1460	0.968169	4.031830	4.031830
		10.0	0.570	3.779840	6.220159	6.220159	10.0	0.4740	3.143236	6.856764	6.856764
		15.0	0.9650	6.399204	8.600795	8.600795	15.0	0.900	5.968170	9.031830	9.031830
		20.0	1.4600	9.681697	10.31830	10.31830	20.0	1.3000	8.620689	11.37931	11.37931
		25.0	1.9000	12.59947	12.40053	12.40053	25.0	1.8000	11.93634	13.06367	13.06367
		30.0	2.450	16.24668	13.75331	13.75331	30.0	2.4000	15.91512	14.08488	14.08488
		35.0	3.180	21.08753	13.91246	13.91246	35.0	3.1000	20.55703	14.44297	14.44297
		40.0	3.900	25.86207	14.13793	14.13793	40.0	3.8500	25.53053	14.46949	14.46949
	700 °C	5.00	0.100	0.663129	4.336870	4.336870	5.00	0.055	0.364715	4.635278	4.635278
		10.0	0.200	1.326259	8.673740	8.673740	10.0	0.100	0.663129	9.336870	9.336870
		15.0	0.340	2.254642	12.74535	12.74535	15.0	0.230	1.525198	13.47480	13.47480
		20.0	0.610	4.045093	15.95491	15.95491	20.0	0.470	3.116711	16.88330	16.88330
		25.0	0.930	6.167108	18.83289	18.83289	25.0	0.728	4.827586	20.17240	20.17240
		30.0	1.440	9.549072	20.45093	20.45093	30.0	1.250	8.289150	21.71080	21.71080
		35.0	1.882	12.48010	22.51989	22.51989	35.0	1.740	11.53846	23.46154	23.46154
		40.0	2.442	16.19363	23.80640	23.80640	40.0	2.320	15.38462	24.61540	24.61540
	800 °C	5.00	0.088	0.583554	4.416445	4.416445	5.00	0.062	0.411140	4.588859	4.588859
		10.0	0.152	1.007957	8.992042	8.992042	10.0	0.100	0.663129	9.336870	9.336870
		15.0	0.212	1.405835	13.59416	13.59416	15.0	0.162	1.074270	13.92573	13.92573
		20.0	0.300	1.989389	18.01061	18.01061	20.0	0.220	1.458886	18.54111	18.54111
		25.0	0.456	3.023873	21.97612	21.97612	25.0	0.346	2.294429	22.70557	22.70557
		30.0	0.828	5.490716	24.50928	24.50928	30.0	0.708	4.694961	25.30504	25.30504
		35.0	1.250	8.289124	26.71087	26.71087	35.0	1.140	7.559681	27.44032	27.44032
		40.0	1.720	11.40583	28.59416	28.59416	40.0	1.600	10.61008	29.38992	29.38992
	900 °C	5.00	0.040	0.265252	4.734748	4.734748	5.00	0.030	0.198938	4.801061	4.801061
		10.0	0.080	0.530504	9.469496	9.469496	10.0	0.048	0.318303	9.681697	9.681697
		15.0	0.153	1.014588	13.98541	13.98541	15.0	0.065	0.431035	14.56896	14.56896
		20.0	0.200	1.326259	18.67374	18.67374	20.0	0.084	0.557029	19.44297	19.44297
		25.0	0.354	2.347480	22.65252	22.65252	25.0	0.170	1.127321	23.87267	23.87267
		30.0	0.726	4.814324	25.18567	25.18567	30.0	0.287	1.903183	28.09681	28.09681
		35.0	1.120	7.427055	27.57294	27.57294	35.0	0.478	3.169761	31.83024	31.83024
		40.0	1.540	10.21220	29.78779	29.78779	40.0	0.892	5.915119	34.08488	34.08488
	1000 °C	5.00	0.032	0.212202	4.787798	4.787798	5.00	0.010	0.066313	4.933687	4.933687
		10.0	0.057	0.377984	9.622016	9.622016	10.0	0.035	0.230954	9.767904	9.767904
		15.0	0.092	0.610079	14.38992	14.38992	15.0	0.050	0.331565	14.66843	14.66843
		20.0	0.132	0.875331	19.12467	19.12467	20.0	0.062	0.411141	19.58886	19.58886
		25.0	0.200	1.326259	23.67374	23.67374	25.0	0.100	0.663129	24.33687	24.33687
		30.0	0.340	2.25464	27.74535	27.74535	30.0	0.1600	1.061008	28.93899	28.93899
		35.0	0.590	3.912467	31.08753	31.08753	35.0	0.290	1.923076	33.07692	33.07692
		40.0	0.820	5.437666	34.56233	34.56233	40.0	0.550	3.647215	36.35278	36.35278

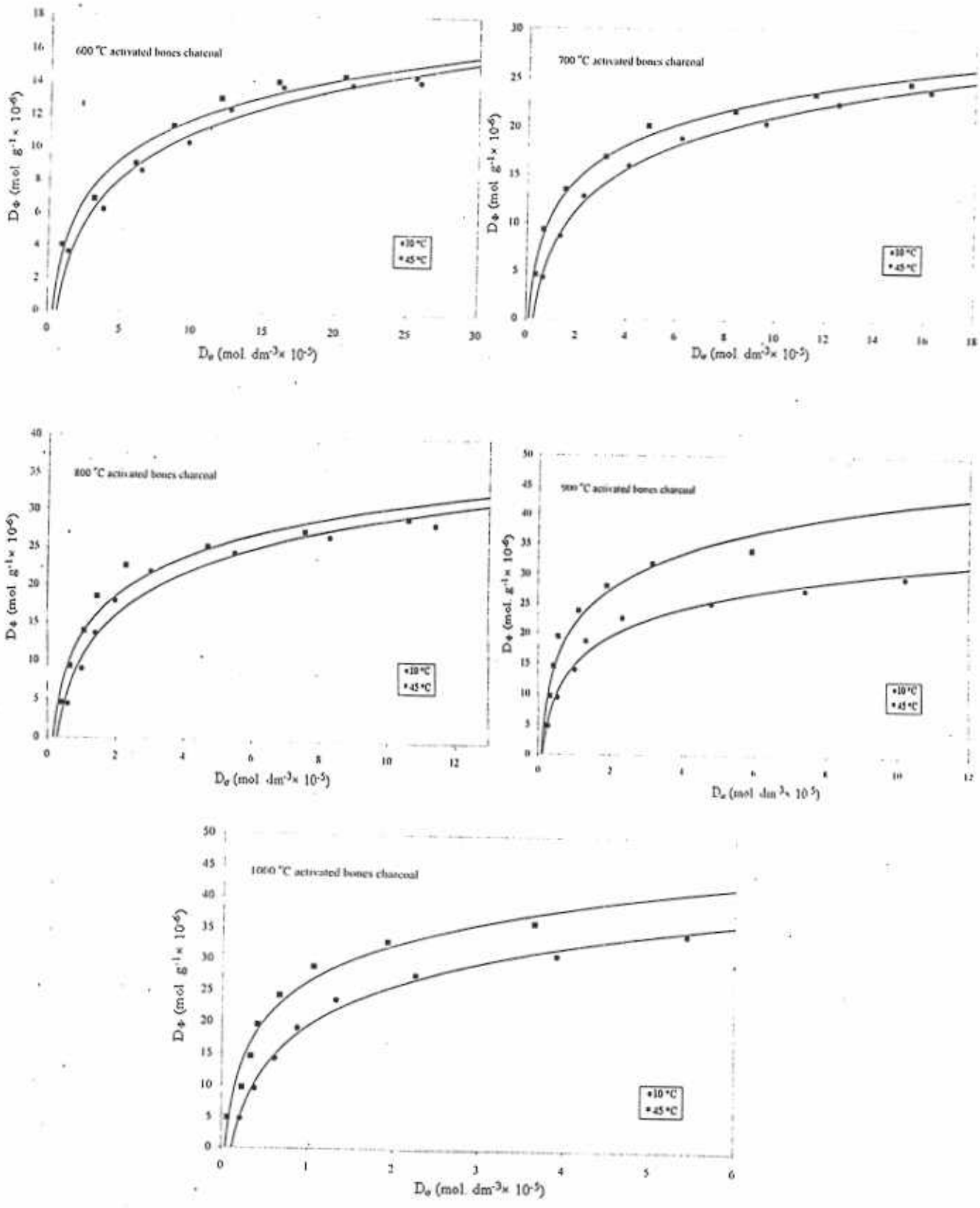


Figure 4.103 Adsorption isotherms of acid orange 10 on animal bones charcoal (ABC) samples

Table 4.102 Adsorption isotherm of acid orange 10 on carbon samples

Sample		D_o ($mol.dm^{-3} \times 10^{-5}$)	at 10°C				D_o ($mol.dm^{-3} \times 10^{-5}$)	at 45°C			
			Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_q ($mol.g^{-1} \times 10^{-4}$)		Abs	D_e ($mol.dm^{-3} \times 10^{-5}$)	D_o-D_e ($mol.dm^{-3} \times 10^{-5}$)	D_q ($mol.g^{-1} \times 10^{-4}$)
Regenerated (RG)	400 °C	5.00	0.600	3.978779	1.021221	1.021221	5.00	0.504	3.342175	1.657825	1.657825
		10.0	1.160	7.692307	2.307692	2.307692	10.0	1.050	6.962864	3.037135	3.037135
		15.0	1.850	12.26790	2.732095	2.732095	15.0	1.740	11.53846	3.461538	3.461538
		20.0	2.580	17.10875	2.891247	2.891247	20.0	2.420	16.04774	3.952254	3.952254
		25.0	3.260	21.61804	3.381963	3.381963	25.0	3.150	20.88859	4.111410	4.111410
		30.0	3.920	25.99469	4.005310	4.005310	30.0	3.870	25.66313	4.336870	4.336870
		35.0	4.680	31.03448	3.965517	3.965517	35.0	4.570	30.30504	4.694960	4.694960
		40.0	5.400	35.80902	4.190982	4.190982	40.0	5.300	35.14588	4.854111	4.854111
	600 °C	5.00	0.320	2.122016	2.877984	2.877984	5.00	0.210	1.392573	3.607427	3.607427
		10.0	0.550	3.647215	6.352785	6.352785	10.0	0.394	2.612732	7.387267	7.387267
		15.0	1.014	6.724138	8.275862	8.275862	15.0	0.925	6.133952	8.866047	8.866047
		20.0	1.510	10.01326	9.986737	9.986737	20.0	1.420	9.416446	10.58355	10.58355
		25.0	2.050	13.59416	11.40583	11.40583	25.0	1.950	12.93104	12.06896	12.06896
		30.0	2.660	17.63926	12.36074	12.36074	30.0	2.580	17.10875	12.89124	12.89124
		35.0	3.350	22.21485	12.78514	12.78514	35.0	3.300	21.88328	13.11671	13.11671
		40.0	4.050	26.85676	13.14324	13.14324	40.0	4.020	26.65783	13.34217	13.34217
	800 °C	5.00	0.240	1.591512	3.408488	3.408488	5.00	0.170	1.127321	3.872679	3.872679
		10.0	0.330	2.188328	7.811671	7.811671	10.0	0.272	1.803714	8.196286	8.196286
		15.0	0.633	4.197612	10.80238	10.80238	15.0	0.376	2.493368	12.50663	12.50663
		20.0	1.022	6.777188	13.22281	13.22281	20.0	0.686	4.549072	15.45093	15.45093
		25.0	1.500	9.946950	15.05305	15.05305	25.0	1.170	7.758620	17.24138	17.24138
		30.0	2.172	14.40318	15.59682	15.59682	30.0	1.700	11.27321	18.72679	18.72679
		35.0	2.890	19.16446	15.83554	15.83554	35.0	2.400	15.91519	19.08488	19.08488
		40.0	3.550	23.54111	16.45888	16.45888	40.0	3.120	20.68965	19.31034	19.31034
	900 °C	5.00	0.200	1.326259	3.673740	3.673740	5.00	0.135	0.895225	4.104775	4.104775
		10.0	0.300	1.989389	8.010610	8.010610	10.0	0.261	1.730769	8.269230	8.269230
		15.0	0.513	3.401857	11.59814	11.59814	15.0	0.426	2.824893	12.17506	12.17506
		20.0	0.933	6.187003	13.81299	13.81299	20.0	0.566	3.753316	16.24668	16.24668
		25.0	1.400	9.283819	15.71618	15.71618	25.0	0.885	5.868700	19.13129	19.13129
		30.0	2.060	13.66047	16.33952	16.33952	30.0	1.360	9.018567	20.98143	20.98143
		35.0	2.640	17.50663	17.49336	17.49336	35.0	1.950	12.93104	22.06896	22.06896
		40.0	3.32	22.0159	17.98408	17.98408	40.0	2.540	16.84350	23.15649	23.15649
	1000 °C	5.00	0.120	0.795755	4.204244	4.204244	5.00	0.080	0.530504	4.469490	4.469490
		10.0	0.320	2.122016	7.877980	7.877980	10.0	0.195	1.293103	8.706896	8.706896
		15.0	0.595	3.945623	11.05437	11.05437	15.0	0.295	1.956233	13.04376	13.04376
		20.0	0.995	6.598143	13.40185	13.40185	20.0	0.462	3.063661	16.93634	16.93634
		25.0	1.520	10.07957	14.92042	14.92042	25.0	0.802	5.318302	19.68169	19.68169
		30.0	2.150	14.25729	15.74271	15.74271	30.0	1.320	8.753315	21.24668	21.24668
		35.0	2.652	17.58620	17.41379	17.41379	35.0	1.850	12.26791	22.73209	22.73209
		40.0	3.250	21.55172	18.44827	18.44827	40.0	2.500	16.57825	23.42175	23.42175

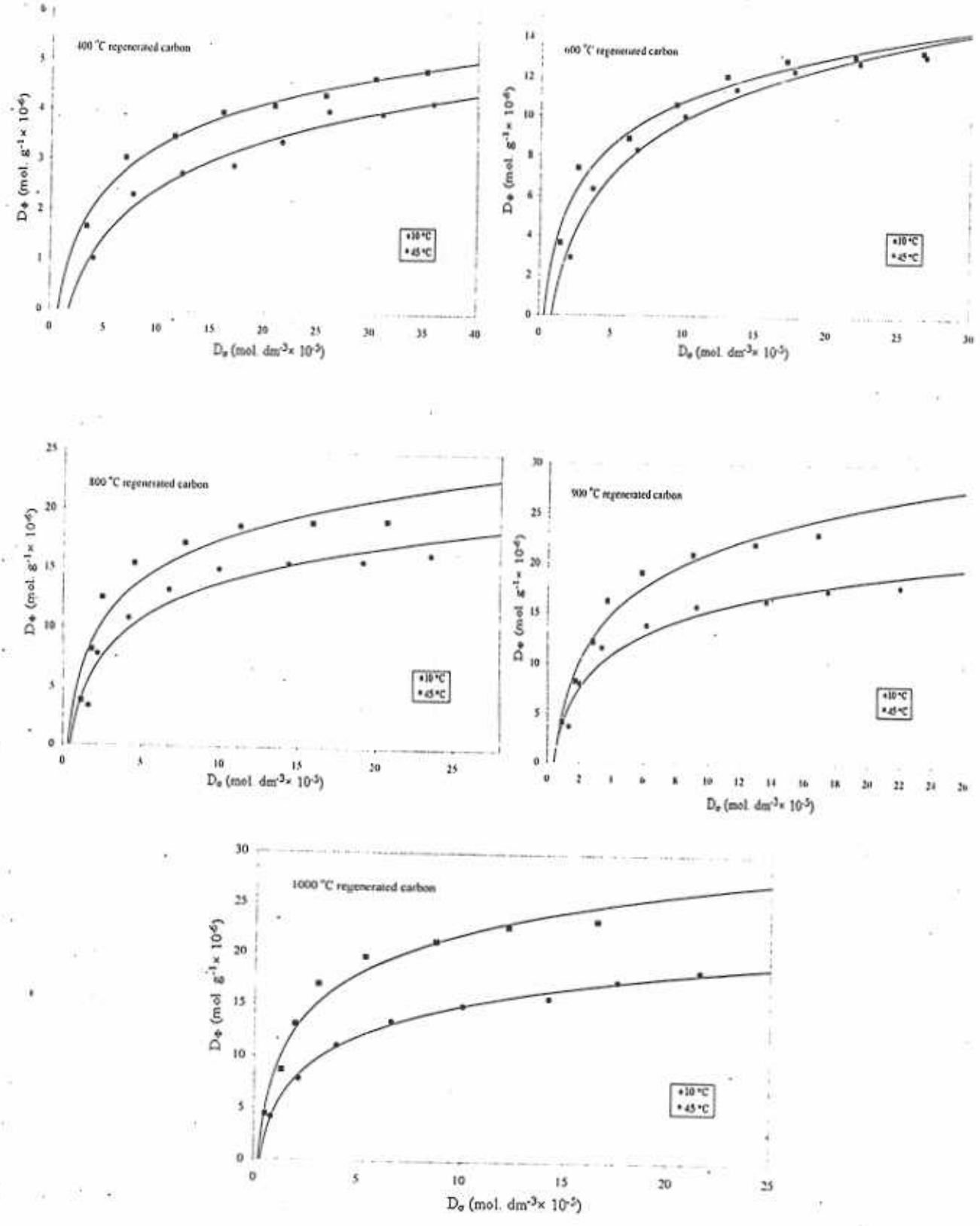


Figure 4.104 Adsorption isotherms of acid orange 10 on regenerated (RG) carbon samples

Table 4.103 Freundlich constants for the adsorption of dyes on carbon samples

Dye	Sample	Constants	PT carbon		PC carbon		CC carbon		AA carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid blue 1	Raw	n	1.29750	1.54320	1.57200	1.65280	1.05930	1.11060	1.65670	2.51630
		K (mol/g)	96.1200	195.010	1133.08	1341.84	17.4680	22.2260	254.140	700.780
	400 °C	n	1.36810	1.54790	2.17060	2.62950	2.03540	2.27940	1.52340	1.71930
		K (mol/g)	157.890	399.015	6933.36	14565.3	3745.08	6129.69	650.530	1390.05
	800 °C	n	1.03530	1.36740	2.07510	2.54640	2.61020	4.28080	2.39060	3.23720
		K (mol/g)	205.550	581.140	12459.01	28486.9	11204.8	54339.1	7543.94	22833.8
Brilliant blue R	Raw	n	1.29930	1.407000	1.226600	1.538400	1.532300	2.225600	1.301570	1.981300
		K (mol/g)	247.002	369.0700	242.7900	937.2960	769.0060	5501.630	233.2010	3428.570
	400 °C	n	1.845300	1.829800	1.716700	1.480800	2.675900	2.694600	2.012000	2.085900
		K (mol/g)	1197.030	1576.870	1816.740	2858.350	11711.18	19076.26	3928.050	4227.220
	800 °C	n	2.284600	2.774600	1.788500	3.155500	4.389800	4.192800	3.095900	3.002100
		K (mol/g)	4886.830	10738.59	1521.870	11496.52	25667.99	57068.06	11608.58	20696.08
Acid yellow 29	Raw	n	4.424700	4.446400	1.786030	2.193460	2.09900	2.930800	2.095900	2.602800
		K (mol/g)	1145.960	45752.40	2148.230	5389.450	4920.17	15605.80	5352.930	11036.90
	400 °C	n	2.391200	3.743900	2.538070	2.805800	2.97973	3.705070	3.743910	3.228900
		K (mol/g)	6236.030	8795.530	8720.220	11434.61	17726.92	25977.86	7958.530	17285.09
	800 °C	n	3.010200	3.396700	3.675100	4.904300	4.338300	4.312200	3.968200	4.308400
		K (mol/g)	11885.80	15633.90	22606.60	41522.90	34961.40	32565.20	28767.40	32663.00
Acid yellow 34	Raw	n	2.693200	4.198100	1.906900	2.017300	2.754800	2.726200	2.468500	2.706300
		K (mol/g)	8031.280	31920.40	2504.130	2684.900	6732.480	10046.70	7841.610	10547.03
	400 °C	n	3.306800	8.628100	3.909300	4.221100	3.629700	3.193800	3.844600	3.210200
		K (mol/g)	13950.90	92874.90	26742.25	29260.68	7450.220	11851.38	7532.630	12572.90
	800 °C	n	3.937000	4.514600	3.510000	3.517400	4.340200	4.242600	3.938500	4.314000
		K (mol/g)	21431.13	207108.8	47192.95	44981.20	10425.39	23956.60	22811.04	25848.20
Acid orange 7	Raw	n	2.182900	2.701200	2.763900	2.659500	2.452700	2.868600	2.327200	2.295600
		K (mol/g)	3803.200	8129.860	8617.060	10868.20	6562.900	11580.70	5495.500	12817.90
	400 °C	n	3.711950	4.040400	4.580800	4.580800	4.484300	3.907700	4.323300	4.623200
		K (mol/g)	19964.20	23552.80	26238.90	41522.80	34682.80	59159.90	32273.40	36534.00
	800 °C	n	6.426700	6.816600	5.858200	5.724000	4.359100	4.559900	6.297200	7.374600
		K (mol/g)	60294.70	62317.60	50312.05	123747.6	67914.17	71539.14	59635.10	72547.70
Acid orange 10	Raw	n	6.535900	2.391700	3.581600	3.496500	2.619100	2.839200	2.857100	2.765400
		K (mol/g)	2489.900	9751.900	1857.500	4424.800	12175.70	13824.50	8448.900	11648.11
	400 °C	n	3.724300	3.878900	3.790700	3.767800	5.467400	5.408300	4.780100	4.545400
		K (mol/g)	20812.30	22270.09	3284.590	23040.20	24909.30	52052.07	23980.50	36717.17
	800 °C	n	6.172800	5.851300	5.941700	4.784600	6.238300	5.608500	8.006400	8.271200
		K (mol/g)	55938.04	47476.96	53583.68	32500.15	59278.38	125366.9	68734.05	92503.30

Table 4.104 Freundlich constants for the adsorption of acid dyes on carbon samples

Dye	Sample	Constants	SO carbon		AB charcoal		RG carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid blue 1	Raw	n	0.7971000	1.0558000	xxxx	xxxx	xxxx	xxxx
		K (mol/g)	1.2831000	26.488210	xxxx	xxxx	xxxx	xxxx
	400 °C	n	1.2328900	1.3633200	xxxx	xxxx	2.5726700	4.0404000
		K (mol/g)	81.255600	132.71440	xxxx	xxxx	1650.9300	5635.8300
	600 °C	n	2.0247000	2.0916100	1.7337000	2.3969300	1.7476400	2.3185700
		K (mol/g)	1771.8800	2018.4700	238.60200	1089.4190	14444.940	22334.770
	800 °C	n	3.7821400	4.8971000	1.9661800	3.2701100	2.2872800	3.3322200
		K (mol/g)	17832.890	19239.100	424.19700	3397.1700	20496.300	86916.220
	900 °C	n	4.0371400	4.6728000	2.4691300	3.7230100	2.7901700	4.0502000
		K (mol/g)	12165.990	15773.710	1256.6400	4727.8900	46774.800	416565.90
	1000 °C	n	32892.500	43739.190	2510.4060	5822.5800	139455.30	400953.20
		K (mol/g)	32892.500	43739.190	2510.4060	5822.5800	139455.30	400953.20
Brilliant blue R	Raw	n	1.9073000	3.1635500	xxxx	xxxx	xxxx	xxxx
		K (mol/g)	547.90300	2518.70400	xxxx	xxxx	xxxx	xxxx
	400 °C	n	2.8026900	4.17710900	xxxx	xxxx	2.3792000	3.4176000
		K (mol/g)	1882.5800	4370.7900	xxxx	xxxx	488.28500	14616.410
	600 °C	n	3.5906600	5.2854100	1.8185100	3.9062500	4.7573700	3.0731400
		K (mol/g)	3273.1200	6121.11700	1099.5900	9870.4400	1589.2200	6435.5900
	800 °C	n	4.9382700	6.3816200	3.7664700	2.0708200	6.5876200	18205.800
		K (mol/g)	5751.4080	7472.6100	2517.9490	10779.480	4919.6800	18205.800
	900 °C	n	5.4112550	6.3371300	4.3994700	2.1701300	5.9808600	6.8352000
		K (mol/g)	6325.2100	8063.4700	1259.0520	2079.5900	9857.6190	22426.530
	1000 °C	n	7.2780200	6.7476000	4.4365500	2.7586200	6.1652000	2.8312500
		K (mol/g)	8820.2010	56528.480	30570.780	84288.430	17625.460	32128.530
Acid yellow 29	Raw	n	0.8249400	2.1222400	xxxx	xxxx	xxxx	xxxx
		K (mol/g)	23.657900	8915.0800	xxxx	xxxx	xxxx	xxxx
	400 °C	n	2.7300000	2.1052600	xxxx	xxxx	2.8514300	3.5880800
		K (mol/g)	692.14810	3935.9200	xxxx	xxxx	1536.8600	2521.7200
	600 °C	n	1.9327400	2.8498100	2.1786400	3.6036000	4.6019300	5.0403200
		K (mol/g)	1870.6900	6796.7500	325.02400	1551.8450	3139.4400	3541.4800
	800 °C	n	2.5335600	3.3311100	2.7107610	3.2927200	4.6816400	4.0048000
		K (mol/g)	4803.4900	8980.4000	4959.2000	8204.1800	7593.1300	4540.5300
	900 °C	n	5.0175600	6.6401000	3.0712500	4.6750800	4.0783000	3.9824000
		K (mol/g)	12837.160	19289.180	6599.1750	18107.830	14181.590	32679.390
	1000 °C	n	4.2390800	7.9428100	7.8988900	7.4626800	6.7934700	7.4183000
		K (mol/g)	19647.390	25387.190	16293.140	29637.620	22094.850	37145.570

Table 4.105 Freundlich constants for the adsorption of acid dyes on carbon samples

Dye	Sample	Constants	SO carbon		AB charcoal		RG carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid yellow 34	Raw	n	1.8497900	1.7108000	xxxx	xxxx	xxxx	xxxx
		K (mol/g)	362.41800	1023.5100	xxxx	xxxx	xxxx	xxxx
	400 °C	n	8296.5900	9954.6900	xxxx	xxxx	922.88070	1018.5140
		K (mol/g)	8296.5900	9954.6900	xxxx	xxxx	922.88070	1018.5140
	600 °C	n	4.2607500	4.8756700	1.4723200	2.1673160	3.8925600	4.2122000
		K (mol/g)	18670.490	21899.080	85.944300	475.13540	2953.7700	5518.7100
	800 °C	n	6.1199500	5.8343000	4.1580000	4.9504900	4.5187500	5.2465000
		K (mol/g)	22114.740	46202.990	2254.3100	3022.0700	6039.0370	7611.38100
	900 °C	n	6.8119890	6.4267300	4.9736500	15.015010	4.7393300	5.50055000
		K (mol/g)	23694.540	49463.970	3080.9700	9649.8700	6477.5600	8050.58000
	1000 °C	n	13.623970	7.6103500	4.8732900	4.1666600	5.0813000	5.77700000
		K (mol/g)	38793.100	56398.6200	21601.1100	30625.850	7149.5100	8521.09000
Acid orange 7	Raw	n	1.3931400	1.8335100	xxxx	xxxx	xxxx	xxxx
		K (mol/g)	147.62800	531.92300	xxxx	xxxx	xxxx	xxxx
	400 °C	n	1.8960900	1.8436500	xxxx	xxxx	2.8232000	3.6218700
		K (mol/g)	651.12300	930.29300	xxxx	xxxx	2662.9700	4170.9500
	600 °C	n	1.9040300	1.9164400	2.4789200	2.3657000	1.3324400	1.6866200
		K (mol/g)	1328.2260	1573.2500	30.253100	44.620700	8140.4400	29569.500
	800 °C	n	1.9230700	2.9316900	1.1336500	1.4858000	1.3777900	1.4843000
		K (mol/g)	2263.3400	4041.2120	78.309200	192.90500	12269.800	32305.700
	900 °C	n	3.3955800	3.9184900	2.2614200	3.1565600	1.1072900	1.4637000
		K (mol/g)	2725.4800	3903.3800	106.83600	370.29500	19164.210	146810.80
	1000 °C	n	5.0327100	5.3219700	4.6019300	7.9872200	1.2232400	1.4442500
		K (mol/g)	7485.3200	7823.5900	1017.5900	2476.7400	21343.440	221460.60
Acid orange 10	Raw	n	2.9726000	3.0835600	xxxx	xxxx	xxxx	xxxx
		K (mol/g)	5949.1200	15367.340	xxxx	xxxx	xxxx	xxxx
	400 °C	n	2.6028100	2.5000000	xxxx	xxxx	1.6909000	2.3815100
		K (mol/g)	23411.910	33423.010	xxxx	xxxx	269.88600	342.85200
	600 °C	n	3.6010000	7.1073200	2.0379000	2.3934000	1.8181800	2.4764000
		K (mol/g)	47051.590	145509.90	10.77.1700	1923.11200	700.36300	2381.5300
	800 °C	n	3.8759600	4.5808500	1.7630400	1.98728000	2.082800	2.1877000
		K (mol/g)	68322.800	141209.50	3253.8600	14650.0600	914.42900	1049.8400
	900 °C	n	3.2020400	3.4916200	2.1561000	1.93986000	2.1021600	1.7461100
		K (mol/g)	17693.710	220113.80	7798.6000	58413.3000	2322.2600	4827.5700
	1000 °C	n	2.8702600	4.3687000	1.7667800	1.92490000	2.3523000	1.6447300
		K (mol/g)	342525.00	384000.80	13442.810	113493.400	3751.8600	12667.560

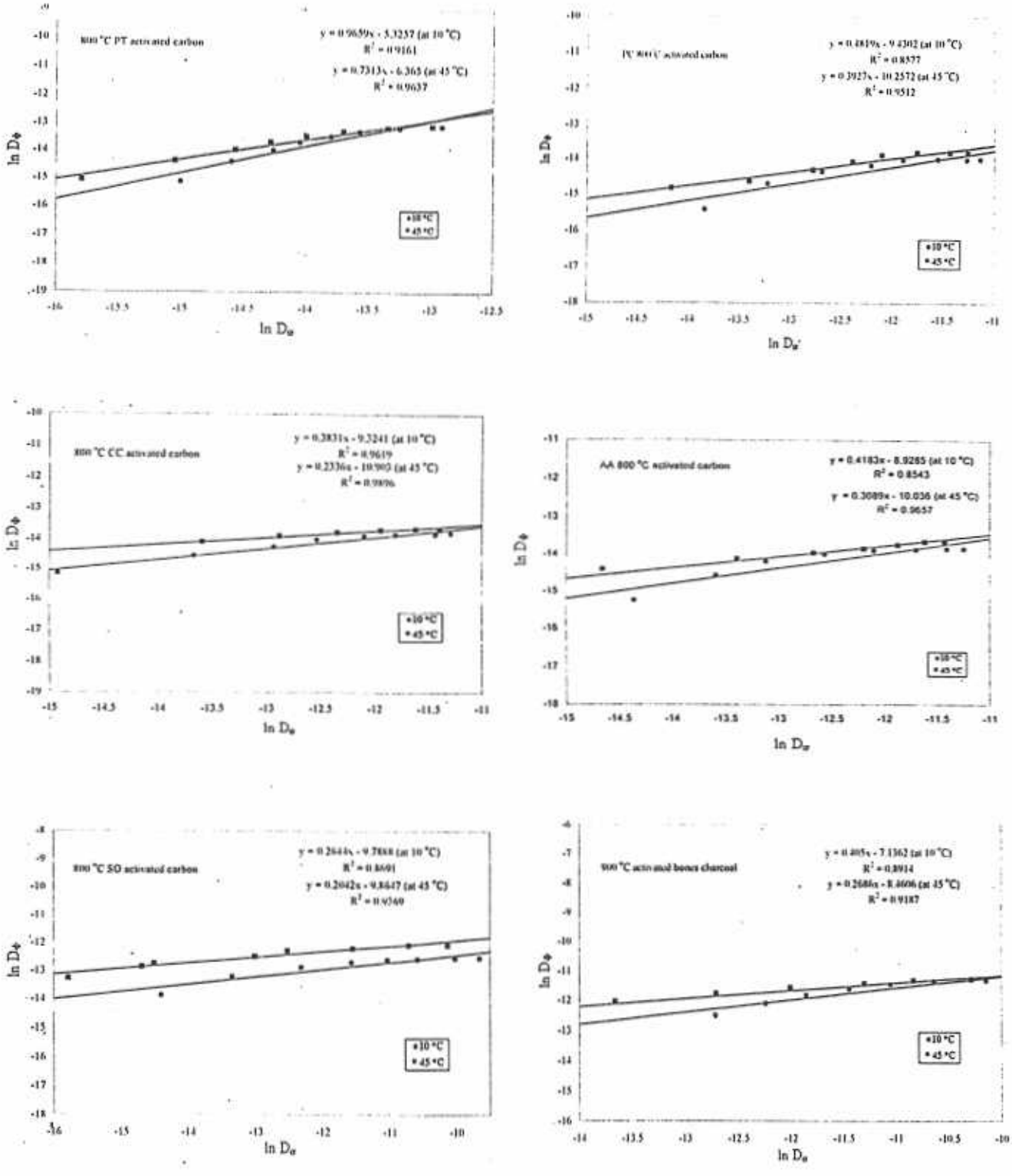


Figure 4.105 Freundlich plots for the adsorption of acid blue 1 on 800 °C activated carbon samples

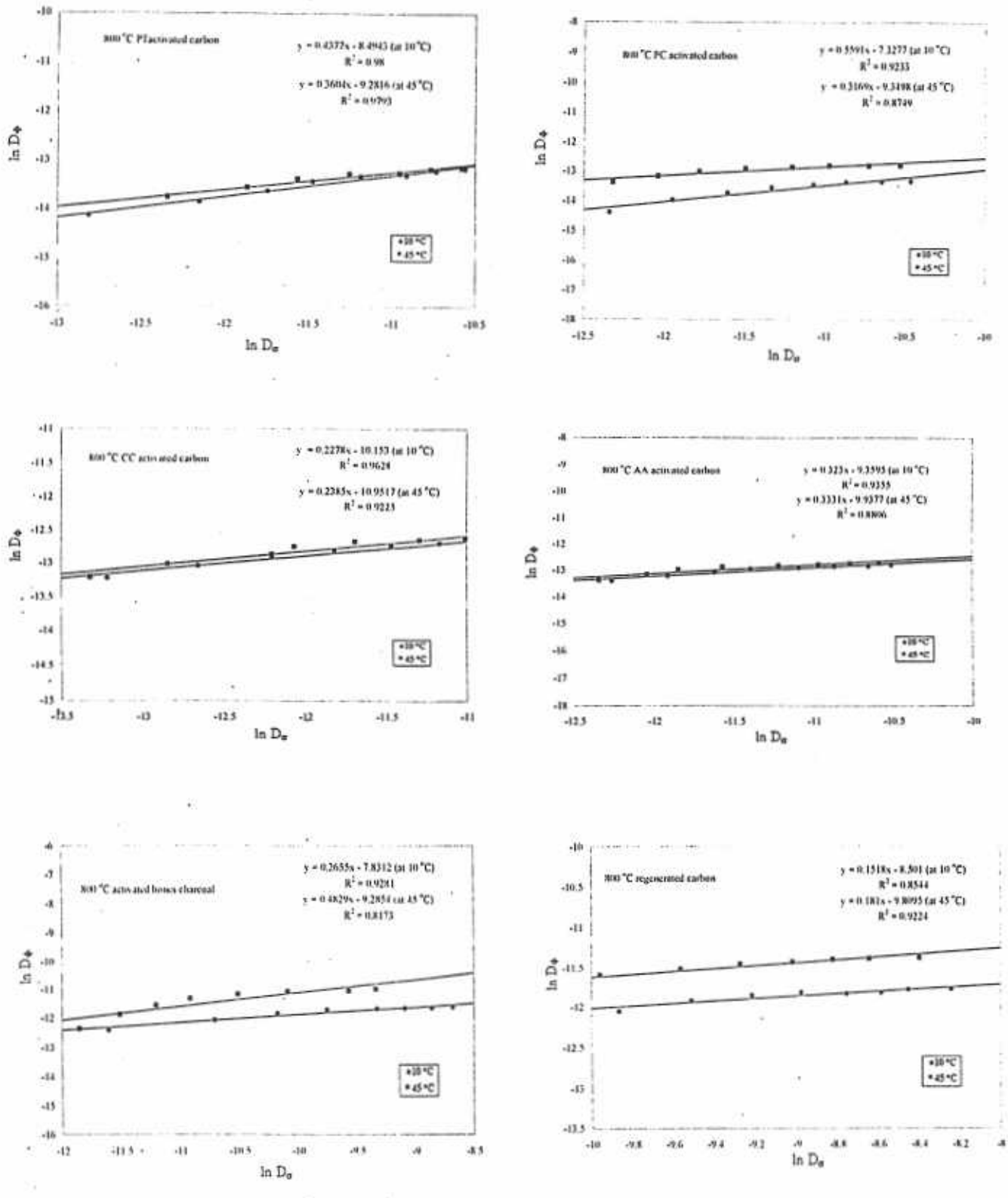


Figure 4.106 Freundlich plots for the adsorption of brilliant blue R on 800 °C activated carbon samples

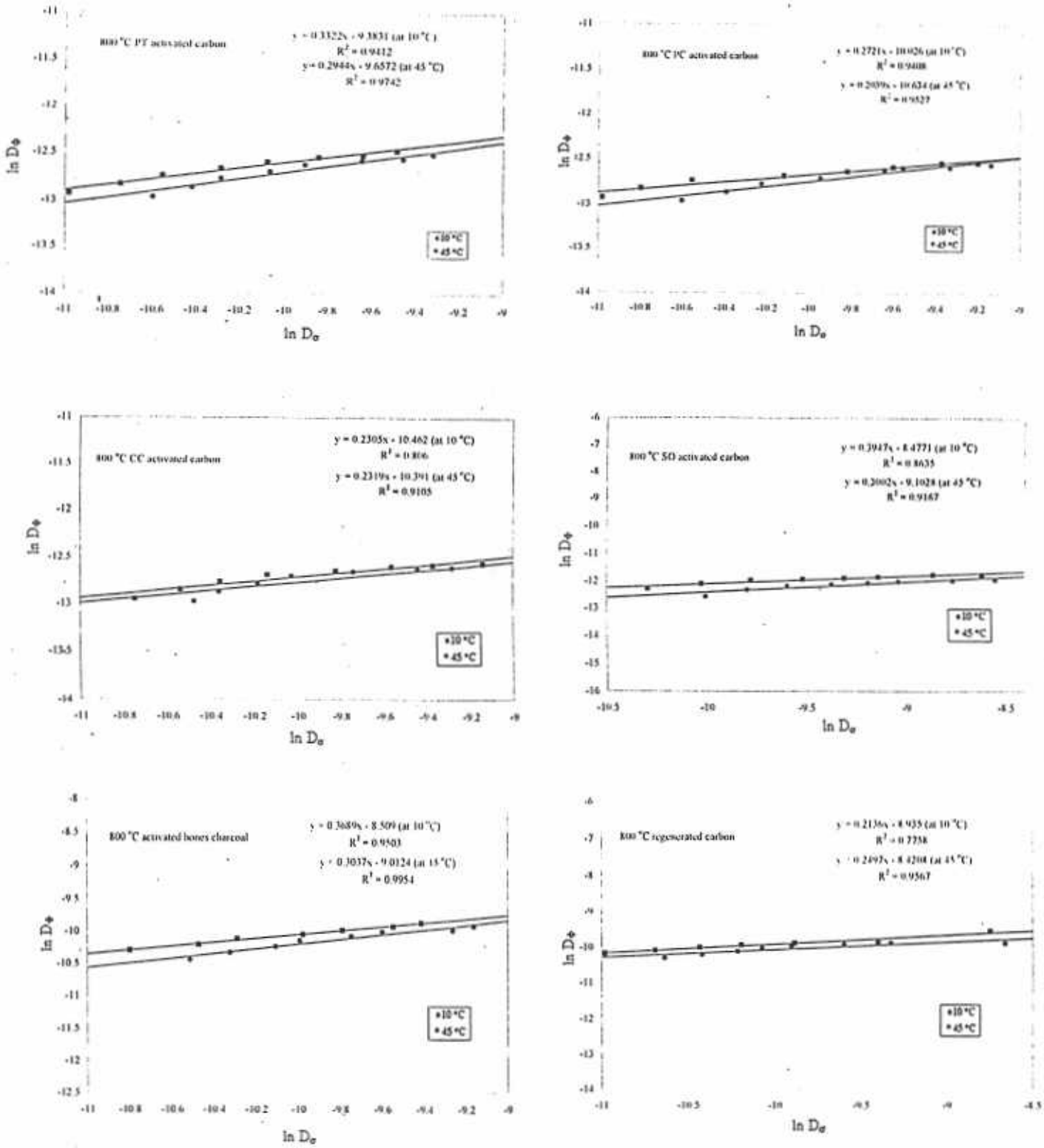


Figure 4.107 Freundlich plots for the adsorption of acid yellow 29 on 800 °C activated carbon samples

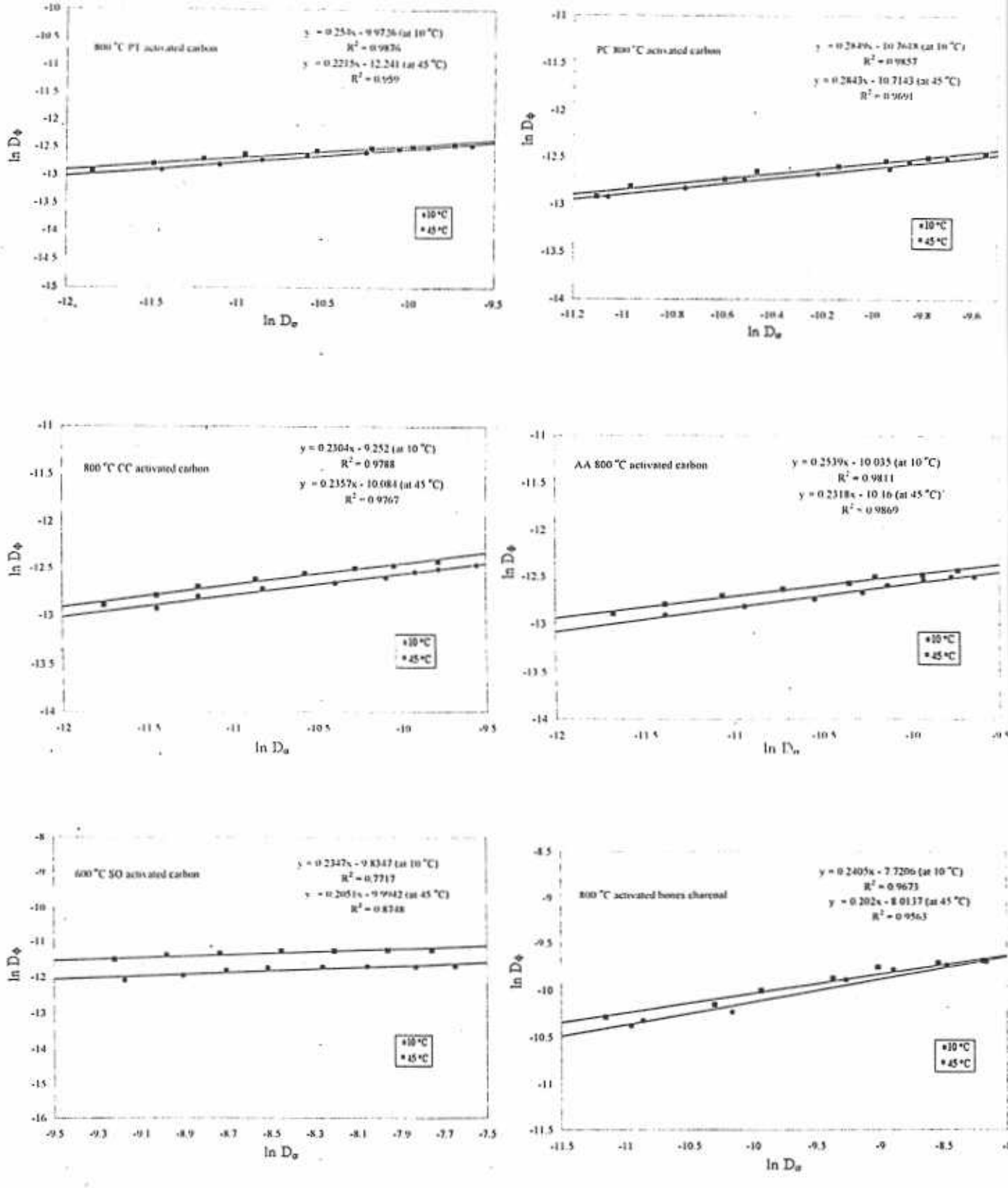


Figure 4.108 Freundlich plots for the adsorption of acid yellow 34 on 800 °C activated carbon samples

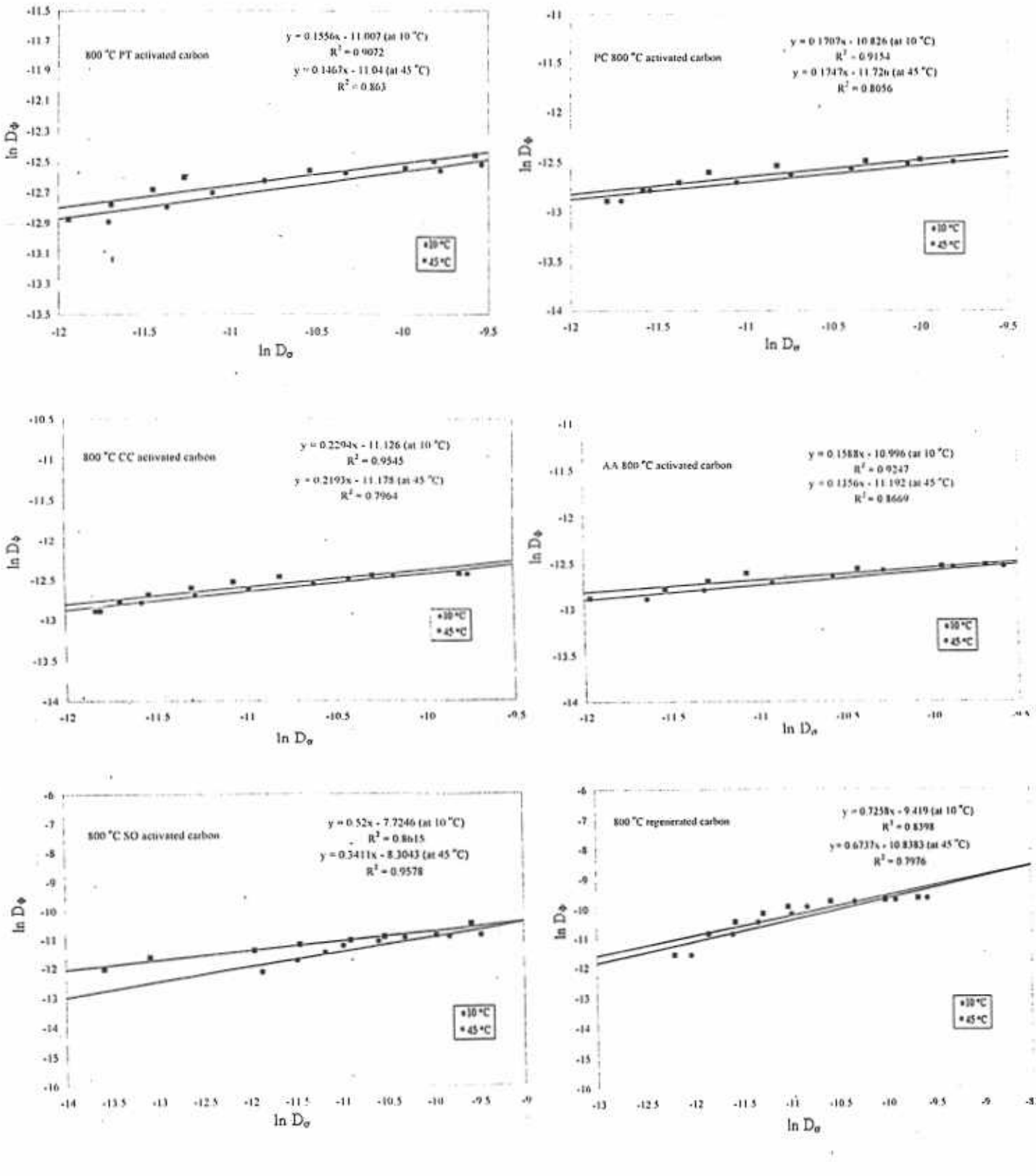


Figure 4.109 Freundlich plots for the adsorption of acid orange 7 on 800 °C activated carbon samples

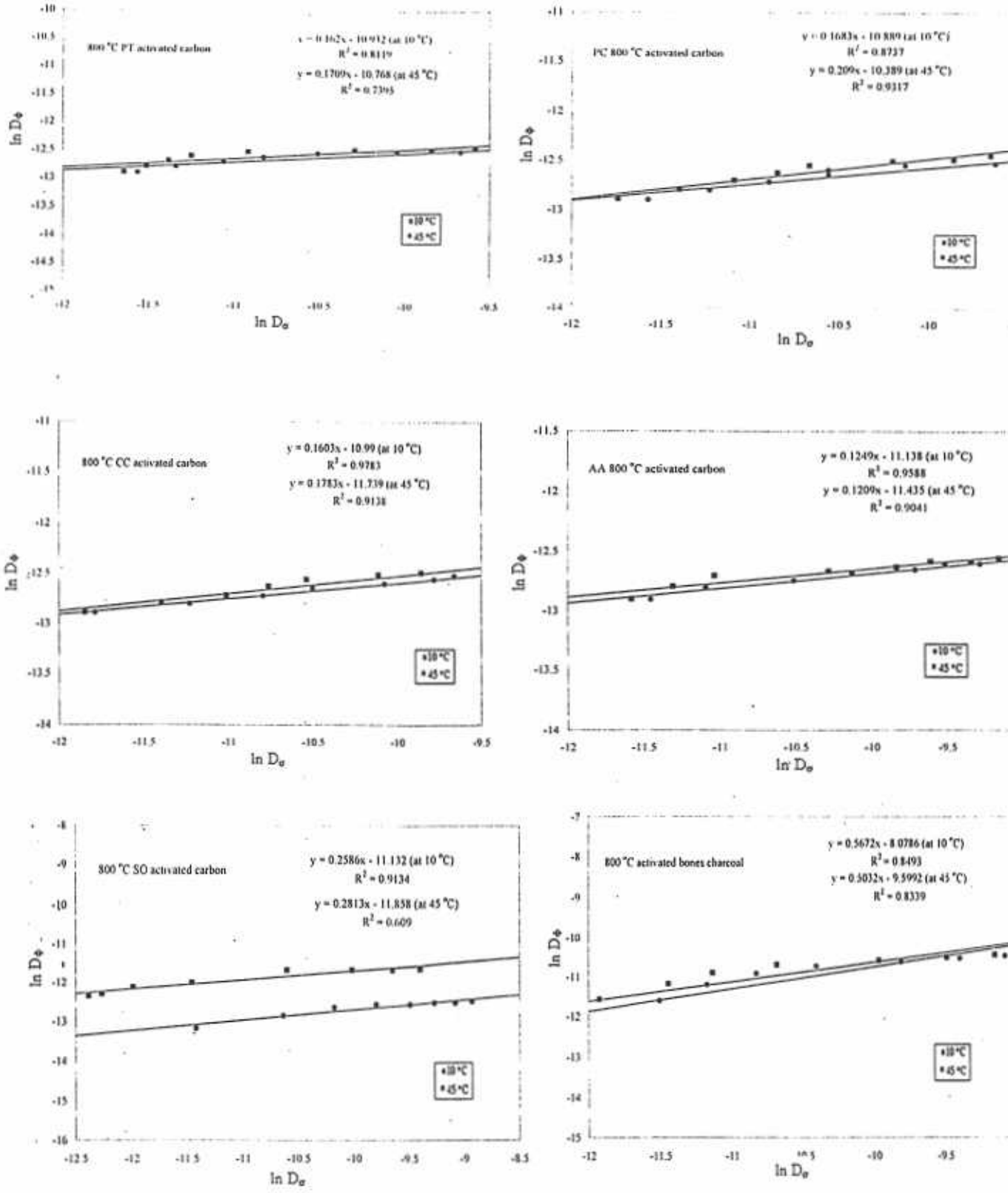


Figure 4.110 Freundlich plots for the adsorption of acid orange 10 on 800 °C activated carbon samples

Table 4.106 Langmuir constants for the adsorption of dyes on carbon samples

Dye	Sample	Constants	PT carbon		PC carbon		CC carbon		AA carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid blue 1	Raw	b (mol. g^{-1})	0.17424	0.17689	0.06895	0.08769	0.08010	0.08835	0.06980	0.08440
		K_l (dm^3. g^{-1})	2.38468	2.60660	3.96970	4.92320	3.73610	5.35410	3.15230	5.54120
	400 °C	b (mol. g^{-1})	0.21262	0.23816	0.08755	0.10589	0.10410	0.10925	0.11530	0.12120
		K_l (dm^3. g^{-1})	1.40240	1.68930	3.84450	3.78990	5.04330	7.52800	2.10650	2.79850
	800 °C	b (mol. g^{-1})	0.39551	0.42303	0.10310	0.12772	0.11666	0.12300	0.11910	0.12840
		K_l (dm^3. g^{-1})	4.96530	5.79520	3.74150	3.71440	6.86570	21.1940	6.20930	9.56423
Brilliant blue R	Raw	b (mol. g^{-1})	0.13601	0.14053	0.16463	0.18505	0.18456	0.19940	0.18274	0.19551
		K_l (dm^3. g^{-1})	0.54370	0.75450	0.29490	0.5213	0.60020	1.21600	0.46350	0.64770
	400 °C	b (mol. g^{-1})	0.20988	0.22699	0.18428	0.28498	0.19845	0.22076	0.18511	0.20372
		K_l (dm^3. g^{-1})	0.82360	1.09600	0.62240	0.48550	1.77410	2.46960	0.90550	0.98040
	800 °C	b (mol. g^{-1})	0.22833	0.24992	0.24443	0.33338	0.34953	0.36542	0.32646	0.35355
		K_l (dm^3. g^{-1})	2.17950	2.95750	0.83840	2.44180	5.34260	6.51720	1.98910	2.17320
Acid yellow 29	Raw	b (mol. g^{-1})	0.22054	0.25449	0.25456	0.29676	0.22837	0.26965	0.25336	0.26495
		K_l (dm^3. g^{-1})	0.84060	2.29760	0.31890	0.44490	0.43680	0.87280	0.35760	0.66220
	400 °C	b (mol. g^{-1})	0.43079	0.36657	0.28238	0.38467	0.34079	0.35100	0.31568	0.37310
		K_l (dm^3. g^{-1})	0.30680	0.8960	0.42630	0.41980	0.36520	0.70890	0.50910	0.72645
	800 °C	b (mol. g^{-1})	0.47474	0.45486	0.33079	0.39584	0.38046	0.39668	0.38510	0.39307
		K_l (dm^3. g^{-1})	0.39960	0.6780	0.71950	0.97430	0.73540	0.79070	0.59070	0.80700
Acid yellow 34	Raw	b (mol. g^{-1})	0.23921	0.28124	0.34508	0.35098	0.28158	0.29492	0.28161	0.28779
		K_l (dm^3. g^{-1})	1.88490	3.89700	0.35090	0.54970	0.77910	1.08250	0.75430	0.93010
	400 °C	b (mol. g^{-1})	0.29139	0.39345	0.37720	0.39209	0.38892	0.41790	0.37947	0.41490
		K_l (dm^3. g^{-1})	1.57020	2.45470	0.86591	1.02670	0.99880	1.23250	0.89350	1.09810
	800 °C	b (mol. g^{-1})	0.44708	0.43412	0.45076	0.45648	0.42961	0.49529	0.45151	0.48379
		K_l (dm^3. g^{-1})	1.07630	1.77630	0.68180	0.79100	1.11600	1.35730	0.82380	1.28060
Acid orange 7	Raw	b (mol. g^{-1})	0.24339	0.30462	0.27026	0.27568	0.22801	0.28213	0.30512	0.31448
		K_l (dm^3. g^{-1})	1.02160	1.62560	0.80060	0.92380	1.27890	1.45790	0.77690	0.88560
	400 °C	b (mol. g^{-1})	0.39027	0.39568	0.35819	0.36269	0.35434	0.38482	0.35608	0.38322
		K_l (dm^3. g^{-1})	1.34390	1.74420	1.81900	2.10080	1.65170	1.74420	1.43980	1.65720
	800 °C	b (mol. g^{-1})	0.39407	0.40228	0.39796	0.40630	0.44265	0.44600	0.38476	0.39888
		K_l (dm^3. g^{-1})	2.16770	2.90700	2.32170	2.93420	1.82120	2.42230	2.16710	3.15660
Acid orange 10	Raw	b (mol. g^{-1})	0.27360	0.31010	0.22006	0.23343	0.25775	0.26848	0.25259	0.27894
		K_l (dm^3. g^{-1})	0.69270	0.9040	0.82000	0.78710	0.58560	0.89120	0.84130	0.97270
	400 °C	b (mol. g^{-1})	0.38313	0.38424	0.37126	0.37322	0.32966	0.33981	0.33584	0.36797
		K_l (dm^3. g^{-1})	1.27620	1.51070	0.95641	1.08070	1.98360	2.09700	1.36440	1.46130
	800 °C	b (mol. g^{-1})	0.38808	0.41354	0.38975	0.42279	0.38871	0.40175	0.35311	0.39143
		K_l (dm^3. g^{-1})	2.52030	2.37840	1.87140	1.93680	1.86520	2.28100	2.01920	2.84263

Table 4.107 Langmuir constants for the adsorption of dyes on carbon samples

Dye	Sample	Constants	SO carbon		AB charcoal		RG. carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid blue 1	Raw	b (mol. g^{-1})	0.339000	0.463910	xxxx	xxxx	xxxx	xxxx
		K_l (dm^3. g^{-1})	0.417000	0.516423	xxxx	xxxx	xxxx	xxxx
	400 °C	b (mol. g^{-1})	0.624220	0.796050	xxxx	xxxx	1.869510	1.997600
		K_l (dm^3. g^{-1})	0.245800	0.321200	xxxx	xxxx	0.468800	1.271500
	600 °C	b (mol. g^{-1})	0.527670	0.875580	1.038420	1.137650	3.048780	3.281920
		K_l (dm^3. g^{-1})	0.739400	0.839600	0.798100	1.716400	0.987000	1.499500
	800 °C	b (mol. g^{-1})	0.666000	0.993340	1.686910	2.074690	3.463803	3.845110
		K_l (dm^3. g^{-1})	3.227600	5.534300	0.755800	1.826400	1.396700	2.313700
	900 °C	b (mol. g^{-1})	1.067660	1.601020	2.023880	2.474020	4.156275	4.478280
		K_l (dm^3. g^{-1})	15.53270	18.37060	0.996300	2.304400	1.903400	2.313700
	1000 °C	b (mol. g^{-1})	1.408650	1.627600	2.436765	2.773070	4.599820	4.835589
		K_l (dm^3. g^{-1})	3.295700	4.679300	1.257600	3.357600	3.269100	5.891700
Brilliant blue R	Raw	b (mol. g^{-1})	1.767720	3.322300	xxxx	xxxx	xxxx	xxxx
		K_l (dm^3. g^{-1})	0.052631	0.199400	xxxx	xxxx	xxxx	xxxx
	400 °C	b (mol. g^{-1})	2.007630	3.306870	xxxx	xxxx	0.448792	0.692664
		K_l (dm^3. g^{-1})	0.254600	0.363400	xxxx	xxxx	0.085000	0.219000
	600 °C	b (mol. g^{-1})	3.304690	3.377230	0.937209	1.041120	0.606423	1.178689
		K_l (dm^3. g^{-1})	0.267100	0.655000	0.156600	1.001900	0.321600	0.409900
	800 °C	b (mol. g^{-1})	3.327780	3.494060	0.969086	2.088118	0.820479	1.235483
		K_l (dm^3. g^{-1})	0.506400	1.121910	0.771800	0.561800	0.544500	0.623100
	900 °C	b (mol. g^{-1})	3.371540	3.486750	1.042752	2.070390	0.976650	1.309760
		K_l (dm^3. g^{-1})	0.700680	1.185120	1.315300	0.728300	0.520500	0.947600
	1000 °C	b (mol. g^{-1})	3.455420	3.611412	1.140771	2.407890	1.346619	1.426126
		K_l (dm^3. g^{-1})	1.483300	1.588600	1.735800	1.190300	0.214800	1.010900
Acid yellow 29	Raw	b (mol. g^{-1})	0.251490	0.277307	xxxx	xxxx	xxxx	xxxx
		K_l (dm^3. g^{-1})	0.038000	0.123100	xxxx	xxxx	xxxx	xxxx
	400 °C	b (mol. g^{-1})	0.396290	0.621389	xxxx	xxxx	4.008020	4.353500
		K_l (dm^3. g^{-1})	0.175870	0.043000	xxxx	xxxx	0.154400	0.247400
	600 °C	b (mol. g^{-1})	0.855724	0.861400	4.120310	5.691519	5.274260	5.356180
		K_l (dm^3. g^{-1})	0.119380	0.232600	0.324300	0.589500	0.491700	0.614100
	800 °C	b (mol. g^{-1})	0.856160	0.929280	6.305170	6.493500	5.509642	5.449590
		K_l (dm^3. g^{-1})	0.189700	0.332300	0.336000	0.557300	0.860100	1.694300
	900 °C	b (mol. g^{-1})	1.338860	1.352080	6.459948	6.906077	6.333120	6.514657
		K_l (dm^3. g^{-1})	1.091600	1.776100	0.498300	1.158400	0.592200	0.813800
	1000 °C	b (mol. g^{-1})	1.424901	1.464129	7.230657	7.462686	7.656967	7.782101
		K_l (dm^3. g^{-1})	1.027000	1.828150	2.191700	3.244500	0.706700	1.626500

Table 4.108 Langmuir constants for the adsorption of dyes on carbon samples

Dye	Sample	Constants	SO carbon		AB charcoal		RG carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid yellow 34	Raw	b (mol. g^{-1})	0.853387	1.010200	xxxx	xxxx	xxxx	xxxx
		K_l (dm^3. g^{-1})	8.621000	17.13900	xxxx	xxxx	xxxx	xxxx
	400 °C	b (mol. g^{-1})	0.875500	1.350438	xxxx	xxxx	3.759398	7.874010
		K_l (dm^3. g^{-1})	0.096500	0.16430	xxxx	xxxx	0.032800	0.045300
	600 °C	b (mol. g^{-1})	0.937380	1.435956	4.743833	5.402485	8.110300	8.149950
		K_l (dm^3. g^{-1})	0.195000	0.275300	0.080800	0.166400	0.205500	0.241700
	800 °C	b (mol. g^{-1})	1.292150	1.580270	6.729475	7.132667	8.149959	8.333330
		K_l (dm^3. g^{-1})	0.395600	0.373900	0.335900	0.410600	0.312770	0.407100
	900 °C	b (mol. g^{-1})	1.376841	1.643925	7.022472	7.142857	8.333330	8.431700
		K_l (dm^3. g^{-1})	0.495400	0.467700	0.410400	0.589200	0.349500	0.473400
	1000 °C	b (mol. g^{-1})	1.417430	1.767096	7.645259	8.223684	5.847953	6.234414
		K_l (dm^3. g^{-1})	2.100300	3.216450	0.474900	0.926100	0.586800	0.747000
Acid orange 7	Raw	b (mol. g^{-1})	1.496334	1.572079	xxxx	xxxx	xxxx	xxxx
		K_l (dm^3. g^{-1})	0.150950	0.22626	xxxx	xxxx	xxxx	xxxx
	400 °C	b (mol. g^{-1})	1.702997	1.827819	xxxx	xxxx	2.490660	2.636435
		K_l (dm^3. g^{-1})	0.215700	0.267700	xxxx	xxxx	0.189460	0.510150
	600 °C	b (mol. g^{-1})	1.847060	2.023470	5.665720	6.353240	5.194805	6.357279
		K_l (dm^3. g^{-1})	0.261360	0.283600	0.296700	0.504300	0.259200	0.515300
	800 °C	b (mol. g^{-1})	2.515090	3.679176	7.993600	8.583690	7.968127	8.944543
		K_l (dm^3. g^{-1})	0.508700	1.280260	0.551800	1.008650	0.490230	0.582200
	900 °C	b (mol. g^{-1})	3.537318	4.253509	8.110300	9.615380	8.203445	9.532888
		K_l (dm^3. g^{-1})	1.429900	3.037460	1.771550	3.598600	0.254300	0.312800
	1000 °C	b (mol. g^{-1})	4.113533	4.773269	10.26690	13.92757	8.312550	10.16260
		K_l (dm^3. g^{-1})	0.504400	2.277100	3.746160	12.82140	0.476200	0.858700
Acid orange 10	Raw	b (mol. g^{-1})	0.050191	0.056821	xxxx	xxxx	xxxx	xxxx
		K_l (dm^3. g^{-1})	0.336300	0.384990	xxxx	xxxx	xxxx	xxxx
	400 °C	b (mol. g^{-1})	0.089598	0.094500	xxxx	xxxx	0.565003	0.583976
		K_l (dm^3. g^{-1})	0.237700	0.341800	xxxx	xxxx	0.07670	0.127600
	600 °C	b (mol. g^{-1})	0.172155	0.204616	1.804729	1.924557	1.634789	1.651800
		K_l (dm^3. g^{-1})	0.397100	1.214720	0.156010	0.633170	0.161480	0.199800
	800 °C	b (mol. g^{-1})	0.403697	0.927040	3.612716	4.965243	1.997204	2.293577
		K_l (dm^3. g^{-1})	0.835300	2.144500	0.362900	0.401400	0.225400	0.316600
	900 °C	b (mol. g^{-1})	1.118818	1.24254	4.992511	6.653359	2.156102	2.951590
		K_l (dm^3. g^{-1})	4.424700	7.01040	0.492500	0.669100	0.246200	0.242900
	1000°C	b (mol. g^{-1})	1.251090	1.418239	7.412899	9.407337	2.049180	2.687449
		K_l (dm^3. g^{-1})	2.712200	9.145260	0.450110	0.801000	0.310200	0.440300

Table 4.110 Gibbs free energy (ΔG^{o}) for the adsorption of dyes on carbon samples

Dye	Sample	K_T and $\Delta G^{\#}$	PT carbon		PC carbon		CC carbon		AA carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid blue 1	Raw	K_T ($l\ mol^{-1}$)	98.7380	100.240	39.0730	49.692	45.391	50.066	39.554	47.828
		ΔG^{o} ($kJ.mol^{-1}$)	-10.8054	-12.1817	-8.62420	-10.3265	-8.97691	10.3463	-8.65304	-10.2254
	400 °C	K_T ($l\ mol^{-1}$)	120.487	134.960	49.6130	60.0060	58.9914	61.909	65.338	68.682
		ΔG^{o} ($kJ.mol^{-1}$)	-11.2738	-12.9680	-9.18620	-10.8251	-9.59354	-10.9076	-2.83390	-11.1821
	800 °C	K_T ($l\ mol^{-1}$)	224.120	239.720	58.4240	72.3760	66.109	69.7016	67.492	72.762
		ΔG^{o} ($kJ.mol^{-1}$)	-12.7341	-14.4869	-9.5708	-11.3206	-9.86160	-11.2211	-9.91027	-11.3347
Brilliant blue R	Raw	K_T ($l\ mol^{-1}$)	112.340	116.070	135.980	152.850	152.445	164.702	150.94	161.489
		ΔG^{o} ($kJ.mol^{-1}$)	-11.1091	-12.5694	-11.5584	-13.2971	-11.8274	-13.4946	-11.8342	-13.5512
	400 °C	K_T ($l\ mol^{-1}$)	173.359	187.490	152.210	235.390	163.917	182.340	152.89	168.27
		ΔG^{o} ($kJ.mol^{-1}$)	-12.1298	-13.8377	-11.9981	-12.2487	-11.9981	-13.7636	-11.8342	-13.5512
	800 °C	K_T ($l\ mol^{-1}$)	188.590	206.430	201.890	275.370	288.710	301.833	269.65	292.03
		ΔG^{o} ($kJ.mol^{-1}$)	-12.3279	-14.0916	-13.3302	-15.0961	-13.3299	-15.0961	-13.1692	-15.0087
Acid yellow 29	Raw	K_T ($l\ mol^{-1}$)	125.70	145.05	145.090	169.150	130.166	153.69	144.41	151.02
		ΔG^{o} ($kJ.mol^{-1}$)	-11.3735	-13.1586	-11.7110	-13.5650	-11.4556	-13.3116	-11.6999	-13.2653
	400 °C	K_T ($l\ mol^{-1}$)	245.54	208.94	160.950	219.250	194.24	200.06	179.93	212.65
		ΔG^{o} ($kJ.mol^{-1}$)	-12.9489	-14.1236	-11.9551	-14.2501	-12.3974	-14.0087	-12.2174	-14.1701
	800 °C	K_T ($l\ mol^{-1}$)	-270.59	259.26	188.210	225.221	216.85	226.09	219.49	224.04
		ΔG^{o} ($kJ.mol^{-1}$)	-13.1774	-14.6941	-12.3232	-14.3219	-12.6565	-14.3321	-12.6850	-14.3081
Acid yellow 34	Raw	K_T ($l\ mol^{-1}$)	99.226	116.660	143.140	145.590	116.802	122.07	116.77	119.38
		ΔG^{o} ($kJ.mol^{-1}$)	-10.8170	-12.5827	-11.6792	-13.1685	-11.2007	-12.7026	-11.2001	-12.6437
	400 °C	K_T ($l\ mol^{-1}$)	120.870	163.210	156.470	162.640	161.33	173.35	157.41	172.10
		ΔG^{o} ($kJ.mol^{-1}$)	-11.2813	-13.4705	-11.8887	-13.4613	-11.9606	-13.6298	-11.9028	-13.6107
	800 °C	K_T ($l\ mol^{-1}$)	185.450	180.070	186.980	189.350	178.21	205.45	187.29	200.68
		ΔG^{o} ($kJ.mol^{-1}$)	-12.2885	-13.7304	-12.3078	-13.8633	-12.1947	-14.0790	-12.3117	-14.0161
Acid orange 7	Raw	K_T ($l\ mol^{-1}$)	85.266	106.710	94.680	96.570	79.870	98.870	124.745	110.17
		ΔG^{o} ($kJ.mol^{-1}$)	-10.4603	-12.3471	-10.7067	-12.0831	-10.3065	-12.1443	-11.3555	-12.4315
	400 °C	K_T ($l\ mol^{-1}$)	136.170	138.620	125.480	127.060	124.130	134.810	124.740	134.250
		ΔG^{o} ($kJ.mol^{-1}$)	-11.5712	-13.0387	-11.3694	-12.8085	-11.3439	-12.9651	-11.3554	-12.9541
	800 °C	K_T ($l\ mol^{-1}$)	138.050	140.930	139.420	142.340	155.070	156.250	134.790	139.740
		ΔG^{o} ($kJ.mol^{-1}$)	-11.5940	-13.0832	-11.6172	-13.1088	-11.8675	-13.3553	-11.5377	-13.0601
Acid orange 10	Raw	K_T ($l\ mol^{-1}$)	123.770	131.910	93.610	99.290	109.640	114.210	107.450	118.650
		ΔG^{o} ($kJ.mol^{-1}$)	-11.3371	-12.9026	-10.6799	-12.1565	-11.0518	-12.5266	-11.0044	-12.6275
	400 °C	K_T ($l\ mol^{-1}$)	173.320	173.450	167.950	168.840	149.130	153.720	151.930	166.460
		ΔG^{o} ($kJ.mol^{-1}$)	-12.1293	-13.6314	-12.0552	-13.5602	-11.7756	-13.3121	-11.8194	-13.5226
	800 °C	K_T ($l\ mol^{-1}$)	175.560	187.070	176.310	191.260	175.840	181.740	159.740	177.07
		ΔG^{o} ($kJ.mol^{-1}$)	-12.1595	-13.8313	-12.1696	-13.8898	-12.1633	-13.7548	-11.9374	-13.6862

Table 4.111 Gibbs free energy (ΔG^o) for the adsorption of dyes on carbon samples

Dye	Sample	Constants	SO carbon		AB charcoal		RG carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid blue-1	Raw	K_T ($l\ mol^{-1}$)	192.104	262.8890	xxxx	xxxx	xxxx	xxxx
		ΔG^o ($kJ.mol^{-1}$)	-12.3714	-14.7308	xxxx	xxxx	xxxx	xxxx
	400 °C	K_T ($l\ mol^{-1}$)	353.733	451.106	xxxx	xxxx	1059.41	1131.99
		ΔG^o ($kJ.mol^{-1}$)	-13.8078	-16.1584	xxxx	xxxx	-16.3888	-18.5909
	600 °C	K_T ($l\ mol^{-1}$)	299.020	496.173	588.450	644.680	1727.68	1859.79
		ΔG^o ($kJ.mol^{-1}$)	-13.4125	-16.4102	-15.0053	-17.1024	-17.5395	-19.9035
	800 °C	K_T ($l\ mol^{-1}$)	377.410	562.906	955.940	1175.69	1292.86	2178.94
		ΔG^o ($kJ.mol^{-1}$)	-13.9603	-16.7438	-16.1469	-18.6910	-16.8573	-20.3222
	900 °C	K_T ($l\ mol^{-1}$)	605.022	907.266	1146.89	1401.90	2355.28	2537.75
		ΔG^o ($kJ.mol^{-1}$)	-15.0707	-18.0057	-16.5755	-19.1563	-18.2686	-20.7252
	1000 °C	K_T ($l\ mol^{-1}$)	798.253	922.330	1380.87	1571.44	2606.62	2740.23
		ΔG^o ($kJ.mol^{-1}$)	-15.7228	-18.0493	-17.0123	-19.4581	-18.5072	-20.9282
Brilliant blue R	Raw	K_T ($l\ mol^{-1}$)	1460.12	2744.18	xxxx	xxxx	xxxx	xxxx
		ΔG^o ($kJ.mol^{-1}$)	-17.14359	-20.9320	xxxx	xxxx	xxxx	xxxx
	400 °C	K_T ($l\ mol^{-1}$)	1658.28	2731.44	xxxx	xxxx	370.690	572.130
		ΔG^o ($kJ.mol^{-1}$)	-17.4430	-20.9197	xxxx	xxxx	-13.9180	-16.7868
	600 °C	K_T ($l\ mol^{-1}$)	2729.60	2789.60	774.130	859.950	500.890	973.580
		ΔG^o ($kJ.mol^{-1}$)	-18.6156	-20.9754	-15.6506	-17.8642	-14.6263	-18.1923
	800 °C	K_T ($l\ mol^{-1}$)	27448.7	2886.05	801.090	1724.76	677.700	1020.49
		ΔG^o ($kJ.mol^{-1}$)	-18.63210	-21.0653	-15.7312	-19.7042	-15.3376	-18.3167
	900 °C	K_T ($l\ mol^{-1}$)	2784.80	2880.00	861.300	1710.12	806.700	1081.85
		ΔG^o ($kJ.mol^{-1}$)	-18.6627	-21.0597	-15.9016	-19.6817	-15.7476	-18.4710
	1000 °C	K_T ($l\ mol^{-1}$)	2854.14	2982.99	942.260	1988.89	1112.29	1177.97
		ΔG^o ($kJ.mol^{-1}$)	-18.7206	-21.1526	-16.1131	-20.0809	-16.5034	-18.6961
Acid yellow 29	Raw	K_T ($l\ mol^{-1}$)	143.340	158.060	xxxx	xxxx	xxxx	xxxx
		ΔG^o ($kJ.mol^{-1}$)	-11.6824	-13.3857	xxxx	xxxx	xxxx	xxxx
	400 °C	K_T ($l\ mol^{-1}$)	225.870	354.180	xxxx	xxxx	2284.50	2481.40
		ΔG^o ($kJ.mol^{-1}$)	-12.7524	-15.5189	xxxx	xxxx	-18.1968	-20.6659
	600 °C	K_T ($l\ mol^{-1}$)	487.740	490.981	2348.5	3244.05	3006.22	3052.90
		ΔG^o ($kJ.mol^{-1}$)	-14.5637	-16.3824	-18.2618	-21.3744	-18.8428	-21.2138
	800 °C	K_T ($l\ mol^{-1}$)	487.990	529.670	3593.8	3701.165	3140.38	3106.15
		ΔG^o ($kJ.mol^{-1}$)	-14.5649	-16.5829	-19.2628	-21.7229	-18.9455	-21.2596
	900 °C	K_T ($l\ mol^{-1}$)	763.120	770.660	3682.04	3936.33	3609.75	3713.22
		ΔG^o ($kJ.mol^{-1}$)	-14.5649	-16.5829	-19.3198	-21.8858	-19.2732	-21.7316
	1000 °C	K_T ($l\ mol^{-1}$)	812.165	834.52	4121.33	6492.4	4364.30	4435.60
		ΔG^o ($kJ.mol^{-1}$)	-15.7635	-17.7848	-19.5851	-23.2088	-19.7198	-22.2015

Table 4.112 Gibbs free energy (ΔG^o) for the adsorption of dyes on carbon samples

Dye	Sample	Constants	SO carbon		AB charcoal		RG carbon	
			10 °C	45 °C	10 °C	45 °C	10 °C	45 °C
Acid yellow 34	Raw	K_T ($l\ mol^{-1}$)	253.990	419.040	xxxx	xxxx	xxxx	xxxx
		ΔG^o ($kJ.mol^{-1}$)	-14.7768	-15.9634	xxxx	xxxx	xxxx	xxxx
	400 °C	K_T ($l\ mol^{-1}$)	363.166	560.170	xxxx	xxxx	1559.40	3266.20
		ΔG^o ($kJ.mol^{-1}$)	-13.8698	-16.7309	xxxx	xxxx	-17.2984	-21.3924
	600 °C	K_T ($l\ mol^{-1}$)	388.830	595.650	1967.78	2241.00	3364.20	3380.90
		ΔG^o ($kJ.mol^{-1}$)	-14.0304	-16.8932	-17.8456	-20.3965	-19.1075	-21.4837
	800 °C	K_T ($l\ mol^{-1}$)	535.990	655.510	271.400	2958.70	3380.70	3456.70
		ΔG^o ($kJ.mol^{-1}$)	-14.7856	-17.1465	-18.6683	-21.1310	-19.1189	-21.5423
	900 °C	K_T ($l\ mol^{-1}$)	571.120	681.910	2912.90	2962.90	3456.70	3497.50
		ΔG^o ($kJ.mol^{-1}$)	-14.9350	-17.2508	-18.6683	-21.1310	-19.1713	-21.5733
	1000 °C	K_T ($l\ mol^{-1}$)	587.960	733.010	3171.33	3411.27	2425.70	2586.09
		ΔG^o ($kJ.mol^{-1}$)	-15.0034	-17.4419	-18.9686	-21.5073	-18.3379	-20.7751
Acid orange 7	Raw	K_T ($l\ mol^{-1}$)	524.210	550.750	xxxx	xxxx	xxxx	xxxx
		ΔG^o ($kJ.mol^{-1}$)	-14.7333	-16.6861	xxxx	xxxx	xxxx	xxxx
	400 °C	K_T ($l\ mol^{-1}$)	596.610	640.340	xxxx	xxxx	872.550	923.620
		ΔG^o ($kJ.mol^{-1}$)	-15.0377	-17.0845	xxxx	xxxx	-4.50034	-18.0530
	600 °C	K_T ($l\ mol^{-1}$)	647.080	708.880	1984.80	2225.73	1819.89	2227.10
		ΔG^o ($kJ.mol^{-1}$)	-15.2288	-17.3534	-17.8659	-20.3784	-17.6618	-20.3800
	800 °C	K_T ($l\ mol^{-1}$)	881.110	1288.90	2800.40	300.120	2791.50	3133.54
		ΔG^o ($kJ.mol^{-1}$)	-15.9552	-18.9341	-18.6759	-21.1739	-18.6684	-21.2827
	900 °C	K_T ($l\ mol^{-1}$)	1239.2	1490.10	2841.30	3368.50	2873.90	3339.66
		ΔG^o ($kJ.mol^{-1}$)	-16.7576	-19.3176	-18.7099	-21.4739	-18.7368	-21.4512
	1000 °C	K_T ($l\ mol^{-1}$)	1441.09	1672.22	3596.80	4879.30	2912.10	3560.30
		ΔG^o ($kJ.mol^{-1}$)	-17.1127	-19.6224	-19.2647	-22.4536	-18.7679	-21.6204
Acid orange 10	Raw	K_T ($l\ mol^{-1}$)	22.7050	25.7050	xxxx	xxxx	xxxx	xxxx
		ΔG^o ($kJ.mol^{-1}$)	-7.34701	-8.58380	xxxx	xxxx	xxxx	xxxx
	400 °C	K_T ($l\ mol^{-1}$)	40.5320	42.7490	xxxx	xxxx	255.59	264.17
		ΔG^o ($kJ.mol^{-1}$)	-8.71050	-9.92850	xxxx	xxxx	-13.0432	-14.7437
	600 °C	K_T ($l\ mol^{-1}$)	77.8790	92.5640	816.420	870.630	739.55	747.24
		ΔG^o ($kJ.mol^{-1}$)	-10.2471	-11.9711	-15.7757	-17.8969	-15.5431	-17.4927
	800 °C	K_T ($l\ mol^{-1}$)	182.620	419.370	1634.320	2246.17	903.490	1037.56
		ΔG^o ($kJ.mol^{-1}$)	-12.2523	-15.9655	-61.5515	-20.4025	-16.0142	-18.3605
	900 °C	K_T ($l\ mol^{-1}$)	506.130	562.100	2258.50	3009.80	975.380	1335.24
		ΔG^o ($kJ.mol^{-1}$)	-14.6507	-16.7400	-18.1698	-21.1763	-16.1943	-19.0275
	1000°C	K_T ($l\ mol^{-1}$)	565.970	641.580	3353.40	4255.70	924.01	1215.75
		ΔG^o ($kJ.mol^{-1}$)	-14.9137	-17.0897	-19.0998	-22.0921	-16.0670	-18.7795

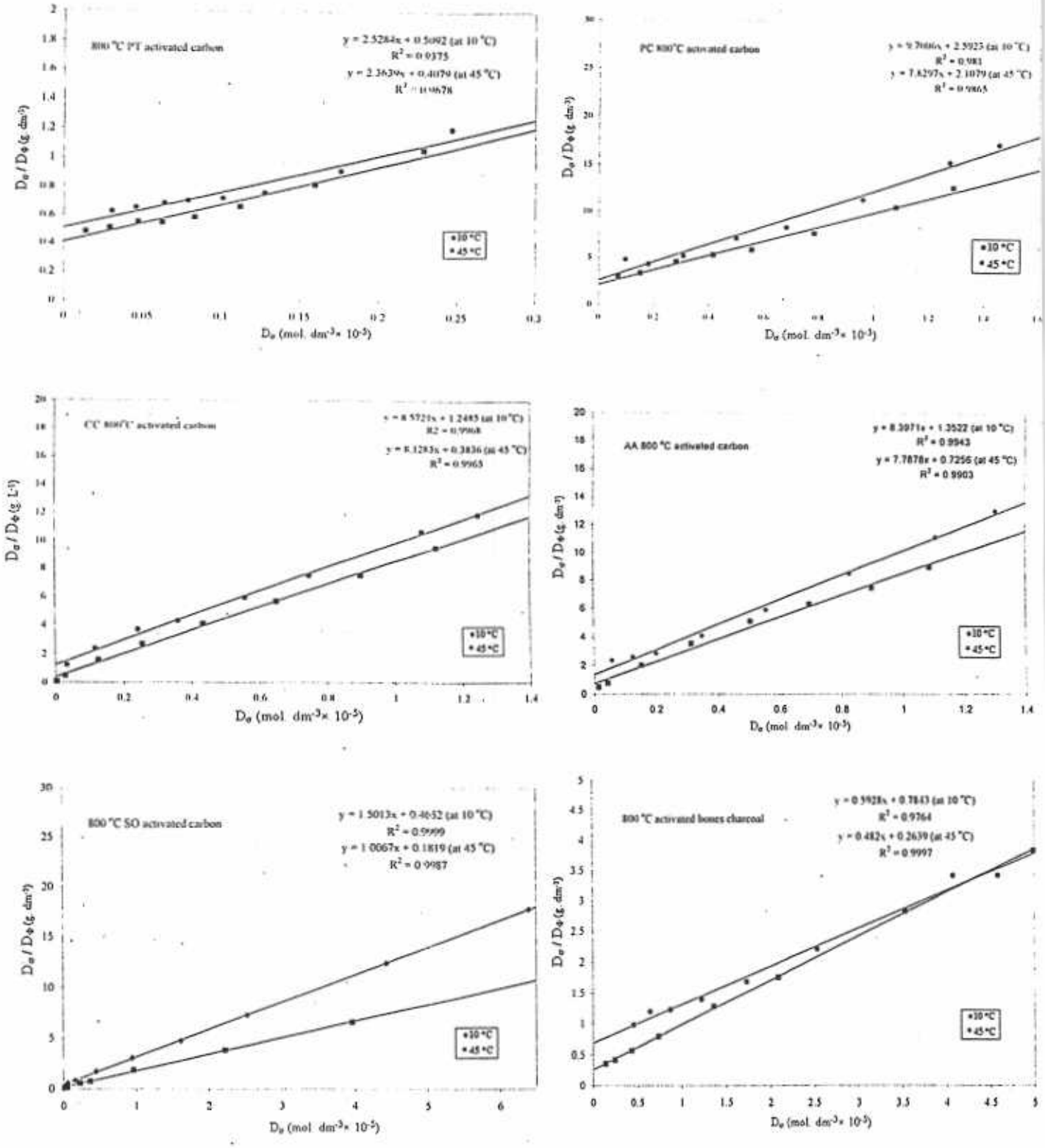


Figure 4.111 Langmuir plots for the adsorption of acid blue 1 on 800 °C activated carbon samples

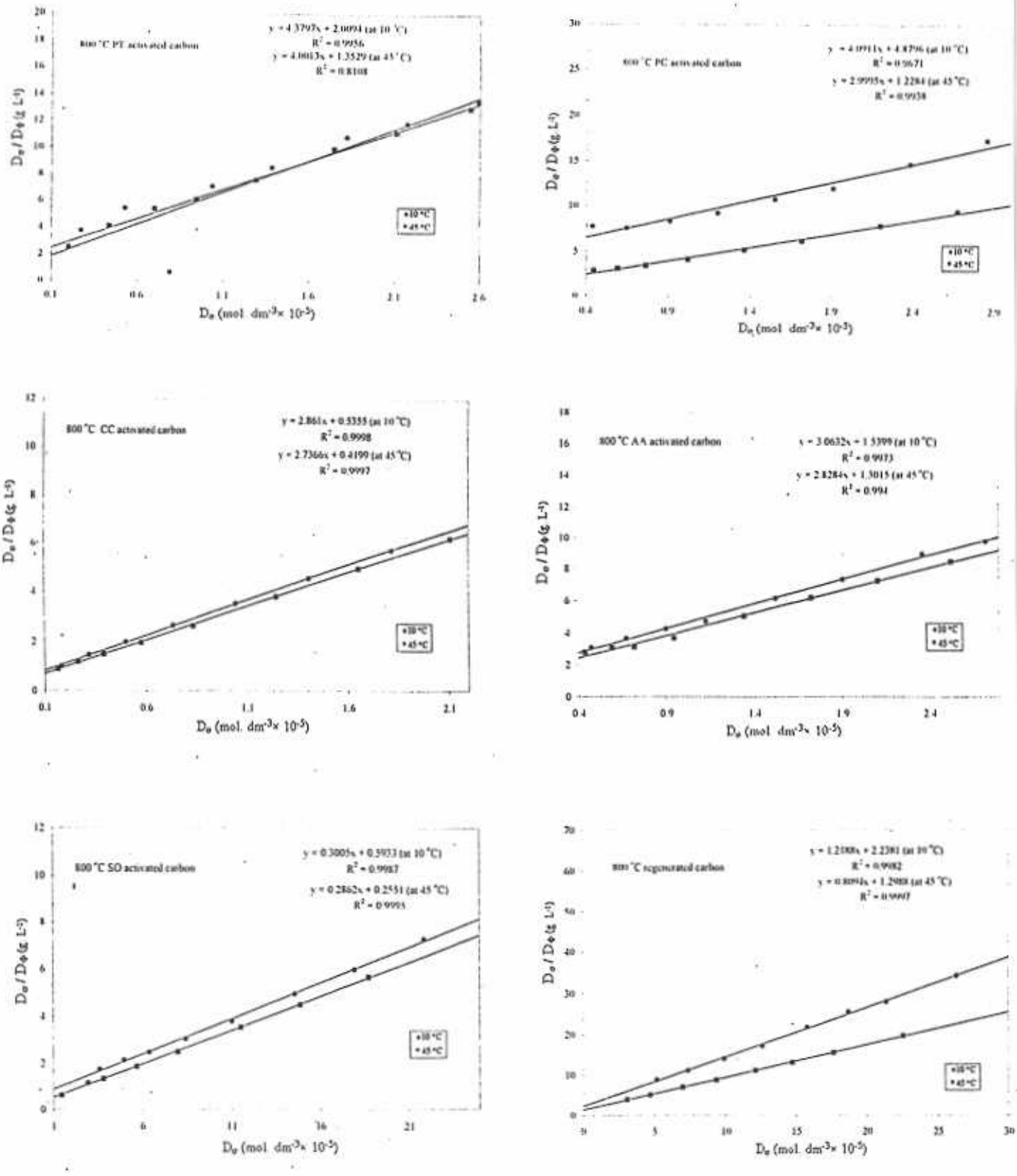


Figure 4.112 Langmuir plots for the adsorption of brilliant blue R on 800 °C activated carbon samples

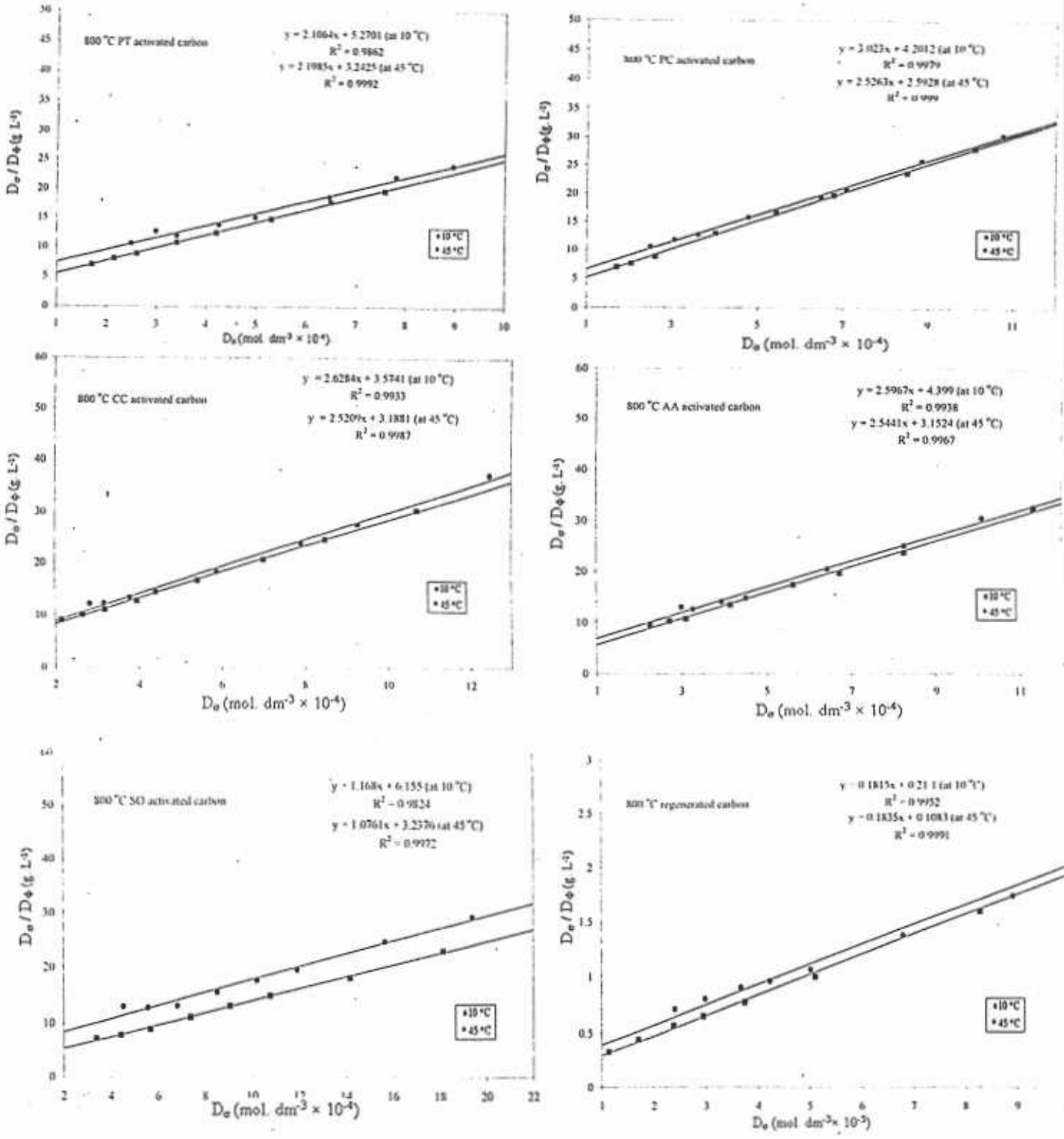


Figure 4.113 Langmuir plots for the adsorption of acid yellow 29 on 800 °C activated carbon samples

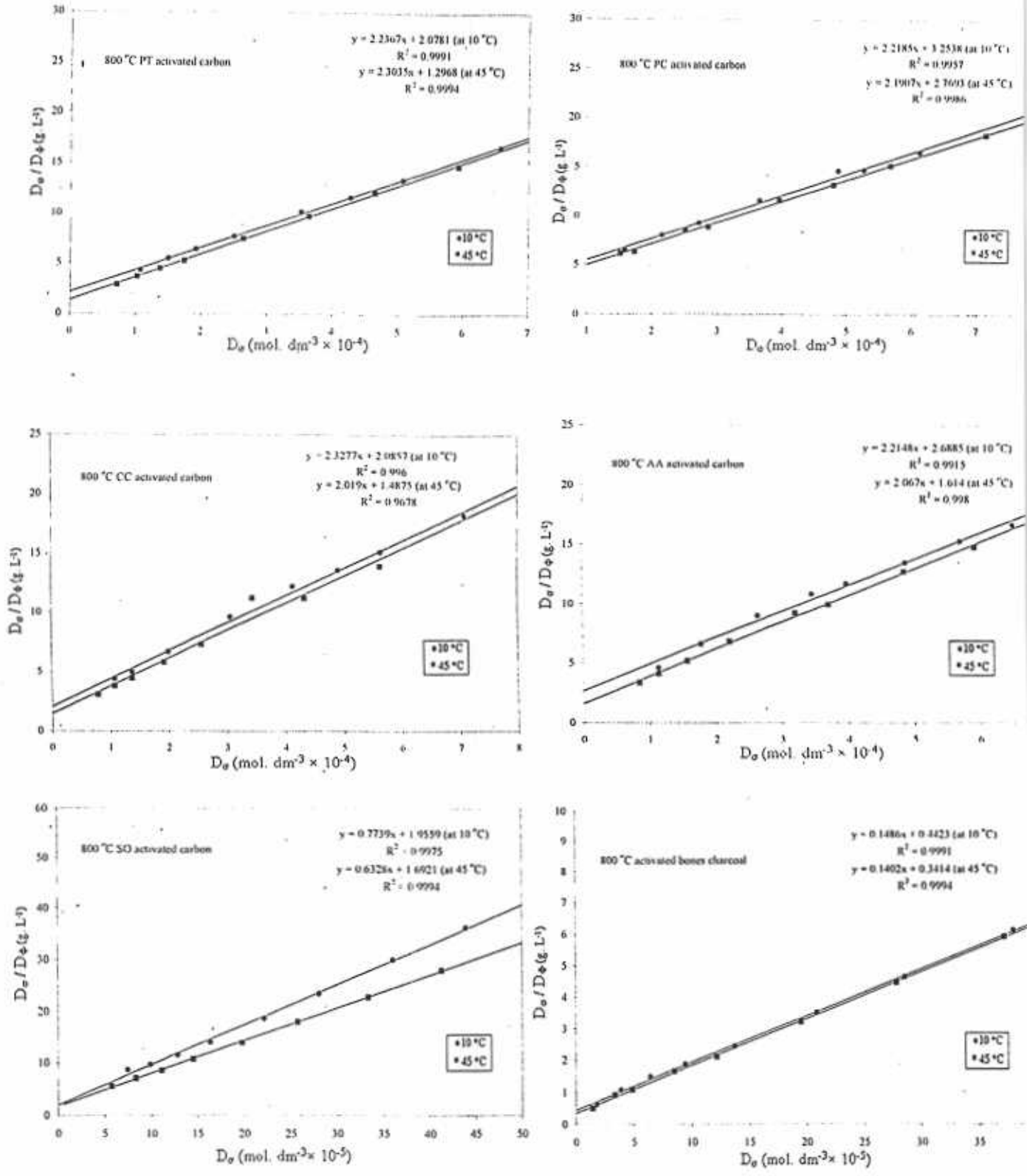


Figure 4.114 Langmuir plots for the adsorption of acid yellow 34 on 800 °C activated carbon samples

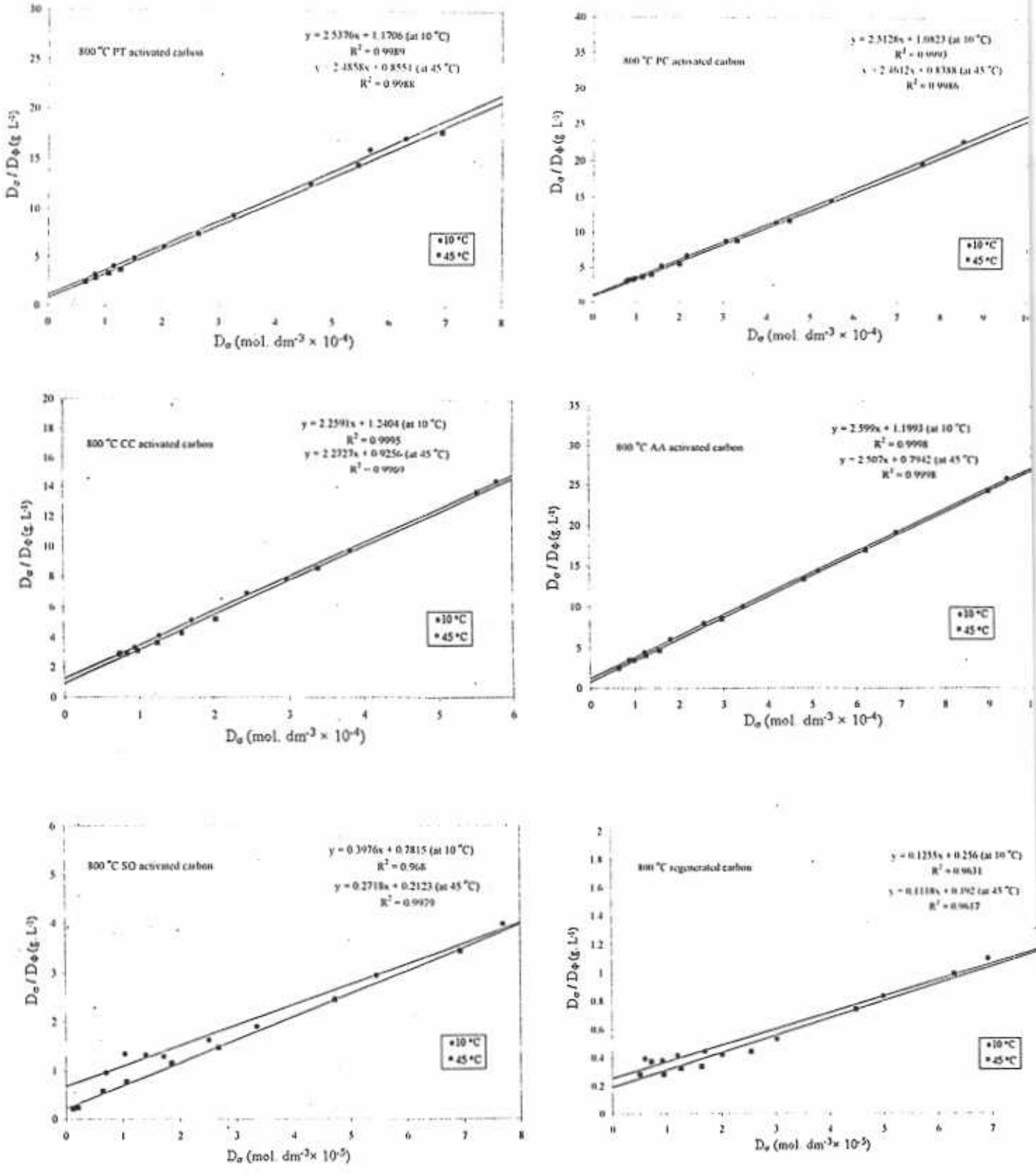


Figure 4.115 Langmuir plots for the adsorption of acid orange 7 on 800 °C activated carbon samples

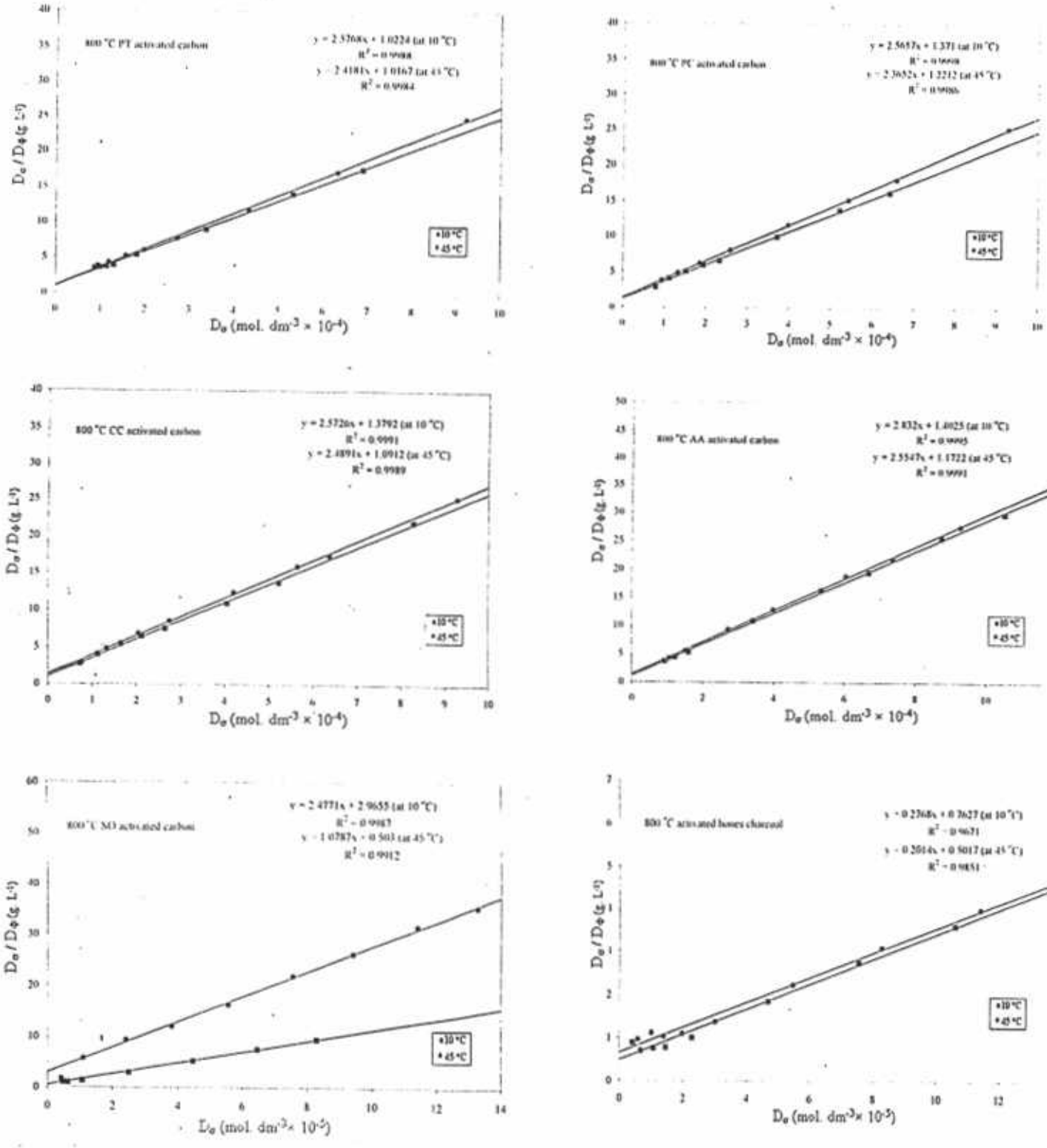


Figure 4.116 Langmuir plots for the adsorption of acid orange 10 on 800 °C activated carbon samples

Table 4.113 DR adsorption maximum ($D_{\Phi m}$) for dyes on *Paulownia tomentosa* (PT) carbon sample

Dyes	Raw		400 °C activated		800 °C activated	
	$D_{\Phi m}$ (mol.g^{-1} × 10^{-5})		$D_{\Phi m}$ (mol.g^{-1} × 10^{-5})		$D_{\Phi m}$ (mol.g^{-1} × 10^{-5})	
	10°C	45 °C	10°C	45 °C	10°C	45 °C
Acid blue 1	5.1101	8.7060	6.7600	11.660	9.2250	18.790
Brilliant blue R	1.1170	1.6680	2.1940	2.7950	4.4100	8.3130
Acid yellow 29	0.6478	0.7633	2.0210	2.7610	2.9650	3.8880
Acid yellow 34	0.6770	0.8658	1.4020	1.6350	1.8380	2.9770
Acid orange 7	0.3029	0.6156	0.7224	1.0460	0.7333	1.2770
Acid orange 10	0.3331	0.6893	0.5406	1.1550	0.5406	1.1550

Table 4.114 DR adsorption maximum ($D_{\Phi m}$) for dyes on *Populus caspica (PC)* carbon sample

Dyes	Raw		400 °C activated		800 °C activated	
	$D_{\Phi m}$ (mol.g^{-1} × 10^{-5})		$D_{\Phi m}$ (mol.g^{-1} × 10^{-5})		$D_{\Phi m}$ (mol.g^{-1} × 10^{-5})	
	10°C	45 °C	10°C	45 °C	10°C	45 °C
Acid blue 1	0.1046	0.2.997	0.4210	0.7952	0.7392	1.5850
Brilliant blue R	0.4172	0.5660	2.1590	4.8670	2.8600	10.720
Acid yellow 29	1.0210	1.7750	1.7090	3.8490	3.8370	6.3970
Acid yellow 34	0.3385	0.6325	0.6750	1.1920	1.3410	1.4690
Acid orange 7	0.4278	0.5581	0.7275	1.0350	0.8145	1.6030
Acid orange 10	0.2340	0.2561	0.7709	1.0680	1.0760	1.2470

Table 4.115 DR adsorption maximum ($D_{\Phi m}$) for dyes on *Corncobs (CC)* carbon sample

Dyes	Raw		400 °C activated		800 °C activated	
	$D_{\Phi m}$ (mol.g^{-1} × 10^{-5})		$D_{\Phi m}$ (mol.g^{-1} × 10^{-5})		$D_{\Phi m}$ (mol.g^{-1} × 10^{-5})	
	10°C	45 °C	10°C	45 °C	10°C	45 °C
Acid blue 1	0.0391	0.2118	0.8227	1.0590	1.5310	3.1800
Brilliant blue R	0.1746	0.3020	0.6034	0.7818	1.0100	1.1440
Acid yellow 29	0.2468	1.0160	0.4139	1.6430	0.9056	2.6610
Acid yellow 34	0.4244	0.4804	0.9587	1.5580	1.0560	1.6700
Acid orange 7	0.4295	0.7319	0.8675	1.1760	1.1680	1.1810
Acid orange 10	0.2319	0.6237	0.7018	0.7282	1.3170	1.1500

Table 4.116 DR adsorption maximum ($D_{\Phi m}$) for dyes on *Ailanthus altissima (AA)* carbon sample

Dyes	Raw		400 °C activated		800 °C activated	
	$D_{\Phi m}$ (mol.g^{-1} × 10^{-5})		$D_{\Phi m}$ (mol.g^{-1} × 10^{-5})		$D_{\Phi m}$ (mol.g^{-1} × 10^{-5})	
	10°C	45 °C	10°C	45 °C	10°C	45 °C
Acid blue 1	0.8072	1.5400	1.7260	2.0520	2.6450	4.1400
Brilliant blue R	0.3142	0.6524	0.5786	1.3470	1.3950	1.6270
Acid yellow 29	0.2545	1.2770	0.8597	1.2230	1.0270	1.6150
Acid yellow 34	0.2899	0.6168	1.0040	1.4700	1.1590	1.5200
Acid orange 7	0.4970	0.7452	0.9029	0.9781	0.9626	1.2480
Acid orange 10	0.3726	0.4680	0.8203	0.9202	1.5550	1.5820

Table 4.117 DR adsorption maximum ($D_{\Phi m}$) for dyes on *Salvadora oleoides (SO)* carbon sample

Dyes	Raw		400 °C activated		600 °C activated		800 °C activated		1000 °C activated	
	$D_{\Phi m}$ (mol.g^{-1}×10^{-5})		$D_{\Phi m}$ (mol.g^{-1}×10^{-5})		$D_{\Phi m}$ (mol.g^{-1}×10^{-5})		$D_{\Phi m}$ (mol.g^{-1}×10^{-5})		$D_{\Phi m}$ (mol.g^{-1}×10^{-5})	
	10°C	45 °C	10°C	45 °C	10°C	45 °C	10°C	45 °C	10°C	45 °C
Acid blue 1	1.7560	3.3180	5.1650	5.9030	7.1050	8.8270	8.9700	16.270	10.690	21.280
Brilliant blue R	0.9336	1.3190	1.4190	2.8200	2.7390	5.1800	3.2050	6.2700	15.800	17.170
Acid yellow 29	0.1343	0.5111	1.3960	2.9710	1.8780	2.9650	3.4030	4.3130	2.9680	4.5390
Acid yellow 34	0.5015	1.1980	2.7750	3.2210	4.5210	5.1850	6.1650	7.6440	8.1650	8.4730
Acid orange 7	1.1260	1.7890	9.4530	14.460	13.590	18.090	21.490	25.880	28.100	32.550
Acid orange 10	0.1737	0.1905	0.3880	0.5734	0.45380	0.9388	1.0950	1.1780	6.0260	8.9790

Table 4.118 DR adsorption maximum ($D_{\Phi m}$) for dyes on *animal bone charcoal* (ABC) sample

Dyes	Raw		600 °C activated		800 °C activated		900 °C activated		1000 °C activated	
	$D_{\Phi m}$ (mol.g^{-1}×10^{-5})		$D_{\Phi m}$ (mol.g^{-1}×10^{-5})		$D_{\Phi m}$ (mol.g^{-1}×10^{-5})		$D_{\Phi m}$ (mol.g^{-1}×10^{-5})		$D_{\Phi m}$ (mol.g^{-1}×10^{-5})	
	10°C	45 °C	10°C	45 °C	10°C	45 °C	10°C	45 °C	10°C	45 °C
Acid blue 1	XXX	XXX	2.6610	3.3780	5.3600	5.7060	8.5220	11.920	5.9190	11.110
Brilliant blue R	XXX	XXX	0.9441	1.9230	2.6400	9.3430	4.1700	13.940	4.5390	8.9550
Acid yellow 29	XXX	XXX	3.9400	4.4240	9.0550	23.020	12.920	26.620	29.490	30.550
Acid yellow 34	XXX	XXX	4.9540	8.6990	16.260	19.810	20.710	22.940	25.550	28.660
Acid orange 7	XXX	XXX	20.730	20.970	45.970	133.50	76.120	230.20	86.920	911.80
Acid orange 10	XXX	XXX	1.9850	2.4760	8.6040	20.830	21.730	31.060	46.880	53.080

Table 4.119 DR adsorption maximum ($D_{\Phi m}$) for dyes on regenerated (RG) carbon sample

Dyes	400 °C activated		600 °C activated		800 °C activated		900 °C activated		1000 °C activated	
	$D_{\Phi m}$ (mol.g^{-1}×10^{-5})		$D_{\Phi m}$ (mol.g^{-1}×10^{-5})		$D_{\Phi m}$ (mol.g^{-1}×10^{-5})		$D_{\Phi m}$ (mol.g^{-1}×10^{-5})		$D_{\Phi m}$ (mol.g^{-1}×10^{-5})	
	10°C	45 °C	10°C	45 °C	10°C	45 °C	10°C	45 °C	10°C	45 °C
Acid blue 1	3.2550	4.8410	42.700	63.780	79.010	84.360	77.020	86.420	83.620	130.90
Brilliant blue R	0.2640	0.7004	1.5210	3.7580	1.8830	2.3740	2.6160	4.4990	4.6430	7.1340
Acid yellow 29	1.9020	4.2390	11.680	15.200	13.040	28.250	16.600	17.020	26.820	31.570
Acid yellow 34	3.7750	5.5260	18.770	32.380	16.850	26.570	18.240	22.730	19.780	27.090
Acid orange 7	1.7910	2.9450	47.950	72.410	118.90	142.10	156.20	189.60	196.80	219.80
Acid orange 10	1.9890	2.2010	4.9670	6.0260	6.0310	12.840	12.280	23.630	12.090	28.020

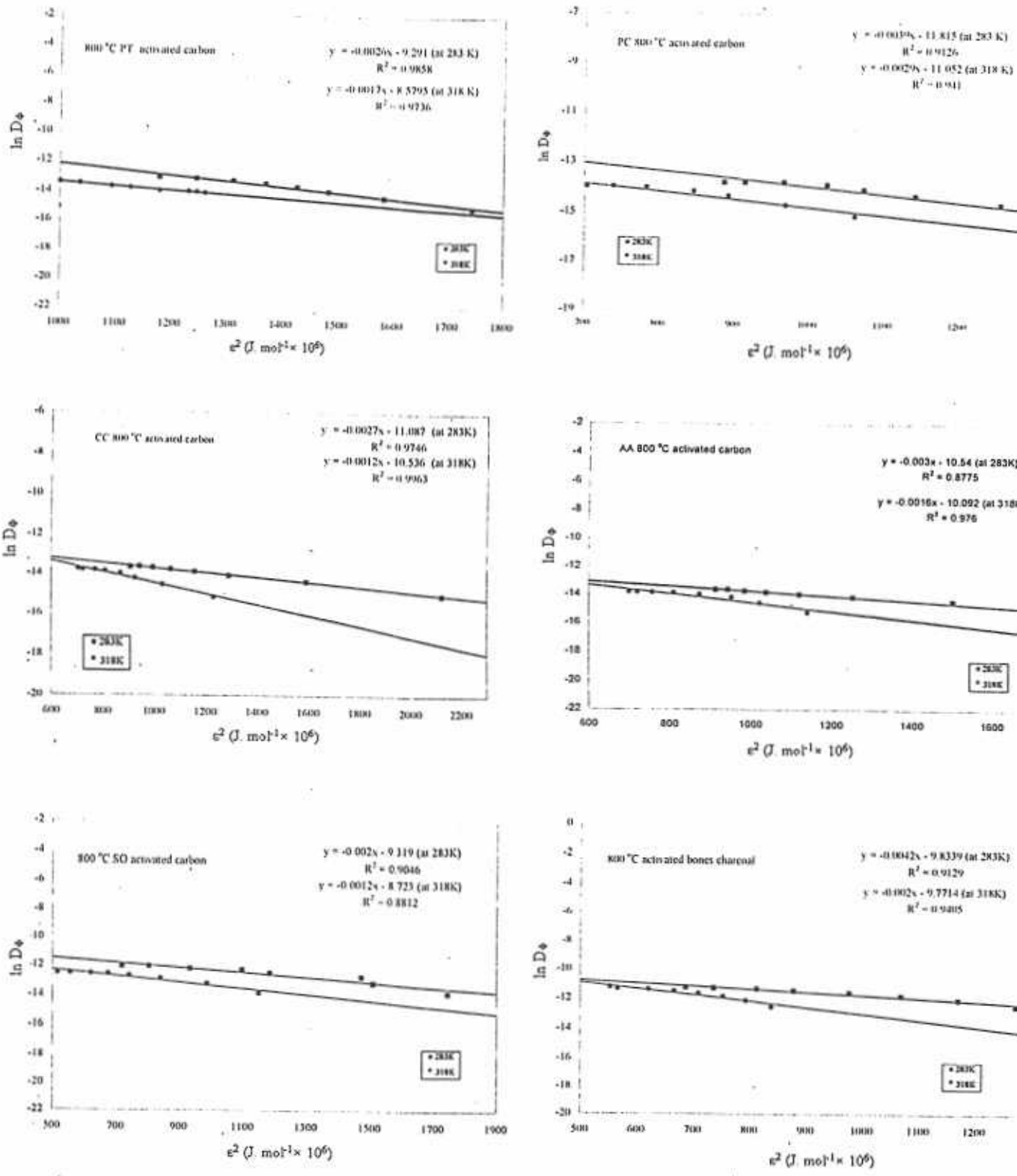


Figure 4.117 Dubinin-Radushkevich plots for the adsorption of acid blue 1 on 800 °C activated carbon samples

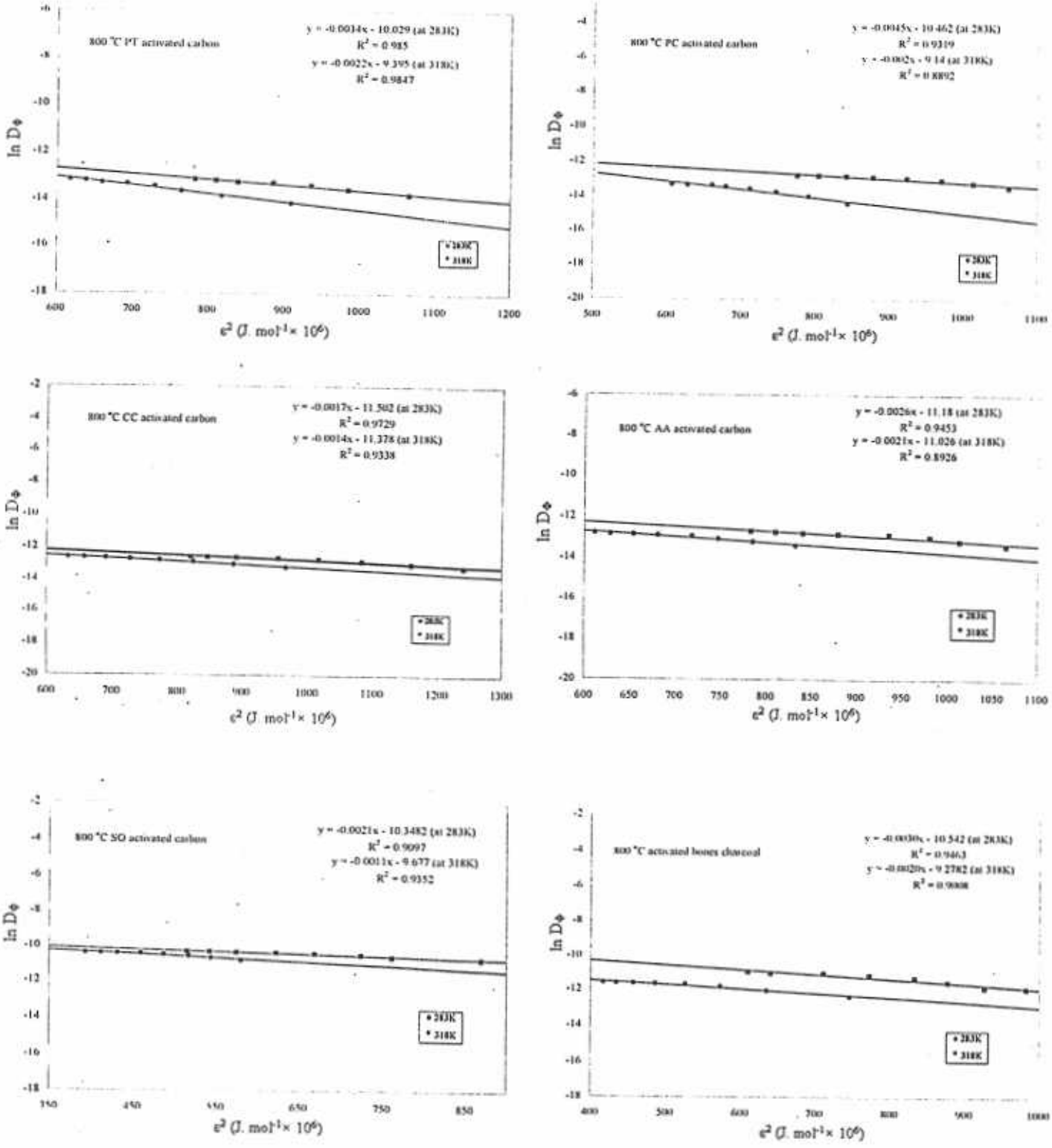


Figure 4.118 Dubinin-Radushkevich plots for the adsorption of brilliant blue R on 800 °C activated carbon sample.

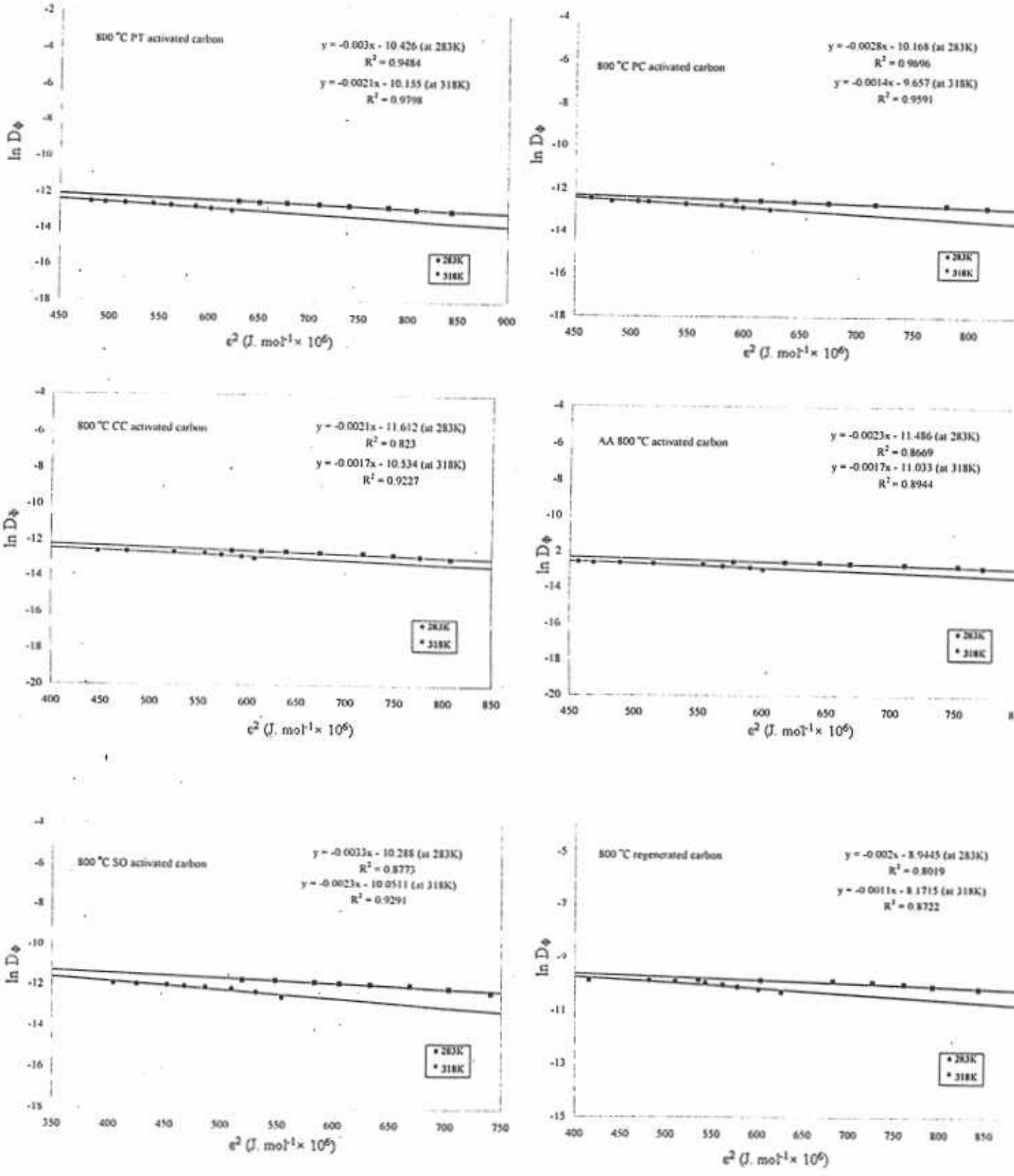


Figure 4.119 Dubinin-Radushkevich plots for the adsorption of acid yellow 29 on 800 °C activated carbon samples

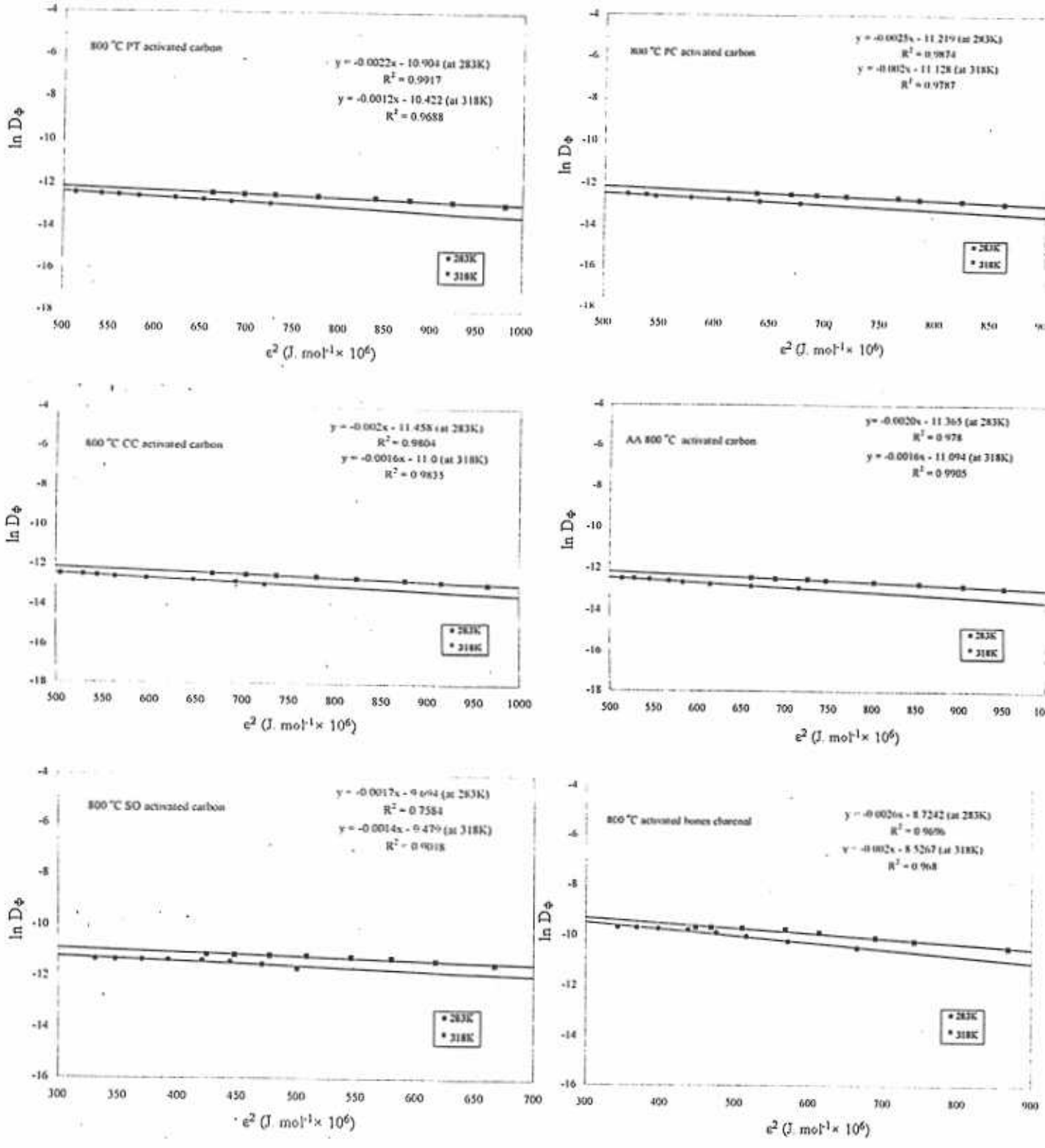


Figure 4.120 Dubinin-Radushkevich plots for the adsorption of acid yellow 34 on 800 °C activated carbon sample

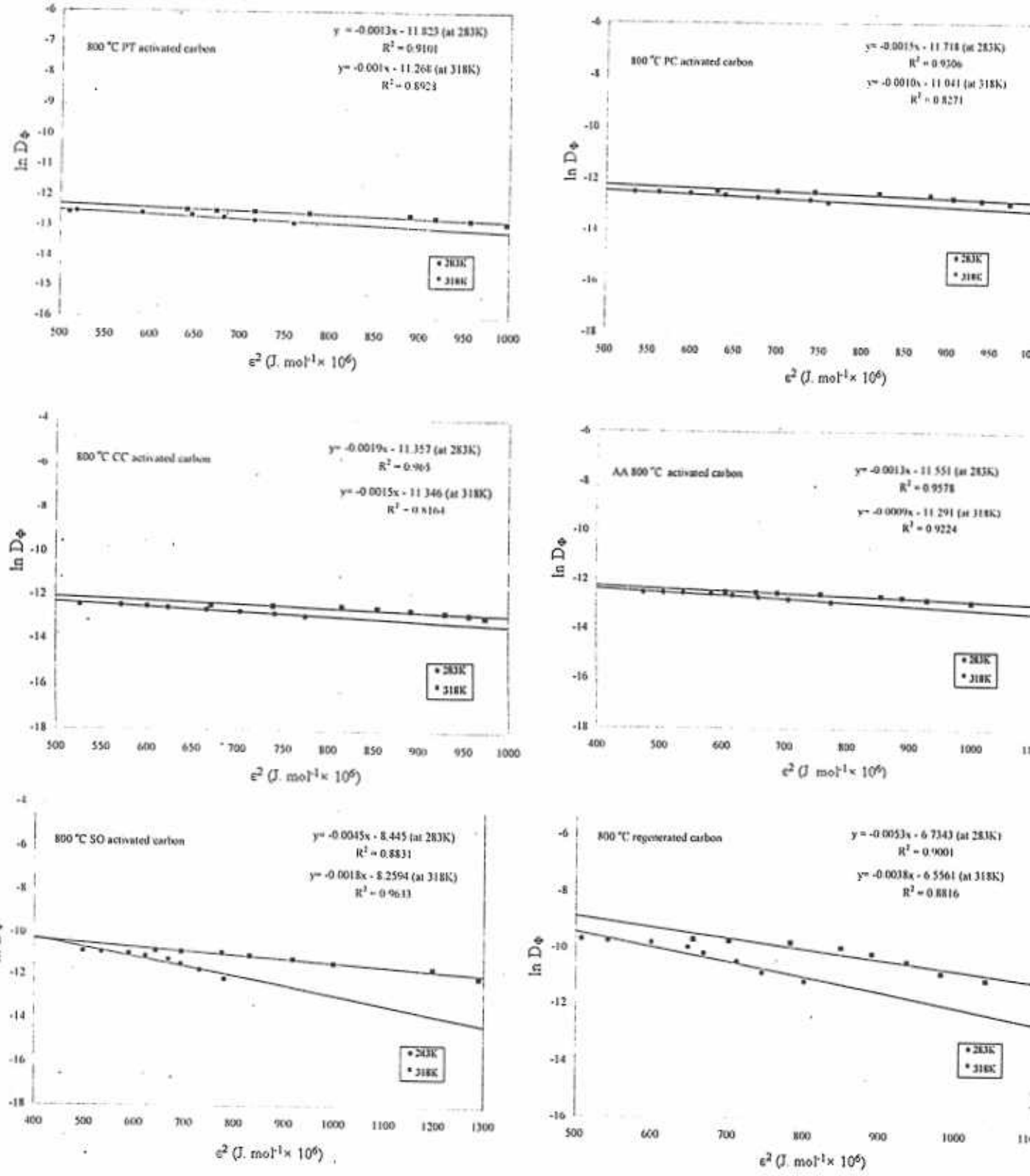
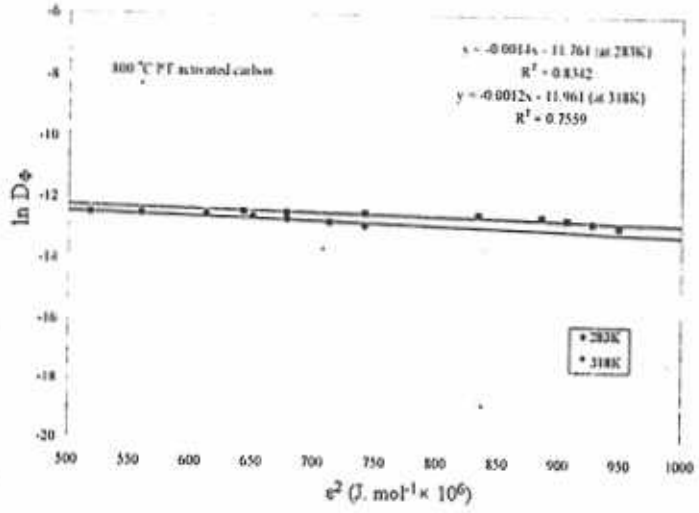
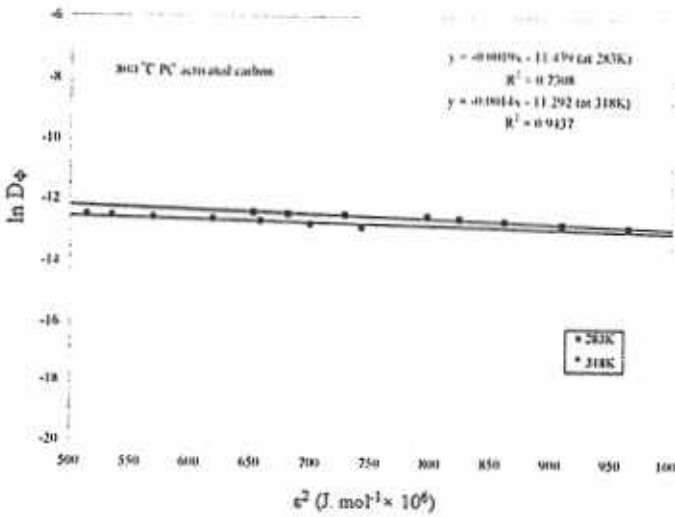
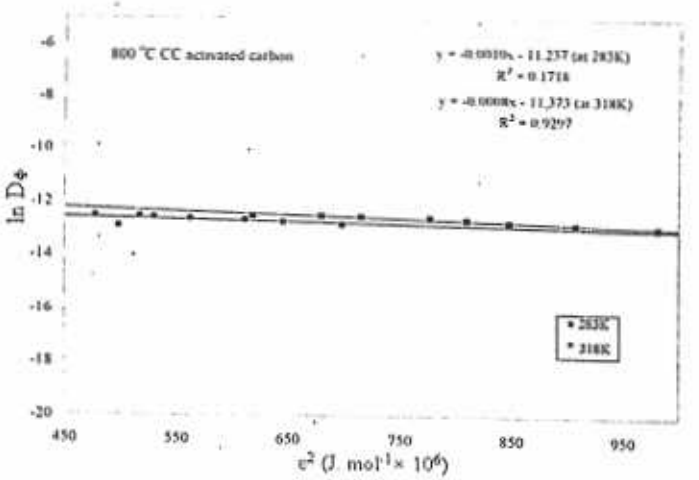
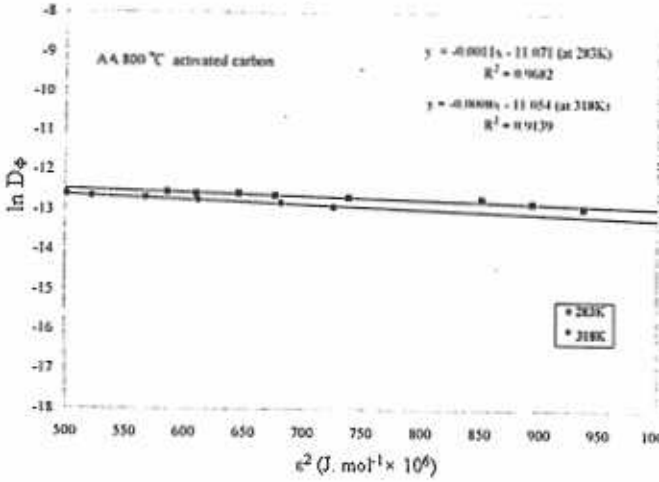


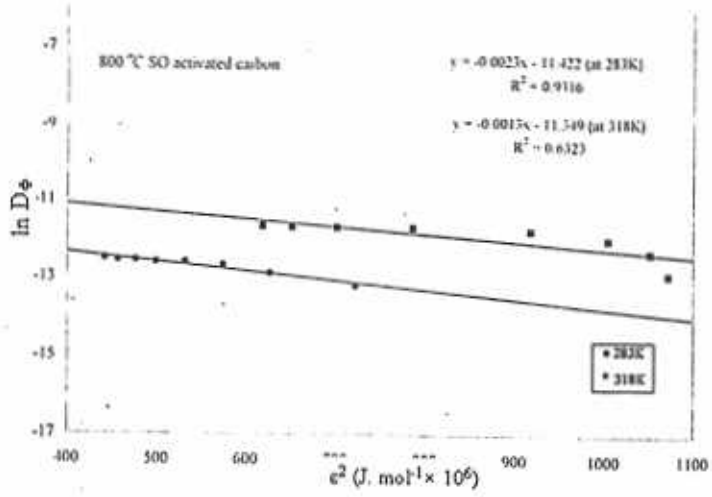
Figure 4.121 Dubinin-Radushkevich plots for the adsorption of acid orange 7 on 800 °C activated carbon sample.











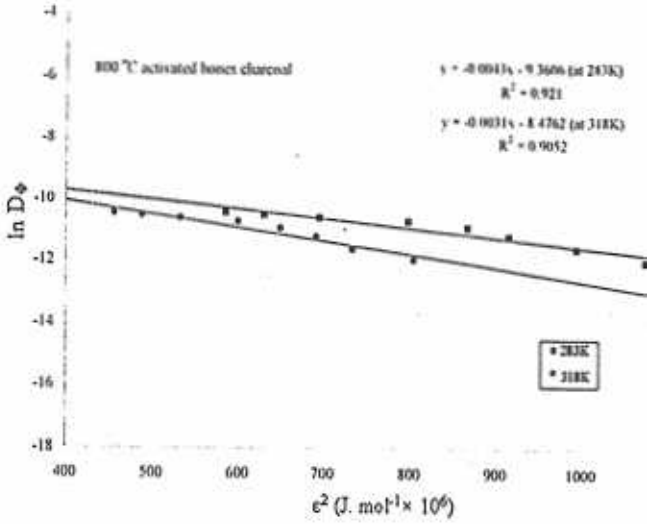


Figure 4.122 Dubinin-Radushkevich plots for the adsorption of acid orange 10 on 800 °C activated carbon samp

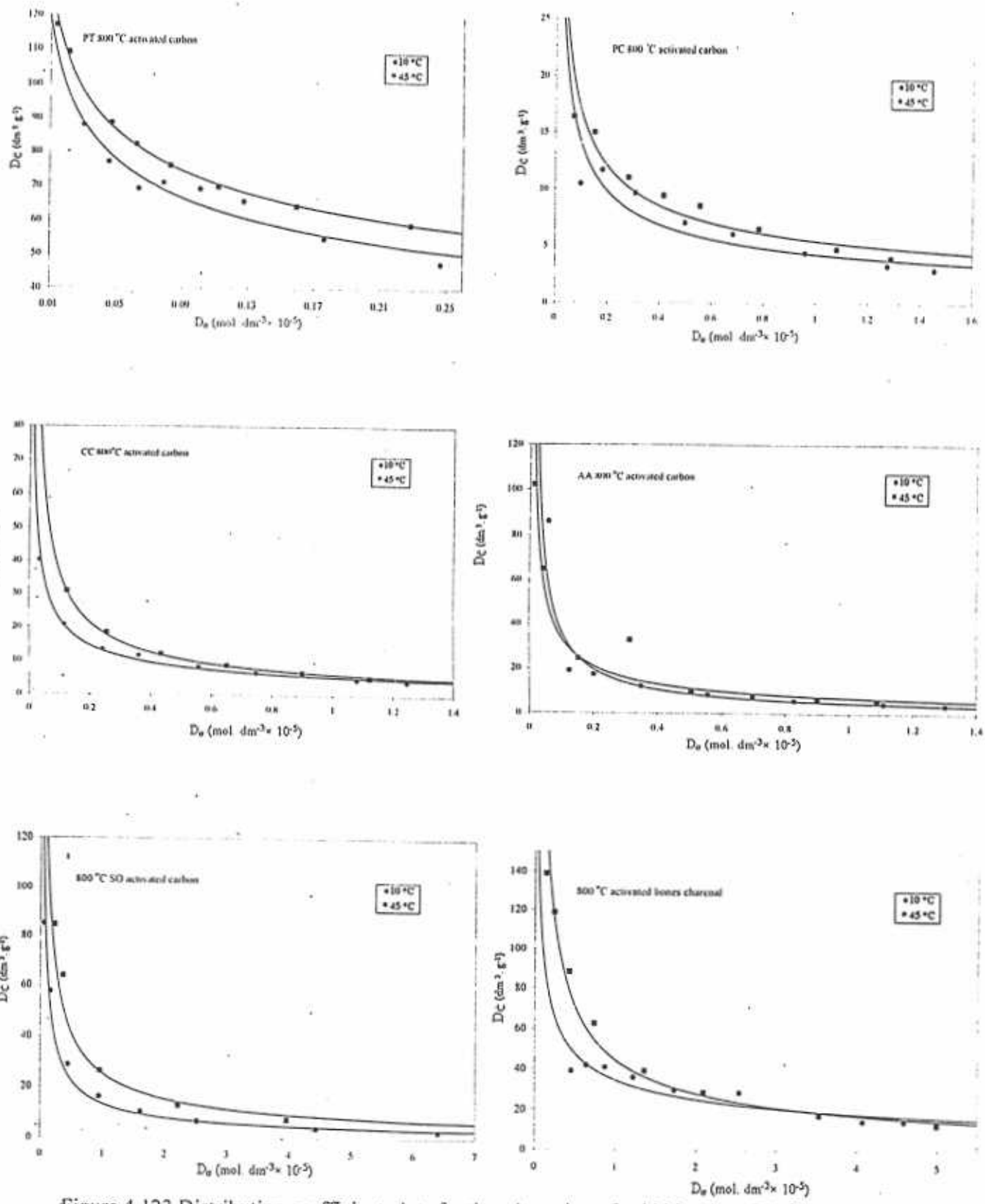


Figure 4.123 Distribution coefficient plots for the adsorption of acid blue 1 on 800 °C activated carbon sample.

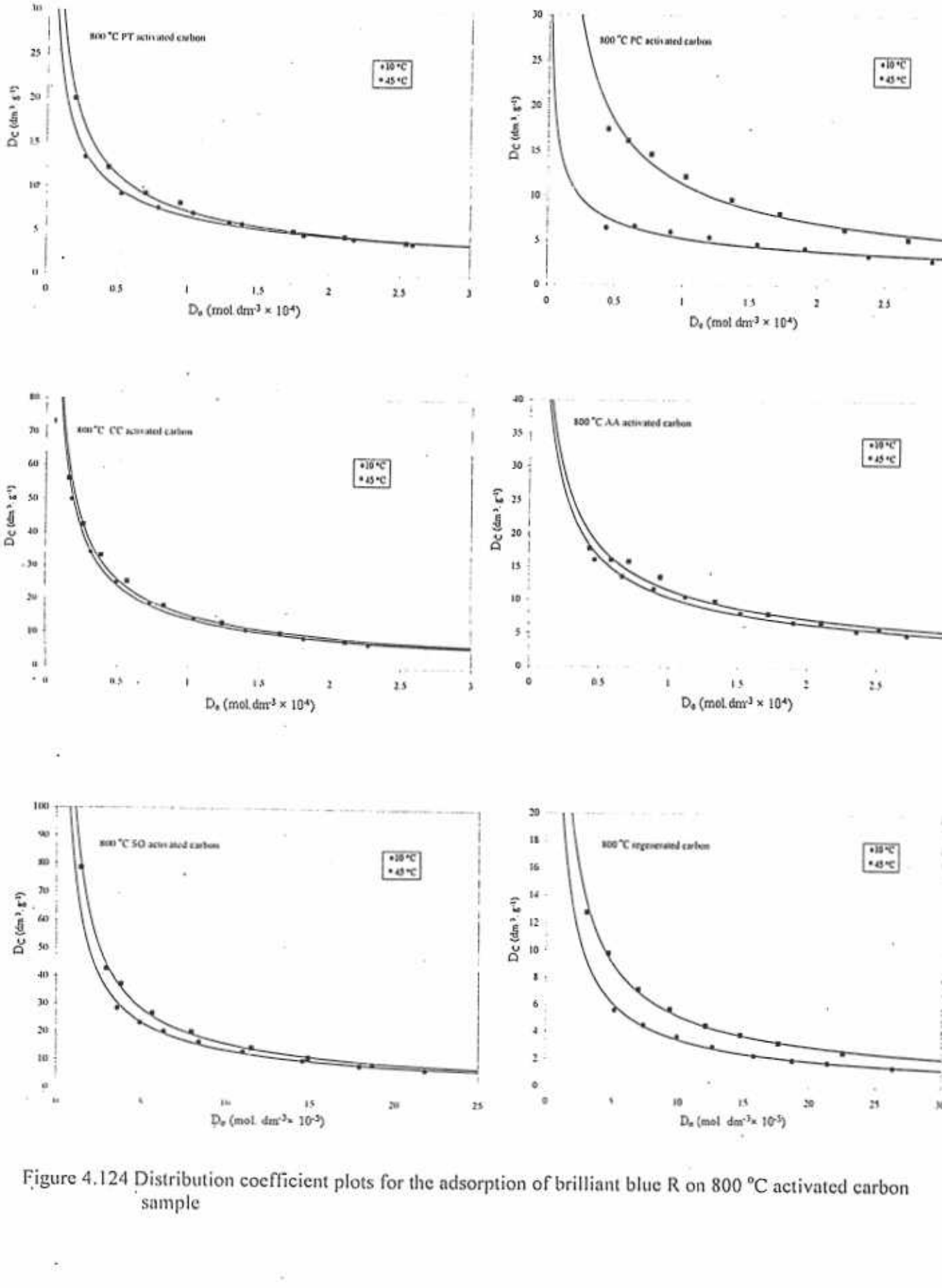


Figure 4.124 Distribution coefficient plots for the adsorption of brilliant blue R on 800 °C activated carbon sample

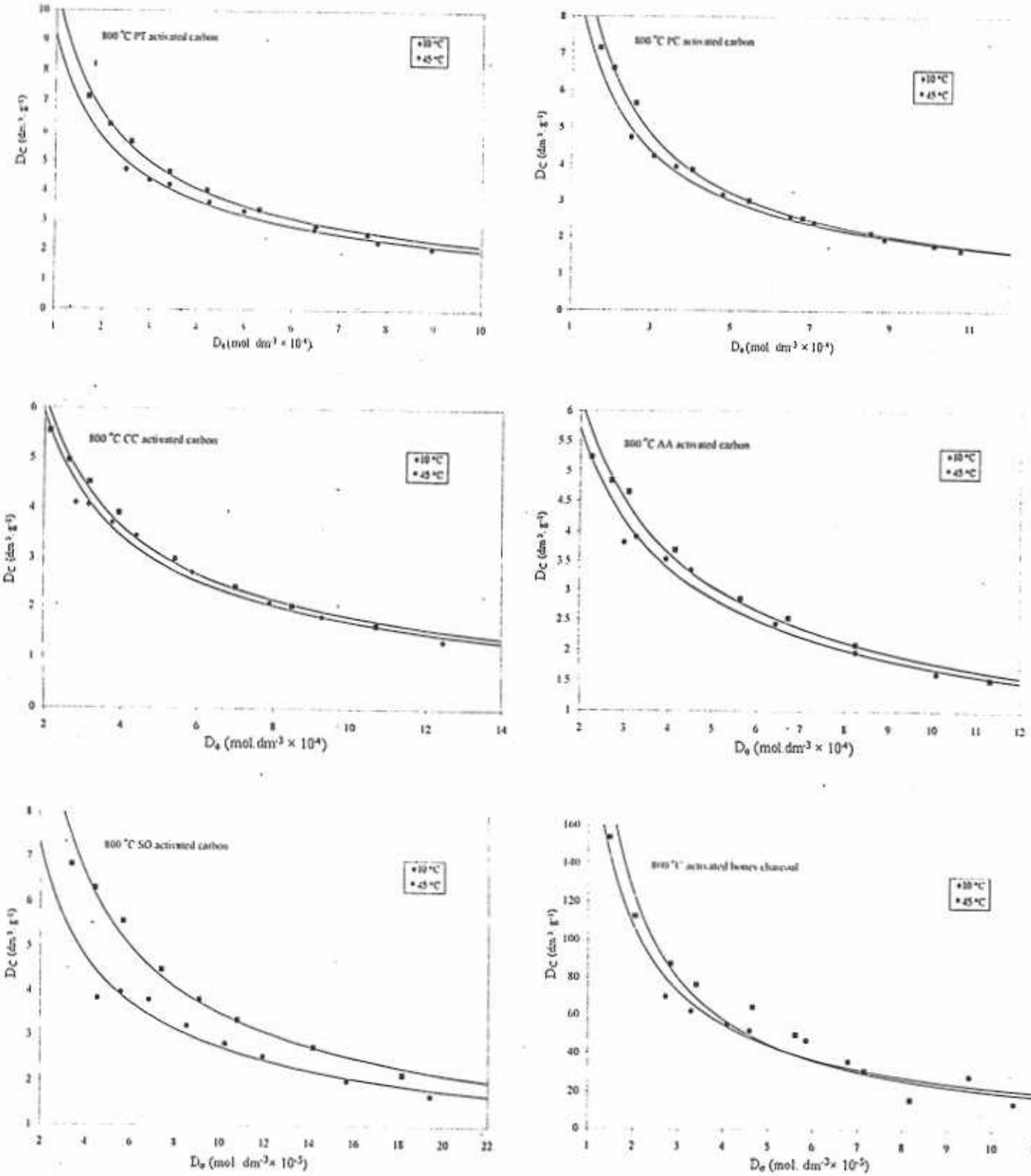


Figure 4.125 Distribution coefficient plots for the adsorption of acid yellow 29 on 800 °C activated carbon sample

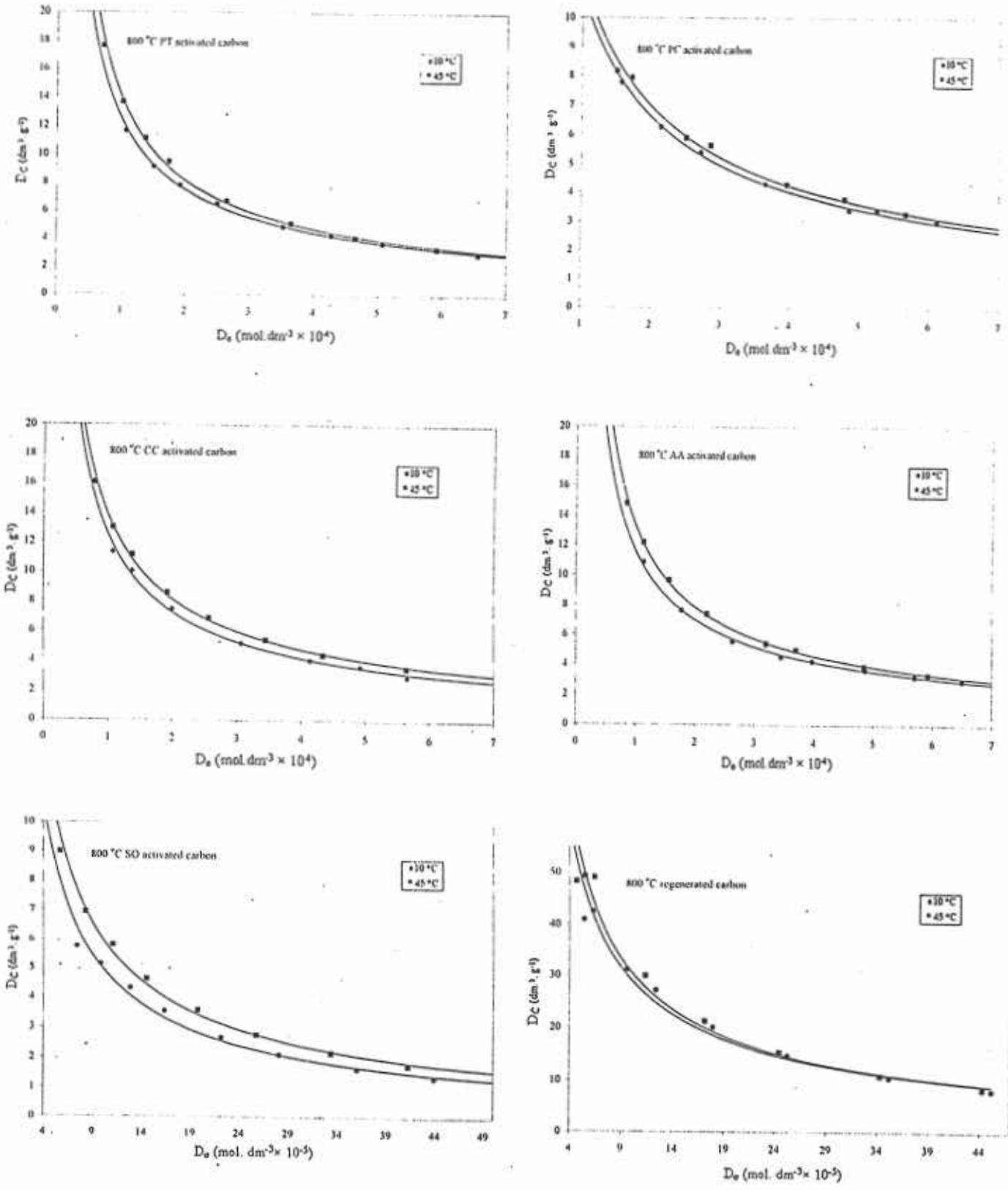


Figure 4.126 Distribution coefficient plots for the adsorption of acid yellow 34 on 800 °C activated carbon sample.

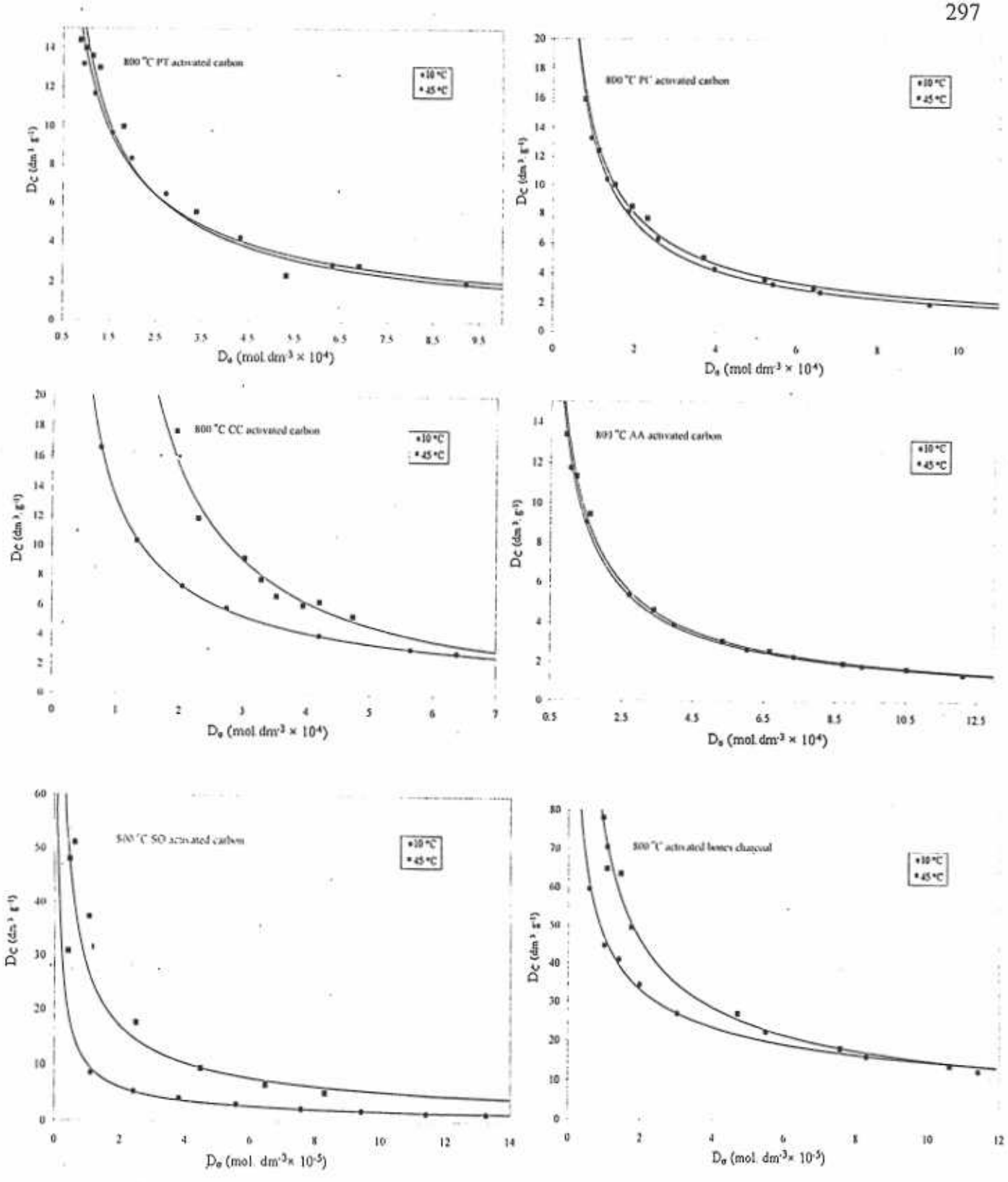


Figure 4.127 Distribution coefficient plots for the adsorption of acid orange 10 on 800 °C activated carbon sample.

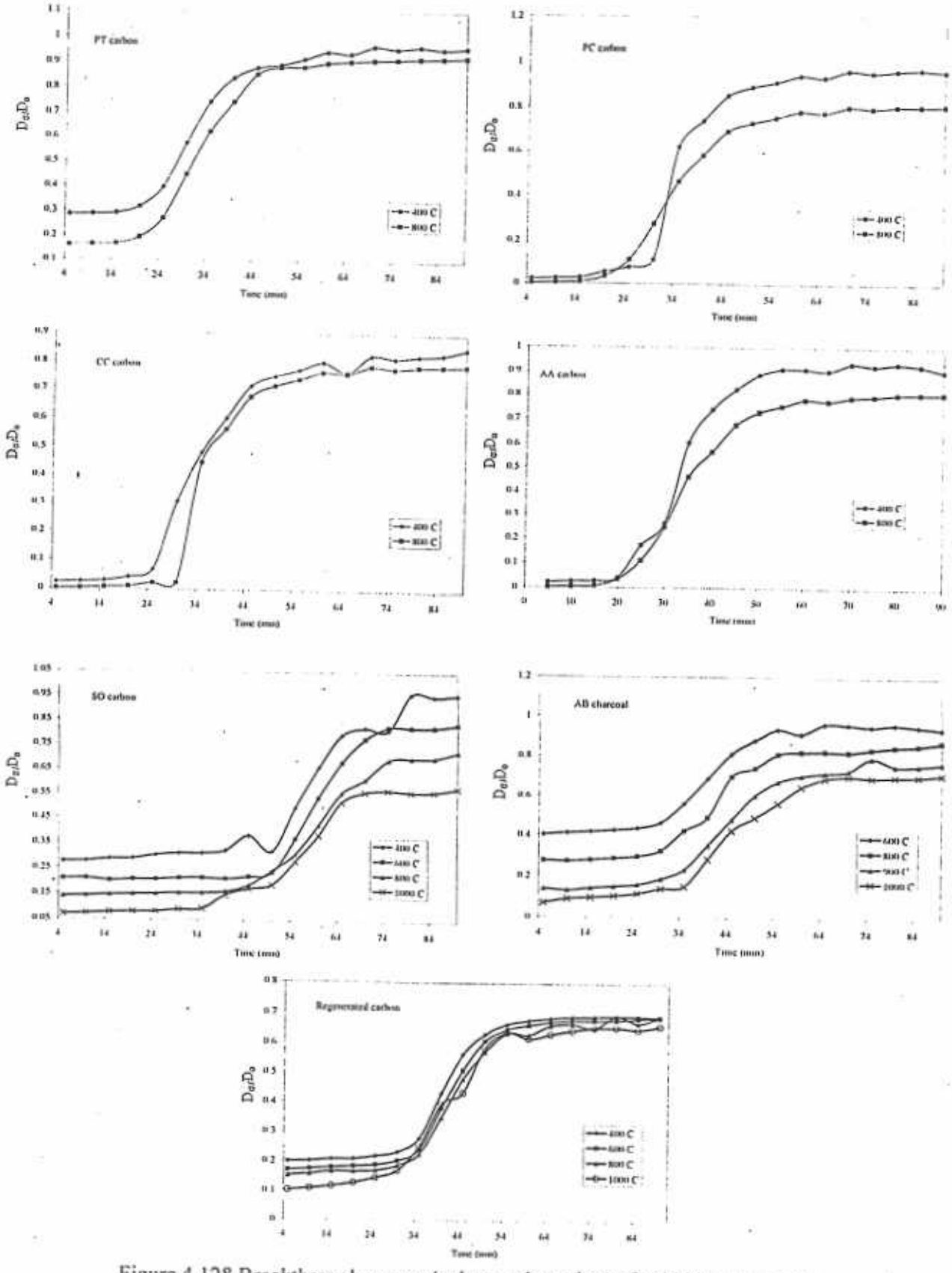


Figure 4.128 Breakthrough curves (column adsorption) of acid blue 1 on carbon samples

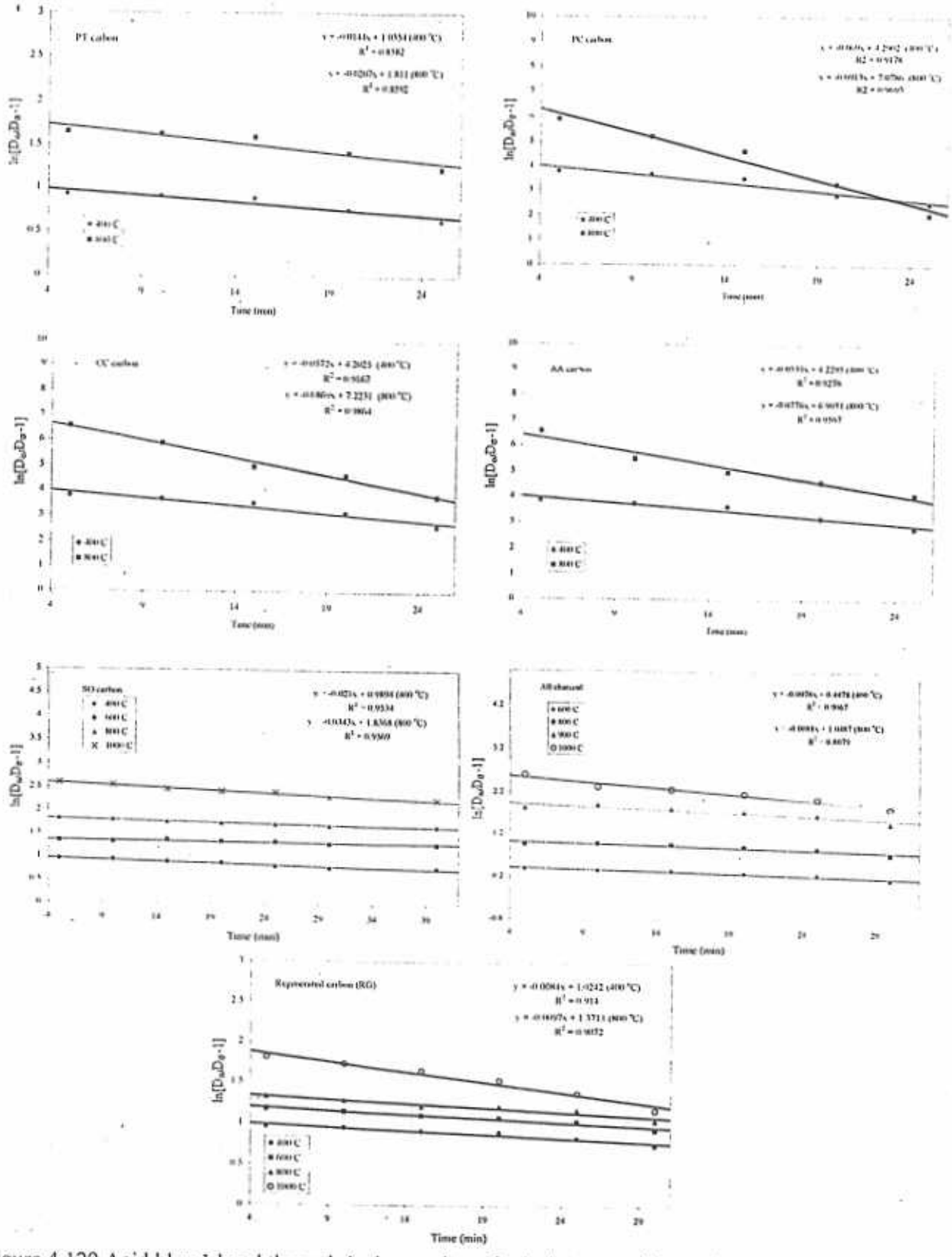


Figure 4.129 Acid blue 1 breakthrough (column adsorption) plots according to the Thomas model on carbon samples.

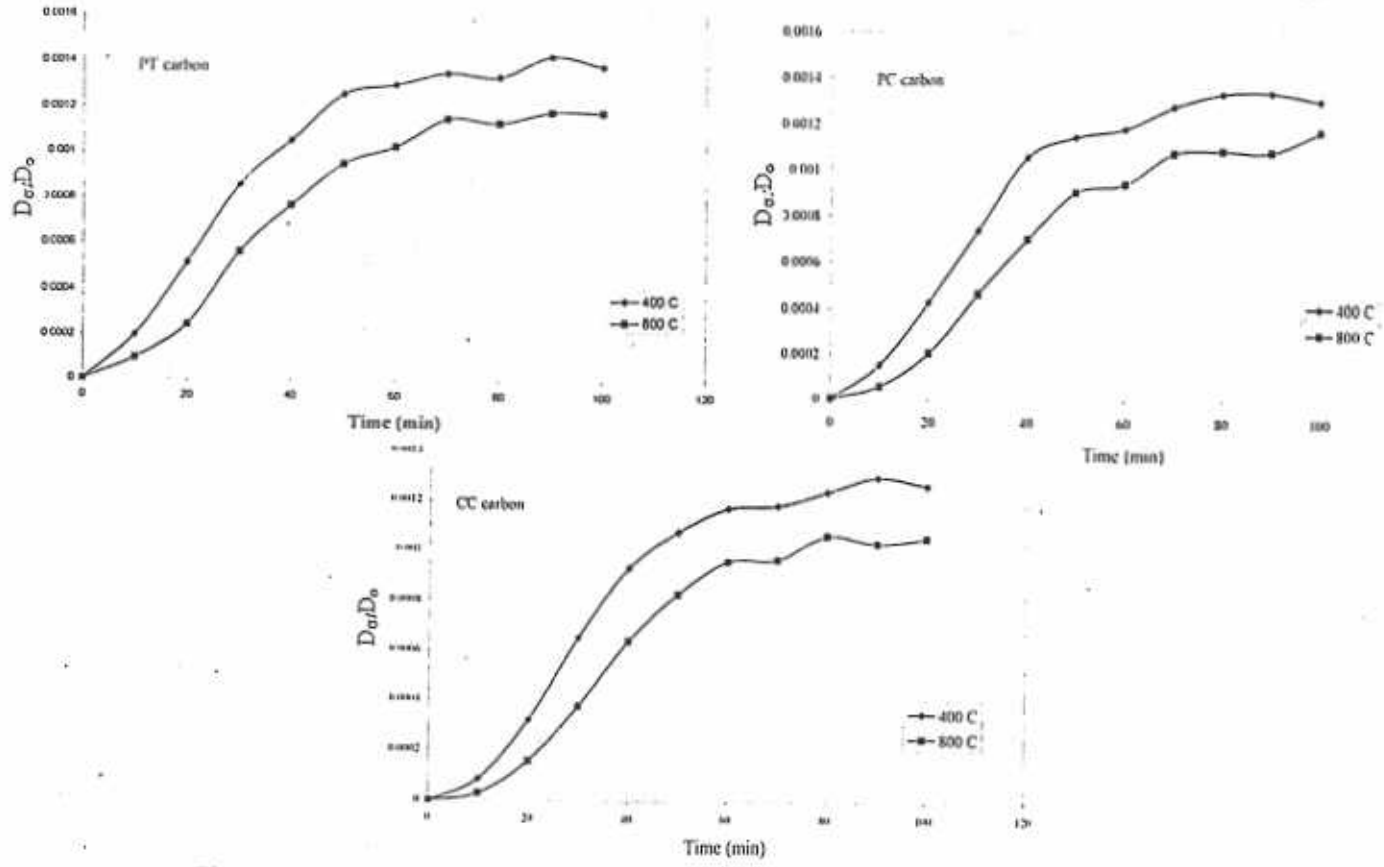


Figure 4.130 Breakthrough (column adsorption) curves of Nickel on carbon samples

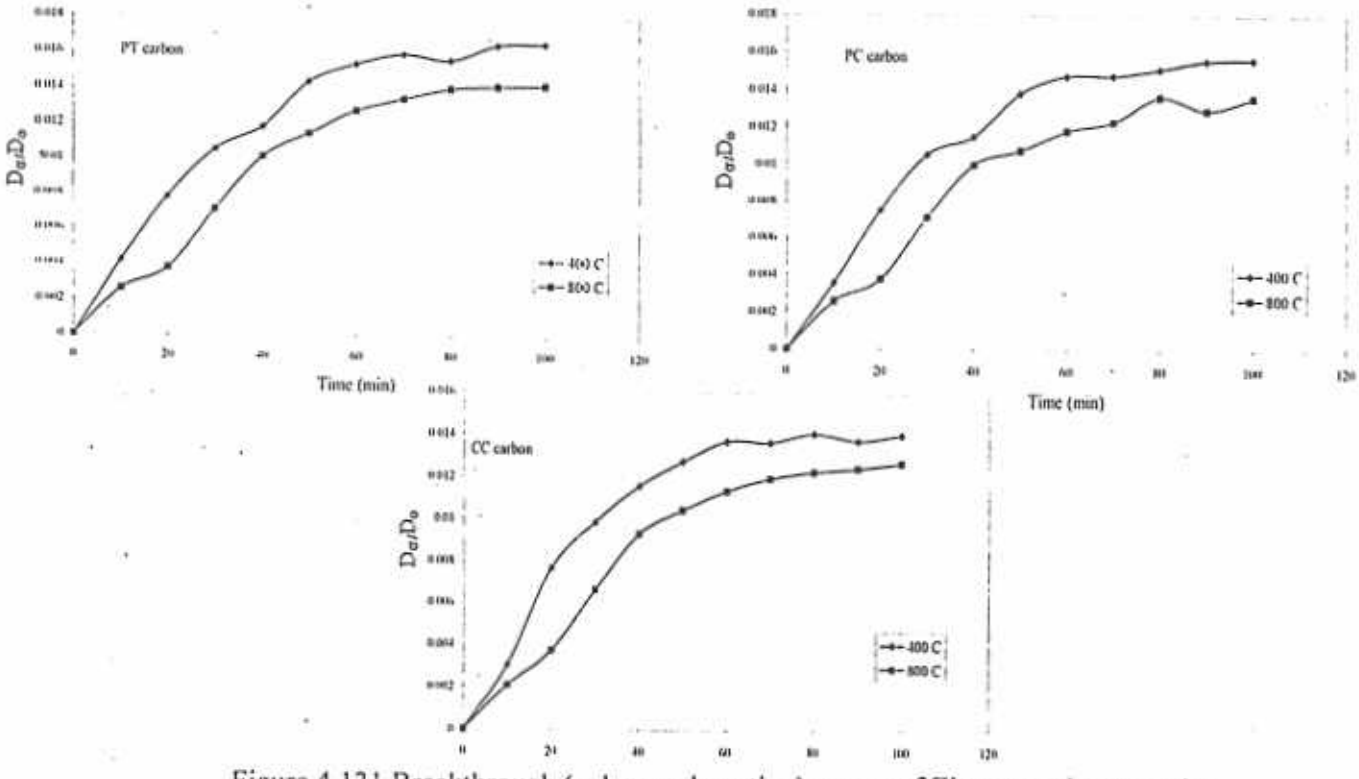


Figure 4.131 Breakthrough (column adsorption) curves of Zinc on carbon samples

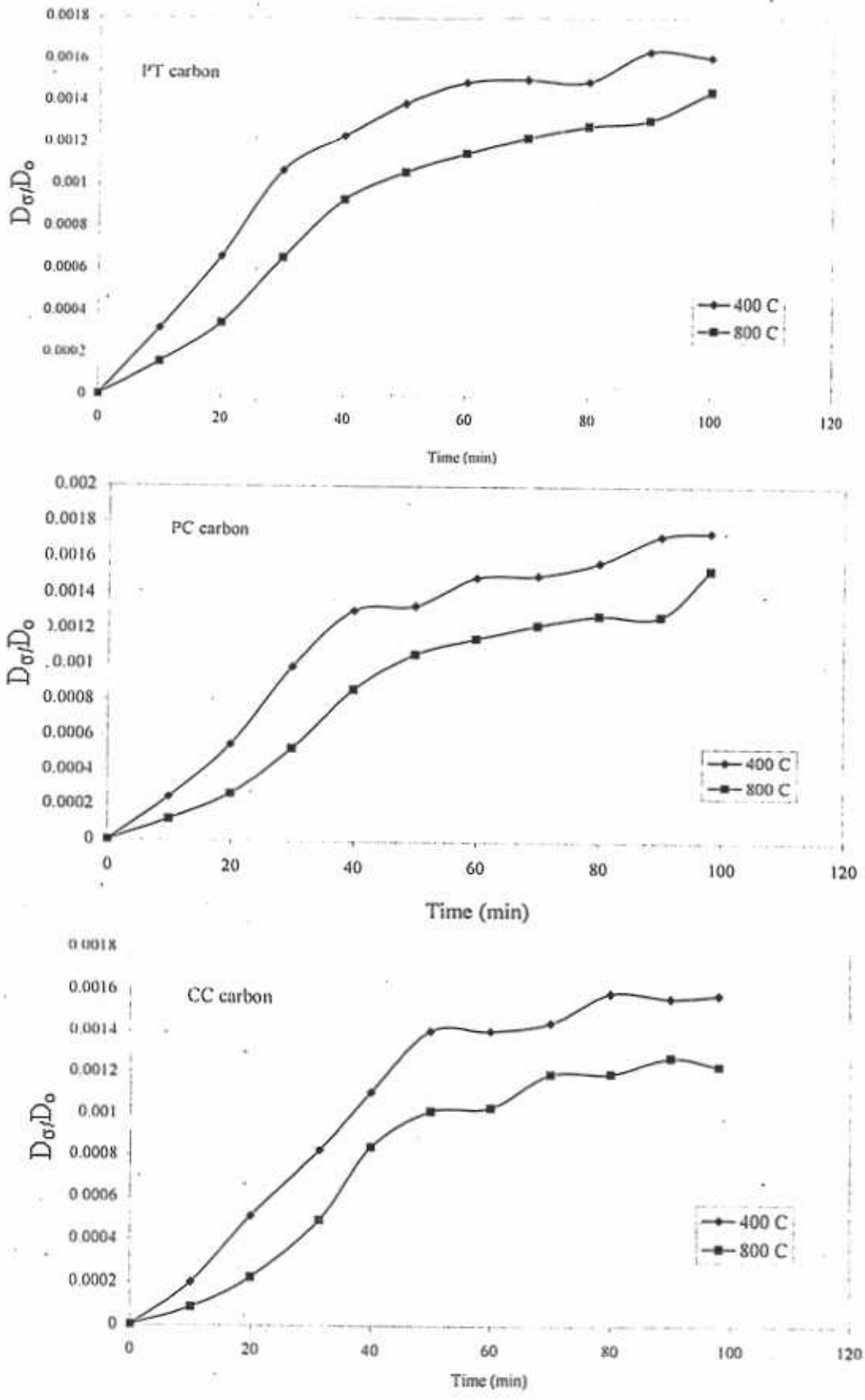


Figure 4.132 Breakthrough (column adsorption) curves of Copper on carbon samples

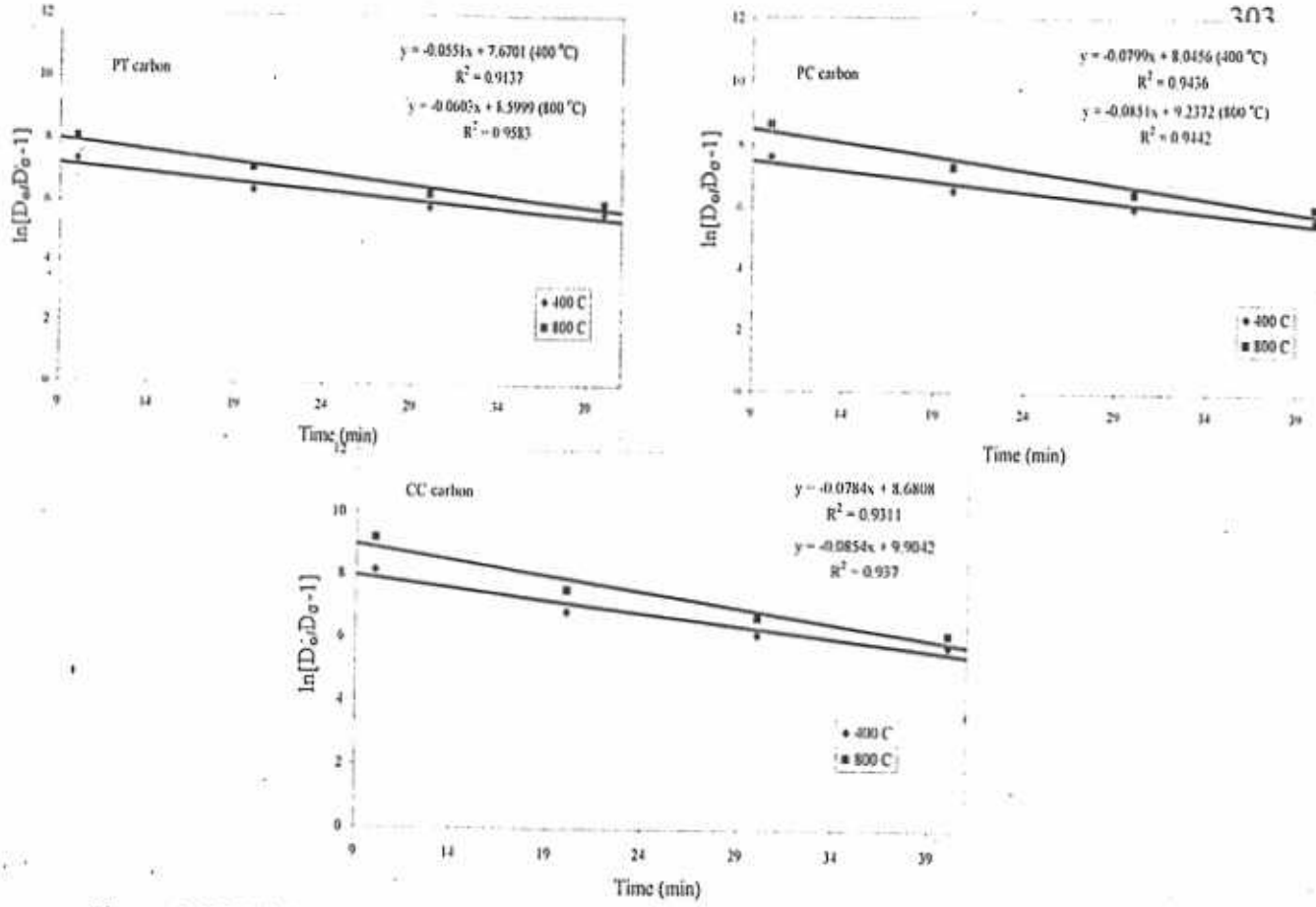


Figure 4.133 Nickel breakthrough plots according to the Thomas model on carbon samples

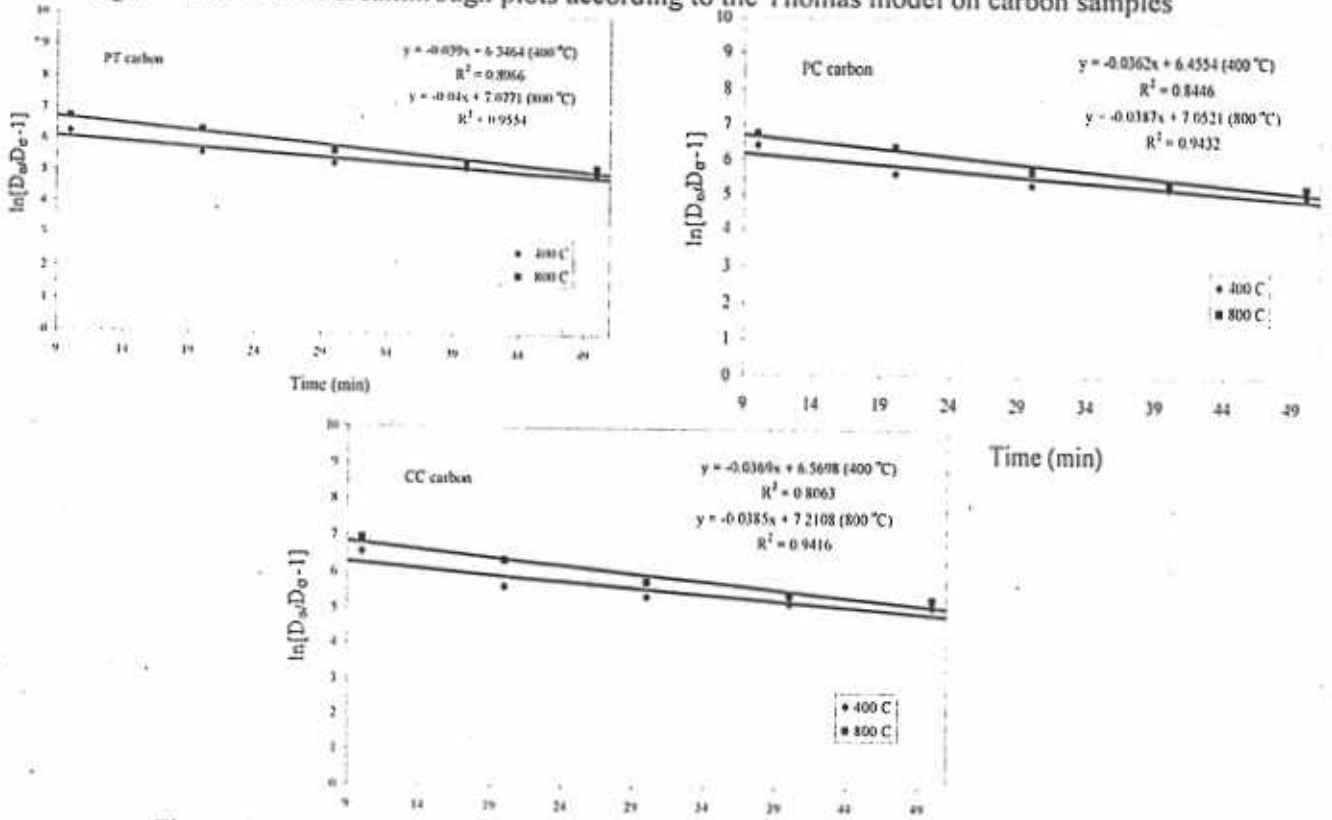


Figure 4.134 Zinc breakthrough plots according to the Thomas model on carbon samples

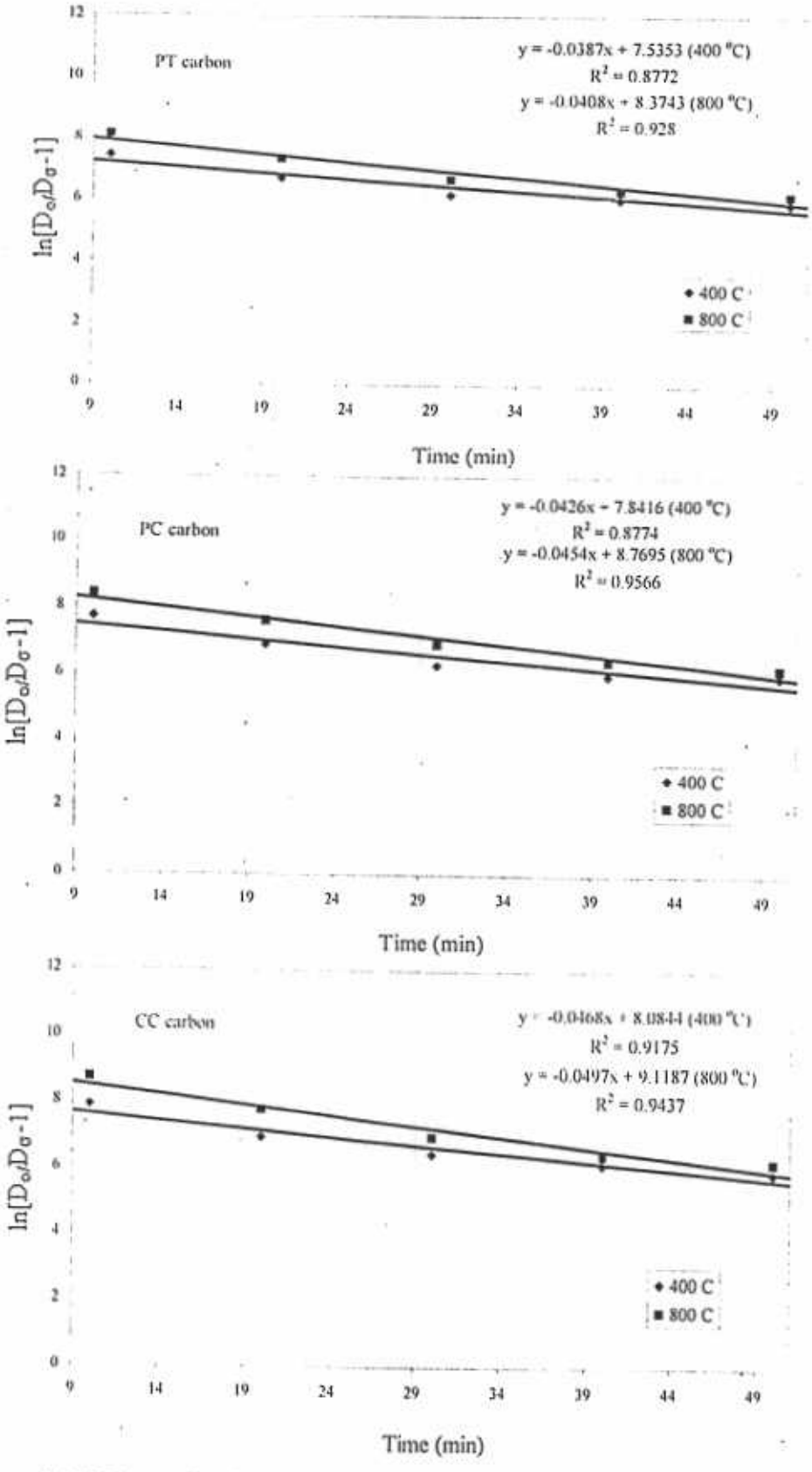


Figure 4.135 Copper break through plots according to the Thomas model on carbon samples

4. RESULTS AND DISCUSSION

Low cost agricultural waste *(Corncobs-CC)*, wood of trees *(Paulownia tomentosa-PT, Populus caspica-PC, Ailanthus altissima-AA, Salvadora oleoides-SO)* and animal bones were utilized for the preparation of activated carbon. Industrial spent carbon of *Fuji Corn complex Nowshera* was regenerated. The samples were characterized by determining moisture content, pH, ash content, bulk density, surface area (BET, DR, BJH, Langmuir), pore size distribution, FTIR, EDS, XRD and SEM analysis. Adsorption of the dyes (acid blue 1, brilliant blue R, acid yellow 29, acid yellow 34, acid orange 7 and acid orange 10) on the carbon samples was carried out at 10°C and 45°C. Adsorption kinetic models of first order, Bangham, intraparticle diffusion (parabolic law) and equilibrium adsorption models of Freundlich, Langmuir, and DR were used to analyze the adsorption data. The column adsorption method (break through technique) was used for the acid blue 1 and treatment of industrial waste water.

4.1. Characterization of adsorbent

4.1.1. Moisture content

Moisture content of the activated carbon samples were found to be in the range 0.001-2.2%. With the increase in activation temperature the % moisture decreases (Table 4.1). At the activation temperature of 400 °C, the moisture loss was found to be RC (92%), AA (60%), SO (44%), PC (43%), PT (25%), BC (20%) and CC (97%) as compared to the respective Raw samples.

4.1.2. pH

pH for all carbon samples increases with increase in activation temperature (Table 4.1). The RC sample has values of near neutral pH i.e. 6.39-7.53. All other samples have pH in the alkaline range of 8.85 to 11.490. This is ascribed to a decrease in the polarity of carbon surface, as well as the decomposition and evolution of some of the acidic oxygen surface functional groups.

4.1.3. Ash content

Ash is the residue of mineral matter present in the material. High ash content was found in the sample of SO (68.4-46.3%) and RC (50.1-25%). While the rest of the samples have relatively less ash contents (3.00 -12.4%) as shown in Table 4.1.

4.1.4. Bulk density

The bulk densities of the carbon samples were found to be in the range: 465-165 kg/m^3 (Table 4.1). The bone charcoal samples have high bulk densities due to the presence of mineral hydroxyapetite. The bulk density of samples decreases with increase of activation temperatures due to the emission of the volatile matter during activation.

4.1.5. Surface area

The surface area of the carbon samples were determined by BET, BJH, Langmuir and DR methods and are given in Table 4.2 and 4.3. The BET surface area (m^2 g^{-1}) is one of the most widely known methods associated with carbon. The BET equation is given by

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$$\frac{1}{W\left((P_\circ / P)-1\right)} = \frac{1}{W_m C} + \frac{C-1}{W_m C}\left(\frac{P}{P_\circ}\right) \qquad (4.1)$$

Where W is the weight of gas adsorbed at a relative pressure, P/P_o and W_m is the weight of adsorbate constituting a monolayer coverage. The term C, the BET C constant, is related to the energy of adsorption in the first adsorbed layer and consequently its value is an indication of the magnitude of the adsorbent/adsorbate interactions. The standard multipoint BET method requires a minimum of three points in the appropriate relative pressure range. The weight of a monolayer of adsorbate W_m can then be obtained from the slope and intercept of the BET plot. From equation (4.1):

$$S = \frac{C-1}{W_m C} \qquad (4.2)$$

$$i = \frac{1}{W_m C} \qquad (4.3)$$

Thus, the weight of a monolayer W_m can be obtained by combining equations (2) and (3).

$$W_m = \frac{1}{S+i} \qquad (4.4)$$

The total surface area St of the sample can be expressed as:

$$S_t = \frac{W_m N A_{CS}}{M} \qquad (4.5)$$

Where N is Avogadro's number (6.023×10^{23}) and M is the molecular weight of the adsorbate and C is cross sectional area of nitrogen gas (16.2 $Å^2$/mol). The nitrogen adsorption isotherms for all carbon samples were determined and it was found that all curves exhibit type I isotherm which are characterized by unimolecular adsorption and applies to microporous adsorbent with small pore sizes [158].

Surface area (S_{BET}) [157] of the all carbon samples were obtained by plotting $1/W[(P_o/P)-1]$ against P/P_o of the N_2 adsorption and the values are given in Table 4.2 and 4.3. As indicated by these results, the SO carbon and regenerated carbon has high surface area of 587 $m^2.g^{-1}$ and 418 $m^2.g^{-1}$, activated at 800 °C. The surface area of other carbon activated at 800 °C are, PT carbon (219 $m^2.g^{-1}$), PC (398.29 $m^2.g^{-1}$), CC carbon (412 $m^2.g^{-1}$), AA carbon (387 $m^2.g^{-1}$) and BC (140.23 $m^2.g^{-1}$). These values were compared with the BET surface area of China GA commercial carbon (560.44 $m^2.g^{-1}$) and found that the surface area of SO carbon is greater than China carbon by 27 $m^2.g^{-1}$. The surface area of other carbon samples were lower than the commercial China GA as, PT (314 $m^2.g^{-1}$), PC (162 $m^2.g^{-1}$), CC carbon (148 $m^2.g^{-1}$), AA carbon (173 $m^2.g^{-1}$) RG carbon (142 $m^2.g^{-1}$) and BC (420.21 $m^2.g^{-1}$). The surface area (S_{BET}) was found to increase with the increase in activation temperature (Table 4.2 and 4.3). During activation the blind pores opened, which in turn increase the porosity and surface area of the samples. A high non-polar surface at high temperature is another reason for high surface area is due to the fact that polar functional groups situated at the pore opening emit and leaving the surface with wide pore volume [159].

Porosity can also be predicted from the N_2 adsorption isotherms. Type-I isotherms were obtained for all carbon samples (Table 4.1 and 4.2). Such types of isotherms are concave to the P/P_o axis and N_2 uptake is governed by accessible micropores volume rather than the internal surface area. Such a behavior was observed for all the samples indicating the porous structures. The results in Table 4.2 and 4.3 shows that activation temperature has a significant effect on pore volume and increases with the increase in activation temperature. The micropore volume ($cm^3.g^{-1}$) of all 800 °C activated carbon samples were found as 0.23 for > PC, 0.220 > SO, RG, 0.21 for CC > 0.20 for AA > 0.11 for PT > 0.100 for ABC. The

mesopores volumes (cm^3.g-1) of carbon samples determined by BJH method were found in the sequence: 0.370 for SO > 0.360 for ABC > 0.320 for AA > 0.310 for RG > 0.250 for CC > 0.230 for PC > 0.210 for PT. The increase in pore volume with rise in activation temperature is due to by removal of the tar as volatile matter that was trapped in the porous structure.

The surface area of all carbon samples were determined by applying the DR equation by plotting volume adsorbed (cm^3. g^{-1}) vs. $\log^2 (P/P_o)$ and the results are given in Table 4.2 and 4.3. The surface area ($m^2.g^{-1}$) of 800 °C activated carbon samples were compared and found as, PC $_{644.68}$ > SO $_{624.30}$ > RG $_{612.16}$ > CC $_{592.33}$ > AA $_{559.69}$ > BC $_{398.35}$.The surface area of each sample was compared with DR surface area ($m^2.g^{-1}$) of china BA commercial activated carbon (806.19) and found that the surface area of our samples are lower than China GA carbon as, PC (161.51), SO (181.89), RG (194.03), CC (214.19), AA (246.5) and BC 407.84). The micropore volume was evaluated by applying the DR equation and was estimated from the intercept of straight lines. The results are given in Table-4.2 and 4.3. The data shows that when the activation temperature increases the micropore volume increases. At 800 °C activation temperature the PT carbon samples was found to be a high micropore volume (0.230 cm^2 g^{-1}). The micropore volume (cm^2 g^{-1}) of other samples were found as, SO $_{0.22}$ > RG $_{0.22}$ > CC $_{0.21}$ > AA $_{0.200}$ > PT $_{0.11}$ > BC $_{0.100}$.

4.1.6. FTIR Studies

FTIR spectra of raw and activated carbons prepared from the wood of *Paulownia tomentosa* (PT), *Populus caspica* (PC), *Corncobs* (CC), *Ailanthus altissima* (AA), *Salvadora oleoides* (SO), Animal bones (BC) and Regenerated carbon (RG) samples are given in Fig. 4.1- 4.7.

The bands in the region of 3387.5 cm^{-1} and 3230.5 cm^{-1} are attributed to the presence of hydroxyl group (-OH) stretching and is characteristic of the hydrogen bonding [160]. These bands can be seen in PT, CC, SO, BC and regenerated samples. The bands are more evident in Raw and lower temperature activated samples (Fig. 4.1, 4.3, 4.5 and 4.6), but its intensity decreases with the increase in the temperature of activation. This reveals that this surface group was eliminated at high activation temperature. Peaks in the region of 3030-3050cm^{-1} were recorded in the Raw and 400 ^{0}C activated PT samples only (Fig-4.1 a, b) and are attributed to the -CH stretching [161], which are completely removed during activation at 800°C, as is shown in Fig.-4.1c. The Raw and 400 °C sample of PT, PC, CC, AA, RC and BC carbon show bands at 2920 cm^{-1} - 2850 cm^{-1} (Fig.-4.1-4.4, 4.6, 4.7) that are ascribed to aliphatic -CH_3, and -CH_2 stretching which may be mainly due to the -CH_2 groups[161]. Such bands are absent in the carbon samples activated at high temperatures. Peaks at 2000-1900cm^{-1} in the Raw and 300-500°C activated samples of SO carbon (Fig 4.5) is due to the generation of C ≡ C stretching of the occluded acetylene [162]. These peaks were not found in the same sample activated at 600-1000°C. Bands at 2332 cm^{-1} in the Raw and 400 °C activated carbons of SO, BC and RC samples are due to the presence of ketones [161] whereas these peaks disappear in the samples exposed to 600 – 1000 °C activation as can be seen in the spectra (Fig.4.5-4.7).

The peaks in the region 1500 – 1600 cm^{-1} shown in Fig.4.1-4.3, 4.5, 4.7 are mainly due to the generation of C ≡ C stretching with the intensity accentuated by oxygen containing functional groups [162], these peaks disappear at activation temperature of 800 °C and above. The bands at 1400-1500 cm^{-1} are typically attributed to the presence of C=C bonds in benzene rings[161]. These bands were found in the carbon samples of PT (Fig. 4.1), PC

(Fig.4.2) and BC (Fig.4.6). A weak absorption bands at 1271-1251 cm^{-1} in the Raw and 400°C activated PT, PC, CC and spent samples (Fig.4.1-4.3, 4.6) represent C = O stretching which indicate the presence of oxygen containing functional groups such as carboxyl's, lactones, phenols and ethers of the type C_6H_5-O-CH_3 or –CH_2-O-CH_3[161]. Some bands in the region 1000-1100 cm^{-1}, indicating the presence of mineral matter [163] were present in all the carbons (Fig. 4.1 - 4.7). The bands between 900-700 cm^{-1} represent aromatic HCC rocking / single ring, having isolated / two neighboring hydrogen [161]. Such bands were found in all the carbons including the Raw samples.

4.1.7. EDS Studies

The energy dispersive spectral studies give a semi-quantitative analysis of the carbon samples. The results of EDS analysis (both % weight and % atomic) for PT, PC, CC, AA, RG and ABC carbon samples are given in Table 4.4 and 4.5, which shows that high carbon contents (% atomic) were found in 800 °C activated PT sample (92.59). Rest of the samples show the carbon contents (% atomic) as 91.57 (AA), 88.30 (CC), 88.00 (RG), 85.89 (PC) and 80.70 (SO) respectively. The concentrations of oxygen in all samples decreased with the increase in activation temperature. Other elements like sulfur, potassium, chlorine, silica, iron, magnesium, copper, phosphorus, sodium, calcium, aluminum and molybdenum were present in the same samples in trace quantities [164].

In the bones charcoal activated at 600 °C, 800 °C and 1000 °C both organic and inorganic composition is evident in Table 4.5. The samples activated at different temperatures as, carbon: 25.29% (600 °C), 22.94 % (800 °C), 43.85% (1000 °C); oxygen: 53.09% (600 °C), 54.04% (800 °C), 34.85% (1000 °C); calcium: 13.08% (600 °C), 14.16% (800 °C), 10.890% (1000 °C); phosphorus: 7.610% (600 °C), 7.740% (800 °C), 6.3700%

(1000 °C), respectively. Other elements like magnesium, sodium, aluminum and chlorine were found in trace quantities. Bone is composed of about 70% inorganic substance called hydroxyapetite [$Ca_{10}H_{12}(PO_4)_6$] that has no carbon atom. The organic phase consisting of about 30% of bone is collagen with a tiny fraction of other compounds like chondroitin sulfate, Keratin sulfate and phospholipids [165]. The results confirm that the contents of phosphorus and oxygen in the samples decrease with the increase in the activation temperature, and that these may have evolved as volatile substances during the carbonization.

4.1.8. XRD studies

XRD spectra of the typical raw carbon samples are given in Fig. 4.8-4.14. The d values of the samples were matched with the d values of standard spectra in the ORIGIN 50 software of the spectrophotometer. The XRD profiles for Raw PT carbon (Fig. 4.8) show distinct absorption bands at d values of 11.042, 7.49, 6.91, 6.36, 5.44 (2θ) etc. These d values match with the phase of β-chromium, 1.10 phenanthroline chloride boron fluorides ($C_{24}H_{16}BCl_2CrF_4N_4$). Similarly d values for 400 °C activated sample were found as 7.8, 7.13, 6.75, 5.21 and 5.05 (2θ) which match the strychnine nitrate ($C_{21}H_{22}N_{202}.HNO_3$) phase. For 800 °C activated the d values depict calcium tartrate hydrate ($C_4H_4CaO_6.4H_2O$) like phase.

The X-ray diffraction patterns of PC carbon (Fig. 4.9) have a peak at $2\theta \approx 22^\circ$ showing the disordered graphitic 002 planes [160]. All the carbon samples (Raw, 400 °C and 800 °C activated) match the phase of 2-methyl-2-(4-isopropoxyphenyl} propane-dioic acid ($C_{13}H_{16}O_5$).

Figure 4.10 shows the XRD profile of CC carbon obtained over the angular range of 8-30° (2θ). The d values were found to be matching the phases of trans- dichlorobispyridine

platinum ($C_{10}H_{10}C_{l2}N_2Pt$), potassium oxide (K_2O_2) and chlorine (Cl_2). It indicates that the surface of all sample i.e. Raw and activated at 400 °C and 800 °C carries these phases.

XRD pattern for AA carbon samples were recorded over the angular range of 6-30° (2θ). The peak at 2θ ≈ 22° corresponds to the disordered graphitic 002 planes [160]. For Raw AA carbon d values at 9.45062, 7.4306, 6.96427, 6.167, 5.55178, 5.44996, 5.10683 etc were recorded at their respective 2θ and after matching with the d values of the computer ORIGIN 50 software the phase of molybdenum sulfide chloride-Mo $(S_2)_3SCl_4$ [File No. 74-2043] was detected. Values of d obtained for 400 °C carbon sample i.e. 3.10784, 3.6896, 3.79836, 4.52536, 4.71609, 5.09226, 6.55332, 7.75536 and 11.18168 (Fig. 4.11) which show the presence of phase of chromium carbonyl cobalt tungsten phosphide-$(CO)_5Cr(CO)_5WP_2CO_2(CO)_6$ [File No. 77-2229]. Similarly the d values of 800 °C activated carbon match with the phase of 2, 4-dinitromesitylene-$C_9H_{10}N_2O_4$ [File No.13-0780] at 12.26714, 10.64368, 9.11039, 7.13208, 6.7525, 4.92385, 4.79189, 4.45781, 3.8144 and 3.34823.

The XRD spectra of SO carbon obtained over the angular range of 20 - 46° (2θ) have discrete peaks and can be seen in Fig. 4.12. The d values for Raw and 400 °C degassed activated carbon match the chemical phase of calcium sulfate {γ-$CaSO_4$} [file number 37-0184]. The 800 °C activated carbon has chemical phase corresponding to sodium potassium chloride (Na.9003K.099Cl) [File No. 75-0305] while that of 1000°C has the phase of sodium zinc molybdenum oxide hydroxide {$Na_2Zn_2(OH)_2(MO_4)_2$} [File No.-70-0411] and calcium carbonate {$CaCO_3$} [File No.-72-0506].

The XRD profiles for spent carbon have distinctive absorption bands that match with the phases of iron carbide (Fe_3C and FeC) [File No. 85-0871 and 03-0410], 4-aminopyridine

($C_5H_6N_2$) [File-No.10-0529] and molybdenum oxide phthivazidate hydrate ($C_{28}H_{26}MoN_6O_8.H_2O$) [File No. 43-1822]. Carbon regenerated at 400 °C match with the phase of m-dinitrobenzene ($C_6H_4N_2O_4$) [File No.10-0536]. The 800 °C and 1000 °C regenerated samples have peaks at the same position as that of the phases of carbon (C) [File No.25-0284], iron oxide (Fe_3O_4) [File No. 76-0958], molybdenum oxide ($Mo_{17}O_{47}$) [File No.71-0566] and molybdenum oxide (Mo_8O_{23}) [File No.84-1247]. These results indicate that the hydrogen and nitrogen are present in the spent and in 400 °C carbon. These elements are eliminated during regeneration at 800 °C and 1000 °C, while carbon, oxygen, iron and molybdenum are retained in the samples (Fig. 4.13) as indicated by the presence of peaks at their respective positions in the standard spectra in ORIGIN-50.

The X-ray diffraction patterns of bones charcoal obtained at 2θ of 20 - 44° are given in the (Fig. 4.14) showing distinct peaks. The peaks for 600°C degassed charcoal are matching to the phase of calcium phosphate ($Ca_x+2P_{2x}O_6+2$) [file number 44-0752], magnesium oxide (MgO) [File No. 27-0759] and sodium [File No. 01-0832]. The 800°C and 1000°C degassed charcoal indicate the existence of several elements when spectral peaks were matched with the standard spectra of computer software ORIGIN-50. The elements in the phases are of calcium, magnesium, sodium, hydrogen, phosphorus, carbon oxide, chloride, fluoride, (Ca. Mg. Na. $H_3)_5$ (P. C)$_3$ O_{12} (OH. Cl. F) [File No.12-0529]; sodium, calcium, hydrogen, carbonate, phosphate, hydrate Ca_8H_2 $(PO4)_6$. H_2O-$NaHCO_3$-H_2O [File No. 47-0261] and sodium, calcium, hydrogen, carbonate, phosphate, hydrate Ca_8H_2 $(PO_4)_6$. H_2O-$NaHCO_3$-H_2O [File No. 47-0262].

4.1.9. SEM Studies

SEM micrographs both in 5000x and 1000x magnification (plate 4.1 - 4.8) of all carbon samples showed smooth areas as well as roughness with oval and hexagonal pore patterns. Within each oval/hexagonal pore, presences of the macropores are clearly noticeable.

4.2. Adsorption Studies

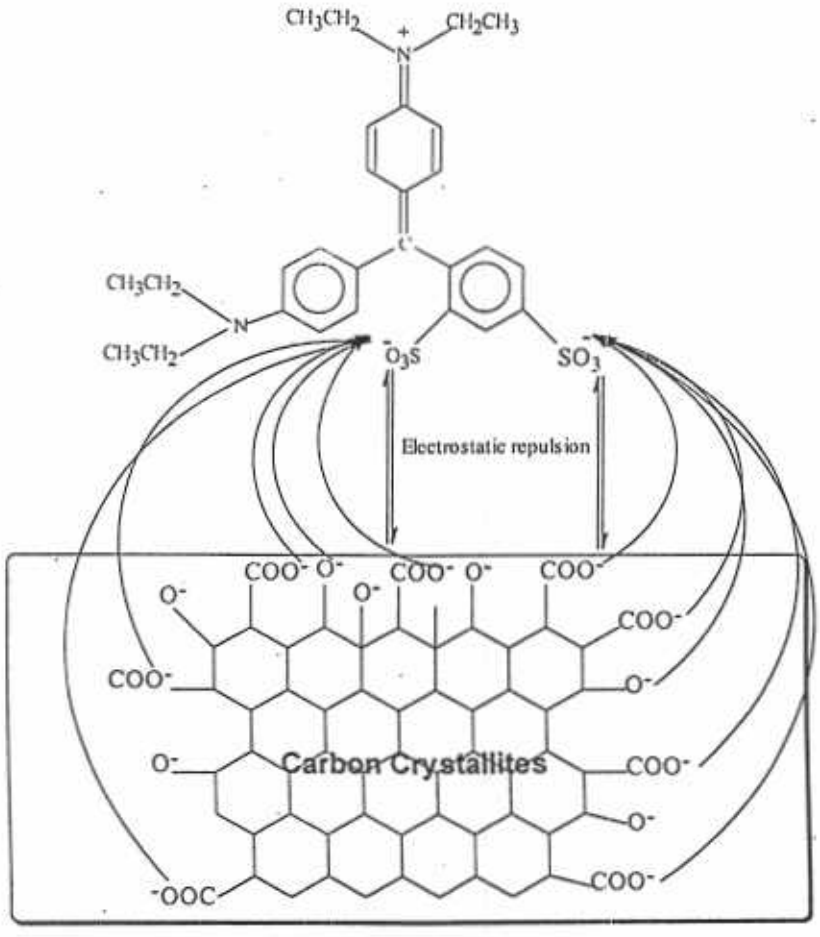
4.2.1. Effect of contact time

The equilibrium time on the adsorption of all the six dyes (acid blue 1, brilliant blue R, acid yellow 29, acid yellow 34, acid orange 7 and acid orange 10) studied at 10 °C and 45 °C on the seven types of activated carbons samples (PT, PC, CC, AA, SO, BC and regenerated) and are shown in Fig. 4.15 to 4.49 and 4.69 to 4.74. It can be seen that the adsorption was fast in the initial fifteen seconds and then declined due to the possible diffusion in to the micropores. The increase in adsorption temperature has resulted in the increase adsorption, indicating endothermic nature of the process.

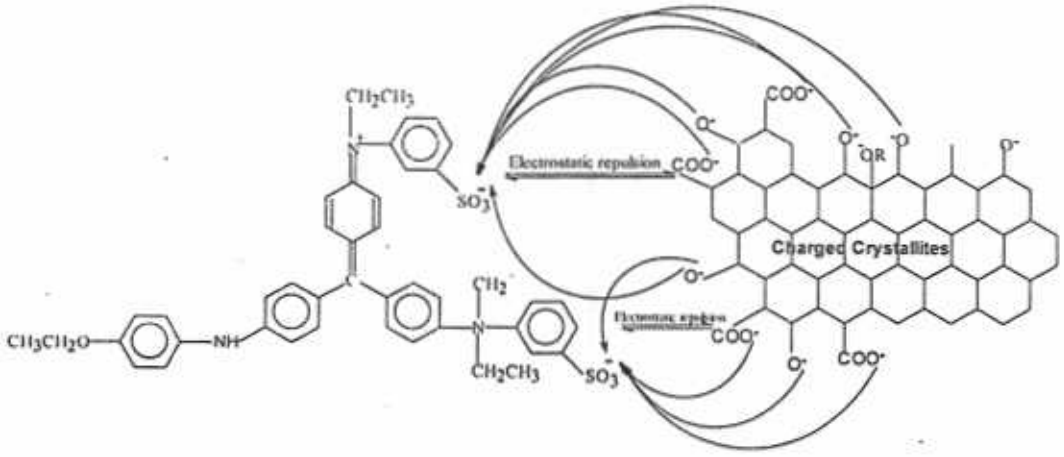
4.2.2. Effect of surface functional groups

All the six selected adsorbate are anionic dyes (triphenylmethane and azo) which contains a sodium salt of sulphonic acid group. In aqueous solution, it ionizes to an anionic SO^{-}_3 group. The acidic dye anion will suffer Columbic repulsion upon approaching the surface due to the presence of oxygen contain functional groups on Raw and 400 °C degassed carbon samples (Fig. 4.1-4.7). The adsorption of dyes on the samples activated at temperature of 600 °C and above, the adsorption is which might be due to the decrease in polarity of the carbon surface as well as to the decomposition and evolution of some of the acidic oxygen surface functionalities. A slight increase in adsorption might also have occurred due to an increase in the surface area resulted from activation at temperature of 800-

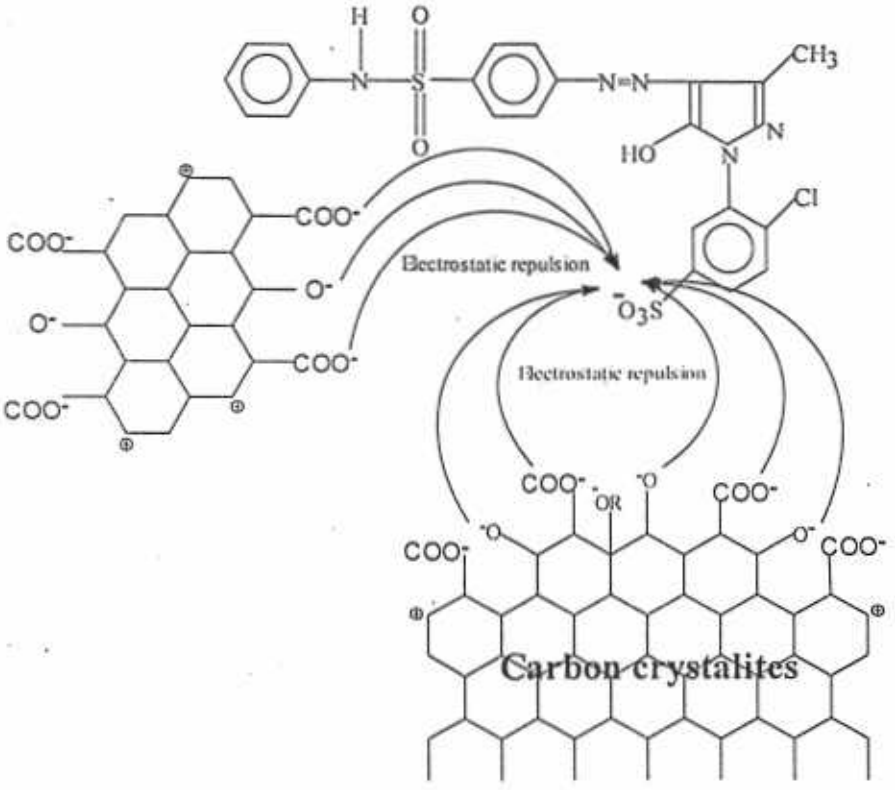
1000 °C. During degassing at higher temperatures the blind pores might have opened, which in turn might have increased the porosity and surface area of the samples. The absence of polar groups on the surface of the 800 °C, 900 °C and 1000 °C degassed sample, as indicated by the FTIR results may be another reason for the high adsorption of dyes. Lower adsorption of dye on the Raw and 400 °C carbon activated on the other hand may be due to the fact that polar functional groups situated at the pore opening adsorb water strongly through hydrogen bonds that in turn result in pore constriction or pore blockage [159]. A schematic representation of the electrostatic repulsion between the dyes ions and the negatively charged carbon surface of the Raw and 400 °C samples is depicted in scheme 4.1- 4.6.



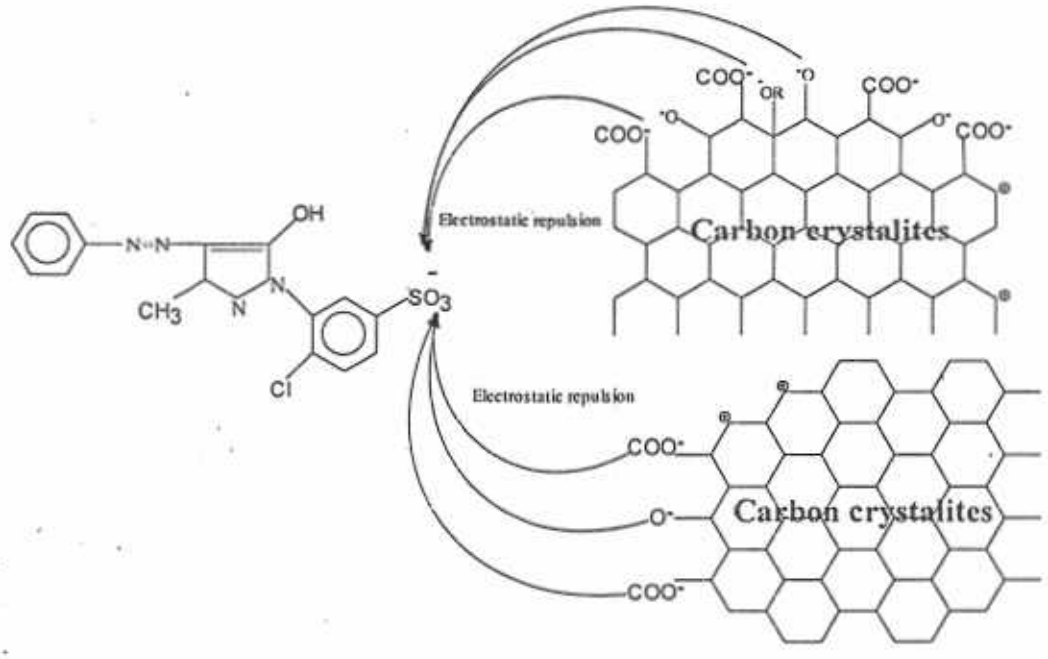
Scheme 4.1 Electrostatic repulsion between acid blue 1 and functional groups on the Raw and 400°C activated carbon surace



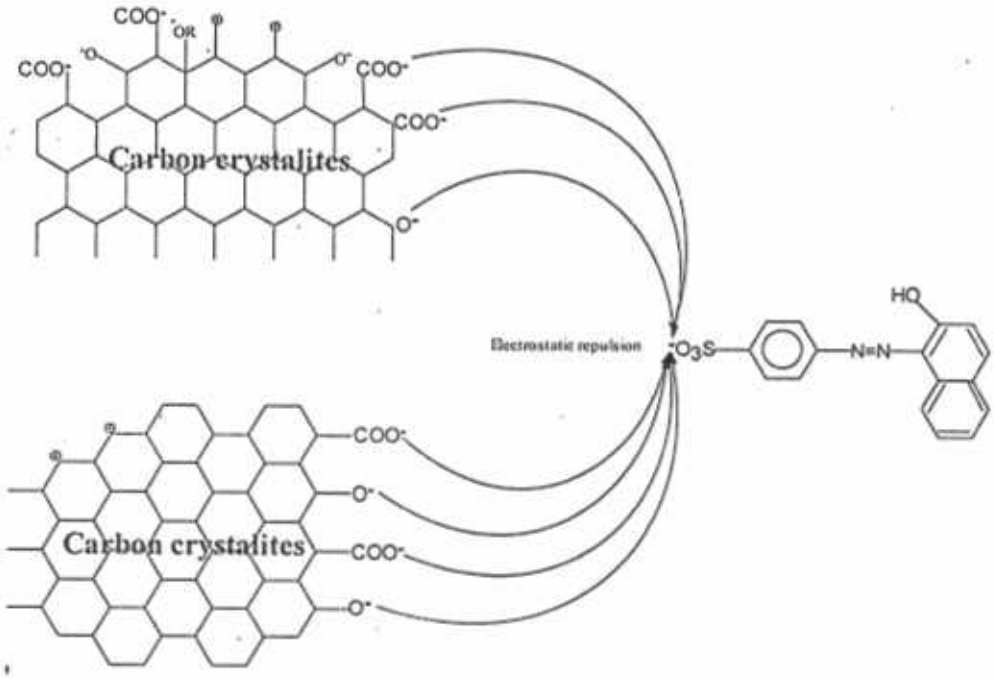
Scheme 4.2 Electrostatic repulsion between Brilliant blue R ion and functional groups on the Raw and 400°C activated carbon surace



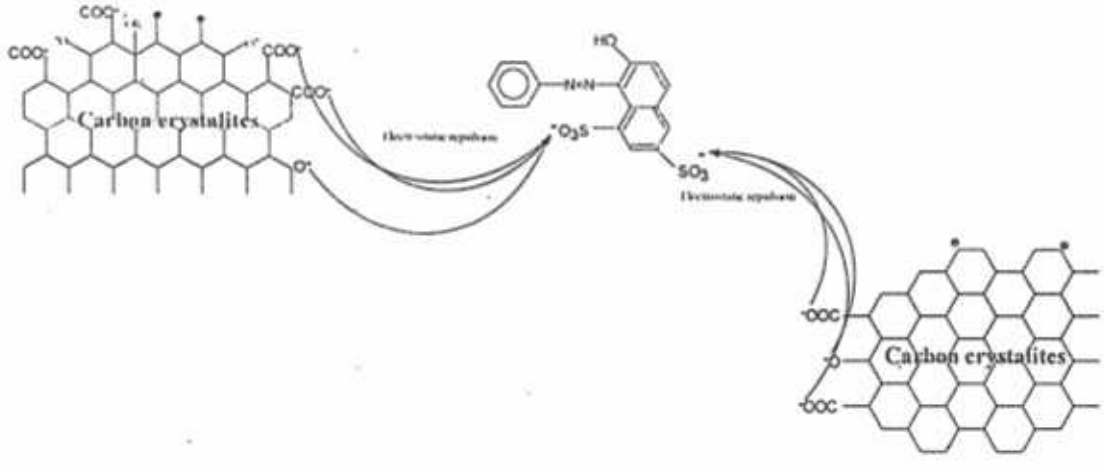
Scheme 4.4 Electrostatic repulsion between acid yellow 29 ion functional groups on the Raw and 400°C activated carbon surface



Scheme 4.3 Electrostatic repulsion between acid yellow 34 ion and functional groups on the Raw and 400°C activated carbon surface



Scheme 4.5 Electrostatic repulsion between acid orange 7 ion functional groups on the Raw and 400°C activated carbon surface



Scheme 4.6 Electrostatic repulsion between acid orange 10 ion anf functional groups on the Raw and 400°C activated carbon surface

4.2.3. Kinetic Models

The rate constant for the adsorption of acid dyes on carbon surface was determined using first rate kinetic equation. Such an equation in the linear form can be expressed as [166]:

$$\ln D_e = \ln D_o - k_{ad} t \qquad (4.6)$$

Here D_o and D_e are the solution concentration ($mol.dm^{-3}$) at t=0 and t=t respectively and k_{ad} is the rate constant. From the linear plots of ln D_e vs. t for adsorption of the dyes on the carbon surface at 10 °C and 45 °C the values of rate constants at different temperatures were derived and are shown in Table 4.48 - 4.54. It was noted that the rate constant has increased with the increase in temperature of adsorption and also have high values for the samples activated at high temperatures. The rate constant (s^{-1}) of the adsorption each dye at 45 °C on carbon samples activated at 800 °C were found in the following sequence; for acid blue 1: 0.0965 for BC > 0.0340 for CC > 0.0315 for RG > 0.0268 for PT > 0.0195 for PC > 0.0160 for SO > 0.0145 for AA, for brilliant blue R: 0.0171 for AA > 0.0170 for PT > 0.0154 for SO > 0.0130 for CC > 0.0105 for PC > 0.0067 for BC > 0.0053 for RG, for acid yellow 29: 0.1222 for PT > 0.0665 for CC > 0.0514 for RG > 0.0267 for BC > 0.0259 for AA > 0.0168 for PC > 0.0157 for SO, acid yellow 34: 0.0531 for SO > 0.0451 for PT > 0.0421 for CC > 0.0396 for AA > 0.0290 for BC > 0.0269 for RG > 0.0269 for PC, for acid orange 7: 0.0390 for BC > 0.0216 for CC > 0.0160 for SO > 0.0098 for RG > 0.0079 for PC > 0.0063 for PT > 0.0056 for AA, and acid orange 10: 0.0363 for BC > 0.0334 for AA > 0.0209 for CC > 0.0177 for RG > 0.0127 for PC > 0.0087 for PT > 0.0087 SO. The correlation coefficients (r^2) for the first order model (0.8 – 0.90) were closer to 1, indicating a better agreement.

The energy of activation for the adsorption was calculated using the Arhenius equation [167] in the form:

$$\ln \frac{k_2}{k_1} = \frac{E_a}{R}\left[\frac{T_2 - T_1}{T_1 T_2}\right] \qquad (4.7)$$

Where E_a is the activation energy, k_1 and k_2 are rate constants, R is the gas constant (8.314 J K^{-1} mol^{-1}) and T is the absolute temperature (K). The energies of activation (kJ mol^{-1}) calculated for the dyes adsorption is given in Table 4.48-4.54. The activation energies (*kJ mol⁻¹*) of the dyes on carbon samples activated at 800 °C were found in the following sequence order. Acid blue 1: 0.078 for PT < 0.12151 for PC < 0.16222 for BC < 0.229243 for CC < 0.2611 for AA < 4.020071 for RG < 1096.518 for SO. Brilliant blue R: 3.4003931 for PT < 3.7868 for SO < 5.608671 for BC < 6.55710231 for RG < 8.09986 for CC < 8.6678 for AA < 20.777 for PC. Acid yellow 29: 3.147102 for PC < 8.381 for AA < 10.8914 for BC < 12.38314 for RG < 13.994 for PT < 15.230 for SO < 15.7038 for CC. Acid yellow 34: 0.73928 for BC < 0.975565 for RG < 7.29067 for PC < 9.8151552 for CC < 11.771378 for PT < 15.596637 for SO < 16.50183 for AA. Acid orange 7: 2.139526 for PT < 2.32449 for BC < 2.85455 for AA < 3.77913 for CC < 6.590688 for RG > 7.385934 for PC < 35.08434 for SO. Acid orange 10: 1.936728 for PC < 2.65434 for AA < 2.695305 for BC < 3.0748689 for CC < 3.3962287 for RG < 4.37463 for PT < 8.704688 for SO. The data shows that increase in the activation temperature result a decrease in the activation energy. The high activation energy of the dye adsorption on the Raw and 400 °C degassed carbon samples may be due to the fact that polar functional groups present at the pore opening block the entrance of the dye molecules and thus an energy barrier may arise from this repulsion [159]. From the values of activation energies, thermodynamic parameters such as enthalpy change of activation ($\Delta H^{\#}$) and entropy change of activation ($\Delta S^{\#}$) were calculated (Table 4.48–4.54) by using the following equations [166].

$$\Delta H^{\#} = Ea - RT \qquad (4.8)$$

$$\Delta S^{\neq} = R \left[\ln \frac{kh}{k_B T} + \frac{\Delta H^{\neq}}{RT} \right] \qquad (4.9)$$

Where k = Rate constant

k_B = Boltzmann constant (1.3806×10^{-23} J K^{-1})

h = Planck constant (6.626×10^{-34} J s)

The enthalpy of activation ($\Delta H^{\neq}$ kJmol^{-1}) for the dyes adsorption on 800 °C activated carbon samples are: Acid blue 1: -2.5659 to -1547.337; Brilliant blue R: 0.756541 to 18.13315; Acid yellow 29: 0.50355 to 13.05992; Acid yellow 34: -1.904572 to 13.857979, Acid orange 7: -0.5043256 to 32.440486; Acid orange 10: -0.707124 to 0.75237677. The positive values indicate endothermic and the negative values the exothermic adsorption process. These values decrease with the increase in the temperature of adsorption as well as with the temperature of activation of the samples. Negative values of the entropy of activation ($\Delta S^{\neq}$) reflect affinity of the dye towards the carbon which decreases with the increase in adsorption temperature (Table 4.48 – 4.54) meaning that the dye molecules have acquired a more stable oriented position on the surface.

4.2.4. Bangham equation

The Bangham linear equation in the following form was used to check the pore diffusion during the adsorption process.

$$\log \log \frac{D_\circ}{D_\circ - D_\sigma W} = \log \frac{k_\circ W}{2.303\ V} + \alpha \log t \qquad (4.10)$$

Where D_o is the initial concentration (mol.dm^{-3}) of dye in the solution, V is the volume (dm^3) of solution, W is the weight (g) of charcoal, D_σ is the amount adsorbed at time t. Values of the constants $\propto$ and k_o calculated from the slopes and intercepts of the linear plots (Fig. 4.57 – 4.62) are given in Table 4.55 – 4.57. The α values decreased while k_o increased with the

increase in temperature of adsorption and same trend was found in the case of increase in temperature of sample activation, indicating that the diffusion of dye into pores of the carbon is important and adsorption in to the pores is a diffusion controlled process[168, 169].

4.2.5. Parabolic diffusion law (Intraparticle diffusion)

The intraparticle diffusion was analyzed by applying the parabolic diffusion equation to the data. For a solid liquid adsorption process, the solute transfer is usually characterized by either external mass transfer (boundary layer diffusion) or intraparticle diffusion or both. Adsorption dynamics can be described by the three consecutive steps i.e. transport of the solute from bulk solution through liquid film to the adsorbent exterior surface; solute diffusion into the pores of adsorbent except for a small quantity of adsorption on the external surface; parallel to this is the intraparticle transport mechanism of the surface diffusion and adsorption of solute on the interior surfaces of the pores and capillary spaces of the adsorbent. Of the three steps, the third step is assumed to be rapid and negligible to be considered. The overall rate of adsorption will be controlled by the slowest step, which would be either film diffusion or pore diffusion. However, the controlling step might be distributed between intraparticle and external transport mechanisms. However in both the cases the external diffusion is involved in the adsorption process. The adsorption of dyes onto carbon particles may be controlled by the film diffusion at earlier stages and then as the adsorbent particles are loaded with dye ions, the adsorption is then controlled by the intraparticle diffusion. Literature show that the plot of D_Φ versus $t^{1/2}$ represent multi-linearity, which characterizes the two or more steps involved in the adsorption process [170]. According to Weber and Morris[171] intraparticle diffusion is defined by the equation:

$$D_\Phi = k_{ad}\, t^{1/2} + B \qquad (4.11)$$

The k_{ad} value can be obtained from the slope of the plot of D_Φ (amount adsorbed in mol/g) vs. $t^{1/2}$. It can be seen from Fig. 4.63 – 4.68 that the adsorption process consists of two stages. The intraparticle diffusion coefficient (k_{ad}) given in Table 4.58-4.60 increases with the increase in adsorption temperature and also with the activation temperatures of the sample. The k_{ad} values of dyes on carbon samples activated at 800 °C were found in the following sequence. For acid blue 1:2.5581 for BC > 1.1538 for PT > 0.9643 for CC > 0.9150 for SO > 0.9127 for RG > 0.7824 for AA > 0.6670 for PC. For brilliant blue R: 3.7391 for SO > 3.258 for BC > 1.3108 for RG > 1.3725 for PT > 1.3102 for PC > 1.2262 for CC > 1.1912 for AA. For acid yellow 29: 16.151 for RG > 10.179 for BC > 2.6055 for SO > 2.1674 for CC > 1.8683 for PT > 1.834 for AA > 1.8328 for PC. For acid yellow 34: 5.6696 for BC > 5.1759 for SO > 3.8282 for RG > 2.1114 for PT > 1.7418 for AA > 1.6639 for CC > 1.5247 for PC. For acid orange 7: 6.7615 for RG > 6.5791 for BC > 4.2902 for SO > 1.8314 for PT > 1.4057 for CC > 1.0048 for AA > 0.966 for PC. For acid orange 10: 2.8431 for BC > 1.5663 for SO > 1.2804 for RG > 1.3539 for PT > 1.0708 for CC > 0.8069 for AA > 0.7629 for PC. Acid yellow 29 has greater diffusion coefficient values as compared to other dyes. The correlation coefficient (r^2) values for the intraparticle diffusion model (0.8–0.9997) were closer to 1 indicating better agreement of the fit for the dyes adsorption. This is attributed to the instantaneous utilization of the most readily available adsorbing sites on the adsorbent surface [172-174].

4.3. Adsorption isotherm Studies

Adsorption isotherms of the dyes at 10 °C and 45 °C on all carbon samples are shown in Fig. 4.75-4.104) and the data has given in Table 4.73 – 4.97. It was observed at lower

concentration most of the dye is adsorbed and the adsorption gradually decreased with increase in concentration. The process when reach to equilibrium, giving a plateau in the graph of amount adsorbed ($mol.g^{-1}$) vs. equilibrium conc. ($mol.\ dm^{-3}$). On the Raw and 400 °C activated carbon samples the dye uptake is low as compared to sample activated at high temperature of 600 to 1000 °C which might be due to the removal of surface acidic oxygen functionalities [139] that leave the surface pores open (Fig. 4.1 – 4.7). The sensitivity of the adsorption process towards temperatures of adsorption as well as carbon activation was observed such that it increases with the increase in temperature, indicating the overall process to be endothermic with surfaces of greater surface area with pore opening and high interaction for acid dyes.

4.3.1. Freundlich isotherm

Freundlich equation [175] in the following linear form was found to apply to the dyes adsorption isotherms data shown in Fig. 4.105 - 4.110,

$$\ln D_e = \ln K + \frac{1}{n} \ln D_e \qquad (4.12)$$

Values of the parameters *n* and K (adsorption capacity) calculated from the figures are given in Table 4.103 and 4.105. The constant *n* gives information about the surface heterogeneity and its affinity for the solute [176]. A larger value of 1/n indicates effectiveness of the adsorbent. When 1/n >1.0, the adsorbed concentration of the solute is greater than that present in the solution[177]. The values of constant, K ($mol.g^{-1}$) indicate adsorption capacity of the carbon samples and were found to be in the following sequence: For acid blue 1; 86916.22 for RG > 54339.1 for CC > 28486.9 for PC > 22833.8 for AA > 54339.1 for SO > 3397.17 for BC > 581.140 for PT. For brilliant blue R: 57068.06 for CC > 20696.08 for AA > 18205.8 for RG > 11496.52 for PC > 10779.48 for BC > 10738.59 for PT > 7472.61 for

SO. For acid yellow 29: 41522.9 for PC > 32663.0 for AA > 32565.20 for CC > 15633.9 for PT > 8980.4 for SO > 8204.18 for BC > 4540.53 for RG. For acid yellow 34: 207108.8 for PT > 46202.99 for SO > 44981.20 for PC > 25848.20 for AA > 23956.60 for CC > 7611.381 for RG > 3022.07 for BC. For acid orange 7: 123747.6 for PC > 72547.70 for AA > 71539.14 for CC> 62317.60 for PT > 32305.7 for RG > 4041.212 for SO > 192.905 for BC. For acid orange 10: 384000.8 for SO > 125366.9 for CC > 113493.4 for BC > 92503.30 for AA > 47476.96 for PT > 32500.15 for PC > 12667.56 for RG. The data shows that the adsorption capacity of carbon increases as the temperature of increases and it also has a greater values for adsorption on the samples activated at higher temperature.

4.3.2. Langmuir isotherm

Langmuir isotherm [178] in the following form when applied to the adsorption data, gives linear plots (Fig.4.111-4.116).

$$\frac{D_e}{D_\varphi} = \frac{1}{bK_l} + \frac{D_e}{b} \qquad (4.13)$$

Where b is the amount of adsorption (mol/g) corresponding to a complete monolayer coverage and K_l (L/g) is the binding energy constant. The linear plots of D_e/D_Φ (g dm^{-3}) against D_e (mol dm^{-3}) gave the values of K_l and b (Table 4.106-4.108). The isotherm was best fit to the data with correlation coefficient, $r^2 > 0.960$. The adsorption capacities (b) were high for high temperature adsorption and also for the case of the samples activated at high temperatures (Table 1). Comparing the adsorption capacity b ($mol.g^{-1}$) values of the 800 °C activated carbon samples were found in the following sequence.

Acid blue 1: 3.845110 for RG > 2.074690 for BC > 0.993340 for SO > 0.42303 for PT > 0.12840 for AA > 0.12772 for PC > 0.12300 for CC. **Brilliant blue R:** 3.494060 for SO >

2.088118 for BC > 1.235483 for RG > 0.35355 for AA > 0.36542 for CC > 0.33338 for PC > 0.24992 for PT. **Acid yellow 29**: 6.493500 for BC > 5.449590 for RG > 0.929280 for SO > 0.45486 for PT > 0.39668 for CC > 0.39584 for PC > 0.39307 for AA. **Acid yellow 34:** 8.333330 for RG > 7.132667 for BC > 1.58027 for SO > 0.49529 for CC > 0.48379 for AA > 0.43412 for PT. **Acid orange 7:** 8.944543 for RG > 8.583690 for BC > 3.679176 for SO > 0.44600 for CC > 0.40630 for PC > 0.40228 for PT > 0.39888 for AA. **Acid orange 10:** 4.965243 for BC > 2.293577 for RG > 0.927040 for SO > 0.42279 for PC > 0.41354 for PT > 0.40175 for CC > 0.39143 for AA.

The adsorption of dyes from solution on a carbon is a measure of the tendency to pass from one phase into the other. The driving force for such a tendency is represented by the Gibbs free energy (ΔG^o) [179]. Negative free energy (ΔG^o) values for the systems indicate the spontaneity in the affinity of the adsorption. Gibbs free energy was calculated as suggested by Yu Lin [180] as,

$$K_T \approx bM_A \qquad (4.14)$$

$$\Delta G^{\prime} = -RT \ln K_T \qquad (4.15)$$

Where b ($mol.g^{-1}$) is the Langmuir monolayer adsorption capacity and M_A is the molecular weight of the dye. The data (Table-4.109-4.112) show that $\Delta G^{\prime}$ values decrease with the increase in temperature of adsorption, which reveals higher adsorption at higher temperatures.

4.3.3. Dubinin-Radushkevich (DR) equation

The DR adsorption equation[181] which is based on Polanyi potential $\left[\varepsilon = RT \ln\left(1 + \frac{1}{D\sigma}\right)\right]$ is given by:

$$D_{\phi} = D_{\phi m} \exp^{(-B\varepsilon^2)} \qquad (4.16)$$

OR $$\ln D_{\phi} = \ln D_{\phi m} - B\varepsilon^2 \qquad (4.17)$$

Where ε is the Polanyi potential, D_{ϕ} is the amount of dye adsorbed in $mol.g^{-1}$, $D_{\phi m}$ is the adsorption maximum, D_e is the equilibrium concentration $(mol.dm^{-3})$, B is a constant and is called the mean energy of adsorption, R is a gas constant and T is the absolute temperature. The adsorption data when plotted according to the equation ($\ln D_{\phi}$ vs. ε^2) give linear plots (Fig 4.117-4.122) from where the values of constant B and adsorption maximum ($D_{\phi m}$) were calculated (Table 4.113-4.119). The data show that both the activation temperature of the carbon and the adsorption temperature effect the adsorption maximum values i.e. increase in either of these temperatures have increased the adsorption maximum as found by the application of the DR equation, for adsorption of the dyes on all of our activated carbon samples.

4.3.4. Distribution coefficient of the dyes on the carbon surface.

Affinity of the dye for the carbon matrices was determined by calculating the distribution coefficient, using the following equation [182]:

$$D_c = \frac{D_o - D_e}{WD_e} \qquad (4.18)$$

Here D_c is the distribution coefficient, D_o and D_e are the solution concentration ($mol.dm^{-3}$) at t=0 and t=t respectively, W is the weight of carbon sample. The plots of D_c vs. D_e are given in Fig. 4.123-4.127. These plots show that, for a fixed amount of adsorbent, the extent of adsorption and the distribution coefficient, D_c, decrease as the dye concentration was increased over the concentration ranges used (Table-4.73-4.102). Values of the distribution coefficients for the samples activated at high temperatures have high values. The trend is that

values for the same initial concentration of all the dyes are in the sequence: $D_{c\ 800\ ^{o}C} > D_{c\ 400\ ^{o}C} > D_{c\ Raw\ ^{o}C}$, and $D_{c1000\ ^{o}C} > D_{c\ 900\ ^{o}C} > D_{c\ 800\ ^{o}C} > D_{c\ 600\ ^{o}C} > D_{c\ 400\ ^{o}C} > D_{c\ Raw}$ respectably.

4.3.5 Waste water treatment

The different activated carbon samples prepared from the various source materials were used for the treatment of waste water. The waste water used was (i) aqueous solution of dye acid blue 1 as contaminant (ii) effluent waste water from a glass industry. On flowing the water at the rate of 5 ml. min^{-1}, through the columns, each filled with different activated carbon, It was observed that the contaminant in general were mostly retained by the upper layer area of carbon bed. In this layer the adsorbent was exhausted first due to its loading to maximum capacity. Below this area then due to the mass transfer of the contaminants during downward flow through the column the adsorbent, a state of equilibrium is established between contaminants and the adsorbent with no more change in concentration. An amount of 4 gram activated carbon filling the column of 10 cm was totally exhausted in time period of 25 – 35 minutes. The inlet flow (C_{in}) was continuous and the concentration of the contaminants in the out flow (C_{out}) of the column was monitored by collecting the water after each five minutes flow till there was an maximum saturation of the adsorbent and no change in the concentration of the contaminant was observed i.e. $C_{in} = C_{out}$. In case of dyes, the adsorption was found to be a function of the length of carbon packed column or the mass transfer zone of the column and S shape of curves of D_o/D_o vs. time were obtained (Fig. 4.128 to 4.135). As the glass industrial waste water has a broad spectrum of contaminants, prediction about the shape of the curves is difficult.

The Thomas kinetic model as used by Banat and Al-Asheh [183] for the column adsorption study has the linear form equation of the form:

$$\ln\left(\frac{D_o}{D_\sigma}-1\right)=\frac{kq_oM}{Q}-kD_ot \qquad (4.19)$$

Where D_σ is the contaminant concentration (mol l^{-1}) at time; k is the Thomas rate constant [cm^3. min^{-1}.g^{-1})], q_o is the adsorption capacity (mol.g^{-1}), M is the mass of adsorbent (g), and Q is the volumetric flow rate (ml/min). The rate of flow plots for ln [D_o/D_σ -1] vs. t was linear as shown in Fig. 4.128 to 4.135. The fitting of the data to the equation was judged by the correlation coefficient r^2 (0.8 - 0.940). Slope of the curve gave the rate constant of the flow, k (min^{-1}). The adsorption capacities (q_o. *mol.* g^{-1}) for 800 °C activated carbon samples, calculated from the linear plots of Thomas model, are 109.359 for acid blue 1, 178.273 for nickel, 256.56 for copper and 221.159 for zinc.

4.4 CONCLUSIONS

The studies presented cover the preparation, characterization and adsorption properties of the activated carbons developed from the local source material such as agricultural waste *(Corncobs-CC)*, low cost wood of fast growing trees *(Paulownia tomentosa-PT, Populus caspica-PC, Ailanthus altissima-AA, Salvadora oleoides-SO)*, bones and industrial spent carbon. Dyes (acid blue 1, brilliant blue R, acid yellow 29, acid yellow 34, acid orange 7 and acid orange 10) were used as adsorbate. The following conclusions are drawn from the studies.

1. The moisture contents of the samples activated at 400 °C were found to be in the sequence: 97% for CC > 92% for RG > 60% for AA > 44% for SO > 43% for PC > 25 % for PT > 20%for ABC.

2. pH of the activated carbon samples was alkaline (pH = 8.85-11.490), however the RG carbon sample was neutral (pH = 6.39-7.53).

3. Ash content was found to be high in the sample of SO (68.4-46.3%) and RG (50.1-25%). While the rest of the samples have small amount of ash (3.00 -12.4%).

4. Bulk density of the carbon samples was found to be in the range: 465-165 kg/m^3. With the rise in activation temperature the bulk density decreased.

5. The BET (m^2g^{-1}) surface area analysis of the carbon samples activated at 800 °C showed that SO carbon has the high surface area of 587. The surface area of other carbon samples activated at 800 °C was found in the sequence: 418 for RG > 412 for CC carbon > 398.29 for PC > 387 for AA carbon > 219 for PT carbon > 140.23 for BC.

6. The pore volume (cm^3g^{-1}) of the 800 °C activated carbon samples were found to be in the sequence: 0.23 for PC > 0.220 for SO, RG > 0.21 for CC > 0.20 for AA, 0.11 for PT > 0.100 for ABC. The pore volume was also found to increase with rise in activation temperature.

7. The Raw and 400 °C activated carbon surfaces carried the oxygen containing functional groups such as carboxyl's, lactones, phenols etc which were eliminated at high activation temperatures.

8. The XRD analysis showed that the elements like carbon, hydrogen, nitrogen, oxygen, boron, chromium, fluorine, nitrogen and molybdenum were present in the activated carbons.

9. The EDS analysis showed high carbon contents (% atomic) in carbons activated at high temperatures as compared to Raw and the 400 °C activated samples. The concentrations of oxygen in the samples were found to decrease with the increase in activation temperature. Other elements like sulfur, potassium, chlorine, silica, iron, magnesium, copper, phosphorus, sodium, calcium, aluminum and molybdenum were present in trace quantities in the samples.

10. The rate of adsorption of dyes on all carbon samples was high in the initial fifteen seconds and then declined due to the possible diffusion and hindrances in penetration of the dye molecules in to the micropores.

11. The values of the first order rate constants were high at high temperatures of adsorption and also for the sample activated at high temperatures.

12. Increase in activation temperature resulted in decrease of activation energy of the dye adsorption. The high activation energy of the dye adsorption on the Raw and 400 °C activated carbon samples was due to the presence of polar functional groups at the pore openings that blocked the entrance of the dye molecules and thus resulted in the energy barrier.

13. Negative values of the entropy of activation ($\Delta S^{\#}$) of dye adsorption reflected affinity of the dye molecules towards the carbon which decreased with the increase in adsorption temperature. The dye molecules have thus acquired a more stable oriented position on the surfaces at high temperature adsorption and also on samples that were activated at high temperatures.

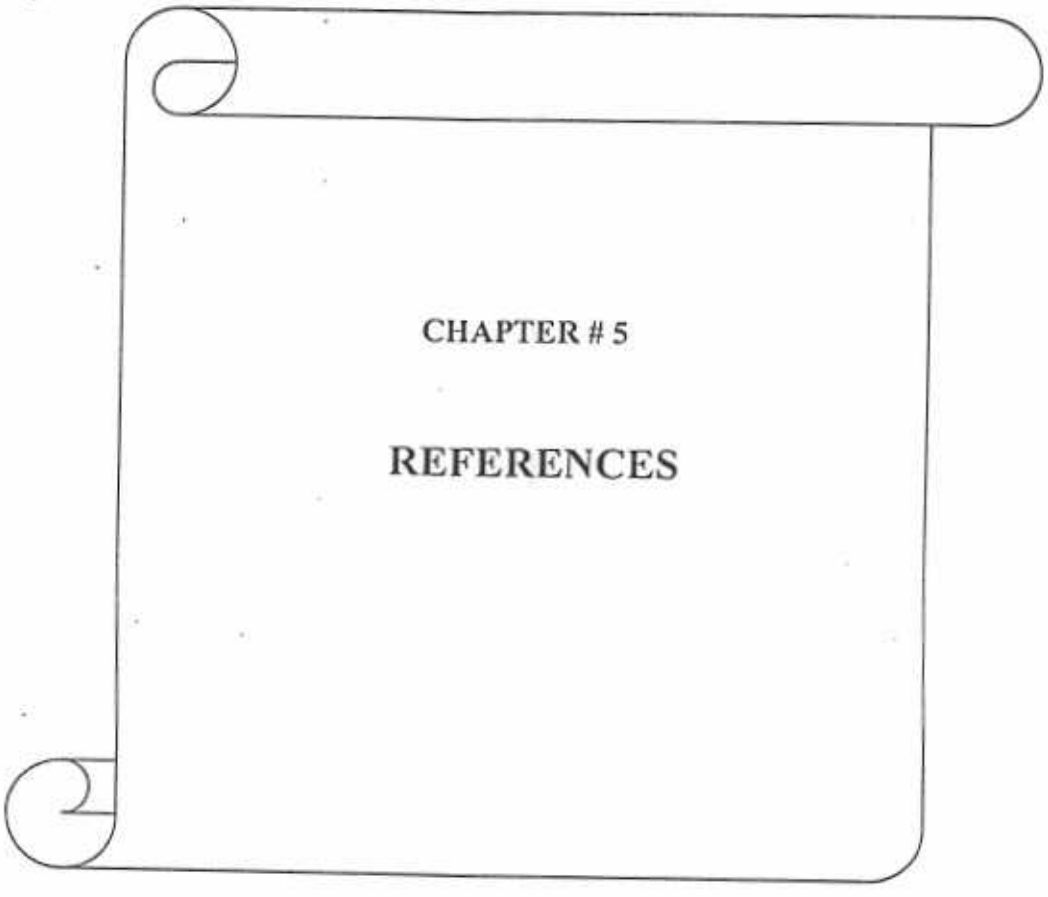
14. Analysis of the kinetic data showed that Bangham and intraparticle diffusion models were applied to the dyes adsorption and that the adsorption of dye is a diffusion controlled process.

15. Adsorption of dyes increased with the increased in temperature thereby indicating the process was endothermic.

16. The Freundlich, Langmuir and DR equations were used to estimate the model parameters. The best fit of the isotherms, found from the correlation coefficients (r^2) were in the sequence : DR > Langmuir > Freundlich.

17. Distribution coefficient of the dyes on the surfaces of carbon activated at different temperatures was found to be in the sequence: $D_{c1000\,^{o}C} > D_{c\,900\,^{o}C} > D_{c\,800\,^{o}C} > D_{c\,600\,^{o}C} > D_{c\,400\,^{o}C} > D_{c\,Raw}$.

18. The wastewater of Omar glass industry was treated by column adsorption. Thomas model was used to derive the adsorption capacity ($mol.g^{-1}$) of the carbon samples for the dye and also for Ni^{+2}, Cu^{+2} and Zn^{+2} adsorption from the waste water.



CHAPTER # 5

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5. REFERENCES

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