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Removal of Cibacron Blue 3G-A from industrial wastewater using agricultural waste products as adsorbents

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Abstract

RPHCL has a porous structure with a random distribution of distinct pore diameters.

In this work, the efficacy of agricultural waste was tested in removing Cibacron Blue 3G-A (CCB) colour from contaminated textile wastewater. In this study, Rhamnus pits (RP) were used as a readily accessible waste material as an adsorbent by carbonizing and impregnating it with a strong base (KOH) and a strong acid (HCL), respectively. The method of impregnation was carried out systematically. The carbonization process involved inciting the RP pits at a temperature of 300 °C, followed by impregnating some of the sample with hydrochloric acid HCL (a strong acid) and some with sodium hydroxide KOH (a strong base), and finally inciting the sample at a temperature of 600 °C as part of the activation process. One kind of adsorbent was not treated with any kind of impregnation; another type was treated with a strong acid; and a third type was treated with a strong base. (CCB) dye used as adsorbed the adsorption capacity and maximum adsorption rate were determined after variables affecting the adsorption process were analyzed. Results showed that KOH- and HCL-impregnated samples removed 96.6% and 88.24% of the sample, respectively, more effectively than the untreated control sample, which removed just 62.42%. Adsorption was performed at 30 degrees Celsius (86 degrees Fahrenheit), 0.05 g/10 ml of dye solution, 60 minutes, and a concentration of 25 mg/l of dye solution. The equilibrium adsorption curves were calculated using two widely used adsorption isotherm models. For KOH-activated RP pits, the Langmuir isotherm model offered a good fit to the data. In this study, the comparison and contrast are according to the pseudo-second-order and pseudo-first-order kinetic models for adsorption. It has been shown that the adsorption rate rapidly rises initially but gradually reduces when equilibrium is reached. When applied to the data, the pseudo-second-order model demonstrated an excellent fit with a confidence level of 0.999.

Keywords: CCB, Rhamnus Pits, Adsorption, Activated carbon, kinetic, Thermodynamic.

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1- Introduction

Due to the increased use of synthetic chemicals in industry, which causes the discharge of heavy metals, dyes, pigments, and other inorganic and organic chemical compounds into the environment, water treatment has become a significant issue in the contemporary period [1].
Innumerable sectors employ the more than 70,000 metric tons of synthetic dyes produced each year [2].
Reactive dyes in particular are rising in popularity as a result of their numerous advantageous properties, such as their inexpensive price, outstanding color fastness, brilliant colures, and ability to generate a wide spectrum of colors, from dark to bright, vivid tones [3–5].
Chemically, the structures of reactive dyes are extremely complex. Reactive dyes have organic rings, vinyl sulfonic groups, and chlorine atoms in their chemical compositions. [6] [7]
The discharge of textile effluents into traditional systems need separation and improved treatment due to the presence of hazardous and carcinogenic dyes [8].
Because dyes are not easily broken down by bacteria, the typical biological wastewater treatment procedure is not effective when used to dye wastewater. So that, scientists have looked at physicochemical strategies for treating textile wastewater that effectively eliminates color [9].
Many products from the forestry and agricultural industries can be transformed into efficient bio sorbents [10].
Ziziphus seeds have been used to extract "2- (10-octyl-9, 10-dihydroanthracene2yl) (methylene) malononitrile (PTZSCN)" aqueous solutions dyes from (GOZiziphus). Ziziphus seeds are biomaterial leftovers. The effects of PH, initial dye dose, temperature, and contact time were investigated in a batch study. Different nonlinear models and techniques, such as the general order model, the intraparticiple diffusion model, and the elvoich model were used to analyze the kinetic data. A nonlinear pseudo-first order kinetic model revealed good agreement for dye adsorption onto GO-ziziphus. The results suggest that wastewater containing colors could be successfully cleaned with GO-ziziphus powder [11].
The fibers from the banana stem was used to remove methylene blue dye (MBD), and their adsorbent effectiveness to examine their potential for use in cleaning up textile effluent waste [12]. pH equal to 10, a temperature of 25 degrees Celsius, a concentration of 5 milligrams per milliliter, a stirring speed of 125 revolutions per minute, a dose of 2.5 milligrams per milliliter, and a mixing period of 150 minutes, banana stem fibers (BSF) killed 97% of MBD [12].

The porous nature of an eggshell makes it a promising material for adsorption studies. The eggshell has three distinctive layers: ceramic material, the cuticle, and a porous layer. The eggshell is made up of spongy layers for more than 90% of its total mass. Protein fibers coupled to calcite create a matrix inside these strata [13].

Adsorption's equilibrium separation process is widely established and has shown to be a successful method for water filtration. Adsorption outperforms other water reuse methods in terms of low implementation costs, high levels of flexibility, and high levels of efficiency, Simplicity of design, ease of usage, and insensitivity to dangerous contaminants Furthermore, and adsorption doesn't result in the formation of harmful substances. [14]

The aim of this research is to use agriculture waste as adsorbent to remove the harmful impact of Cibacron Blue(3GA) dye from textile water by identify the optimal adsorption conditions (concentration, temperature, contact duration, and adsorbent dosage). Rhamnus pits (RP), a byproduct of the fruits, were shown to be promising adsorbent for CCB removal after just a short period of agitation, indicating that RP is a viable material for future uses. The research included thermodynamic, kinetic, and isothermal models.

2- Materials and Methods

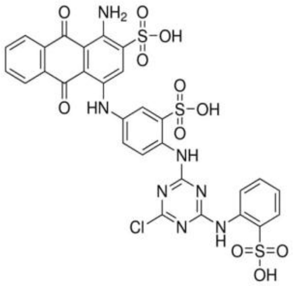
Nitrogen gas, purified to 95%, was used as the an inactive substance for the process. Hydrochloric acid (HCL) and Potassium hydroxide (KOH) with 97% of purity were used as activating agent. The RB5 stock solution prepared by dissolving 0.05 g of cibacron blue (CCB) in 1L of deionized water.

Table 1 shows the CCB features. In this investigation, CCB was chosen because it is often used in the textile industry under a variety of brand names. [15]

Cibacron Blue F3G-A is a mixture of Meta and para substituted isomers of the textile dye while CB3GA represents pure ortho component [16].

The utility of Cibacron Blue affinity resins on an industrial scale has lagged because of concerns of selectivity and toxicity. Issues of toxicity were addressed and tolerance levels have been defined for CB3GA [17] [18].

Table 1. CCB dye's characteristics. [15]

Brand Name	***Description***	***Molecular weight***	***Molecular formula***	**Chemical structure**
Cibacron Blue 3G-A, Anthraquinone derivative dye	Anthraquinone derivative dye. Potent nucleotide-mimetic ligand	840.10	$C_{29}H_{17}ClN_7Na_3O_{11}S_3$	

2.1 Preparing of the Rhamnus pit and two kinds of impregnation

Rhamnus pits (RP) were collected from the local markets in the city of Diwaniyah in Iraq, and the pits were extracted from them, and about one kilogram was collected for the purpose of preparing activated carbon, a picture and a diagram of the experimental installation of a system for the production of activated carbon from RP. The pits were washed with de-ionized water, dried, ground and sifted with a sieve 88 mm. **Figure ١ (a)** shows the form of the resulting powder ready for the incitation process. Several tools were used in order to complete the burning process correctly: (This process was done according to previous adsorption studies)

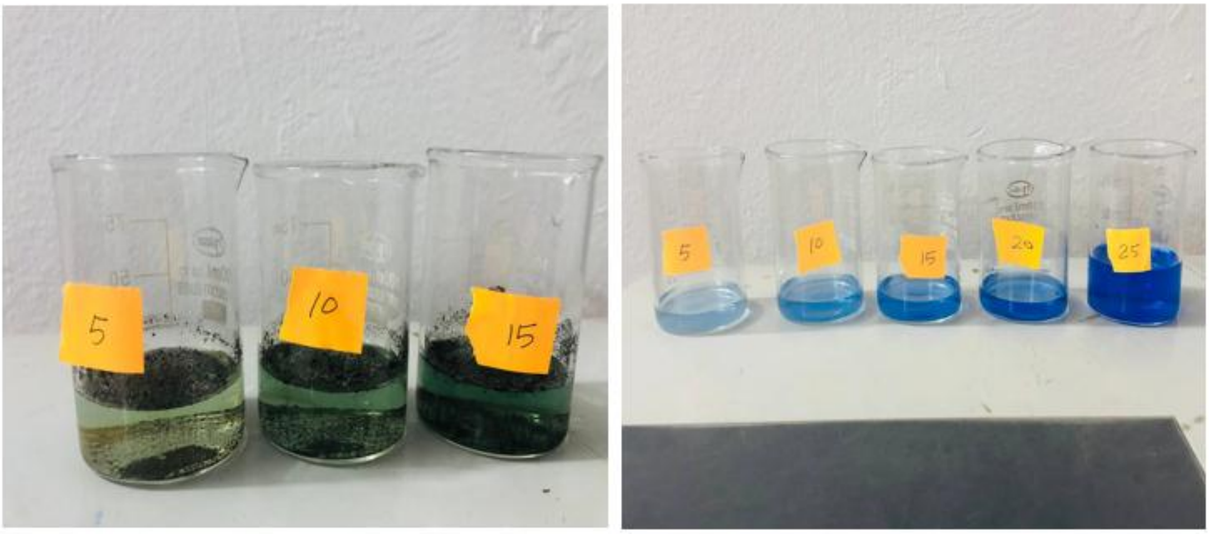
The reactor is shown **Figure 1 (b)** with a steel tube wrapped around the reactor that allows nitrogen to pass in controlled quantities to cool the sample and prevent it from burning due to high temperatures.

Graphite crucible; **Figure 1 (c)** were used to protect the sample from burning due to high temperatures.

A

B

C



D

Figure 1. Adsorption process steps and tools (a) Rhamnus pits preparation (b) picture of vessel (reactor) (c) graphite crucible (d) CCB concentrations preparation after and before adsorption

RP powder is prepared by placing 70 grams of powder in a graphite crucible, covering it with a piece of mineral wool, and placing it in the reactor. The sample was burned in steps as fallow:

1- The carbonization process by burning the RP powder at a temperature of 300 °C for 2 hours in the furnace. The result is activated carbon powder.

2- The impregnation process by soaking part of the sample with a HCL solution and part of the sample with a KOH solution for 24 hours.

3- The process of activation by burning again in the presence of nitrogen gas at temperature of 600 °C for 3 hours after that the powder washed many times with de-ionized water until the pH was 7±0.15

3. Theoretical Models

In order to create the CCB solution, 0.05 grams of CCB powder were mixed with 1 liter of deionized water. Prepared solutions were diluted with de-ionized water to achieve a concentration of 25 ppm in accordance with the law of dilution through equation (1). We

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used five solutions with known concentrations to calculate kinetic and adsorption isotherm parameters as shown in **Figure 1 (d)**.

$$C1V1 = C2V2 \qquad (1)$$

Where V1, V2 stands for initial and final volume, C1, C2 stands for initial and final concentration (mg/g), and (Liter)

The equilibrium data, known also as the isotherms adsorption, gives context for the kind of interaction between the adsorbent and the adsorbed species. Various models may be used to derive parameters that provide important details about the adsorbent's surface properties and its connection with the adsorbate. In this study, some of the equations from the Freundlich and Langmuir modules were analyzed. A boiling flask was used to study the adsorption isotherms of CCB onto natural (RP), RP pre-carbonization with base and then carbonation to activated carbon (RPKOH), and RP pre-carbonization with acid and then carbonation to activated carbon (RPHCL) at temperatures of 30, 40, 50, and 60 degrees Celsius. After that, was placed the flask on the magnetic stirrer's heated plate.

As a first step, the equilibrium time was determined to be 1 hour by periodically sampling liquid from a boiling flask; after this duration, there was no discernible change in concentration.

For the second part, adsorption equilibrium isotherms were obtained by combining 0.05 g of each kind of produced RP with solutions of CCB at various concentrations (5, 10, 15, 20, and 25) ppm. For 1 hour, the mixture was stirred constantly while kept at the same temperature on a hot plate magnetic stirrer, achieving equilibrium. The completed product was analyzed in September 2022 using an Ultra violet-visible photo spectrometer instrument (UV) at the laboratory at Alqadisya University/College of Civil Engineering. Using an equation, one may determine the amount of adsorption (2) [19].

$$qe = \frac{(C0-Ce)*V}{W} \qquad (2)$$

Where

qe	Adsorption equilibrium rate (mg/g)
Co	Initial concentration (mg/g)
Ce	Final concentration (mg/g)
V	Volume (Liter)
W	Wight (gram)

Finally, the kinetics were analyzed in the same way as in equilibrium, but samples were collected at varying periods up until the final sample was obtained at equilibrium.

3.1 Adsorption Models

Commonly, the equilibrium of adsorption of the adsorbate onto the surface of the adsorbent at a constant temperature is described by means of adsorption isotherms. Optimization of adsorbent utilization relies heavily on the information provided by adsorption isotherms, which characterize the interaction between adsorbates and adsorbents [20].

As a result of the interactions between the adsorbate and adsorbent molecules, adsorption isotherms may also shed light on the adsorption process.

3.1.1 Langmuir, Isotherm

It is a significant model that explains the adsorption of the pure substance on the surface of adsorbents and is considered to be one of the most important models. This model is predicated on the following assumptions. The mathematical model for this phenomenon shows that a monolayer was established on the catalyst's surface, that adsorbate molecules had the same amount of energy in all of their localized positions, and that there was no interaction between the adsorbed molecules on the adsorbent's surface is given by eq. (3) [21]:

$$\frac{Ce}{qe}=\frac{Ce}{qm}+\frac{1}{KL\,qm} \qquad (3)$$

Where:

Ce = equilibrium solute concentration [mg/l].

qe = equilibrium adsorption capacity at, [mg/g].

KL = free energy of adsorption constant [l/mg].

qm = monolayer maximum adsorption capacity [mg/g].

3.1.2 Frendlich Isotherm

The Freundlich adsorption isotherm model accounts for this fact that various locations on an adsorbent's surface will have varying enthalpies. The model of Freundlich adsorption isotherm is shown below [22].

$$\log qe = \log Kf + \frac{1}{n}\log Ce \qquad (4)$$

Where: KF = (mg/g (1/mg) 1/n) the affinity of the adsorbate for the adsorbent, as represented by the n parameter, and the relative adsorption capacity. [mg/g (1/mg) 1/n)]

3.2 Kinetic-Models

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The diffusion process and rate-controlling steps were investigated using kinetic modeling, which included [the pseudo-first order and pseudo-second order [23].

3.2.1 Pseudo-First Order Model

Lagergren model, developed in 1898, assumes a first order adsorption kinetic and can be explain by the Equation (5):

$$\frac{dqt}{dt} = K_1(qe - qt) \qquad (5)$$

For the first phases of an adsorption process, this formula is true because the rate of change in solute uptake with time is directly proportional to the difference between the saturation concentration and the amount of solid uptake with time. The Lagergren pseudo-first-order equation is often used to explain the adsorption kinetics at an interface where diffusion controls the adsorption rate [24].

3.2.2. Pseudo Second Order Model

Pseudo-second-order kinetic rate of adsorption expression of the equation

$$\frac{dqt}{dt} = K_2(qe - qt)^2 \qquad (6)$$

predicts behavior over the whole adsorption range on the basis of the assumption that chemical sorption or chemisorption is the rate-limiting phase. Under these conditions, the adsorption rate depends on the adsorbent's capacity for absorption rather than the adsorbate's concentration. One advantage of this model over Lagergren first order is that it allows for the prediction of the equilibrium adsorption capacity, eliminating the need for experimental measurement of the adsorption equilibrium capacity [24].

4. Result and discussion

4.1 Characterization of Adsorbents (FESEM and BET)

The RP and its derivatives were identified by several test techniques. These checkup procedures include FESEM and BET.

4.1.1 Characterization of RP

FESEM was used to characterize the morphology of the prepared RP in the form of powder by obtaining structural photos and micrographs. **Figure 2** Shows FESEM images of the prepared (RP) without any activation.

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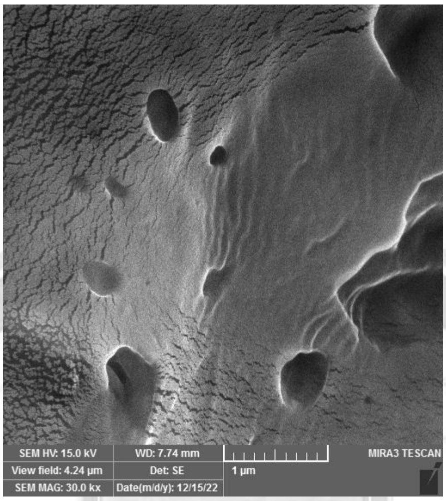

Figure 2. FESEM images for prepared RP, at 10 KX.

An almost completely smooth surface with a few pores and cavities was discovered via investigation. These could lead one to the conclusion that the content's available surface area for the adsorption process is relatively small.

The BET test of the produced RP without activation revealed that it had an average pore diameter of (4V/A by BET) 13.35 nm and a BET surface area of (12.1522 m2/g). It is reasonable to assume that the adsorption will be significantly impacted by the reduced surface area. The large pore diameters may have been caused by the limited surface area. Low surface area is provided by big pores, and high surface area is provided by small holes. Additionally, there are numerous cellulose materials that seal pores.

4.1.2 Characterization of (RPHCL)

Figure 3 shows the FESEM result of the RP that was pre-treated with acidic solution HCL.

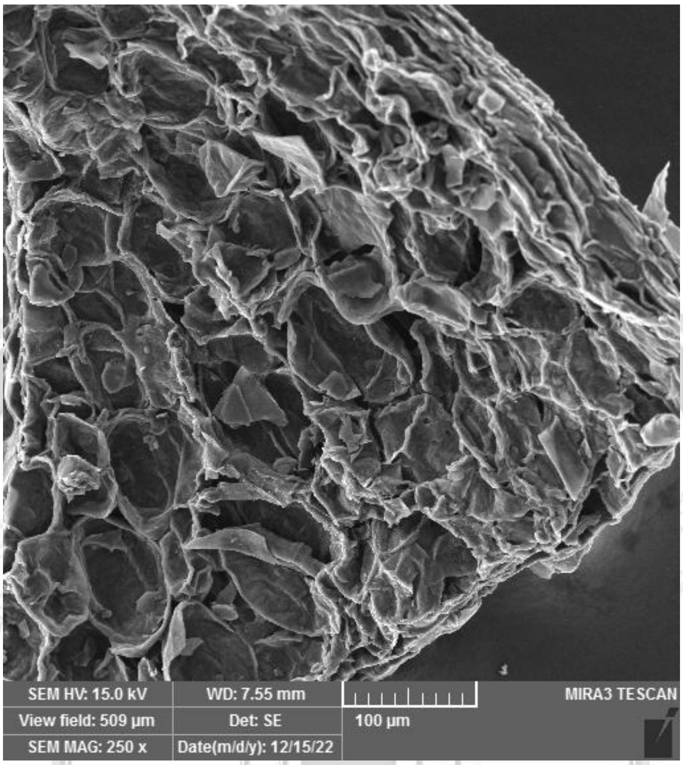

Figure 3. FESEM images for prepared RPHCL, at 10 KX.

It is clearly shown in this figure that the pre-treatment with HCL and carbonization causes the Rhamnus Pits to become more amorphous and porous.

Furthermore, this figure shows that activated carbons made from RP waste have a heterogeneous rough surface with a random distribution of cracks and cavities, as well as porosity, and that there is a considerable chance that the pores will attract and absorb dye molecules.

The BET test of the activated carbon of Rhamnus pits that were pretreated with HCL was observed to have a BET surface area equal to (660.8484 m2/g) and an average adsorption pore diameter of (4V/A by BET) 3.3457 nm, and it could be noticed that a higher surface area was achieved by acid activation than the surface area of Rhamnus pits without activation. Furthermore, the observed reduction of pore size indicates that the cellulose material was degraded by acidic activation. Hence, more fine pores were opened, and more surface area was available for adsorption. These surfaces enhance the adsorbent for the adsorption of adsorbates on the active surfaces, allowing the dye to be captured and absorbed via these pores.

4.1.3 Characterization of (RPKOH)

Figure 4 shows the FESEM test of the activated carbon of Rhamnus pits pretreated with basic solution KOH

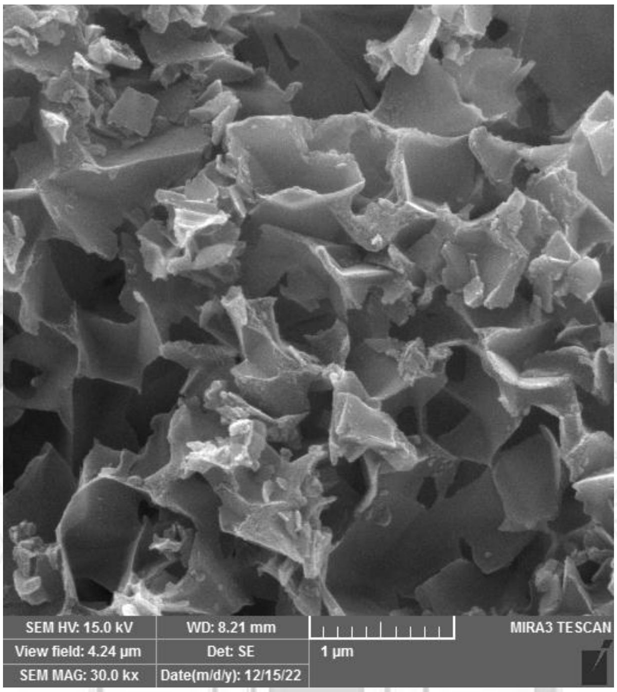

Figure 4. FESEM images for prepared RPKOH, at 10 KX.

It is clearly shown that the pre-treatment with KOH and the carbonization make the Rhamnus pits more porous and amorphous. RPKOH has a more good porous structure, random arrangement, and different sizes of pore.

The RPKOH has a heterogeneous rough surface with a random pattern of cracks and cavities with porosity, as shown in **Figure 4**, and there is a considerable chance that dye molecules will be trapped and adsorbed into these pores.

1The BET test of the activated carbon which was prepared from rice husks and pretreated with hydroxide potassium (KOH) has a BET surface area equal to (784.849 m^2/g), in addition, the adsorption average pore diameter was (4V/A by BET) equals to 2 .2547 nm. It could be noticed that the activation with KOH gave the best result and a higher surface area for the dye to be adsorbed and trapped in these pores. Additionally, the observed reduction in pore size suggests that acidic activation was used to break down the cellulose material. As a result, more tiny pors were exposed, increasing the amount of surface space accessible for adsorption. For the dye to be caught and absorbed via these pores, these surfaces improve the adsorbent for adsorption of adsorbates on the active sites.

4.2 Equilibrium of adsorption

The adsorption equilibrium isotherms showed the effect of temperature for the different concentrations of CCB dye, as different temperatures and different concentrations were studied and the best removal was found at any temperature and at any concentration, and adsorbent is fit for a given models were studied to see their applicability to the entered values.

Adsorption equilibrium isotherms of CCB onto RP, RPHCL, and RPKOH are shown in **Figure 6**. All three CCB curves (RP, RPHCL, and RKOH) for the produced RP exhibit the

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same basic shape, a type (1) classic adsorption isotherm. The process generates heat, or "exothermic" the adsorption capacity (qe) of the RP diminishes as the temperature rises [25].

Figure 5 displays the proportion of CCB dye that was removed by different types of activated carbon., where it was found that the best removal was when activate the RP with a KOH, where R% equal to 96.6% and qe 4.1701mg/g, as showed in **Figure 6 (c)**

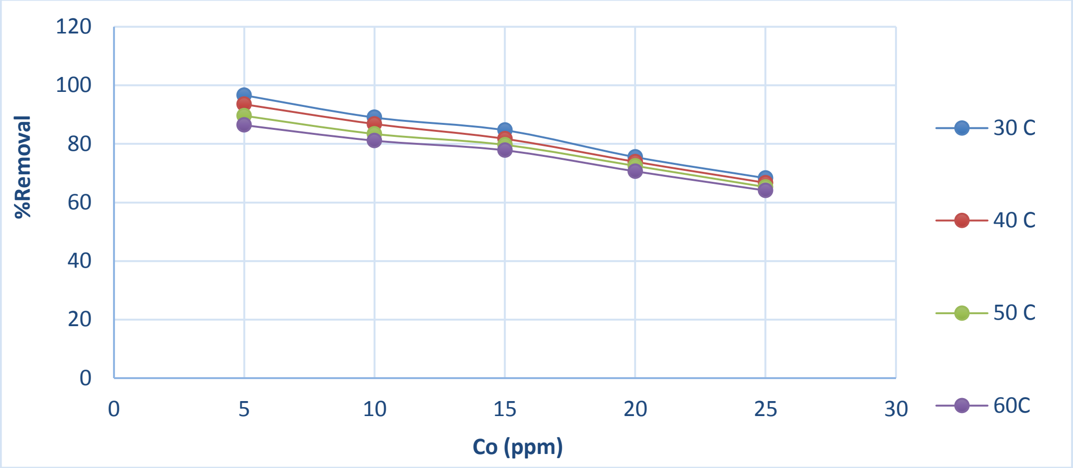
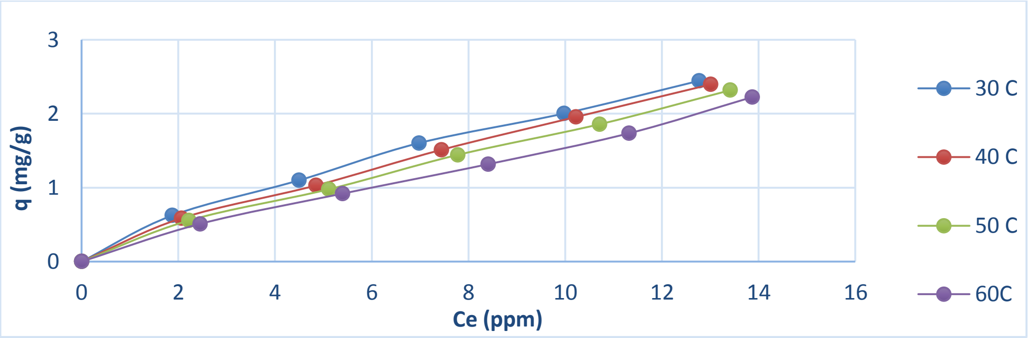


Figure 5. Removal percentage of CCB for different concentrations(5,10,15,20& 25 mg/l) and temperatures(30, 40, 50& 60) C0 for RPKOH.

It show **In Table (2) and (3)** the R^2 value for the two models use, it is shows applicability when using langrage isotherm since it reveals the largest value of R^2. According to the parameters show in Figures 3 and 4 when using KOH as activating agent revels highest value of adoration.

It show **In Table (2) and (3)** that when using RPKOH as activating agent the parameter of the two isotherm achieved best outcomes. This becomes more apparent when the experimental data is plotted linearly using the Frendlich and Langmuir isotherms, as illustrated by the related Equations (3) and (4) [26].



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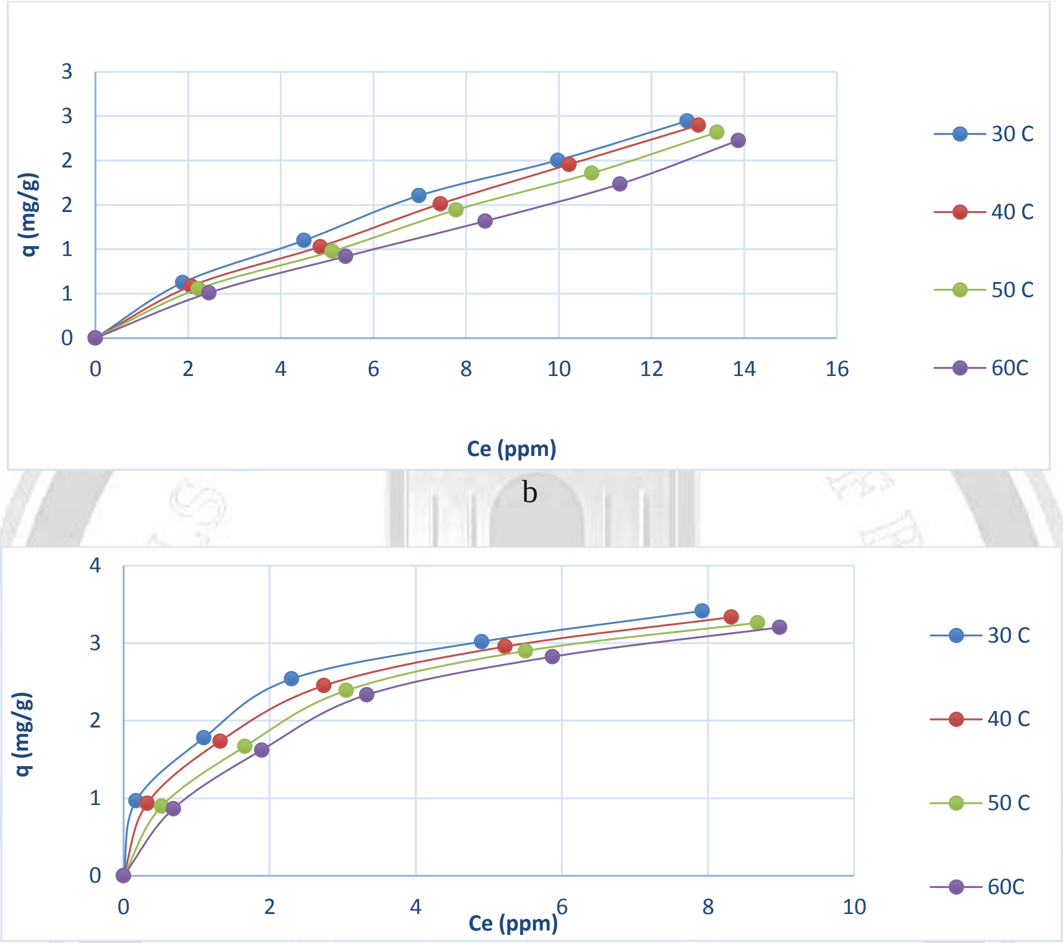
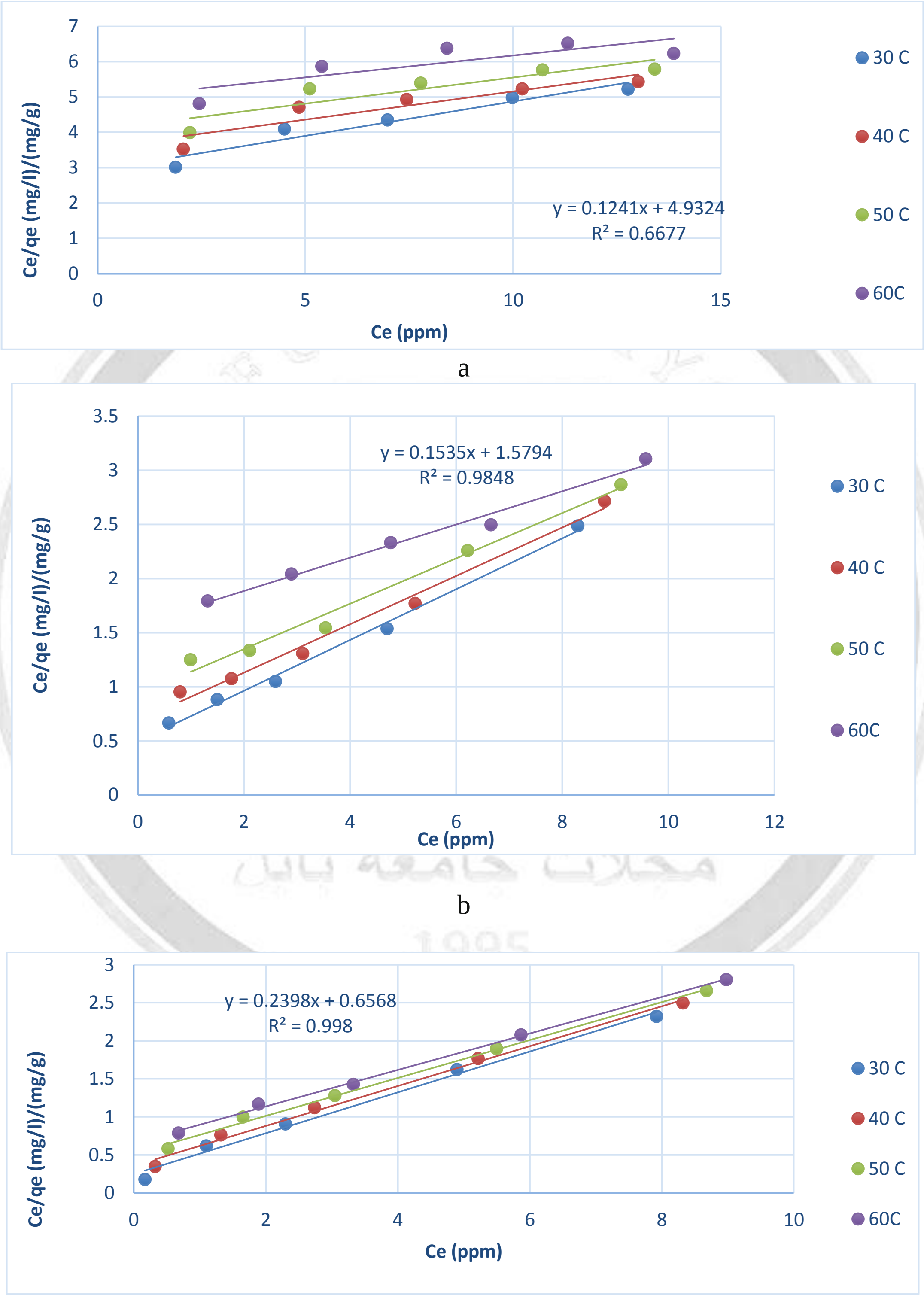


b

c

Figure 6. **Adsorption Isotherms for CCB adsorbed by powder of (a) RP , (b) RPHCL and (c) RPKOH**.

The data displayed in **Figures 7 and 8** are supported by the outcomes of Equations 3 and 4. These graphs show that the Langmuir adsorption isotherm represents the experimental data more accurately than the Frendlich adsorption isotherm. The Langmuir adsorption isotherm is a helpful illustration for adsorbent systems where the adsorbate coverage is restricted to a single molecular layer. In other words, homogeneous surfaces are used with the Langmuir model. As a result, it was determined that CCB adsorption on all Rhamnus preparations is restricted to a monolayer and that the surfaces of all Rhamnus preparations are uniform [27].



a

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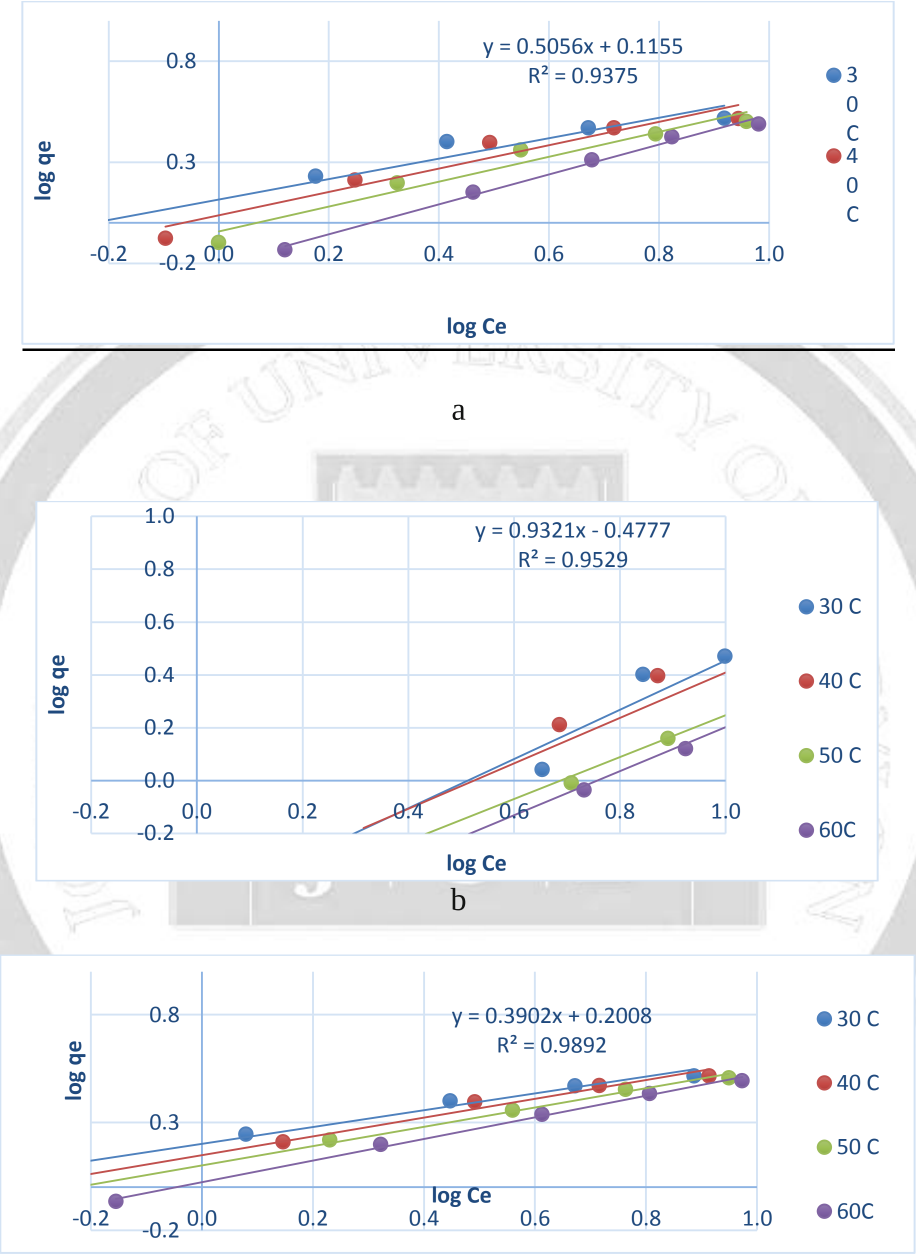
Figure 7. Langmuir isotherm for CCB adsorbed by powder of (a) RP , (b) RPHCL and (c) RPKOH



a

b

c

Figure 8. Frendlich isotherm for CCB adsorbed by powder of (a) RP, (b) RPHCL, and (c) RPKOH.

Table 2. Parameters of the Frendlich isotherm for CCB on RP, RPHCL, and RPKOH

Isotherm models	Activated Carbon		
	RP	RPHCL	RPKOH
Frendlich			
KF (mg/g)	1.243	1.304	1.587
n	1.07	1.9778	2.562

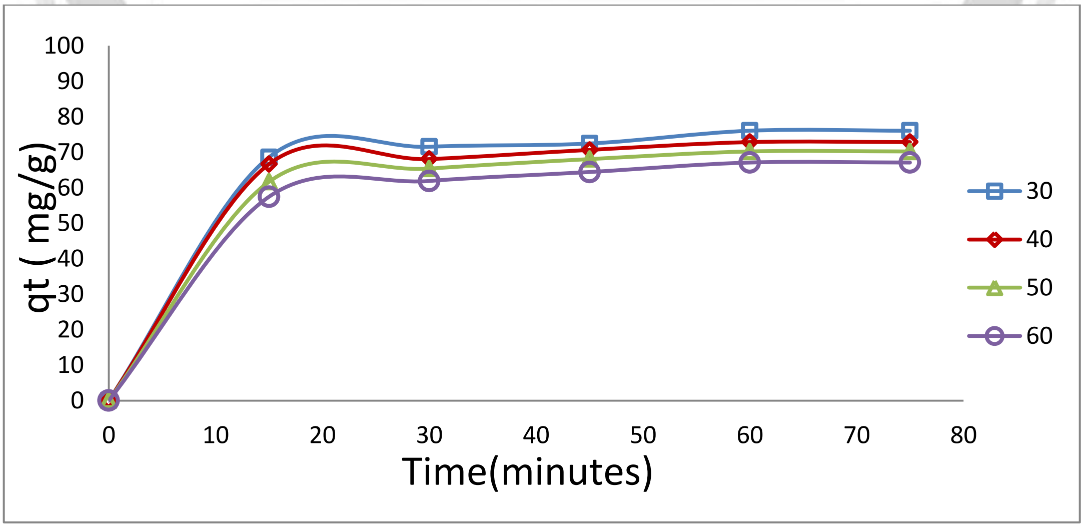
R^2	0.6677	0.9375	0.9892

Table 3. Langmuir isotherm parameters for CCB on RP, RPHCL and RPKOH

Isotherm models	Activated Carbon		
	RP	RPHCL	RPKOH
Langmuir			
q (mg/g)	8.058	6.514	4.1701
KL (L/mg)	0.02516	0.0971	0.3651
R^2	0.9848	0.9887	0.998

4.3 Kinetic of adsorption

Both the first- and second-order pseudo kinetics were used to investigate adsorption rates. **Figure 9** shows the adsorption rates of CCB onto the three distinct kinds of Rhamnus pits at (30, 40, 50, or 60) Co for various types of prepared activated carbons (RP, RPHCL, and RPKOH). It can be seen from the figures that the capacity for the CCB dye increases rapidly in the first 15 minutes, and then increases very little until equilibrium is reached, as predicted by equations (5) and (6), the application of which was investigated. The large concentration of absorbable solute molecules and the availability of the vacant active sites on the adsorbent may account for the high initial rate of adsorption.



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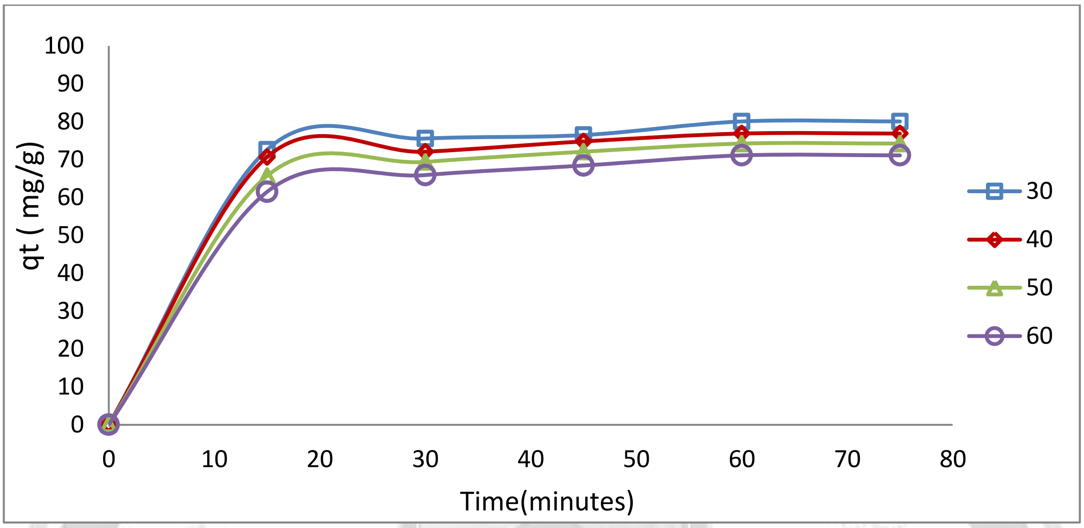

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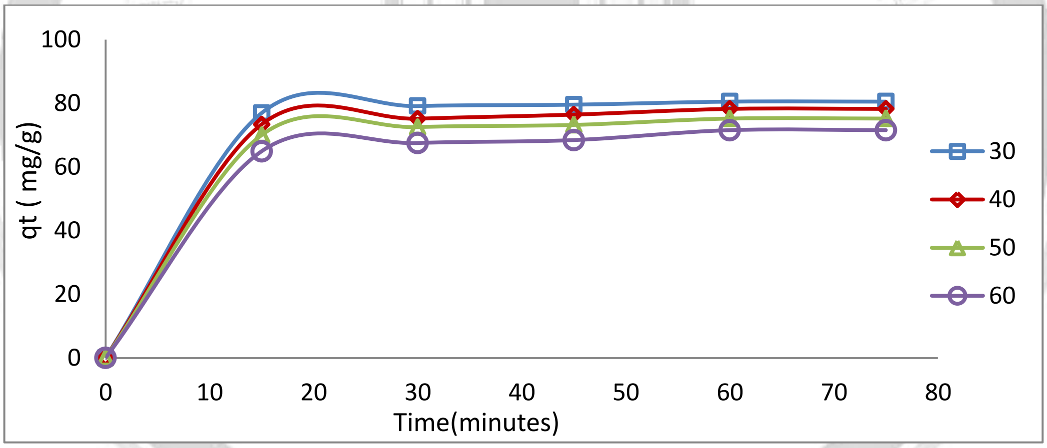

c

Figure 9. **Adsorption of CCB dye by powder of (a) RP, (b) RPHCL, (c) RPKOH as function with time**

The experimental findings are well explained by the pseudo 2nd-order adsorption kinetic model. As a result, this model equation gave the best explanation of the data. For example, **Figure 10** shows a linear representation of the data acquired by fitting the data to the equations of the pseudo-1st order kinetics model, and **Figure 11** shows a similar representation of the data obtained by fitting the data to the equations of the (4, 5). As the figures also illustrate, the data and the 2nd order kinetic model exhibit some moderate consistency. The adsorption process seems to go through a number of distinct phases as shown by this evidence. These findings further reveal the systematically mechanism involved in the adsorption of CCB onto the Rhamnus forms.

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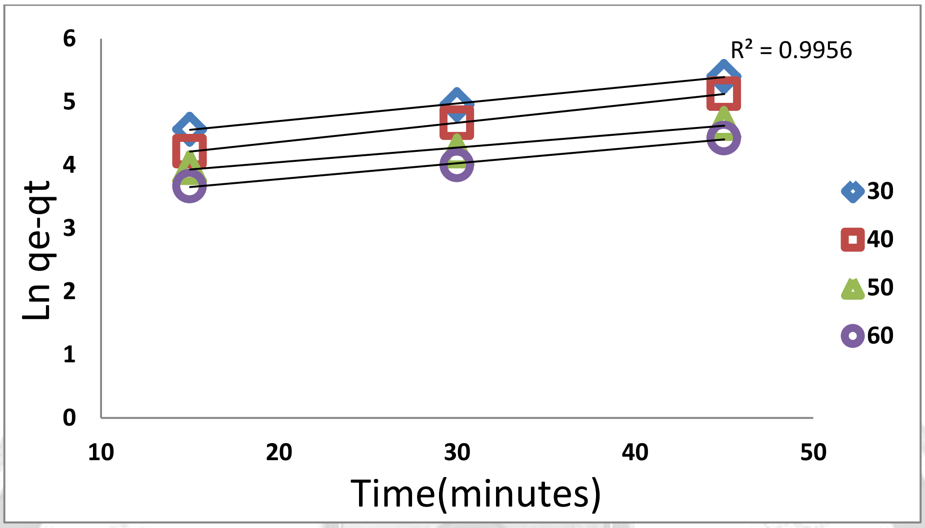

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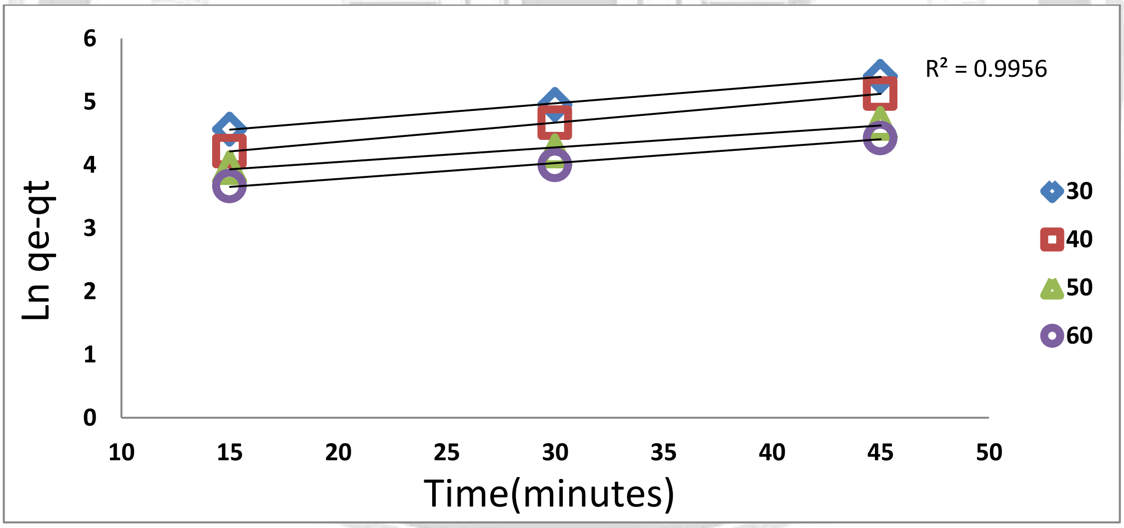

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Figure 10. CCBAdsorption by RP, RPHCL, and RPKOH at various temperatures (30, 40, 50) Co and time, a first-order kinetic model.

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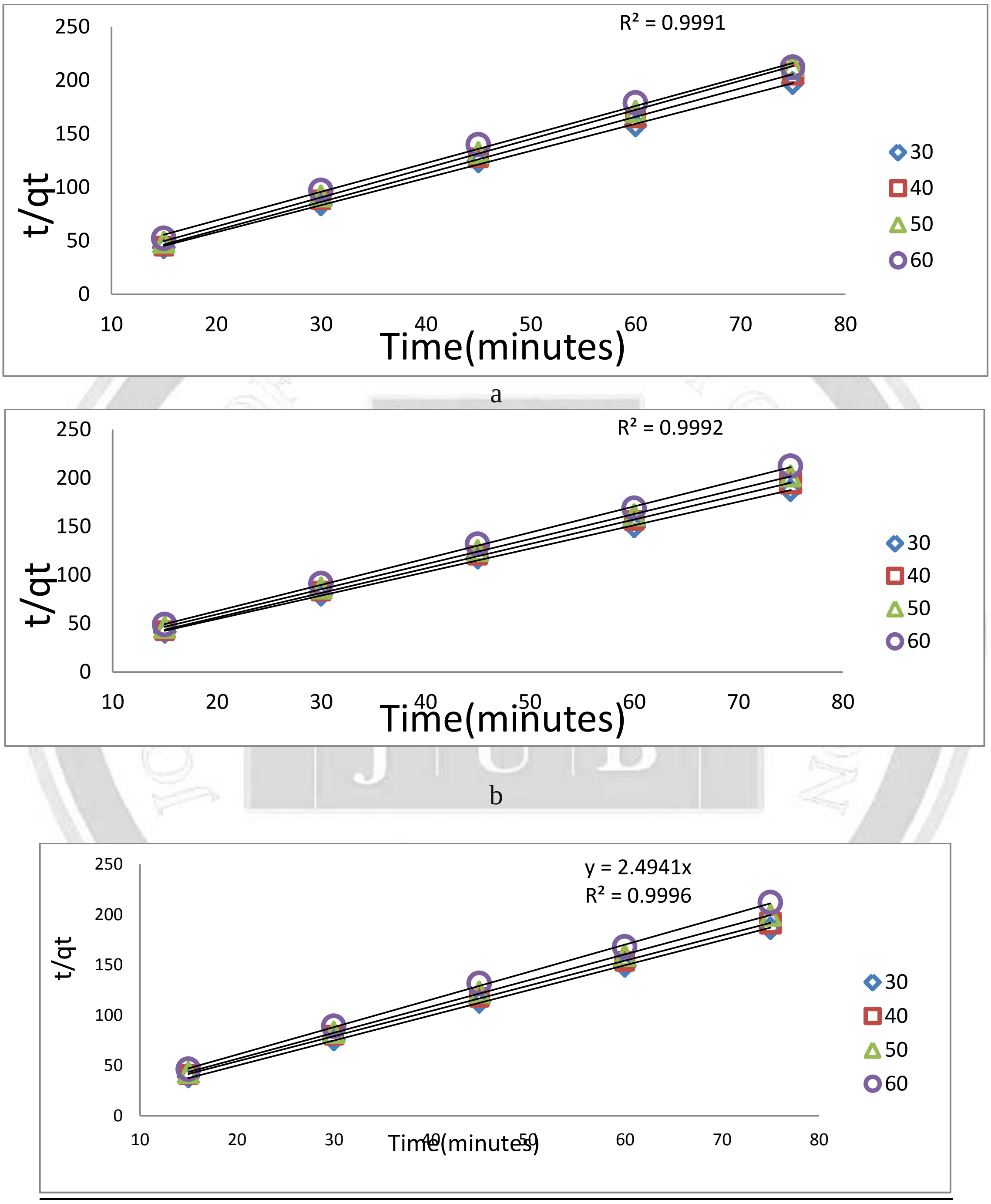

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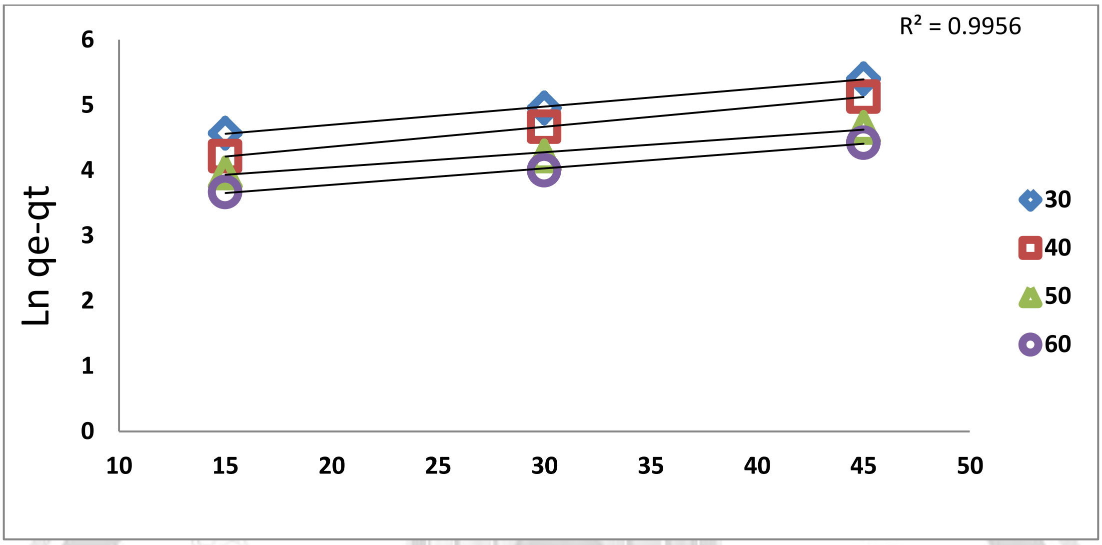
Figure 11. CCB Adsorption by RP, RPHCL, and RPKOH at various temperatures (30, 40, 50) Co and time, a second-order kinetic model.



c

4.4 Temperature effect on the removal percentage

It states how temperature affects various types of activated carbon by demonstrating that higher temperatures result in less activated carbon being removed. **Figure 12** demonstrates that at 30 C0, the R% of RPKOH is equivalent to 96.6%, and by 60 C0, it has dropped to 86.4%. This must be correct since comparable behavior was discovered by [28]. They concluded that this was due to the fact that "adsorption forces between the dye molecules and the active sites lessen with increasing temperature," which explains why CCB removal was diminished at higher temperatures.

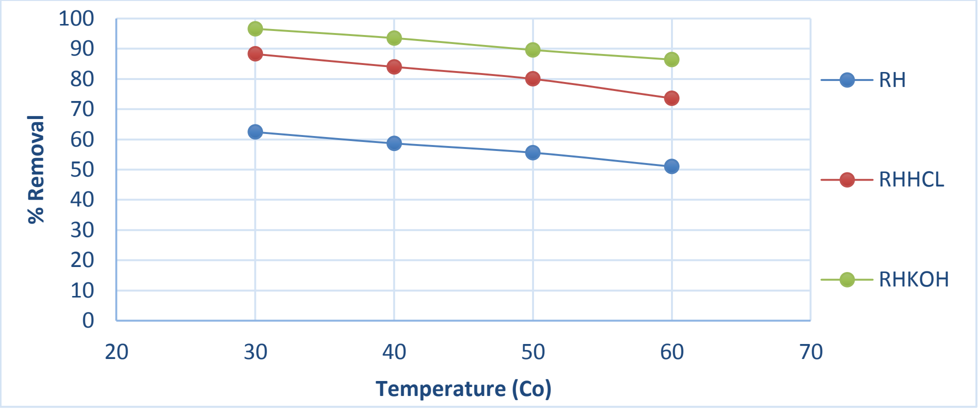


Figure 12. removal percentag for adsorption CCB on RP ,RPHCL and RPKOH at Temperatures 30, 40, 50 C°

Conclusion

This article looked at the possibility of using cheap agricultural waste to produce a manufactured substance with a positive effect on environmental cleanliness. Rhamnus pits need special processing before they can be used to purify textile water. Rhamnus pits are regarded as a not-costly byproduct. The results showed that CCB dye could be effectively removed by Rhamnus activated carbon and that chemical activation had been used to increase the adoration efficiency. The highest removal rates were found for activated carbon activated with KOH, which reached 96.6 percent; activated carbon using HCL, which reached 88.24 percent; and activated carbon without activation, which reached 62.4 percent. At 30 Co, the findings were in close accord with the Langmuir isotherm model; however, when the temperature is raised, the efficiency of the adsorption decreases dramatically because adsorbed molecules have a greater possibility of dissociating from the adsorbent surface and returning to the solution when the temperature is increased. Adsorption of CCB onto any kind of RP is best described by the Langmuir model for the adsorption isotherms and the pseudo-2nd order kinetic model for the kinetic data due to the heterogeneous nature of the surfaces. In comparison to RP and RPHCL, RPKOH was more effective in adsorbing CCB. The results of this research will improve RP as a technique for removing dye from wastewater.

Acknowledgments

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إزالة صبغة ال Cibacron Blue 3G-A من مياه الصرف الصناعي باستخدام منتجات النفايات الزراعية كمواد مازة

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الخلاصة

في هذا البحث، تم اختبار فاعلية المخلفات الزراعية في إزالة لون Cibacron Blue 3G-A (CCB) من مياه الصرف الصحي الملوثة لمياه النسيج. في هذه الدراسة ، تم استخدام(RP) Rhamnus pits (نوى النبق)كمواد نفايات يسهل الوصول إليها كمواد مازة عن طريق الكربنة والتحفيز بقاعدة قوية (KOH) وحمض قوي (HCL) . تم تنفيذ طريقة التحفيز بشكل منهجي. تضمنت عملية الكربنة تحريض نوى النبق RP عند درجة حرارة ٣٠٠ درجة مئوية ، يليها تشريب بعض العينة بحمض الهيدروكلوريك HCL (حمض قوي) وبعضها بهيدروكسيد الصوديوم KOH (قاعدة قوية) ، وأخيراً حرق العينة عند درجة حرارة ٦٠٠ درجة مئوية كجزء من عملية التنشيط. نوع واحد من الممتزات لم تتم معالجته بأي نوع من المحفزات ؛ نوع آخر عولج بحمض قوي ؛ والنوع الثالث عولج بقاعدة قوية. تم استخدام صبغة (CCB) كمادة ممتزة ، حيث تم تحديد سعة الامتزاز والحد الأقصى لمعدل الامتزاز بعد تحليل المتغيرات التي تؤثر على عملية الامتزاز. أظهرت النتائج أن العينات المشبعة بـــ KOH- و HCL أزالت ٩٦.٦٪ و ٨٨.٢٤٪ من العينة ، على التوالي ، بشكل أكثر فاعلية من عينة نوى النبق غير المعالجة ، والتي أزيلت ٦٢.٤٢٪ فقط. تم إجراء الامتزاز عند ٣٠ درجة مئوية (٨٦ درجة فهرنهايت) ، ٠.٠٥ جم / ١٠ مل من محلول الصبغة ، ٦٠ دقيقة ، وتركيز ٢٥ مجم / لتر من محلول الصبغة. تم حساب منحنيات امتصاص التوازن باستخدام نموذجين متساويين للامتصاص مستخدمين على نطاق واسع. بالنسبة لنوى النبق RP التي يتم تنشيطها بواسطة KOH ، قدم نموذج متساوي الحرارة Langmuir ملاءمة جيدة للبيانات. في هذه الدراسة ، تم المقارنة والتباين وفقاً للنماذج الحركية من الدرجة الثانية والنماذج الحركية من pesodo first order. لقد ثبت أن معدل الامتصاص يرتفع بسرعة في البداية ولكنه ينخفض تدريجياً عند الوصول إلى التوازن. عند تطبيقه على البيانات ، أظهر نموذج pesodo second order ملاءمة ممتازة بمستوى ثقة يبلغ ٠.٩٩٩.

الكلمات المفتاحية : CCB ،حفر رامنوس ، امتزاز ، كربون نشط ، حركي ، ديناميكي حراري.