2024, 21(7): 2275-2288
https://doi.org/10.21123/bsj.2023.8782
P-ISSN: 2078-8665 - E-ISSN: 2411-7986
Baghdad Science Journal

Removing Basic Fuchsine Dye by Adsorption over CuCo2O4 Nanocomposite as an Active Adsorbent Surface

***Ali A. Kadhim**[*1], **Muneer A. Al-Da'amy**[2], **Salah H. Kadhim**[3], **Eman Talib Kareem**[4]*

[1]Department of Animal Production, College of Agriculture, University of Kerbala, Karbala, Iraq.
[2]Department of Chemistry, College of Education for Pure Science, University of Kerbala, Karbala, Iraq.
[3]Department of Chemistry, College of Science, University of Babylon, Babylon, Iraq.
[4]Department of Chemistry, College of Science, University of Kerbala, Karbala, Iraq.
*Corresponding Author.

Received 22/03/2023, Revised 22/05/2023, Accepted 24/05/2023, Published Online First 25/12/2023, Published 1/7/2024

Abstract

This study involves the synthesis of $CuCo_2O_4$ spinel-type nanocomposite. This material was synthesized using the co-precipitation method and characterized by Fourier Transform Infrared Spectroscopy (FTIR), X-rays Diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM), and Atomic Force Microscopy (AFM). The activity of the synthesized materials was investigated by following removing basic fuchsine (BF) dye from its aqueous solution by adsorption. Different adsorption parameters were conducted involving the dose of adsorbent surface, time of adsorption, pH of the medium, and temperature. The optimum removal efficiency was around 97 % at contact time 5 minutes, 0.005g of dose the surface adsorbent, pH = 8 and 50 mg. L^{-1} concentration of dye. Thermodynamic parameters for the adsorption of this dye over the prepared materials were also conducted such as free energy (ΔG) negative. While enthalpy (ΔH) positive which indicates the adsorption was spontaneous and endothermic, also entropy (ΔS) was positive shows the affinity of the adsorbent towards the adsorbate.

Keywords: Adsorption, Basic Fuchsine dye, $CuCo_2O_4$, Nanocomposite of spinel type, Pollution of water, water treatment.

Introduction

Pollution of water is the strongest dangerous phenomenon resulting from the rapid increase in agriculture and industry activities [1] . So, pollution treatment has become a prominent goal. This involves the removal of many pollutions such as heavy metals and organic compounds in the water and treatment to use again in human activities is a matter of prime importance to scientists and specialists in the field of water remediation so a huge volume of studies was devoted to the topic [2]. While the enhancement of sanitation water supply will be the best water resources management and boost the growth of countries' economies and contribute significantly to poverty alleviation and disease of their peoples [3].

The textile industry is considered one of the most important economic resource, as it annually produces more than 10^5 types of dyes, with an estimated amount of 7 x 10^5 tons, which produces pollutants that are released into the freshwater environment and sewage water [4].The dyes produced by the textile and paper industries that are released into wastewater and the aquatic environment are pollutants because they are toxic and non-biodegradable compouns [5] . The dyes contain aromatic structures with homogeneous or heterogeneous compounds resistant to biodegradation and disintegration that reason preventing light [6], which makes dyes pollutants in the water environment a deficiency in biochemical and chemical oxygen demand. This requires finding solutions to remove these dyes from the aquatic environmental [7] .

There are three main types of treatment for water pollution and removal of pollutants, these are chemical methods, biological methods, and physical methods (adsorption processes, filters, and reverse osmosis)[8] . Adsorption techniques have been widely used in pollution treatment due to their high efficiency, ease of application, and lower cost compared to other methods, with up to 99% in removing pollutants from water in a short time. The adsorption process can be defined as the adhesion of the particles of the polluting component to the surface solid substance called the adsorbent surface [9].

There are many factors affecting the efficiency of the adsorption process, these are the molecular weight and the concentration of pollutants, the size, nature, surface area, and quantity of the adsorbing surface, the pH of the medium, the presence of additional substances and pollutants in addition to the temperature of the medium [10]. Due to the characteristics of the adsorbent surface affecting the process, which is the number of active sites and the large surface area [11] . Tn this study, a nanocomposite of the type spinel, $CuCo_2O_4$, was synthesized because it is stable in the removal processes [12].

Fuchsin basic (BF) dye, known as Magenta II, has the chemical formula $C_{20}H_{20}ClN_3$ and is a mixture of the three dyes Rosaniline, Pararosaniline, and Magenta II [13] . As well Basic Fuchsin dye belongs to the triarylmethane class dyes [14]. This dye has many applications and uses in textile dyeing, leather dyeing, collagen, muscles, mitochondria, and tuberculosis bacilli [15]. It also possesses Gram-positive anesthetic, bactericidal and fungicidal effects [16]. The blood, liver, spleen, thyroid, and other organs may also suffer from swallowing or inhaling damage. Besides its carcinogenic and mutagenic effects, repeated exposure to the dye may have consequences for the nervous system [17] . This prompted researcher to remove the dye from aqueous solutions before putting it into the water stream to reduce pollution and its risks. where used. The Brião,G.V *et al* [16] synthesized an adsorbent surface of medium porous zeolite prepared from Biopolymer/ZSM-5 zeolite with high efficiency to remove 85% of BF when using a dose of 2.0 g.L^{-1} at an equilibration time of 20 minutes. The adsorption process is identical to Langmuir, Freundlich [16] . While Lu *et al* [18] synthesized in a surface adsorbent from Loess clays with a functionalized copolymer to remove BF dye with the maximum removal percentage at pH = 6, a surface adsorbent dose of 2.0 g.L^{-1}, and an equilibration time of 120 minutes , as well as the adsorption chemical and exothermic, and more Freundlich than Langmui identical [18].

This research aims to remove reactive BF from aqueous by using involve the synthesis of $CuCo_2O_4$ Nanocomposite. Parameters such as contact time, pH, adsorbent concentration, adsorbate content were optimized. It also aims at exploring the best and isotherms models and studying thermodynamics values [19].

Experimental Section

Chemicals and equipment

Materials used in its study were of high purity, these were, Cu $(NO_3)_2.3H_2O$, Co $(NO_3)_2.6$ H2O, Na_2CO_3, NaCl, KCl, $MgCl_2$, $CaCl_2.2H_2O$, NaOH, and HCl, these were purchased from SIGMA, BHD, and HIMEDIA companies. Toxic BF was obtained from the Textile factory in Hilla, Iraq. For all experiments, deionized and double distilled water was used as a solvent. Laboratory equipment and techniques used in this study and devices were manufactured from reputable international origins, such as: Electronic

2024, 21(7): 2275-2288
https://doi.org/10.21123/bsj.2023.8782
P-ISSN: 2078-8665 - E-ISSN: 2411-7986

Balance TP-214 (Sartorius, Germany), Muffle Furnace Size-Two, Oven Bs Size Two (Gallenkamp), Heater with magnetic stir MR Hei-standard (Heldolph. Germany), Ultrasonic, UV-Visible Spectrophotometer Double Beam -6100PC (EMC LAB, Germany), (FT-IR) IRAffinity-1S (Shimadzu, Japan), (X-Ray) XRD-6000, Field-emission Scanning Electron Microscope (FE-SEM) Tescan Mira3 (Mira3 French), and Atomic Force Microscope (AFM)TT-2 AFM (AFM Workshop, USA).

Synthesis of the Adsorbent Surface

The co-precipitation method was used to synthesize cobalt-copper oxides overlapping Nano-type spinel from the equivalent weights of aqueous copper nitrate and cobalt nitrate at 40% and 60% respectively and dissolving them in 400 mL of distilling water. Then, this solution was mixed and heated at 70-75 °C using a heater and magnetic stirrer, during that, the sodium carbonate 0.1 moles. L^{-1}as a precipitant agent was added dropwise until completion of the precipitation of metal carbonates at pH = 9. Afterwards, heating with stirring were continued for 2 hours. Then the solution was filtered and the precipitate was washed with water several times to remove the remaining unreacted sodium carbonate until pH = 7. Then the precipitate was dried at 120 °C and crushed ,then there was burning at 600 ° for four hours, the obtained material was designed as $CuCo_2O_4$ [20] **.**

Preparation of BF Solution

A BF dye solution was prepared at a concentration of 100 mg per liter (ppm) by dissolving 0.1 g. in one liter of water distilling as a stock solution, then by using the visible-ultraviolet spectra to determine the λ_{max} at about 546 nm and series of concentrations 10 – 80 mg per liter was prepared from it to create the standard calibration curve of the dye as shown below Fig. 1.

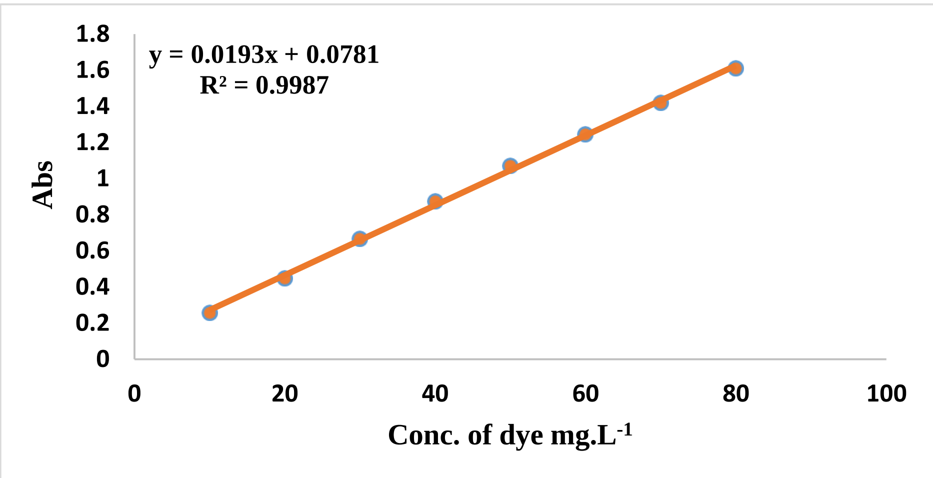

Figure1. Standard calibration curve of concentration mg. L^{-1} of BF at λ_{max} = 546 of its Dye.

Studying the Optimization Conditions for BF Dye Removal

A series of volumetric bottles of 25 mL capacity was taken containing a dye solution with a concentration of 50 ppm. A weight of 5 mg. of adsorbent surface was added to each volumetric vial and placed in a water shaker. The percentage of dye removal by Eq. 1 was found after every 5 minutes for 120 minutes after separating of the adsorbent surface from solution and find the absorbance of the solution. As for the weight of the adsorbent surface, a series of volumetric bottles of 25 mL capacity of 50 ppm dye solution was also added in different weights 0.001 - 0.02 g. of adsorbent surface and finding the percentage of dye removal at the optimization time. In the same way, the same experiments were carried out to find acidity [21].

$$Re\% = \frac{C_i - C_e}{C_i} X100\ \% \qquad 1$$

Whereas, Re % is the removal efficiency of dye over the used material. C_i and C_e are the initial concentration before adsorption and at equilibrium concentration (after adsorption) of the dye respectively.

Adsorption Isotherms

Different initial concentrations 10-80 mg. L^{-1} of BF dye at temperatures 298-338K were conducted to find adsorption capacity (Q_e) by Eq. 2 at the optimum conditions of adsorption to study the isothermal adsorption temperature for adsorption of BF dye according to Gailes's classification using the prepared adsorbent surface by plotting between the adsorption capacity Q_e and C_e[22] .

$$Q_e = \frac{V(C_i - C_e)}{m} \qquad 2$$

Whereas, Qe, is the capacity of the adsorbate at units in mg. g^{-1}.

C_i and C_e are the initial concentration before adsorption and at equilibrium concentration (after adsorption) of the dye respectively, m is the weight of $CuCo_2O_4$ in units of g and

V, is the total volume of the adsorbate solution in units L.

Results and Discussion

Characterization of the Synthesized material

Surface functional groups of the prepared material showed some peaks at the fingerprint region, 667.39 - 572.88 cm^{-1}, appeared as a result of the stretching vibrations of tetrahedral Co^{3+} -O^{2-} bonds and octahedral Cu^{2+} -O^{2-} complexes. Whereas at 2500 cm^{-1} a W-shaped crest appeared as a result of the oscillator links as shown in Fig. 2 [23].

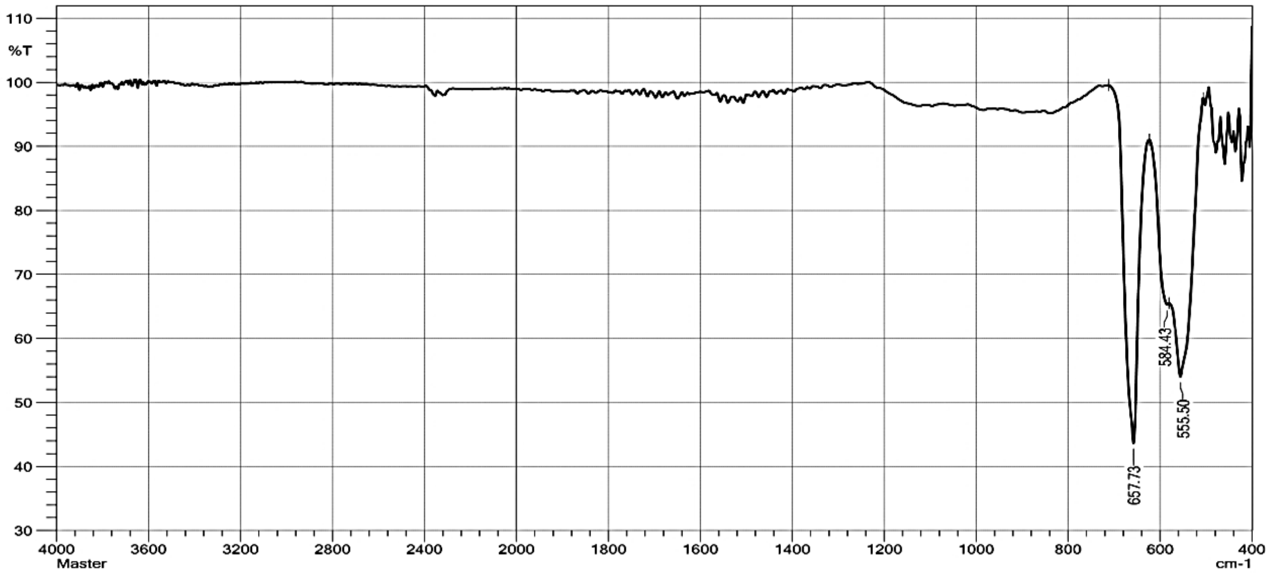

Figure 2. FTIR spectra for the synthesized $CuCo_2O_4$.

XRD patterns for the prepared material is shown in Fig. 3. These patterns are related to 01-087-2177 and 00-001-115 JCPDS, including diffraction angles 2θ (19.063, 31.3382, 36.9182, 38.7951, 44.8771, 48.7963, 59.4515, 68.1347), FWHM 0.2952, 0.1968, 0.1968, 0.1968, 0.1968, 0.1968, 0.2952 ,0.72 and Miller processing (hkl) 111 ,220 ,311, 222 ,400 ,331 ,511, 531 respectively as Co_{tet} $(CuCo)_{oct}O4$ and the sparks equation which depends on the results of X-rays diffraction. The average particle size was calculated using Scherer equation and it was around 1 nm [24] .

2024, 21(7): 2275-2288
https://doi.org/10.21123/bsj.2023.8782
P-ISSN: 2078-8665 - E-ISSN: 2411-7986
Baghdad Science Journal

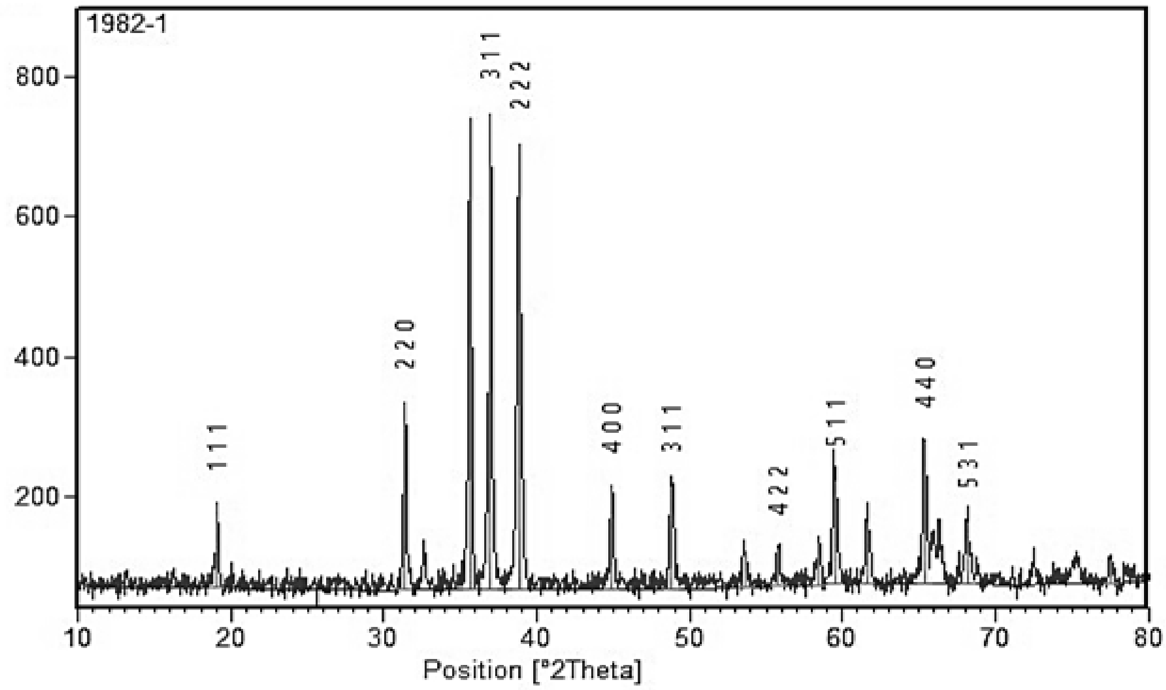

Figure3. X-rays diffraction patterns for the prepared $CuCo_2O_4$ adsorbent surface.

Fig. 4 shows the size and morphology of the prepared material, in almost it shows spherical grains, their sizes ranged from 31 to 364 nm, with large interstitial spaces using the FESEM technique. Fig. 5 shows the surface of the adsorbents 25nm with a high homogeneity when using the AFM technique, which increases the residential locations of the adsorbent surface due to having high surface area and granular distribution as well as the homogeneity of the surface [25].

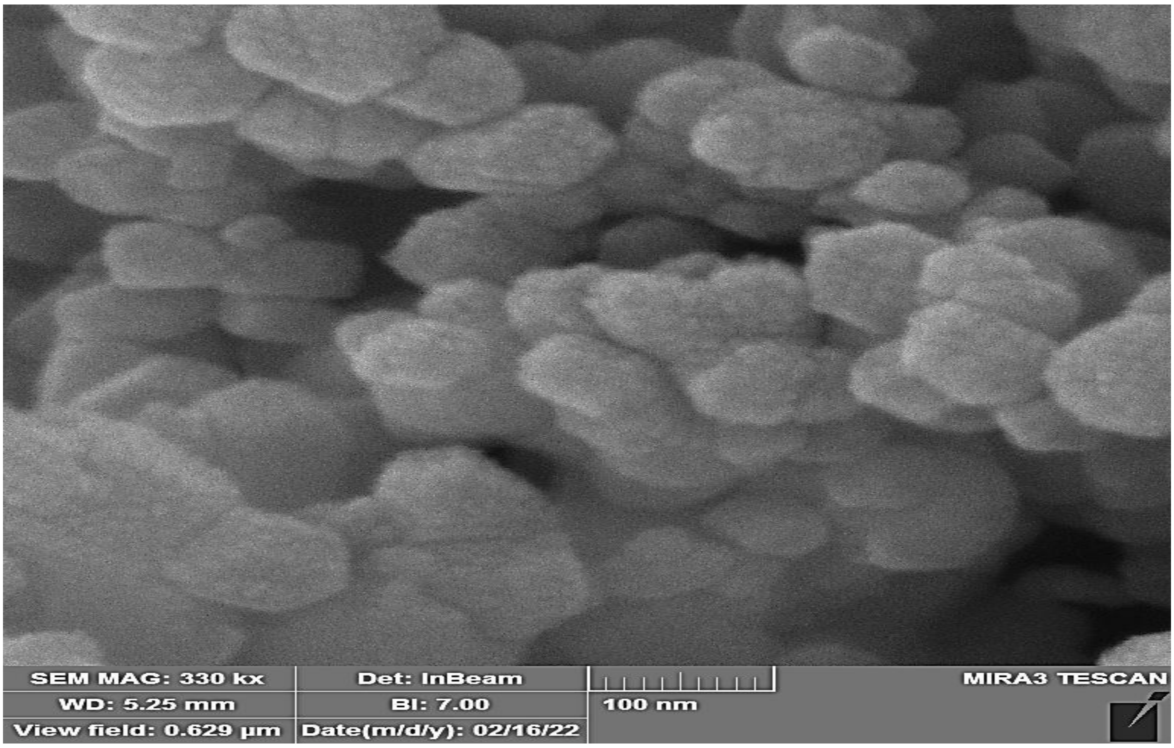

Figure 4. FESEM of the synthesized $CuCo_2O_4$.

2024, 21(7): 2275-2288
https://doi.org/10.21123/bsj.2023.8782
P-ISSN: 2078-8665 - E-ISSN: 2411-7986
Baghdad Science Journal

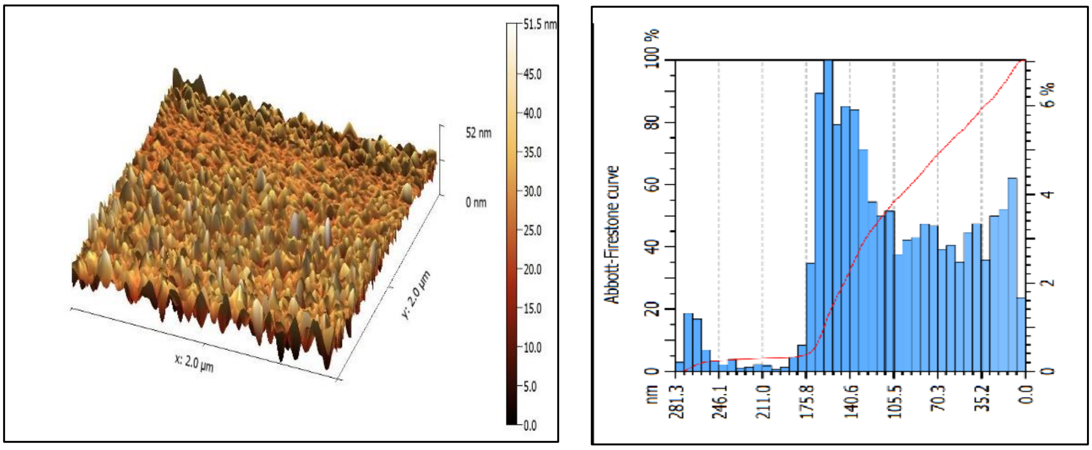

Figure 5. AFM image and histogram for the synthsized $CuCo_2O_4$.

Studying the Optimum Conditions for Adsorption BF by $CuCo_2O_4$ Adsorbent Surface

Contact (Equilibrium) Time

Contact time (Equilibrium time) is the time required for the adhesion of the adsorbent particles with all the active sites on the adsorbent surface to reach the equilibrium state, and it is important in the adsorption process and the efficiency of the adsorbent surface[26]. Fig. 6 shows a sudden increase in the removal efficiency of dye at first five minutes after that shows a very slight rise in Re% from 10-120 minutes indicating that all the dye adhered to the active sites at the surface of the adsorbent at 5 minutes and it was the optimum contact time [27].

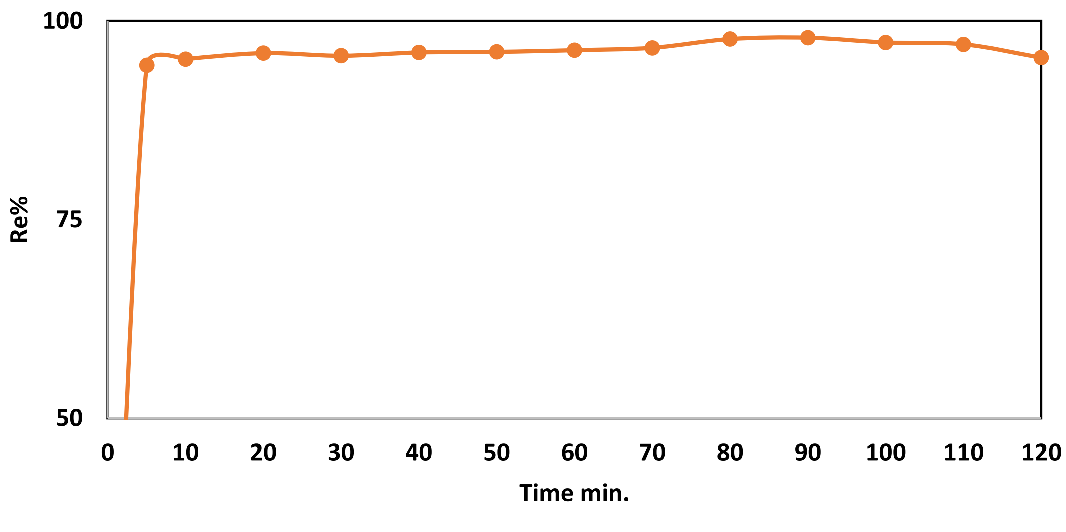

Figure 6. Effect of contact time on BF dye removal by adsorption over $CuCo_2O_4$ at 298K.

Effect of Weight of the Adsorbent on the Efficiency of Dye Removal

Fig. 7, shows the sudden increase at a low dose of 0.001- 0.005 g of adsorbent surface, and then the increase in the removal efficiency continued very slight rise compared with the increase in the surface dose, the found optimal absorbent surface weight of 5 mg to remove 88% of the dye molecules to reason most of the active sites bond to all dye when the dose of 5 mg of adsorbent surface [28].

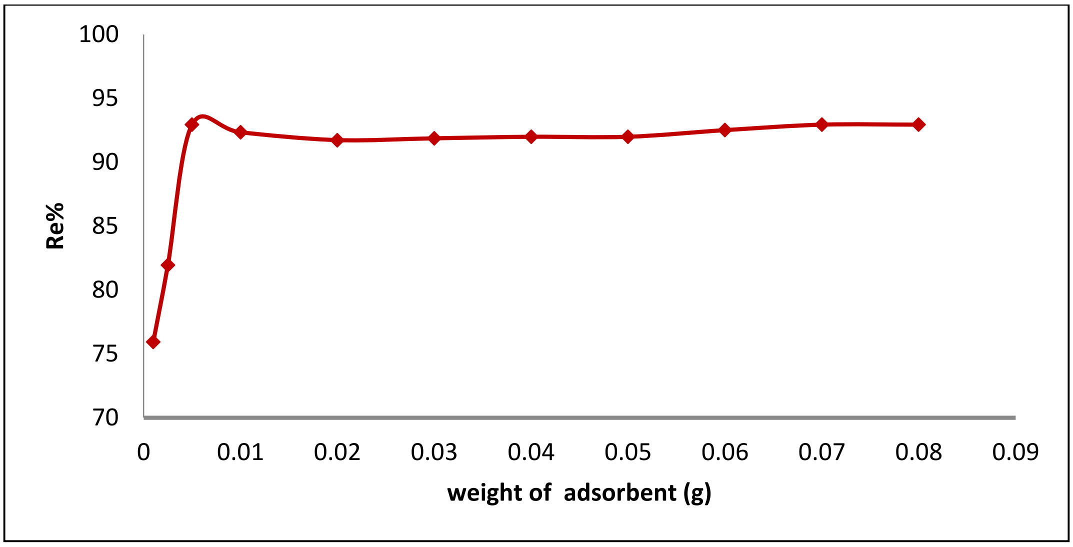

Figure7. Effect of the weight of $CuCo_2O_4$ on the efficiency of BF dye removal at 298 K.

Adsorption Isotherms

The relationship between adsorption capacity (Qe) and C_e concentrations at 10 to 80 mg L^{-1} at different initial concentrations is known as an adsorption isotherm as shown in Fig. 8 [29]. According to the classification of Giles' S4 [30], there was a high affinity of dye molecules towards adsorbent surface at 298-338K [31].

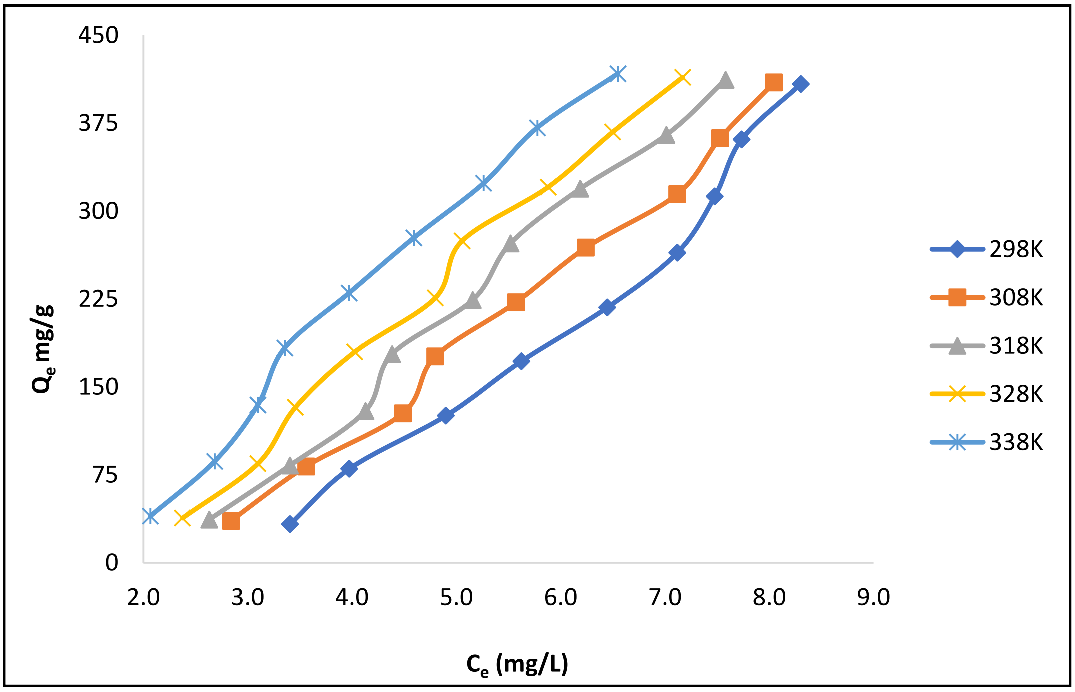

Figure 8. The relationship between Q_e and C_e of BF dye on the adsorbent surface at 298–338 K.

Adsorption isotherms Langmuir originally proposed that the adsorption process occurs on one layer, after that Freundlich and Temkin modified Langmuir's Eqs. 3,4 and 5 respectively for the adsorption process occurring on more than one layer [32].

$$Q_e = \frac{a\,b\,Ce}{1+b\,Ce} \qquad 3 \qquad \text{Langmuir}$$

$$Q_e = K_f\ C_e^{1/n} \qquad 4 \qquad \text{Freundlich}$$

2024, 21(7): 2275-2288
https://doi.org/10.21123/bsj.2023.8782
P-ISSN: 2078-8665 - E-ISSN: 2411-7986
Baghdad Science Journal

$$Q_e = \frac{RT}{b} LnA_T C_e \quad 5 \quad \text{Tekmin}$$

Figs. 9, 10, and 11 show Freundlich, Langmuir, and Temkin equations respectively, while values constants of each model's adsorption equation are listed in Table 1. The obtained results showed that the adsorption process was more fitted with Freundlich and Temkin equations with less fitting with Langmuir models because the adsorption multiple layers [33].

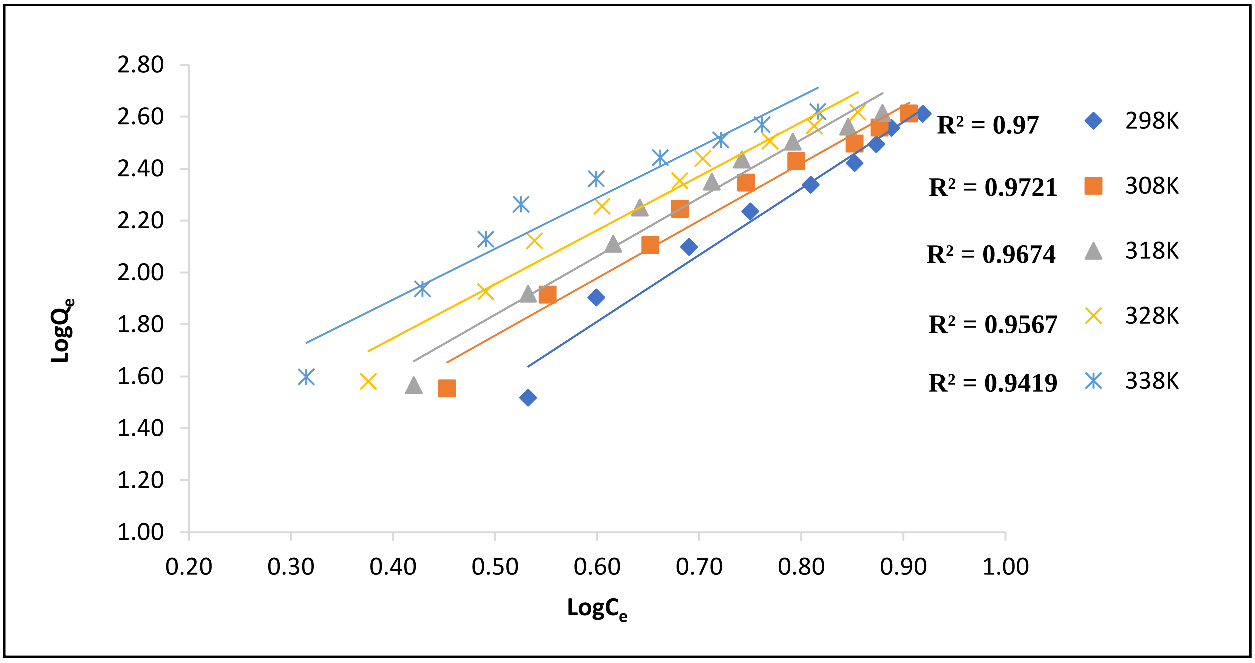

Figure 9. Freundlich isotherm relationship between $logQ_e$ and $LogC_e$ for BF dye adsorption over $CuCo_2O_4$ at temperature ranges from 298 to 338 K.

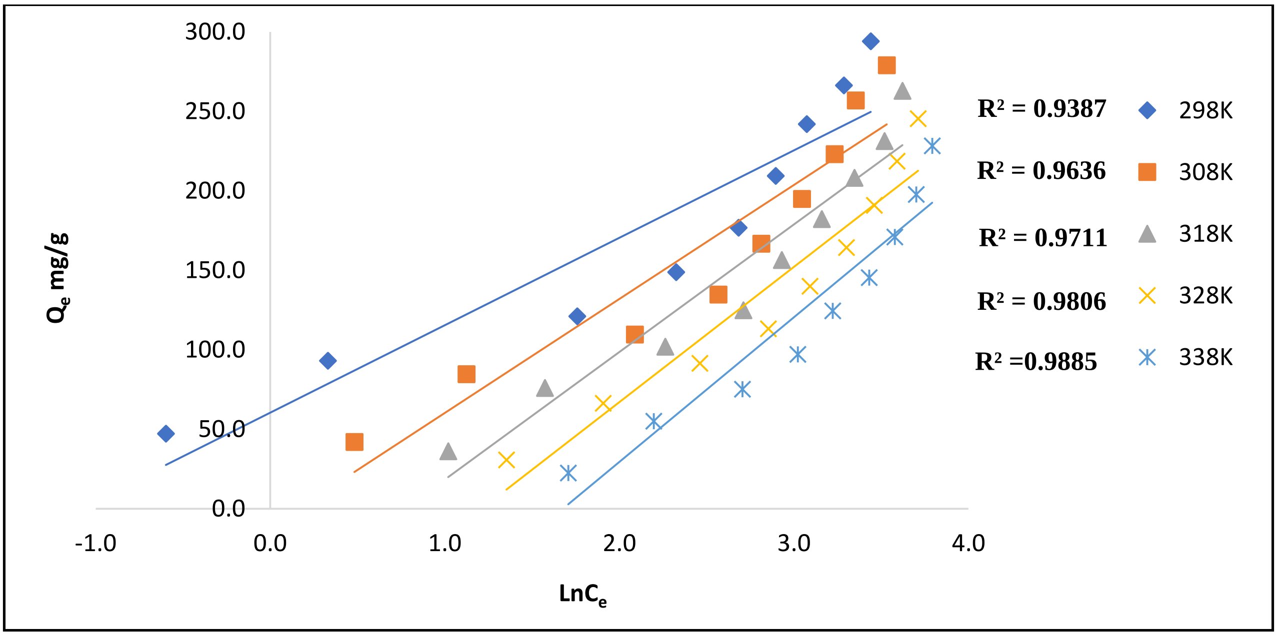

Figure 10. The Temkin isotherm is relationship between Q_e and LnC_e for BF dye adsorption over $CuCo_2O_4$ at temperature ranges from 298-338K.

2024, 21(7): 2275-2288
https://doi.org/10.21123/bsj.2023.8782
P-ISSN: 2078-8665 - E-ISSN: 2411-7986
Baghdad Science Journal

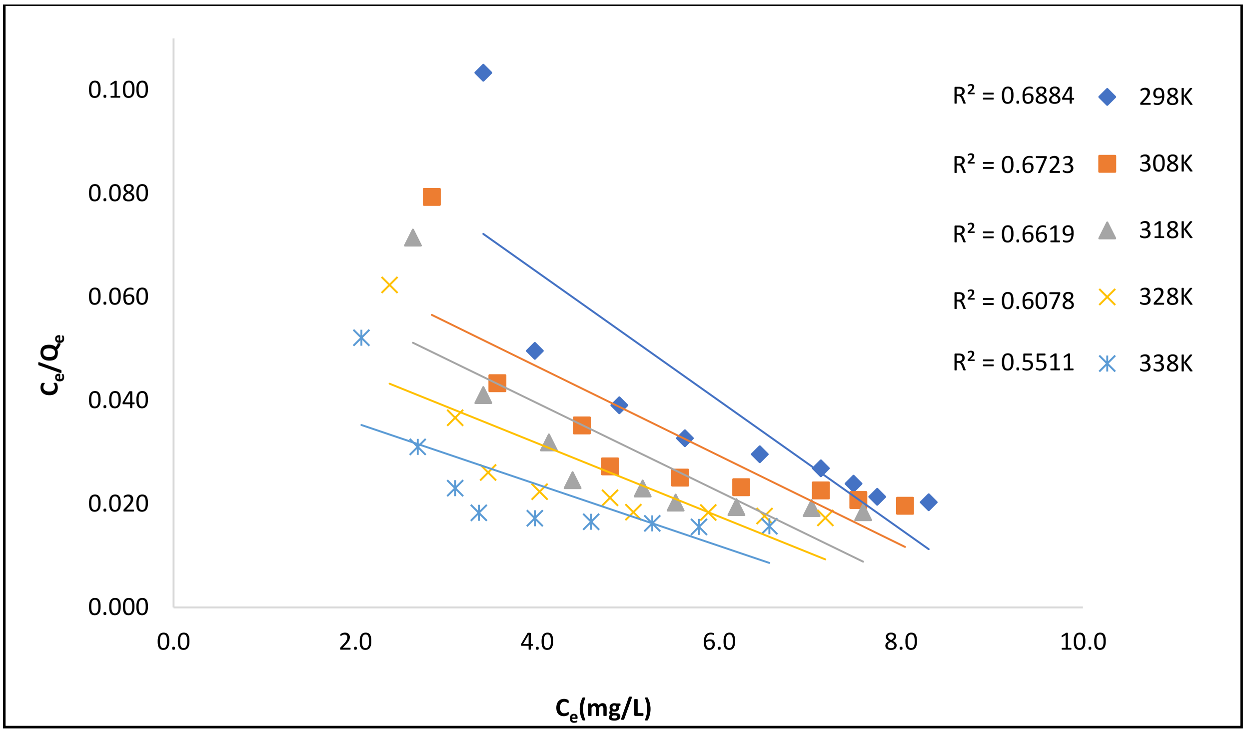

Figure 11. The Langmuir isotherm is relationship between C_e/Q_e and C_e for adsorption of BF dye over $CuCo_2O_4$ at temperature ranges from 298 - 338 K.

Table1. Isothermal parameters and correlation coefficient for BF dye adsorption over $CuCo_2O_4$.

Temperature	Langmuir isotherm				Freundlich isotherm			Temkin isotherm		
K	a	b	RL	R^2	K_f	n	R^2	b_T	K_T	R^2
298	-80.0	-0.1091	-0.2	0.6884	1.87	0.39	0.97	-347.16	1.87	0.9387
308	-116.3	-0.1060	-0.2	0.6723	4.48	0.45	0.9721	-328.14	4.48	0.9636
318	-117.6	-0.1153	-0.2	0.6619	5.16	0.44	0.9674	-202.12	5.16	0.9711
328	-140.8	-0.1181	-0.2	0.6078	8.21	0.48	0.9567	-219.69	8.21	0.9806
338	-169.5	-0.1239	-0.2	0.5511	13.15	0.51	0.9419	-175.06	13.15	0.9885

2024, 21(7): 2275-2288
https://doi.org/10.21123/bsj.2023.8782
P-ISSN: 2078-8665 - E-ISSN: 2411-7986
Baghdad Science Journal

The Effect of the pH Reaction Mixture on the Efficiency of Dye Removal over $CuCo_2O_4$

The effect of pH on the removal efficiency of BF dye over the synthesized $CuCo_2O_4$ was investigated by applying adsorption under different pH values of the solution keeping other adsorption conditions constant. In this manner, a series of pH values from 2 to 12 were carried out [34]. The obtained results showed a significant decrease with decreasing pH as well as in the basic medium due to the competition of H^+ and OH^- dye for their active site on the surface, therefore was the best pH = 8 as shown in Fig. 12 [35].

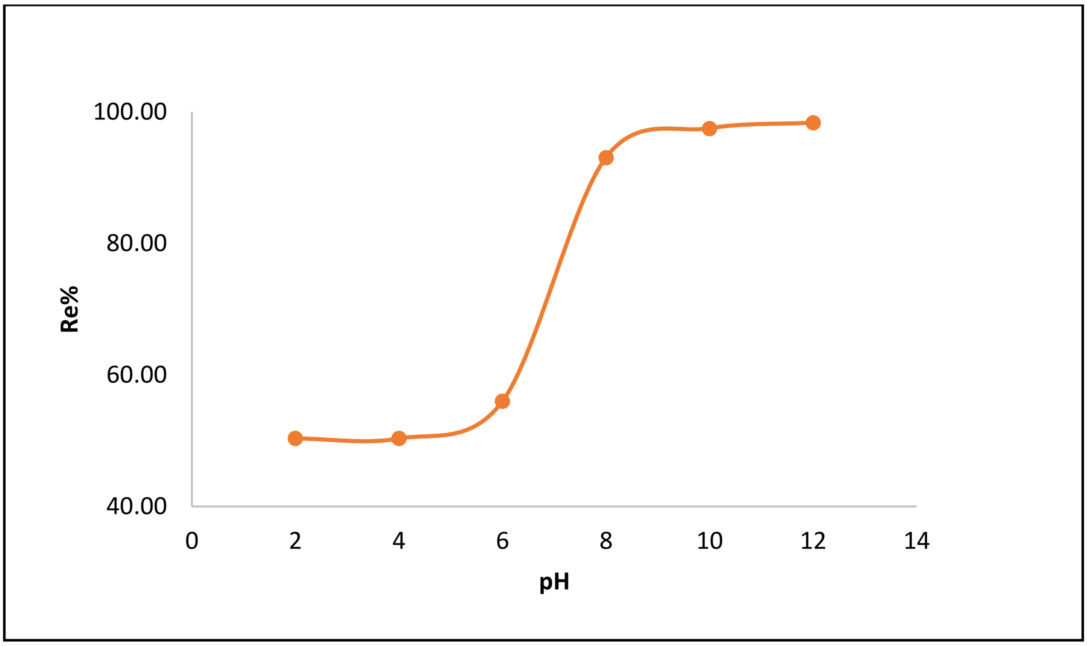

Figure 12. Effect of pH on the efficiency of BF dye removal over $CuCo_2O_4$.

Thermodynamics of BF Dye Adsorption over $CuCo_2O_4$

The effect of temperature was studied and thermodynamic functions (free energy, ΔG, enthalpy ΔH, and entropy ΔS) were investigated. This conception is important for the adsorption process and determining the type of reaction spontaneous, exothermic, or endothermic [16]. The free energy (ΔG), ΔS , K_{eq} and ΔH were calculated using Eqs. 6, 7, 9 and 10 respectively, while ΔH was calculated by sketching the relationship between the equilibrium constant LnKeq and 1/T which was shown in Fig. 13 and Table 2. The adsorption process is spontaneous and does not need energy reason ΔG was negative the surface energy of the adsorbent decreased due to residual forces on the surface of the adsorbent decreases , and the heat of the reaction is positive, indicating that the adsorption process is an endothermic process, while the change in entropy showed a change from a positive value but decreasing state with increasing temperature, shows the affinity of the adsorbent towards the adsorbate and this may be due to the disturbance of the water molecules around the dye [36 37].

$$\Delta G = -R \, LnK_{eq} \, T \qquad 6$$

$$\Delta G = \Delta H - T\Delta S \qquad 7$$

$$LnK_{eq} = \frac{-R\Delta H}{T} + \frac{\Delta S}{R} \qquad 8$$

$$K_{eq} = \frac{Qe\, m}{Ce\, V} \qquad 9$$

$$Slope = -R\Delta H \qquad 10$$

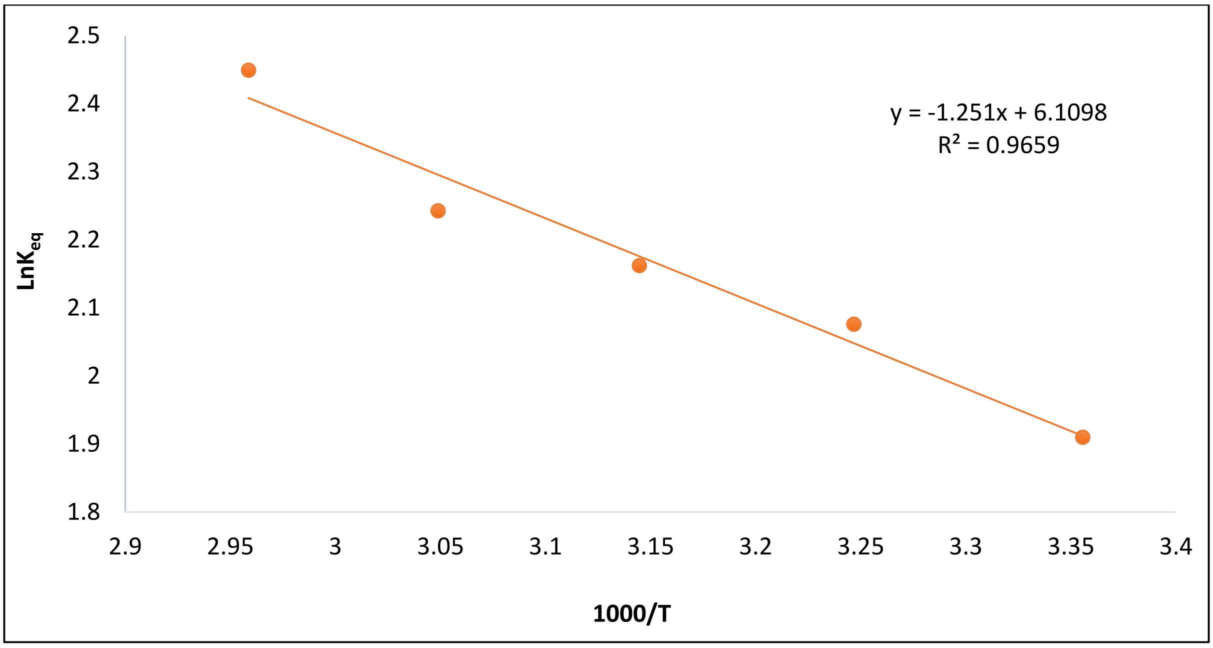

Figure 13. The relationship between the LnK_{eq} and 1000/T

Table 2 and Fig. 13 indicate that the adsorption process was spontaneous and does not need energy as ΔG showed a negative value. The heat of the reaction is positive, indicating that the adsorption process is an endothermic process, while the change in entropy showed a change from a positive value but decreasing state with increasing temperature, this may be due to the disturbance of the water molecules around the dye.

Table 2. The values of C_e, 1/T, K_{eq} and thermodynamic functions for adsorption process to BF dye on $CuCo_2O_4$ at 298 – 338 K

T	C_e	K_{eq}	1000/T	LnK_{eq}	ΔG KJ.mol^{-1}. K^{-1}	ΔH KJ.mol^{-1}.K^{-1}	ΔS J.mol^{-1}.K^{-1}
298	6.448	6.754	1.910	1.9101	-4.7324	10.40	50.7829
308	5.572	7.973	2.076	2.0760	-5.3161	10.40	51.0292
318	5.160	8.690	2.162	2.1621	-5.7164	10.40	50.6832
328	4.799	9.419	2.243	2.2427	-6.1159	10.40	50.3558
338	3.974	11.581	2.449	2.4493	-6.8830	10.40	51.1356

Conclusion

From the obtained results in the current study, it was found that, the best removal efficiency of BF dye over $CuCo_2O_4$ was achieved under the optimal conditions of the initial concentration of dye of 90 mg. L^{-1}, the weight of the adsorbed surface, 0.005 g, pH 8, and contact time was 5 minutes. As well Langmuir, Freundlich, and Temkin models according to the correlation coefficient (R^2) the Freundlich, and Temkin models are better for describing the removal of BF while the Langmuir model was not best isothermal model in describing. While thermodynamic values showed that the adsorption process is a spontaneous and endothermic process. From the isothermal models and thermodynamic values, the removal mechanism was physical absorption.

Acknowledgment

The authors appreciate the cooperation of the Department of Chemistry, College of Education for Pure Sciences in the University of Kerbala, Iraq and the Department of Chemistry College of Science, University of Babylon for their helping and funding to complete this study.

Authors' Declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for re-publication, which is attached to the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee at University of Kerbala.

Authors' Contribution Statement

A. A. K. wrote a part of the manuscript and collected the samples. M. A. wrote conception, design, acquisition of data, analysis, interpretation, drafting the MS, revision and proofreading. S. H.K. conception, design, acquisition of data, analysis, interpretation, drafting the MS, revision and proofreading. E.T.K. did the revision and proofreading. All the authors read the manuscript carefully and approved the final version.

References

1. Xu H, Gao Q, Yuan B. Analysis and identification of pollution sources of comprehensive river water quality: Evidence from two river basins in China. Ecol Indic. 2022; 135: 1-12. https://doi.org/10.1016/j.ecolind.2022.108561.
2. Ahmed Said AEA, Goda MN. Superior Competitive Adsorption Capacity of Natural Bentonite in the Efficient Removal of Basic Dyes from Aqueous Solutions. Chemistry Select. 2021 6(11): 2790-2803. https://doi.org/10.1002/slct.202100575.
3. Tortajada C, Biswas AK. Achieving universal access to clean water and sanitation in an era of water scarcity: strengthening contributions from academia. Curr Opin Environ Sustain. 2018 Oct 1; 34: 21–5. https://doi.org/10.1016/j.cosust.2018.08.001 .
4. Rohmah AA, Purnomo AS, Safitri WN. Biodecolorization of Methylene Blue by Using Bacillus subtilis Immobilized into SA-PVA-Bentonite Matrix in Mineral Salt Medium and Non-nutritious Medium. Indones J Chem. 2022; 22(6): 1637-1650. https://doi.org/10.22146/ijc.76080 .
5. Ismael HA, Mohammad EJ, Atiyah AJ, Kadhim SH, Kahdum KJ. Synthesis and Characteristic Study of Composite Zinc Oxide and Functionalized Activated Carbon with Investigation of its Adsorption Ability: A Kinetic Study. IOP Conf Ser Earth Environ Sci. 2021; 722(1): 12007.http://dx.doi.org/10.1088/1755-1315/722/1/012007 .
6. Ghalehkhondabi V, Fazlali A, Ketabi K. Synthesis and characterization of modified activated carbon (MgO/AC) for methylene blue adsorption: Optimization, equilibrium isotherm and kinetic studies. Water Sci Technol. 2021; 83(7): 1548–65. https://doi.org/10.2166/wst.2021.016 .
7. Thuong NT, Nhi NTT, Nhung VTC, Bich HN, Quynh BTP, Bach LG, et al. A fixed-bed column study for removal of organic dyes from aqueous solution by pre-treated durian peel waste. Indones J Chem. 2019; 19(2): 486-494. https://doi.org/10.22146/ijc.39712.
8. Ibrahim HK, Al-Da' Amy MA, Kreem ET. Decolorization of coomassie brilliant blue G-250 dye using snail shell powder by action of adsorption processes. Res J Pharm Technol. 2019; 12(10): 4921-4925. https://doi.org/10.5958/0974-360X.2019.00853.9 .
9. Kadhim NJ, Mousa SA, Farhan AM, Muhammed EA. A comparative study of the adsorption of crystal violet dye from aqueous solution on rice husk and charcoal. Baghdad Sci J. 2020; 17(1): 295–304. https://doi.org/10.21123/BSJ.2020.17.1(SUPPL.).0295 .

10. Ali I, Gupta VK. Advances in water treatment by adsorption technology. Nat Protoc. 2006; 1(6): 2661–7. https://doi.org/10.1038/nprot.2006.370
11. Liu W, Ge H, Chen X, Lu X, Gu Z, Li J, et al. Fish-Scale-Like Intercalated Metal Oxide-Based Micromotors as Efficient Water Remediation Agents. ACS Appl Mater Interfaces. 2019 May 1; 11(17): 16164–73. https://doi.org/10.1021/acsami.9b01095 .
12. Uzcan F, Soylak M. $CuCo_2O_4$ as affective adsorbent for dispersive solid-phase extraction of lead from food, cigarette and water samples before FAAS detection. Chem Pap . 2021; 75(12): 6367-6375. https://doi.org/10.1007/s11696-021-01797-3 .
13. Goyal SK. Use of rosaniline hydrochloride dye for atmospheric SO_2 determination and method sensitivity analysis. J Environ Monit. 2001 Dec; 3(6): 666-70. https://doi.org/10.1039/b106209n .
14. Niero G, Corrêa AXR, Trierweiler G, Matos AJF, Corrêa R, Bazani HAG, et al. Using modified fish scale waste from Sardinella brasiliensis as a low-cost adsorbent to remove dyes from textile effluents. J Environ Sci Health A Tox Hazard Subst Environ Eng . 2019 Sep 19; 54(11): 1083–90. https://doi.org/10.1080/10934529.2019.1631091.
15. Cooksey CJ, Dronsfield AT. Quirks of dye nomenclature. 4. Fuchsine: four shades of magenta. Biotech Histochem. 2015; 90(4): 288-93. https://doi.org/10.3109/10520295.2014.989543 .
16. Brião G V, Jahn SL, Foletto EL, Dotto GL. Highly efficient and reusable mesoporous zeolite synthetized from a biopolymer for cationic dyes adsorption. Colloids Surf A Physicochem Eng Asp. 2018; 556: 43–50. https://doi.org/10.1016/j.colsurfa.2018.08.019
17. Durmus Z, Kurt BZ, Durmus A. Synthesis and Characterization of Graphene Oxide/Zinc Oxide (GO/ZnO) Nanocomposite and Its Utilization for Photocatalytic Degradation of Basic Fuchsin Dye. Chemistry Select. 2019; 4(1): 271–278. https://doi.org/10.1002/slct.201803635 .
18. Lu T, Wang L, He Y, Chen J, Wang RM. Loess surface grafted functional copolymer for removing basic fuchsin. RSC Adv. 2017; 7(30): 18379– 18383. http://dx.doi.org/10.1039/C7RA00610A.
19. Chafi M, Byadi S, Barhoumi A, Limouni W, Tizliouine A, Jama C, et al. Study of copper removal by modified biomaterials using the response surface methodology, DFT Calculation, and molecular dynamic simulation. J Mol Liq. 2022; 363: 119799. https://doi.org/10.1016/j.molliq.2022.119799 .
20. Arraq R, Kadhim S. Synthesis and Identification of Co3O4·Fe3O4/CaO Spinel Supported Catalyst. Asian J Chem. 2018 Jan 1; 30(11): 2502-2508. https://doi.org/10.14233/ajchem.2018.21507.
21. Al-Abadi SI, Al-Da'Amy MA, Kareem ET. Thermodynamic Study for Removing of Crystal Violet Dye on Iraqi Porcelanite Rocks Powder. IOP Conf Ser Earth Environ Sci. 2021; 790(1): 012055. https://doi.org/10.1088/1755-1315/790/1/012055 .
22. Salman I, Dhahir SA, abed Al-saade K. Congo red Adsorption on Bentonite and Modified Bentonite. Online Int Interdiscip Res J. 2013; 3(5): 62–78
23. Das AK, Kim NH, Lee SH, Sohn Y, Lee JH. Facile synthesis of $CuCo_2O_4$ composite octahedrons for high performance supercapacitor application. Compos B Eng .2018; 150 :269–76. https://doi.org/10.1016/j.compositesb.2018.07.021.
24. Flores-Lasluisa JX, Quílez-Bermejo J, Ramírez-Pérez AC, Huerta F, Cazorla-Amorós D, Morallón E. Copper-Doped Cobalt Spinel Electrocatalysts Supported on Activated Carbon for Hydrogen Evolution Reaction. Materials. 2019 20; 12(8): 1302. https://doi.org/10.3390/ma12081302.
25. Hofmann A. Physical Chemistry Essentials. 2018. 1–499 p. https://doi.org/10.1007/978-3-319-74167-3.
26. AL-Jobouri IS, Dhahir SA, abed Al-saade K. Adsorption Study of Rhodamin B Dye on Iraqi Bentonite and Modified Bentonite by Nanocompounds TIO2, ZNO, AL2O3 and Sodium Dodecyl Sulfate. Am J Environ Sci. 2013; 9: 269–279. https://doi.org/10.3844/ajessp.2013.269.279.
27. Kadhim SH, Mgheer T H, Ismael HI, Kadem KJ, Abbas AS, Atiyah AJ, et al. Synthesis, characterization and catalytic activity of NiO-CoO-MgO nano-composite catalyst. Indones. J Chem. 2019; 19(3): 675–83. https://doi.org/10.22146/ijc.38119.
28. Uddin MK, Nasar A. Walnut shell powder as a low-cost adsorbent for methylene blue dye: isotherm, kinetics, thermodynamic, desorption and response surface methodology examinations. Sci Rep. 2020; 10(1): 1–13. https://doi.org/10.1038/s41598-020-64745-3 .
29. Farhan AM, Zaghair AM, Abdullah HI. Adsorption Study of Rhodamine –B Dye on Plant (Citrus Leaves) . Baghdad Sci J. 2022 Aug 1; 19(4 SE-article): 838. https://doi.org/10.21123/bsj.2022.19.4.0838
30. dos Santos JMN, Lima É, Dotto GL. Basic fundamentals of adsorption modeling for removal of pesticides from water and wastewater. Pestic Remediat Technol Water Wastewater. 2022 Jan 1; 159–88. https://doi.org/10.1016/B978-0-323-90893-1.00008-8.
31. Hussein ZA, Alazawy RA, Haddawi SM. Adsorption of 2,6-dichlorophenol-indophenol sodium dihydrate salt from aqueous solutions using nano magnesium oxide; A thermodynamic study. Egypt J Chem. 2020;

63(10): 4157-4161. https://doi.org/10.21608/EJCHEM.2020.19984.2206.
32. Obaid SA. Langmuir, Freundlich and Tamkin Adsorption Isotherms and Kinetics For The Removal Aartichoke Tournefortii Straw From Agricultural Waste. J Phys Conf Ser. 2020; 1664: 12011. https://doi.org/10.1088/1742-6596/1664/1/012011.
33. Dawood AF, Khalil MAAK. Removal of basic fuchsine dye using (TiO_2/MWCNTs) nanomaterial. Mater Today Proc. 2022 Jan 1; 49: 2888–97. https://doi.org/10.1016/j.matpr.2021.10.221 .
34. Ahmed S, Abdul-hussein E, Tareq S. Adsorption of Malachite Green Dye From Aqueous Solution Onto Iraqi Raw Al-Hussainiyat Clay. European Chemical Bulletin. 2013; 2(11): 866–72.
35. Kareem ET, Chafat AH, Al-Da'amy MA. Iraqi porcelanite Rocks for Efficient Removal of Safranin Dye from Aqueous Solution. Baghdad Sci J. 2023 Apr 1; 20. https://doi.org/10.21123/bsj.2022.6921.
36. Ebelegi AN, Ayawei N, Wankasi D. Interpretation of Adsorption Thermodynamics and Kinetics. Open J Phys Chem. 2020; 10(03): 166–82. https://doi.org/10.4236/ojpc.2020.103010.
37. Hussein ZA, Haddawi SM, Kadhim AA. Study of thermodynamic variables to adsorption of aldomete drug (Methyldopa) from its water solution on the nano zinc oxide surface. Int J Pharm Qual Assur . 2019; 10(2): 315–21. https://doi.org/10.25258/ijpqa.10.2.17.

إزالة صبغة الفوكسين القاعدية عن طريق الامتزاز على متراكب نانوي $CuCo_2O_4$ كسطح ماص نشط

علي عبدالرحيم كاظم[1]، منير عبد العالي الدعمي[2]، صالح هادي كاظم[3]، ايمان طالب كريم[4]

[1]قسم الانتاج الحيواني، كلية الزراعة، جامعة كربلاء، كربلاء، العراق.
[2]قسم الكيمياء، كلية التربية للعلوم الصرفة، جامعة كربلاء، كربلاء، العراق.
[3]قسم الكيمياء، كلية العلوم , جامعة بابل، بابل، العراق.
[4]قسم الكيمياء، كلية العلوم، جامعة كربلاء، كربلاء، العراق.

الخلاصة

تتضمن هذه الدراسة تصنيع مركب نانوي من نوع $CuCo_2O_4$. تم تصنيع هذه المادة باستخدام طريقة الترسيب المشترك. تم تشخيص المواد المحضرة بأستخدام الطيفي للأشعة تحت الحمراء (FTIR) ، حيود الأشعة السينية (XRD) ، المجهر الإلكتروني لمسح الانبعاث الميداني (FESEM) ، والفحص المجهري للقوة الذرية (AFM). تم فحص نشاط المواد المحضرة باتباع إزالة صبغة الفوشسين الأساسية (BF) من محلولها المائي عن طريق الامتزاز. تم دراسة الظروف الفضل للأمتزاز المختلفة مثل وزن السطح الممتز ووقت الامتزاز ودرجة الحموضة الوسط فضلاً عن درجة الحرارة. حيث كانت كفاءة الإزالة المثلى حوالي 97٪ في وقت التلامس 5 دقائق ، 0.005 غم من السطح الممتز مع أفضل درجة حموضة = 8 و تركيز صبغة 50 ملغم.لتر$^{-1}$. تم حساب المعلمات الديناميكية الحرارية لأمتزاز هذه الصبغة على المواد المحضرة أيضًا مثل الطاقة الحرة (ΔG) سالبة بينما المحتوى الحراري (ΔH) موجباً مما يشير إلى أن الامتزاز كان تلقائيًا وممتصًا للحرارة ، كما كان الانتروبيا (ΔS) موجبًا.

الكلمات المفتاحية: تلوث المياه ، معالجة المياه ، الامتزاز ، $CuCo_2O_4$، متراكب نانوي من نوع الإسبنيل ، صبغة الفوكسين القاعدية.