AJSP
المجلة العربية للنشر العلمي

ISSN: 2663-5798 || Arab Journal for Scientific Publishing

الإصدار التاسع – العدد الثامن والثمانون
تاريخ الإصدار: 2 – شباط – 2026م

www.ajsp.net

"Removal of Hazardous Crystal Violet from Aqueous Media by Coffee-Husk Biomass: Equilibrium Behavior, Adsorption Kinetics, and Thermodynamic Assessment"

Researcher:

Maadh Asaad Mahmood

Department of Chemestry, Faculty of Science, Univerity of Maragheh, Iran

Abstract:

Crystal violet (CV) is a cationic triphenylmethane Water-soluble dye which has the ability to persist in aquatic systems and has also been linked to negative health and environmental effects. The paper is a waste coffee husk (WCH) biomass that is examined as a low-cost and renewable biosorbent to remove CV in aqueous media through the batch adsorption experiment carried out at the University of Baghdad. Contact time, initial dye concentration, dose of adsorbent systematically investigated, particle size, initial pH, and temperature were also investigated. The uptake of CV was fast at low contacts and high decolorization was seen in the presence of acid and at ambient temperature. Higher doses of the WCH increased the percentage removal and decreased mass-normalized capacity whereas smaller particle sizes increased the removal since they had more surface area and decreased diffusion length. The higher the temperature the lower adsorption became, which was in favor of an exothermic reaction. Kinetic modelling indicated that the pseudo-second-order model accounted experimentally for the experimental results significantly better than the pseudo-first-order model. Both Langmuir and Freundlich isotherms were in equilibrium over the concentration range studied. The thermodynamic parameters recorded feasibility and spontaneity (negative DG also known as negative DG), exothermicity (negative DH also known as negative DH) and increased interfacial randomness (positive DS). The findings justify the use of WCH as a cheap and non-toxic biosorbent in the process of dye-bearing wastewater remediation.

Keywords: Crystal violet; Coffee husk; Biosorption; Kinetics; Isotherms; Thermodynamics; Wastewater treatment.

1 Introduction

Synthetic dyes find extensive applications in textiles, paper, plastics, leather, pharmaceuticals, etc., and a non-negligible part of them may find its way into the water during processing and pollute its quality, as well as restrict the penetration of light in even small amounts (Asad et al., 2007; Singh et al., 2015; Srikantan et al., 2018). Crystal violet (CV) is a cationic triphenylmethane dye (Figure 1) that has not only been used in the process industry and laboratory staining but has also been linked with irritation and a more considerable damage, which has prompted effective wastewater treatment plans (Sarma et al., 2016; Mittal et al., 2010). Traditional dye-removal techniques (e.g., biological treatment, oxidation, coagulation/flocculation, membrane filtration) can be characterized as expensive, semi-complete, or difficulties in handling the remnant (Gupta et al.,20106; Allen and Koumanova .,2005; Yagub et al.,2014). Activated carbon often is expensive and thus they tend to seek other inexpensive options such as clays, biochars, and farm waste (Adsorption) is often favored because it operates with a simple method and is economically effective (Ahmad, 2009; Mittal et al., 2010) , but there has been an effort to find cheaper alternatives like clays, biochars, and agricultural wastes as adsorbent materials (Ahmad et al., 2012; Alshabanat et al., 2013; Gürses et al., 2006; Hameed et al., 2007) The reason why agricultural residues are appealing adsorbing materials is related to their availability and lignocellulosic properties (cellulose, hemicellulose, lignin) that may react with the dye molecules (Kushwaha et al., 2014). Coffee processing also produces large amounts of husk material that have no high-value application, thus such materials can be used in the environmental remediation (Bulut et al., 2007). Western blotting assay is used to evaluate WCH as a bio biosorbent in the removal of CV, to optimize the important parameters of the batch and to rationalize the process by using kinetic, equilibrium, and thermodynamic models (Lagergren, 1898; Ho & McKay, 1998).

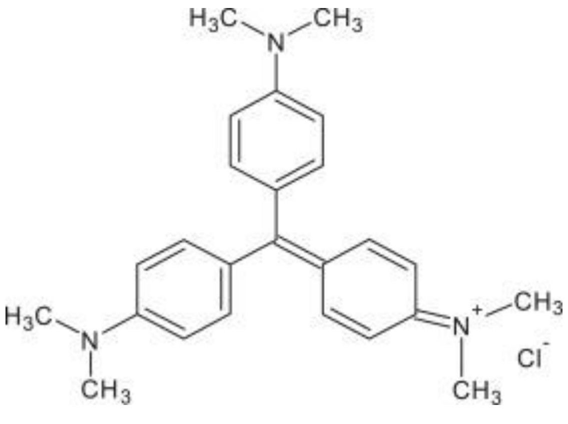


Figure 1: The molecular (chemical) structure of the crystal violet (CV) dye.

2 Materials and methods

2.1 Preparation of the adsorbent material.

Husks of coffee waste were gathered and thoroughly washed using tap water to get any impurities stuck on them, and then dried under the sun over a few days. The dried material was milled in to powder and rinsed several times in distilled water and dried in the oven at 60 to constant mass. They stressed the sieving of the adsorbent to get particle-size fractions of 0.15-0.30, 0.30-0.60, 0.60-1.118, 1.118-2.36, and 2.36-4.75 mm to be used in further adsorption tests.

2.2 Preparation of the adsorbate solution.

Stock crystal violet ($C_{25}H_{30}N_3Cl$) solution (c. 1.0 g/L) was weighed into a stock bottle using twice-distilled water, and then diluted to the desired levels to create batch experiments. The pH of the solution was adjusted by using 0.1 M. The new level of dye concentration was quantified by UV-Avis spectrophotometry at lmax=580nm.

2.3 Adsorption testing procedures.

The experiments of the batch adsorption were carried out in 250 mL Erlenmeyer flasks, in 50 mL of CV solution and a given amount of mass WCH. The flasks were tubed using a mechanical shaker at a speed that was around 140 rpm until equilibrium. There were repeated and average experiments. Aliquots were taken and measured at given times in order to analyze the concentration of dye that was left.

After calculating the adsorption capacity at equilibrium, q e (mg/g), and the removal percentage (%) were determined through the utilization of Equations. (1) and (2):

$$q_e = \frac{(C_0 - C_e)V}{W}, \tag{1}$$

$$\%R = \frac{(C_0 - C_e)}{C_0} \times 100, \tag{2}$$

where C_0 and C_e are initial and equilibrium CV concentrations (mg/L), V is solution volume (L), and W is WCH mass (g).

3 Results and discussion

3.1 Influence of exposure time and the starting dye concentration.

The concentration of CV was greatly affected by the time of contact where the initial rapid adsorption occurred and then the approach to equilibrium was gradual (Figure 2). Its rapid initial uptake may be explained by the presence of a large number of binding sites and the subsequent slow phase may be explained by the saturation of binding sites and diffusion barriers) Bulut & Aydın, 2006; Wang & Li, 2013). Additional concentration of initial CV increased the quantity of adsorbent since more quantity gradient was created to promote mass transfer to the biosorbent surface (Wang & Li, 2013). Similar rapid-then-plateau behaviour has been reported in other CV-based adsorption studies on biosorbents based on low-cost materials(Ahmad et al., 2017; Pavan et al., 2014; Saeed et al., 2010).

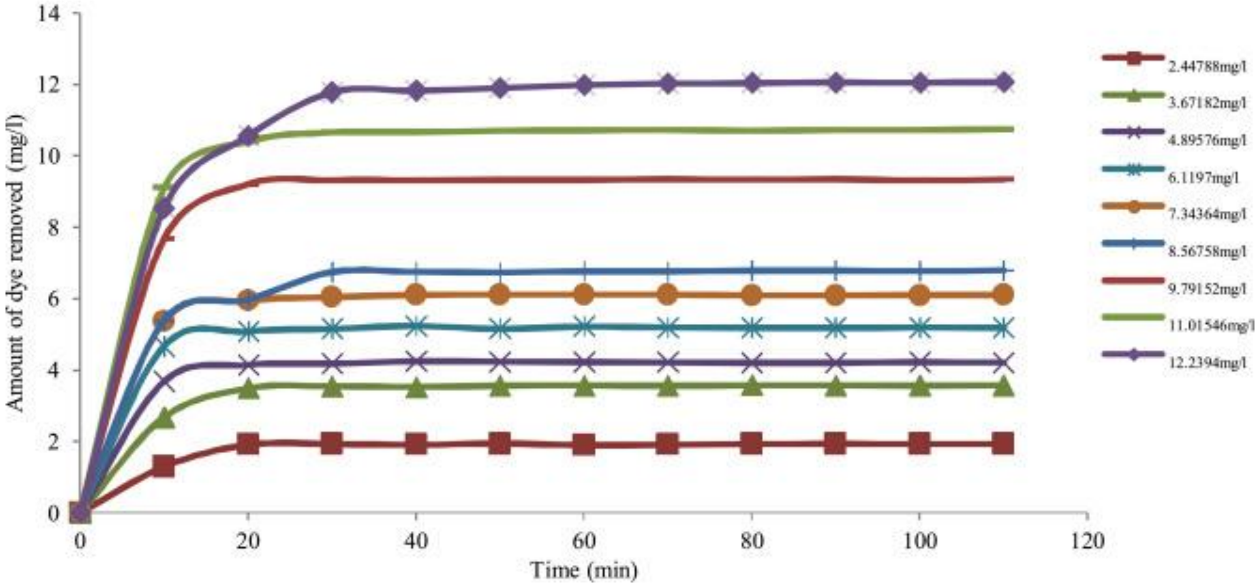


Figure 2: Influence of the starting CV concentration on its adsorption (WCH: 0.25 g; 50 mL; 25°C; pH 4).

3.2 Influence of adsorbent dosage.

The dosage of adsorbent predetermines the adsorbent/sorbate ratio and influences the process and cost of operation(Crini, 2006; Wang & Li, 2013). With the increase in the dose of WCH, percent removal was as well as equilibrium was reached faster(Zhou et al., 2010) (Figure 3). Contrastingly, the adsorption capacity in terms of mg/g declined in the higher dosages which are normally linked to particle aggregation as well as overlap of adsorption sites that minimize effective use of the surface (Robinson et al., 2001).

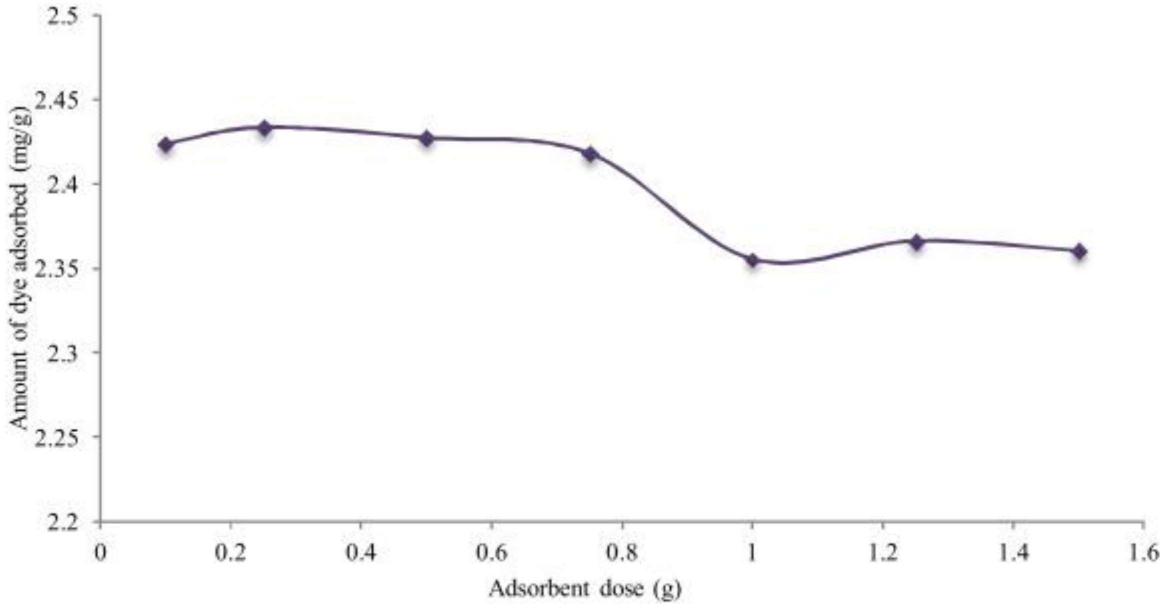


Figure 3: Influence of adsorbent dosage on CV removal (initial dye concentration: 12.2394 mg/L; 50 mL; 25°C; pH 4).

3.3 Influence of particle size.

Figure 4 showed better CV removal with smaller particle size. The best fraction of WCH fraction had the best removal as it had a larger external surface area and shorter intraparticle diffusion length and, therefore, greater accessibility to functional adsorption sites [19, 27].

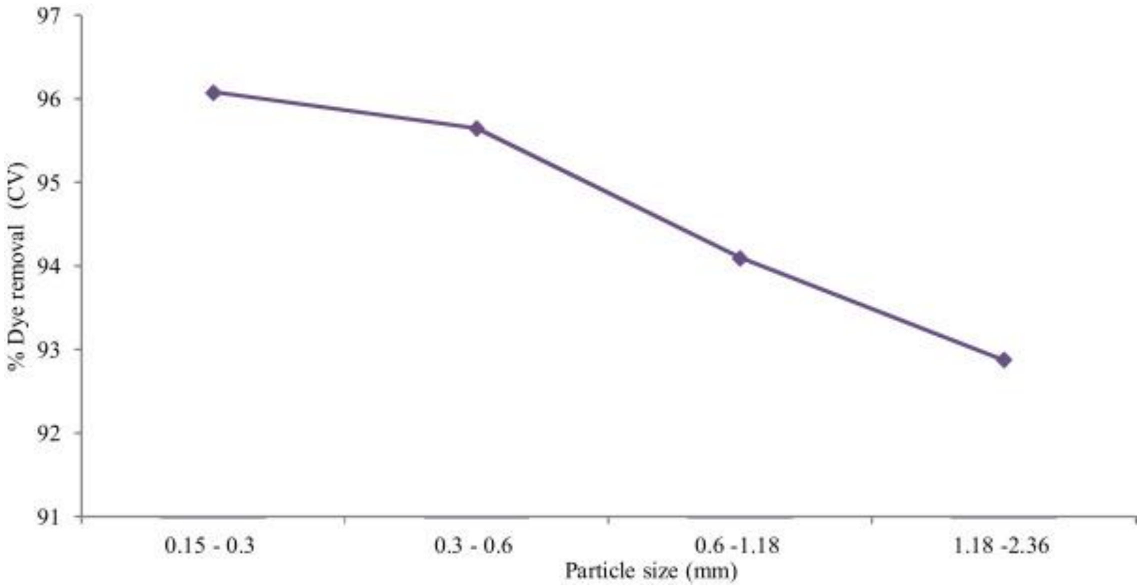
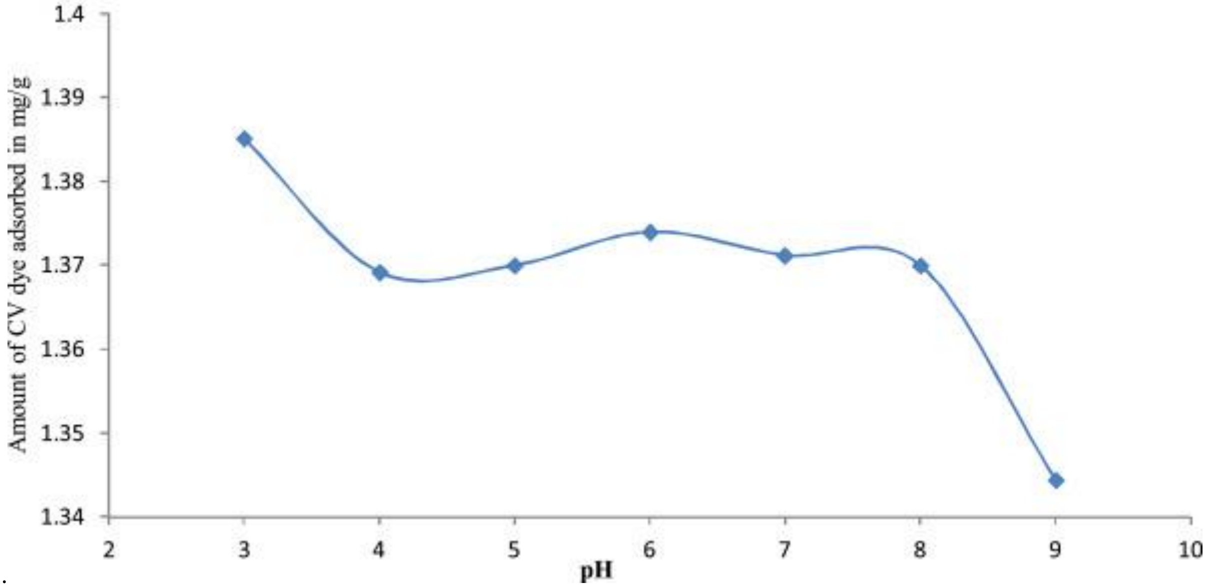


Figure 4: Influence of particle size on CV removal (WCH: 0.25 g; 50 mL; initial dye concentration: 12.239 mg/L; 25°C; pH 4).

3.4 Influence of the solution's initial pH.

PH of the solution controls the adsorbent surface charge and electrostatic interaction between the adsorbent and the cationic dye, thus affecting the uptake (Khattri & Singh, 2009). CV elimination was preferred in acidic environments, and the best results were achieved at pH of about 3 (Figure 5). The adsorption decreased with increased pH, which was in line with adsorption being unfavorable to electrostatic interactions and the competitive effects on the interface (Nasuha et al., 2010; Tahir & Rauf, 2006)



.

Figure 5: Effect of pH on CV removal (WCH: 0.25 g; 50 mL; initial dye concentration: 12.2394 mg/L; 25°C).

3.5 Influence of temperature variation.

Temperature influences the movement of dye, solution viscosity and favorability of energy of adsorption (Hamdaoui, 2006). In the current experiment, the adsorption capacity decreased with raising the temperature (Figure 6), which showed the exothermic mode of adsorption. The increased temperatures probably led to looseness of binding forces and resulted in partial desorption (Dogan et al., 2009). Likewise exothermic behavior has been observed in CV adsorption of different biomass-based sorbents (Ahmad et al., 2017; Nasuha et al., 2010).

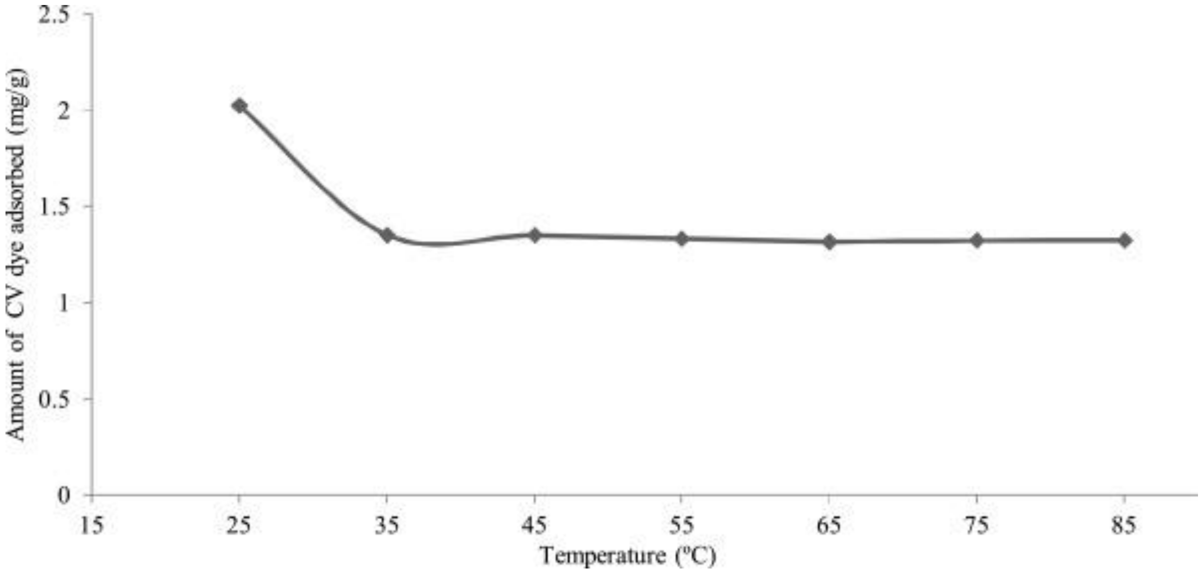


Figure 6: Influence of temperature on crystal violet adsorption (WCH: 0.25 g/50 mL; initial dye concentration: 12.2394 mg/L; particle size: 0.15–3.0 mm).

3.6 Adsorption kinetics analysis.

In wastewater applications, it is important to also have rapid kinetics besides the necessary capacity(Forgacs et al., 2004). Pseudo-first-order (PFO) and pseudo-second-order (PSO) models [33 and 34] were used to analyze the kinetics data and are common and used significantly to explain adsorption rate behavior(Weber & Morris, 1963).

The linear PFO form is:

$$log(q_e - q_t) = log(q_e) - \frac{k_1}{2.303}t, \quad (3)$$

where k_1 is the PFO rate constant, and q_t and q_e are adsorption capacities at time t and at equilibrium.

The PSO model is:

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e}, \quad (4)$$

where k_2 is the PSO rate constant. The PSO model provided excellent agreement with the experimental data ($R^2 > 0.99$), supporting a rate description consistent with stronger surface interactions (Weber & Morris, 1963; Wang & Li, 2013). The fitted parameters are summarized in Table 1. The PSO plots are shown in Figure 7.

Table 1: Kinetic model data for crystal violet removal using waste coffee husk biomass.

CV conc. (mg/L)	Pseudo-first-order				Pseudo-second-order		
(lr)2-5 (lr)6-8	$q_{e,exp}$ (mg/g)	$q_{e,}$ (mg/g)	k_1	R^2	$q_{e,}$ (mg/g)	k_2	R^2
1.224	0.030	0.023	0.004	0.005	0.030	0.0001	0.992

.672	0.406	6.761	0.048	0.768	0.410	0.155	0.999
.120	0.589	9.099	0.030	0.013	0.591	2.520	0.999
.016	1.220	5.848	0.048	0.771	1.227	2.962	0.999
.239	1.368	4.406	0.037	0.299	1.397	0.495	0.999

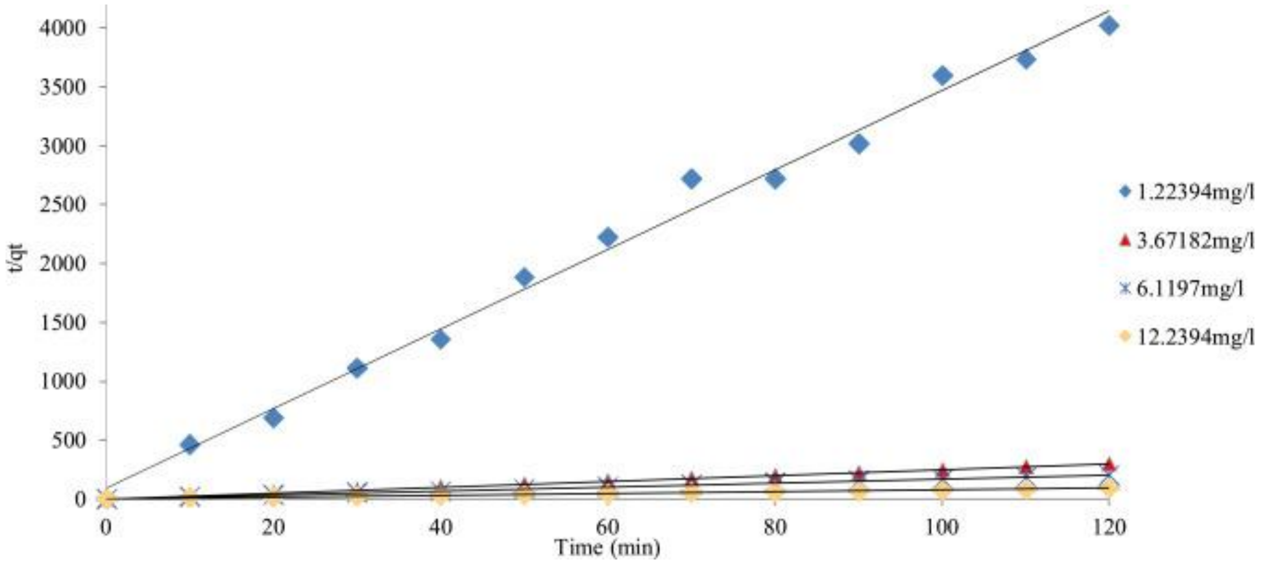


Figure 7: Pseudo-second-order kinetic plot for CV adsorption onto WCH.

3.7 Adsorption equilibrium analysis.

The adsorption isotherms explain how molecules of the dye are distributed between the solid and a liquid phase at equilibrium and are needed in optimizing the process(Weber & Morris, 1963). Langmuir (Langmuir, 1918) and Freundlich (Freundlich, 1906) models were studied in determining the equilibrium data.

The linear Langmuir form is:

$$\frac{1}{q_e} = \frac{1}{q_0 b} \cdot \frac{1}{C_e} + \frac{1}{q_0}, \qquad (5)$$

where q_0 is the monolayer capacity and b is the Langmuir affinity constant. The separation factor is:

$$R_L = \frac{1}{1+bC_0}, \qquad (6)$$

where $0 < R_L < 1$ generally indicates favorable adsorption [39].

The linear Freundlich form is:

$$lnq_e = lnK_F + \frac{1}{n} lnC_e, \qquad (7)$$

where K_F and n are the adsorption capacity and intensity correspondingly(Hall et al., 1966). Figures 8 and 9 are the plots of the isotherms and Table 2 is the summary of the fitted constants. Both models were highly linearized within the concentration range that was tested and it has been reported to be so in similar systems of biosorption (Dubinin & Radushkevich, 1947).

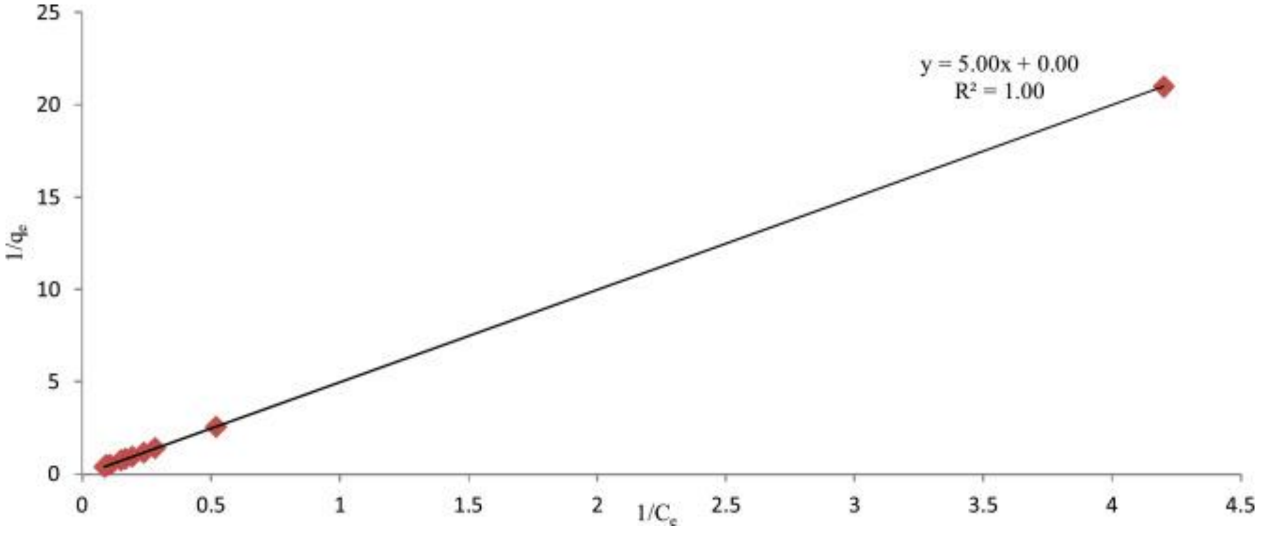


Figure 8: Langmuir isotherm plot for CV adsorption onto WCH.

Table 2: Langmuir and Freundlich isotherm parameters for CV adsorption onto WCH.

Langmuir adsorption isotherm				Freundlich adsorption isotherm		
(lr)1-4 (lr)5-7 q_0	b	R^2	R_L	K_F	n	R^2
0	0	1	1	4.998	1	1

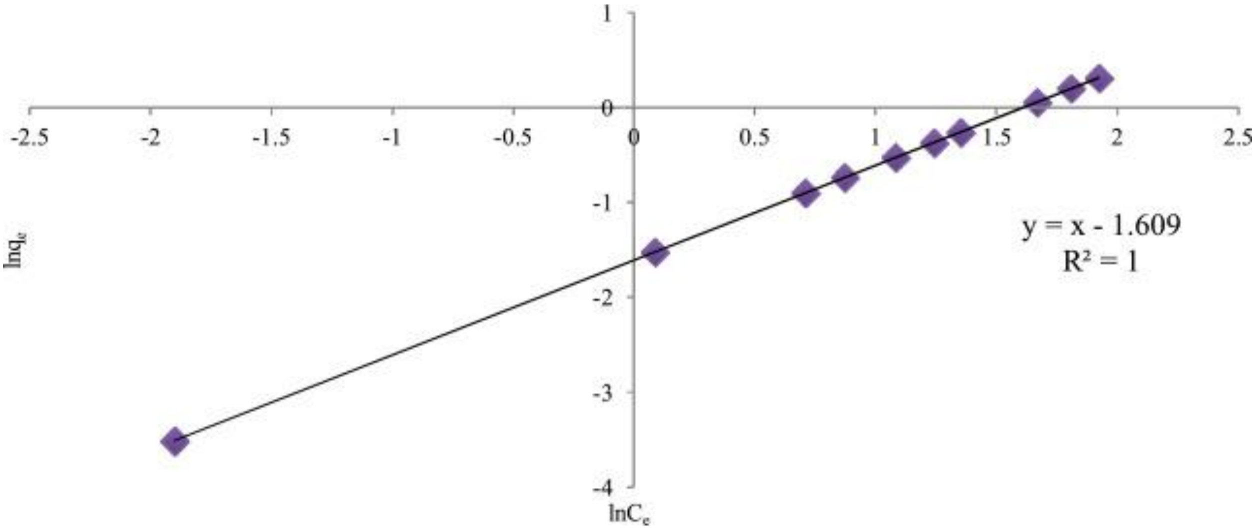


Figure 9: Freundlich isotherm plot for CV adsorption onto WCH.

3.8 Thermodynamic analysis

Thermodynamic parameters were estimated to interpret feasibility and energetic characteristics of adsorption. The standard Gibbs free energy is:

$$\Delta G^\circ = -RT\ln K_d, \tag{8}$$

where R is the gas constant and T is absolute temperature. A Van't Hoff relationship was used:

$$\ln K_d = \frac{\Delta S^\circ}{R} - \frac{\Delta H^\circ}{RT}. \tag{9}$$

The distribution coefficient was expressed as $K_d = C_{solid}/C_{liquid}$ at equilibrium, and ΔH° and ΔS° were obtained from the slope and intercept of the $\ln K_d$ versus $1/T$ plot (Figure 10). Then, ΔG° was computed using Eq. (8). The resulting parameters (Table 3) indicate spontaneous adsorption (negative ΔG°), exothermicity (negative ΔH°), and increased interfacial disorder (positive ΔS°), consistent with related CV adsorption reports (Nasuha et al., 2010; Temkin & Pyzhev, 1940).

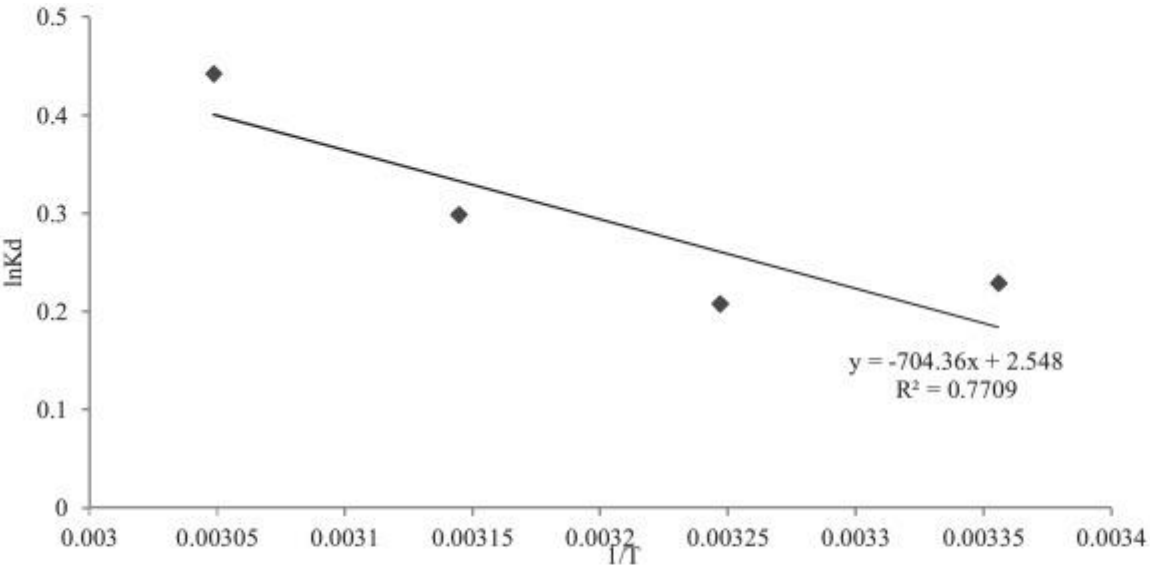


Figure 10: Graph of lnK_d versus 1/T (K⁻¹) for CV sorption on WCH (0.25 g per 50 mL; starting CV level: 12.239 mg/L).

Table 3: Thermodynamic indicators describing CV uptake by WCH.

R^2	ΔH° (kJ/mol)	ΔS° (J/mol·K)
0.770	−5.856	+21.184

Note: Reported ΔG° values across the tested temperature range were negative (approximately -0.002 to -0.004 kJ/mol), indicating feasibility and spontaneity under the examined conditions.

4 Conclusion

Waste coffee husk (WCH) biomass showed a high potential in terms of being a cost-effective biosorbent in removing CV in aqueous media. It was preferred to be removed at acidic (optimal pH 3) temperature and ambient temperature, and fast uptake during the initial period of contact. Higher dose led to increased removal efficiency at the cost of reduced capacity/gram, whereas smaller particle sizes led to an improved adsorption ability because of increased surface accessibility. Higher temperature decreased adsorption and thermodynamic was used to support an exothermic and spontaneous process. Kinetic modeling indicated that there was a significant better fit between kinetic modeling and pseudo-second-order model as compared to the pseudo-first-order model and equilibrium data was also fit to the Langmuir and Freundlich description across the concentration range examined. In general, WCH provides a low-cost renewable method of treating dye-contaminated effluents.

Acknowledgements

The author acknowledges the facilities and technical support provided by the University of Baghdad.

References:

Asad, S., Amoozegar, M. A., Pourbabaee, A. A., Sarbolouki, M. N., & Dastgheib, S. M. M. (2007). Decolorization of textile azo dyes by newly isolated halophilic and halotolerant bacteria. Bioresource Technology, 98(10), 2082–2088.

Singh, R. L., Singh, P. K., & Singh, R. P. (2015). Enzymatic decolorization and degradation of azo dyes – a review. International Biodeterioration & Biodegradation, 104, 21–31.

Srikantan, C., Suraishkumar, G. K., & Srivastava, S. (2018). Effect of light on the kinetics and equilibrium of the textile dye (Reactive Red 120) adsorption by Helianthus annuus hairy roots. Bioresource Technology, 257, 84–91.

Sarma, G. K., Sen Gupta, S., & Bhattacharyya, K. G. (2016). Adsorption of crystal violet on raw and acid-treated montmorillonite, K10, in aqueous suspension. Journal of Environmental Management, 171, 1–10.

Mittal, A., Mittal, J., Malviya, A., Kaur, D., & Gupta, V. K. (2010). Adsorption of hazardous dye crystal violet from wastewater by waste materials. Journal of Colloid and Interface Science, 343(2), 463–473.

Noorimotlagh, Z., Mirzaee, S. A., Martinez, S. S., Alavi, S., Ahmadi, M., & Jaafarzadeh, N. (2019). Adsorption of textile dye in activated carbons prepared from DVD and CD wastes modified with multi-wall carbon nanotubes: Equilibrium isotherms, kinetics and thermodynamic study. Chemical Engineering Research and Design, 141, 290–301.

Wanyonyi, W. C., Onyari, J. M., Shiundu, P. M., & Mulaa, F. J. (2019). Effective biotransformation of reactive black 5 dye using crude protease from Bacillus cereus strain KM201428. Energy Procedia, 157, 815–824.

Abbas, M., Kaddour, S., & Trari, M. (2014). Kinetic and equilibrium studies of cobalt adsorption on apricot stone activated carbon. Journal of Industrial and Engineering Chemistry, 20(3), 745–751.

Harrache, Z., Abbas, M., Aksil, T., & Trari, M. (2019). Thermodynamic and kinetics studies on adsorption of indigo carmine from aqueous solution by activated carbon. Microchemical Journal, 144, 180–189.

Pawar, P. R., & Bhosale, S. M. (2018). Heavy metal toxicity: Health hazards and their removal technique by natural adsorbents: A short overview. International Journal of Creative Research Thoughts (IJCET), 8(8).

Ouyang, J., Zhao, Z., Suib, S. L., & Yang, H. (2019). Degradation of congo red dye by a Fe3O4@CeO2-ZrO2/palygorskite composite catalyst: Synergetic effects of Fe3O4. Journal of Colloid and Interface Science, 539, 135–145.

Chaari, I., Fakhfakh, E., Medhioub, M., & Jamoussi, F. (2019). Comparative study on adsorption of cationic and anionic dyes by smectite rich natural clays. Journal of Molecular Structure, 1179, 672–677.

Carmalin Sophia, A., Arfin, T., & Lima, E. C. (2019). Recent developments in adsorption of dyes using graphene based nanomaterials. In M. Naushad (Ed.), A New Generation Material Graphene: Applications in Water Technology (pp. 439–471). Springer.

Wong, S., Tumari, H. H., Ngadi, N., Mohamed, N. B., Hassan, O., Mat, R., & Saidina Amin, N. A. (2019). Adsorption of anionic dyes on spent tea leaves modified with polyethyleneimine (PEI-STL). Journal of Cleaner Production, 206, 394–406.

Zazycki, M. A., Borba, P. A., Silva, R. N. F., Peres, E. C., Perondi, D., Collazzo, G. C., & Dotto, G. L. (2019). Chitin derived biochar as an alternative adsorbent to treat colored effluents containing methyl violet dye. Advanced Powder Technology. https://doi.org/[Insert DOI if available]

Tezcan Un, U., & Ates, F. (2019). Low-cost adsorbent prepared from poplar sawdust for removal of disperse orange 30 dye from aqueous solutions. International Journal of Environmental Science and Technology, 16, 899–908.

Phele, M. J., Ejidike, I. P., & Mtunzi, F. M. (2019). Adsorption efficiency of activated macadamia nutshell for the removal organochlorine pesticides: Endrin and 4,4-DDT from aqueous solution. Journal of Pharmaceutical Sciences and Research, 11(5).

Liu, L., Hu, S., Shen, G., Farooq, U., Zhang, W., Lin, S., & Lin, K. (2018). Adsorption dynamics and mechanism of aqueous sulfachloropyridazine and analogues using the root powder of recyclable long-root Eichhornia crassipes. Chemosphere, 196, 409–417.

Rangabhashiyam, S., Anu, N., & Selvaraju, N. (2013). Sequestration of dye from textile industry wastewater using agricultural waste products as adsorbents. Journal of Environmental Chemical Engineering, 1(3), 629–641.

Murthy, P. S., & Naidu, M. M. (2012). Recovery of phenolic antioxidants and functional compounds from coffee industry by-products. Food and Bioprocess Technology, 5(3), 897–903.

Khasri, A., & Ahmad, M. A. (2018). Adsorption of basic and reactive dyes from aqueous solution onto Intsia bijuga sawdust-based activated carbon: Batch and column study. Environmental Science and Pollution Research, 25(31), 31508–31519.

Neupane, S., Ramesh, S. T., Gandhimathi, R., & Nidheesh, P. V. (2015). Pineapple leaf (Ananas comosus) powder as a biosorbent for the removal of crystal violet from aqueous solution. Desalination and Water Treatment, 54(7), 2041–2054.

Wanyonyi, W. C., Onyari, J. M., & Shiundu, P. M. (2014). Adsorption of congo red dye from aqueous solutions using roots of Eichhornia crassipes: Kinetic and equilibrium studies. Energy Procedia, 50, 862–869.

Oguntimein, G. B. (2015). Biosorption of dye from textile wastewater effluent onto alkali treated dried sunflower seed hull and design of a batch adsorber. Journal of Environmental Chemical Engineering, 3(4), 2647–2661.

Crini, G., Peindy, H., Gimbert, F., & Robert, C. (2007). Removal of C.I. Basic Green 4 (Malachite Green) from aqueous solutions by adsorption using cyclodextrin-based adsorbent: Kinetic and equilibrium studies. Separation and Purification Technology, 53(1), 97–110.

Etim, U. J., Umoren, S. A., & Eduok, U. M. (2016). Coconut coir dust as a low cost adsorbent for the removal of cationic dye from aqueous solution. Journal of Saudi Chemical Society, 20, S67–S76.

Banerjee, S., & Chattopadhyaya, M. C. (2017). Adsorption characteristics for the removal of a toxic dye, tartrazine from aqueous solutions by a low cost agricultural by-product. Arabian Journal of Chemistry, 10, S1629–S1638.

Ramesha, G. K., Vijaya Kumara, A., Muralidhara, H. B., & Sampath, S. (2011). Graphene and graphene oxide as effective adsorbents toward anionic and cationic dyes. Journal of Colloid and Interface Science, 361(1), 270–277.

Alshabanat, M., Alsenani, G., & Almufarij, R. (2013). Removal of crystal violet dye from aqueous solutions onto date palm fiber by adsorption technique. Journal of Chemistry, 2013, 1–6.

Bouaziz, F., Koubaa, M., Kallel, F., Ghorbel, R. E., & Chaabouni, S. E. (2017). Adsorptive removal of malachite green from aqueous solutions by almond gum: Kinetic study and equilibrium isotherms. International Journal of Biological Macromolecules, 105, 56–65.

Ho, Y. S., Chiang, T. H., & Hsueh, Y. M. (2005). Removal of basic dye from aqueous solution using tree fern as a biosorbent. Process Biochemistry, 40(1), 119–124.

Shoukat, S., Bhatti, H. N., Iqbal, M., & Noreen, S. (2017). Mango stone biocomposite preparation and application for crystal violet adsorption: A mechanistic study. Microporous and Mesoporous Materials, 239, 180–189.

Lagergren, S. (1898). Zur theorie der sogenannten adsorption geloester stoffe. Kungliga Svenska Vetenskapsakademiens Handlingar, 24, 1–39.

Ho, Y. S., & McKay, G. (1998). Kinetic models for the sorption of dye from aqueous solution by wood. Process Safety and Environmental Protection, 76(2), 183–191.

Crini, G., & Badot, P. M. (2008). Application of chitosan, a natural aminopolysaccharide, for dye removal from aqueous solutions by adsorption processes using batch studies: A review of recent literature. Progress in Polymer Science, 33(4), 399–447.

Pavan, F. A., Camacho, E. S., Lima, E. C., Dotto, G. L., Branco, V. T. A., & Dias, S. L. P. (2014). Formosa papaya seed powder (FPSP): Preparation, characterization and application as an alternative adsorbent for the removal of crystal violet from aqueous phase. Journal of Environmental Chemical Engineering, 2(1), 230–238.

Langmuir, I. (1918). The adsorption of gases on plane surfaces of glass, mica and platinum. Journal of the American Chemical Society, 40(9), 1361–1403.

Freundlich, H. M. F. (1906). Over the adsorption in solution. Journal of Physical Chemistry, 57, 385–470.

Poots, V. J. P., McKay, G., & Healy, J. J. (1978). Removal of basic dye from effluent using wood as an adsorbent. Journal of Water Pollution Control Federation, 50(5), 926–935.

Aksu, Z. (2001). Biosorption of reactive dyes by dried activated sludge: Equilibrium and kinetic modelling. Biochemical Engineering Journal, 7(1), 79–84.

Mahdavinia, G. R., Bazmizeynabad, F., & Seyyedi, B. (2015). kappa-carrageenan beads as new adsorbent to remove crystal violet dye from water: Adsorption kinetics and isotherm. Desalination and Water Treatment, 53(9), 2529–2539.

الإصدار التاسع – العدد الثامن والثمانون
تاريخ الإصدار: 2 – شباط – 2026م
www.ajsp.net

ISSN: 2663-5798 || Arab Journal for Scientific Publishing

"إزالة صبغة الكريستال البنفسجي الخطرة من الأوساط المائية باستخدام الكتلة الحيوية لقشور القهوة: سلوك الاتزان، حركية الامتزاز، والتقييم الثرموديناميكي"

إعداد الباحث:

معاذ أسعد محمود
قسم الكيمياء، كلية العلوم، جامعة مراغة، إيران

الملخص:

تعد صبغة الكريستال فيوليت (Crystal violet – CV) صبغة كاتيونية من نوع ثلاثي فينيل الميثان قابلة للذوبان في الماء، وتمتلك القدرة على البقاء في الأنظمة المائية، كما تم ربطها بآثار صحية وبيئية سلبية. تتناول الورقة البحثية استخدام كتلة حيوية مشتقة من قشور القهوة العادمة (Waste coffee husk – WCH) والتي تم فحصها كممتز حيوي (biosorbent) منخفض التكلفة ومتجدد لإزالة صبغة CV من الأوساط المائية، وذلك من خلال تجربة امتزاز دفعية (batch adsorption) أجريت في جامعة بغداد. تم تقصي العوامل التالية بشكل منهجي: وقت التلامس، التركيز الأولي للصبغة، جرعة الممتز، بالإضافة إلى دراسة حجم الجسيمات، الرقم الهيدروجيني (pH) الأولي، ودرجة الحرارة. وقد لوحظ أن امتصاص صبغة CV كان سريعاً عند فترات التلامس القصيرة، كما لوحظت كفاءة عالية في إزالة اللون في الوسط الحامضي وعند درجة حرارة الغرفة. أدت زيادة جرعات قشور القهوة (WCH) إلى زيادة نسبة الإزالة وتقليل القدرة النوعية لكتلة الممتز، بينما أدت أحجام الجسيمات الأصغر إلى زيادة الإزالة نظراً لامتلاكها مساحة سطح أكبر وطول انتشار أقل. أظهرت النتائج أنه كلما ارتفعت درجة الحرارة انخفض الامتزاز، مما يرجح أن التفاعل طارد للحرارة (exothermic). وأشارت النمذجة الحركية إلى أن نموذج الرتبة الثانية الكاذبة (pseudo-second-order) كان أفضل بكثير في تمثيل النتائج التجريبية مقارنة بنموذج الرتبة الأولى الكاذبة. كما أظهرت كل من أيزوثرمات لانغموير وفريندلتش (Langmuir and Freundlich) حالة من التوازن ضمن نطاق التركيز المدروس. سجلت المعايير الديناميكية الحرارية جدوى وتلقائية العملية (قيمة سالبة لطاقة جيبس الحرة ΔG)، وكون التفاعل طارداً للحرارة (قيمة سالبة للمحتوى الحراري (ΔH، وزيادة في العشوائية البينية (قيمة موجبة لدرجة العشوائية/الإنتروبي ΔS).وتبرر هذه النتائج استخدام قشور القهوة العادمة كممتز حيوي رخيص وغير سام في عملية معالجة مياه الصرف الصحي الملوثة بالأصباغ.