RESEARCH ARTICLE

Environmentally Friendly Activated Carbon Derived from Palm Leaf for the Removal of Toxic Reactive Green Dye

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ABSTRACT

Activated carbon (palm leaf): low-cost sorbents, successfully used for dye adsorption from wastewater preparation of palm leaf, obtained from the grower in Iraq and dry in sunlight and im-pregnated to 3% HNO_3 and then dried for 24 hours at 90°C. The adsorption was proved via way of utilizing the (FTIR) and (FE-SEM) analysis, it was observed that there is no change in the beam before and after adsorption only shifts in intensity, evidence of physical adsorption, and FESEM appear image before adsorption contains many smaller granules that are not clustered together and spread on the surface, but after the adsorption we notice the swelling of these particles and they form irregular clusters, evidence of loading the dye inside these granules, which led to swelling. The kinetic model experimental result was carried out via two models first and second order, utilized to describe the adsorption process. Second model kinetic by greater than R^2= 0.9864. The study discusses the thermodynamic Factors having changes in enthalpy, entropy, and Gibbs free energy. Through the results, it was found that the adsorption process is an endothermic and spontaneous reaction.

Keywords: Activated carbon (palm leaf), Adsorption, Dye, Kinetic model, Reactive green, Thermodynamic.

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INTRODUCTION

Textile dyes are one of the utmost hazardous water contaminants, even in the presence of little concentrations. It is difficult for light to penetrate through the water surface, affecting aquatic plants' photosynthesis process. It is also toxic to fish and microorganisms.[1,2] Textile dyes are commonly used in textiles, paper, leather, cosmetics, etc. Dyes are a significant pollution class and can even be famous to the human eye. Disposal of dyes in precious water resources must be avoided, though, and several handling technologies are utilized.[3-6] Therefore, these pollutants are treated using easy, simple and inexpensive methods. One of these methods is adsorption and using several surfaces that are considered environmentally friendly, such as activated carbon, clay, carbon nanotube and zinc oxide. Activated carbon (AC) is a very effective absorbent material for removing organic and inorganic pollutants, especially textile dyes. AC has a very great surface area and high porosity. It is considered one of the oldest and most widely used absorbent materials for sewage treatment.[7-14] The study activated carbon derived from palm leaf to obtain a surface with very high efficiency in the removal of textile dye (Reactive green), and the properties of activated carbon were studied utilizing different techniques, including FE-SEM, FTIR, and study Kinetic and thermodynamic parameter.

MATERIALS AND METHODS

Chemicals used

Palm leaf are obtained from the Iraqi, HCl, NaOH, and Nitric acid HNO_3, were found from Sigma-Aldrich, and reactive green [ƴmax=625 nm] are obtained from Merck, Malaysia.

Preparation of Palm leaf as AC

Palm leaf, were found from farms - Iraq. First, the palm leaf are separated from the leg, washed more than a few times

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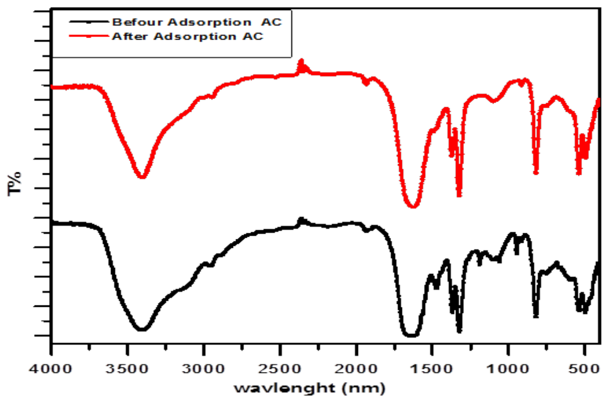

Figure 1: FTIR spectra of (palm leaf) Activated carbon before and after adsorption of RG dye.

with water to remove dust and impurities, dried in sunlight, and then ground to obtain an average size ranging from 63 µm to 2.5 mm. Approximately 100 g were impregnated with 3% HNO^3 and then dry at 90°C for 24 hours. Finally, burned at a temperature (300ºC) for two hours to obtain activated carbon, and it is kept in airtight containers or used in all experiments.

RESULTS AND DISCUSSION

Characterization

The analysis of FTIR spectra before and after dye adsorption was studied within a range 400–4000 cm^{-1}, the spectrum showed a wide peak at 3430 cm^{-1}. Activated carbon (palm leaf) before adsorption and after RG dye adsorption are shown in Figure 1. The data in Figure 1 showed that there is no change in the beam beck, evidence of physical adsorption.[15,16]

The surface activated carbon (palm leaf) was studied via FESEM method before and after adsorption of RG dye to know the nature and porosity of the surface, in addition to recognizing the homogeneity among components, size, nature of the particles and the nature of their distribution.[17] The surface is observed before the adsorption process. It contains many smaller granules that are not clustered together and spread on the surface, but after the adsorption method, we notice the swelling of these particles and they form irregular clusters, evidence of loading the dye inside these granules, which led to swelling[13,18] as shown Figure 2.

Effect of Temperature and Thermodynamic Parameter

The results Figure 3 displayed the adsorption method was endo-thermic because RG dye E% increases through increasing temperature solution. The maximum E% occurred at 20ºC through 1-hour of the equilibrium period. But extra increase in temperature solution leads to extra sorption because of weak bonds physical among the active site of the activated carbon (palm leaf) and RG dye molecules. The principles of the thermos-dynamic parameter are vital because they clarify numerous interactions through adsorption methods. Thermodynamic parameters of dye, like (ΔG), (ΔH), and (ΔS) assessed from the variation of the thermos-dynamic constant (K) by temperature appear in Table 1. quantity enthalpy for

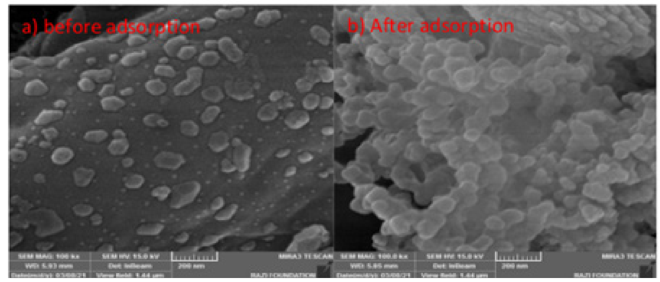

Figure 2: FE-SEM of Activated carbon (palm leaf) (a) before and (b) Reactive Green after adsorption

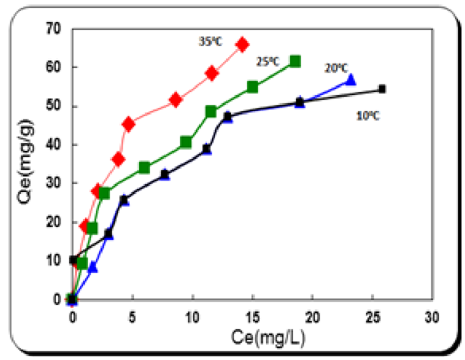

Figure 3: Adsorption isotherms of reactive green dye on activated carbon (palm leaf) at different temperatures.

Table 1: Thermodynamic factors of adsorption for reactive green dye on activated carbon (palm leaf)

ΔH (KJ.mol)	*ΔS (J/mol.K)*	*ΔG (kJ/mol)*	*Keq*
11.1199	71.1445	-17.5422	1729.729
		-17.8522	
		-18.1001	
		-18.7820	

an absorption method use to distinguish among chemical and physical absorption. The little enthalpy value provides strong evidence of weak interaction among dye and Activated carbon (palm leaf), and this will give proof a physical adsorption method among dye and the Activated carbon (palm leaf).[19] Data appear (ΔG) negative entropy is positive for adsorption; this means spontaneous and feasible adsorption occurs through increased orderliness at dye adsorption onto Activated carbon (palm leaf). The endothermic natural of dye adsorption via Activated carbon (palm leaf) reinforced through the values positive of ΔH. Figure 4 and Table 2 demonstrate these parameters whereas Table 1 shows the thermos dynamic values of the estimated dye on activated carbon (palm leaf).[20,21]

Effect of equilibrium Time, Kinetics Models

The desired time to hold out the equilibrium state, of RG dye adsorption on to activated carbon (palm leaf) was determined as a function of the contact time for a constant RG dye concentration about pH 6.0 and 20°C deferent time intervals (1–220 minutes). A constant quantity of activated carbon (palm leaf) 0.05 g and the result are shown in Figure 5. The efficiency adsorption of RG dye was augmented as the time elongated until reaching the value maximum (saturation state); after

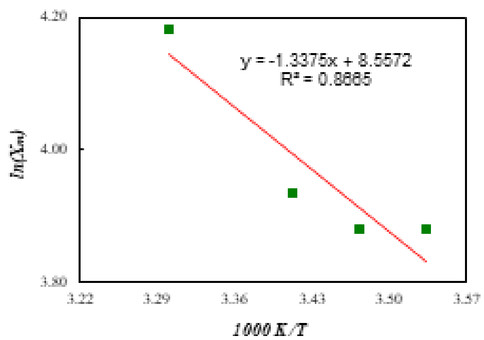

Figure 4: Plot ln Xm against the absolute solution of the reactive adsorption green on activated carbon (palm leaf)

Table 2: Effect of solution temp. on highest adsorption of reactive green onto activated carbon (palm leaf)

T°C	*T/K*	*1000/T(K-1)*	*Ce=14.8*	
			Xm	*lnXm*
10	283	3.53359	48.5	3.8815
20	293	3.41296	48.5	3.8815
25	298	3.35570	51.2	3.9357
33	308	3.24675	65.4	4.1805

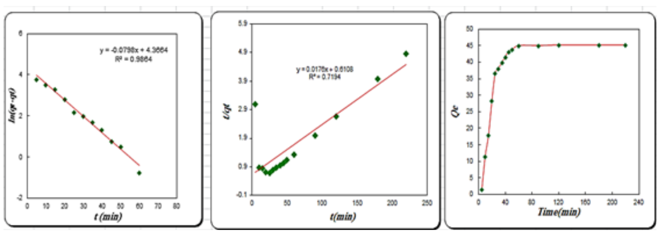

Figure 5: Effect of equilibrium time (A), first model (B), second model (C) onto Activated carbon (palm leaf)

Table 3: Kinetics adsorption of RG dye

Kinetic first model					
Slope	Intercept	k1 (min)$^{-1}$	qe (mg/g)	R^2	
0.0176	0.6108	-0.0176	1.8419	0.7194	
Kinetic Second Model					
0.0798	4.3663	12.5313	0.001458	0.22902	0.9864

that, the adsorption efficiency losses through increasing time due to a desorption system. The model kinetics of adsorption method, that describe the investigational result, elected for adsorption of RG onto decorated activated carbon (palm leaf). Investigational data study was done using the kinetic first and second models as shown in Table 3. The result displays adsorption of RG through the decorated Activated carbon (palm leaf) is achievable process because (R^2) is higher of the second order compared to the First model.[22,23]

CONCLUSION

In this research, an eco-friendly, available and low-cost surface of palm fronds was used. In the adsorption process of the reactive green dye onto (palm leaf) activated carbon, the contact time was reached within 1 hour. The adsorption method fits kinetics second-order because the value (R2) is greater of the kinetic second order compared to the kinetic First order. Also were studied the thermodynamic parameter of the adsorption process data appears negative (ΔG) and positive (ΔS) for adsorption and the values positive of (ΔH) is endo-thermic processes.

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