Removal of reactive dye from wastewaters by adsorption onto aluminium modified activated carbon

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Many industries, such as leather, textile, tanning, plastics, rubber, and cosmetics use huge amounts of synthetic dyes which may release into the wastewater in dyeing processes. Disposal of these wastewaters into the environment, without efficient treatment, causes serious damage to aquatic life (Dalvand et al., 2016). Furthermore, reactive dyes are recalcitrant, non- biodegradable, stable to oxidizing agents and toxic (Rahdar et al., 2021; Saroyan et al., 2019). Various methods (Rahdar et al., 2021), including physical and chemical treatments, have been used to remove these dyes from the wastewater. Adsorption on activated carbon (Kaya et al., 2021; Suma et al., 2019) has been found to be a very efficient technique.

In the current work a novel composite material consisted of activated carbon and aluminium (abbreviated hereafter as AC-Al), was prepared for the removal of a commercial reactive dye (anionic and anthraquinonic) i.e. Reactive Black 5 (RB5) (Travlou et al., 2013) under various experimental conditions.

The effect of the adsorbent's dosage, pH value, contact time and initial RB5 concentration was examined with respect to RB5 removal in order to determine the feasibility of AC-Al. According to the results, with the increase of the adsorbent's dosage, the percentage removal of RB5 is increased, especially, in pH 2±0.1 (Figure 1), the removal rate increases, reaching 100% by 1.0 g/L of AC-Al.

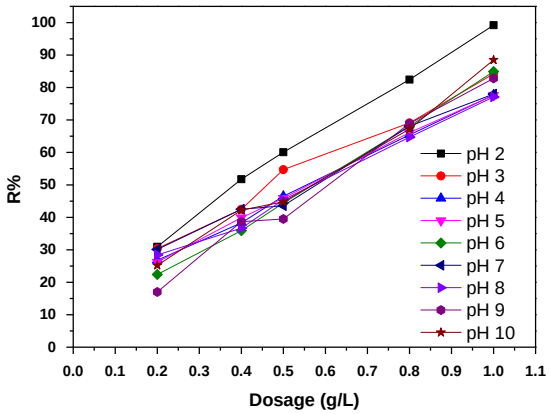

Figure 1. Effect of adsorbent dose and pH on RB5 R% removal on AC-Al, initial RB5 concentration 100 mg/L, pH 2.0-10.0±0.1, T=298 K, contact time 24 h.

Freundlich isotherm and pseudo-second kinetic models (Table 1) fitted the experimental data sufficiently, indicating that the adsorption was characterized as favorable and heterogeneous and was closer to chemisorption and that there is an exchanging or sharing of electrons between the adsorbate and the adsorbent.

Table 1. Constants of Freundlich isotherm model and Pseudo-second order kinetic parameters model for the adsorption of RB5 on-to AC-Al (0.8 g/L), pH 2.0±0.1, T=298 K.

Freundlich isotherm model			
1/n	n	K_F (mg/g)(L/mg)$^{1/n}$	R^2
0.25249	3.96058	46.869	0.96392
Pseudo-second order model (PSO)			
$Q_{e.exp}$ (mg/g)	K_2 (L/mg·min)	$Q_{e.cal}$ (mg/g)	R^2
103.069	0.0276	96.773	0.99087

The values of ΔH^0 and ΔS^0 were determined from the slop and intercept of the plot between ln(Kc) versus 1/T (R^2 = 0.997). A positive value of ΔH^0 (62.621 kJ/mol) suggests the endothermic nature of the process and ΔG^0 values are negative recommending that the process is spontaneous. According to the positive value of ΔS^0 (0.0293

(kJ/mol·K), there is an increase in random interaction between solid/liquid interfaces, which is because the water molecules, which are displaced by the dye molecules, gain more entropy than is lost.

Regeneration experiments were applied to study the reusability of AC-Al for the removal of RB5 dye for four cycles, by using 1M NaOH treatment. According to the results, there is a ~30 % reduction in its efficiency after 4 cycles.

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