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Equilibrium and Kinetics Investigations on Sorption of C.I. Basic Red 14 onto Low-cost Feldspar

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ABSTRACT: Feldspar as a low-cost mineral adsorbent based on silica was used to removal a cationic dye, C.I. Basic Red 14 (Brilliant red 4G), from aqueous solution. The adsorbent was characterized using Scanning Electron Microscopy (SEM), X-ray Fluorescence (XRF) and Fourier Transform Infra-Red spectroscopy (FTIR). The effect of some parameters such as the amount of adsorbent, contact time, the initial concentration of dye, initial pH and electrolyte on dye removal was investigated. Results showed that dye removal increased by increasing pH; contact time and adsorbent dosage, whereas decreased by increasing the dye concentration. Also, the addition of electrolyte caused a negligible decreasing in dye removal. It took about 1 hour to equilibrium the feldspar with C.I. Basic red 14 and dye removal efficiency was 96%. So, feldspar is a suitable and powerful absorbent for removal of cationic dye from aqueous solutions. Equilibrium isotherms were analyzed by Langmuir, Freundlich, Temkin, Redlich-Peterson, and Dubinin–Radushkevich adsorption models and found that the experimental data were correlated reasonably well with Freundlich isotherm. The adsorption kinetics was studied by using pseudo-first-order, pseudo-second-order, and intra-particle diffusion models and realized the adsorption of C.I. Basic red 14 on feldspar followed the pseudo-second-order equation which indicates to chemical sorption.

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1-Introduction

Nowadays there are some serious environmental problems. Global population growth and the increasing pollution of water resources, as well as the increased attention of governments to environmental protection and environmental control, have led to stringent laws to remove pollutants from wastewater [1]. For the treatment of wastewater, various chemical, physical, chemical-physical and biological processes are used. To purification of colored effluents, there are some different methods such as chemical oxidation (fenton, ozonation, ultraviolet light) [2-4], filtration and membrane [5], aerobic and anaerobic microbial decomposition [6], adsorption [7] coagulation and flocculation [8], ion exchange [9], enzymatic decomposition [10]. Among these methods, surface absorption is superior to other methods due to low initial cost, flexibility, easy design, the simplicity of operation and non-susceptibility to toxic contaminants [7]. In the adsorption phenomena, the pollutant molecules transfer from liquid phase to the solid phase Recently, there are many studies on natural, renewable, environmentally friendly, recyclable and inexpensive adsorbents such as organic absorbents (agriculture waste, fruit skin, eggshell, rice husk etc) and mineral adsorbents (feldspar, kaolin, bentonite etc) [11].

An overview of the literature showed that feldspar was used to removal the heavy metals from aqueous solutions, but there is only one report about using the feldspar for the removal of cationic dyes from textile wastewaters [12]. Since, cationic dyes are one of the main pollution sources of the textile wastewaters, in this study, feldspar is used to removal C.I. Basic Red 14 as a common dye in the textile industry. Surface and structural properties of adsorbent and dye removal parameters (amount of feldspar, contact time, the initial concentration of dye solution, pH, and electrolyte) were studied. Isotherms and kinetics of absorption were studied to evaluate the amount of dye adsorbed on the adsorbent in equilibrium.

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2-Methodology

C.I. Basic Red 14 (industrial grade) from Alvan Sabet Co. Iran, feldspar from Setabran Co. Gazvin, Iran and the other chemicals from Merck Co. Germany, supplied and used without any further purification. UV-Vis spectrophotometer used to evaluate dye concentration according to Beer-Lambert law (Equation 1):

$$A = \varepsilon c l \tag{1}$$

Adsorption capacity (q_t) and dye removal efficiency ® were calculated from Equations 2 and 3:

$$q_t = \frac{(C_0 - C_t)}{M} \times v \tag{2}$$

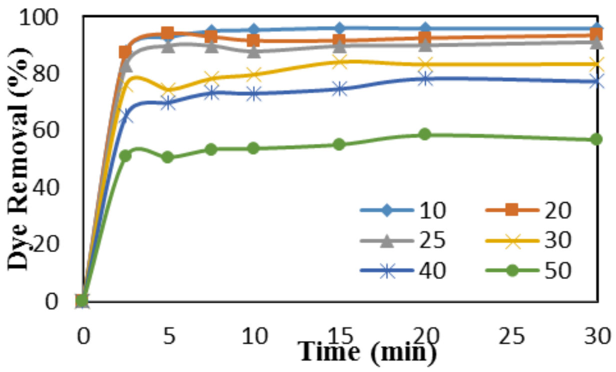
$$R = \frac{(C_0 - C_t)}{C_0} \times 100 \tag{3}$$

3-Results and Discussion

The isoelectric point of feldspar was determined in range of pH about 7-8. To determine the effect of adsorbent concentration on the dye removal various amount of Feldspar as a low-cost mineral material has a good potential for dye removal from wastewaters. The maximum efficiency of dye elimination was 96% (25 mg/l concentration of dye solution, 7.5 g/l feldspar, 350 rpm and room temperature).

Investigation the effect of time and initial dye concentration demonstrated a very fast and short time (less than 5 min) dye removal (Figure 1). At low concentrations of the dye solution, the dye removal is almost complete, due to the sufficient number of adsorbent sites to absorb dye molecules. Therefore, dye molecules can be distributed appropriately on the adsorbent surface, so that the electrostatic gravity forces between dye cations and negative sites on the absorbent surface overlap the inter-molecular repulsion forces between dye molecules. By increasing the concentration of the dye solution, the number of absorbent sites is not sufficient to absorb all the dye molecules. Also, intermolecular repulsion forces between dye molecules will be increased and over electrostatic gravity forces between dye cations and anionic adsorption sites overcome the adsorbent phenomenon. So, 25 mg/l of dye solution was selected as optimal concentration.

Figure 1. Efficiency of dye removal by feldspar at room temperature, natural pH, 7.5 g/l feldspar and



different concentrations of dye solutions.

In the isoelectric point, the surface charge is neutral. At lower pH values the surface of adsorbent has a positive charge, which increases the absorption of negative ions on the adsorbent, while in pH values above the isoelectric point, the absorption of positive ions increased due to the negative charge of the adsorbent surface. The results confirmed that with increasing pH the efficiency of dye removal increased slightly, which could be due to the decrease of the positive charge of the system and consequently the increase of the number of negative sites on the surface of the feldspar and the increase of the electrostatic bond between adsorbent and dye and consequently increased cationic dye removal.

The experimental data were investigated using Langmuir, Freundlich, Temkin, Redlich-Peterson, and Dubinin–Radushkevich adsorption isotherms and correlated coefficients and Total squared error (SSE) were 0.8139, 6.231; 0.9022, 1.205; 0.9313, 1.800;0.8658, 2.830 and 0.822, 4.207 respectively. Results demonstrate the absorption of C.I. Basic Red 14 on feldspar is a chemical and physical absorption process so that the simultaneous absorption process occurs through electrochemical bonding between the positive charge of the dye and the negative charge of feldspar (chemical absorption) and through adsorption surface holes of feldspar (physical adsorption). The adsorption kinetics was studied by using pseudo-first-order, pseudo-second-order, and intra-particle diffusion models and realized the adsorption of C.I. Basic red 14 on feldspar followed the pseudo-second-order equation which indicates to chemical sorption.

4-Conclusions

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