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Sorption of cationic dyes onto activated carbon derived from agro-residues

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Abstract. Batch experiments are carried out for the sorption of cationic dyes such as crystal violet, Malachite green and Rhodamine B dyes onto corncob acid treatment. The operating variables studied are contact time and pH. Equilibrium adsorption isotherms and kinetic were investigated. The experimental data were analyzed by the Langmuir and Freundlich models and the isotherm data fitted well to the Langmuir isotherm. The kinetic data obtained were analyzed using a pseudo-first order and pseudo-second-order equation and intra particle diffusion equation. The experimental data fitted very well the pseudo-second-order kinetic model.

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Key words: cationic dyes, adsorption isotherm, equilibrium kinetic, acid activation, solid wastes

1 Introduction

Discharge of dyes onto natural water bodies represents a serious problem, since highly colored effluents can disturb aquatic life present in this compartment by decreasing sunlight penetration and/or even leading to direct poisoning of living organisms [1–3]. This problem is enhanced because some dyes cannot be degraded by chemical or photochemical processes and presents intrinsic non-biodegradable [4,5]. So that, in these cases, alternative procedures must be employed for the elimination of such dyes before disposal. Undoubtedly, in this field, the study and development of adsorption techniques is a very interesting approach, especially when solid adsorbents are cheap and commercially available. Because of their intense use in several industrial areas, cationic dyes can be considered an important class of compounds to be studied from this point of view. This statement is reinforced by the verification that current literature reports several works regarding the application of solid materials for the adsorption of cationic (or basic) dyes present in aqueous solutions [6–16]. Different materials have been applied for the adsorption of different cationic dyes.

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Many treatment processes have been applied for the removal of dyes from wastewater such as: photocatalytic degradation [3,4], sonochemical degradation [5], micellar enhanced ultrafiltration [6], cation exchange membranes [7], electrochemical degradation [8], adsorption/precipitation processes [9], integrated chemical-biological degradation [10], integrated iron(III) photoassisted-biological treatment [11], solar photo-Fenton and biological processes [12], Fenton-biological treatment scheme [13] and adsorption on activated carbon [14,15]. As synthetic dyes in wastewater cannot be efficiently decolorized by traditional methods, the adsorption of synthetic dyes on inexpensive and efficient solid supports was considered as a simple and economical method for their removal from water and wastewater [16].

The high cost of removal of dyes from aqueous solutions using adsorption on commercial activated carbons though very effective has motivated the search for alternatives adsorbents. Such alternatives include: waste metal hydroxide sludge [17], oil palm trunk fibre [18], broad bean peels [19], biomass fly ash [20], rice straw-derived char [21], durian (Durio zibethinus Murray) peel [22], chitosan bead [23], rice husk [24] and palm kernel fibre [25]. Recently, an extensive list of alternative and cheaper adsorbents for dyes removal has been compiled by Allen and Koumanova [26].

The main objective of this study was to investigate the potentiality of using corncobs acid treatment for the adsorption of cationic dyes such as crystal violet CV, Malachite green MG and Rhodamine B, RB dyes from aqueous solutions. The effects of initial dye concentrations, contact time and pH on the selective cationic dyes were studied. Adsorption isotherms and kinetics parameters were also calculated and discussed.

2 Material and methods

2.1 Adsorbate

Basic dye used in this study was Crystal Violet, CV; Malachite Green, MG, Rhodamine B, RB, purchased from Sigma-Aldrich. The maximum wavelength of these dyes are “586, 620 and 459 n” for CV, MG and RB, respectively. The dye stock solution was prepared by dissolving accurately weight dye in distilled water to the concentration of 1 g/L.

The experimental solutions were obtained by diluting the dye stock solution in accurate proportions to needed initial concentrations.

2.2 Preparation of adsorbent

Corncobs, agro-waste was collected from nearby market as solid wastes. The collected materials were then washed with distilled water for several times to remove all the dirt particles. The washed materials were cut into small pieces (1-3 cm) and dried in a hot air oven at 70 °C for 24 h. activated carbon were prepared by impregnating of the precursor with H_3PO_4 (50 vol.%) followed by thermal treatment at 700 °C for two hours. The cooled activated mass