EFFECT OF DIFFERENT REACTION PARAMETERS ON REMOVAL OF MALACHITE GREEN BY ADSORPTION ON PUMPKIN PEELS

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Abstract

In this work, pumpkin peels (PP), an agricultural solid waste, is proposed as a novel material for the removal of Malachite Green (MG) from aqueous solutions. The studies were carried out under various experimental conditions such as stirring speed, ionic strength and temperature of solution to assess the potentiality Pumpkin Peels for the removal of malachite green dye from wastewater. The results show that increasing in stirring speed leads to an increase in adsorption capacity at equilibrium. The best amount adsorbed at equilibrium was obtained at stirring speed of 300 rpm. The adsorption of MG is favored by high temperatures. The ionic strength disadvantages the adsorption of the dye.

Keywords: Pumpkin Peels , Dye, Malachite Green, Wastewater treatment.

INTRODUCTION

Discharge of colored wastewater from various industries is currently a major problem for environmental management in many countries. Color is a visible pollutant and the presence of even very minute amount of coloring substance makes it undesirable due to its appearance. Basic dyes have high brilliance and intensity of colors and are highly visible even in a very low concentration [1]. Malachite green (MG), a basic dye, is most widely used for coloring purpose, amongst all other dyes of its category [2]. MG was found to be toxic to human cells and might cause liver tumor formation. The use of this dye has been banned in several countries and not approved by US Food and Drug Administration. However, due to its ease and low cost to manufacture, it is still used in certain countries with less restrictive laws for non-aquaculture purposes. Hence, the dye removal is of great importance.

Several techniques have been used for the removal of dyes from industrial effluents. In comparison with other methods, adsorption has been found to be superior in terms of simplicity of design, initial cost, ease of operation, and insensitivity to toxic substances. Although activated carbon is the most effective adsorbent for adsorption of dye, it is quite expensive and hence there is an increasing need for equally effective but cheaper adsorbent. Extensive research has been undertaken recently to develop alternative and economic adsorbents. A number of non-conventional sorbents has been reported in the literature for their capacity to remove MG from aqueous solutions, such as de-oiled soya [3], agro-industry waste, Prosopis cineraria [4], bagasse fly ash [5], hen feathers [6], iron humate [7], modified rice straw [8], orange peel [9], rice husk [10], etc.

The objective of this work was to investigate the potential of Pumpkin Peels an agricultural solid waste, as a novel adsorbent in the removal of the basic dye, MG, from aqueous solutions. The effects of various operating parameters such as stirring speed, ionic strength and temperature of solution on dye removal were investigated.

II. Materials and methods

II.1. Adsorbate

The cationic basic dye (C.I. 42000; Basic Green 4), MG oxalate salt, (molecular formula $C_{52}H_{56}N_4O_{12}$, FW 929), was obtained from Merck and used without further purification. Fig. 1 displays the structure of this dye.

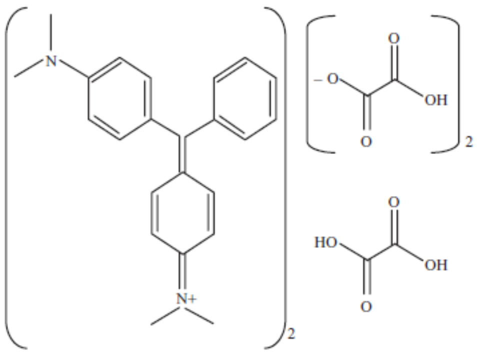

Fig. 1. Chemical structure of MG (oxalate salt).

II.2. Adsorbent

Pumpkin Peels obtained from a local market were dehulled manually in the laboratory. The collected peels were washed several times with water and finally with distilled water to remove any adhering dirt. It was then oven dried at 70 ˚C for 72 h to constant weight. The dried sample was crushed, sieved to a particle size range of 0.5–1 mm, and stored in plastic bottle for further use. No other chemical or physical treatments were used prior to sorption experiments.

II.3. Analysis

A well-known procedure for determining MG concentrations, based on Beer's law calibration plots, was applied using a UV–visible spectrophotometer. The wavelength resolution and the bandwidth were, respectively, 1 and 0.5 nm. The length of the optical path in glass cell was 1 cm. The maximum absorption wavelength was determined as equal to 617 nm. Then, the calibration plot was constructed. The calibration was repeated five times during
the period of measurements.

III. Results and discussion

III.1. Effect of temperature

The adsorption studies were carried out at three different temperatures 25, 35 and 45°C, and the results of these experiments are shown in Fig. 2. Both the adsorption capacity and the removal percentage of MG increase with the increasing temperature, indicating that the adsorption is an endothermic process. This may be a result of increase in the mobility of the dye with increasing temperature. Furthermore, the enhancement in the adsorption capacity might be due to the enhancement of adsorbitive interaction between the active sites of adsorbent and adsorbate ions, creation of some new adsorption sites or the increased rate of intraparticle diffusion of MG molecules into the pores of the adsorbent at higher temperatures [11–13]. The removal percentage
of MG increased from 74.52% to 92.68% with the rise of temperature from 25 to 45 °C, respectively.

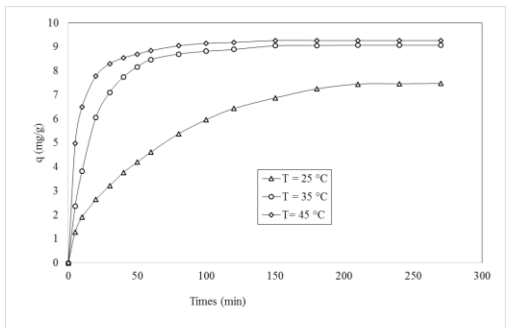

Fig. 2. Effect of temperature on the adsorption of malachite green by Pumpkin Peels.

III.2. Effect of agitation speed

Depending upon the degree of agitation of the fluid particle system, the rate of adsorption is controlled either by film diffusion or pore diffusion. At lower agitation speeds, the fluid film around the particle is thicker and the film diffusion seems to be rate limiting step. The adsorption kinetics is influenced by low mass transfer of adsorbate to the internal surface of particle. It is likely that at higher agitation speeds, the film diffusion increases to a maximum value and pore diffusion thus becomes the rate controlling step [14].The effect of agitation speed on the uptake of dye onto Pumpkin Peels was studied by varying the agitation speeds from 0 to 300 rpm, keeping the concentration, pH, temperature and other parameters constant. The evolution of the adsorbed quantity as a function of time for different stirring speeds is presented in Fig 3. This figure shows that the increase in stirring speed is accompanied by an increase in the amount adsorbed. This can be explained by the fact that the increase in the stirring speed causes a decrease in the thickness of the liquid film at the solid-liquid interface which facilitates the transfer of solute from the solution to the adsorbent. The results obtained also show that there is a significant improvement in the removal efficiency of VM by the biosorbent with the increase of the agitation speed.

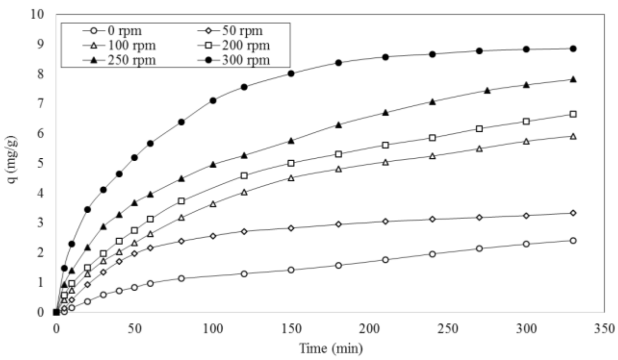

Fig.3. Effect of agitation speed on the adsorption of malachite green by Pumpkin Peels.

III.3. Effect of ionic strength

The effect of medium salinity on the adsorption of malachite green by pumpkin peels was studied in the presence of 0.5 to 5 g/L of sodium chloride (NaCl) for an initial dye concentration of 10 mg/L. Fig 4 . shows the effect of salinity on dye adsorption by pumpkin peels. The results obtained show that the increase in the ionic strength causes a decrease in the amount adsorbed at equilibrium. It appears that the Na^+ ions compete with the malachite green ions to occupy the adsorption sites. In addition, salt forms a screen that blocks the electrostatic interactions between the adsorbent and the adsorbate, causing a reduction in the amount adsorbed with the increase in NaCl concentration.

IV. CONCLUSION

Kinetic and equilibrium studies were reported for the adsorption of MG from aqueous solutions by Pumpkin Peels . Results of sorption showed that Pumpkin Peels , an agricultural solid waste, can be effectively used as a adsorbent for the removal of dye. Experimental data indicated that the amount of dye adsorbed was dependent of operating variables. The results indicate that the adsorption of MG is favored by high temperatures. The ionic strength disadvantages the adsorption of the dye. Increasing in stirring speed leads to an increase in adsorption capacity at equilibrium. The best amount adsorbed at equilibrium is obtained at stirring speed of 300 rpm.

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