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Removal of Safranin O dye from synthetic wastewater by Activated Carbon prepared from Tamarind seeds

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Abstract

Textile, leather, food and paper industries are major contributors of wastewaters containing dye pollutants. Dye wastewaters when discharged in water bodies cause serious human, aquatic and ecological impacts.Out of several methods of removal of dye from wastewaters, activated carbon adsorption is found to be highly simple and effective. Study is performed to prepare an activated carbon from waste material, tamarind seed and to evaluate its efficiency in removal of Safranin O dye from wastewater. Characterization of the prepared tamarind seed activated carbon was carried out for moisture content and surface area. The effect of process parameters, particle size, pH and adsobent dose were evaluated. The results show that particle sizes ranging from 75μm to 300μm have percentages of dye adsorbed between the ranges of 76.14% to 60.18% with 75μm as the best particle size. The amount of dye adsorbed increased with increase in pH value. Maximum percentage dye adsorbed was 88.30% pH 11. Also the percentage of Safranin O dye adsorbed increased with increase in adsorbent dose from 55% to 97% for TSAC with 1.0 gm dose yielding maximum dye removal.

Keywords: Adsorption, tamarind seed, activated carbon, dye removal, activation

INTRODUCTION

Dye containing water can also cause adverse effects on human beings such as the failure or damage of kidney, liver, brain, and the central nervous system. There are various physical, chemical and biological techniques for dye removal from wastewaters. Out of these, physical method of adsorption has proven to be a simple, reliable and feasible on large scale wastewater treatment. There is a pressing need to use low-cost adsorbents preferably derived from waste products for dye removal. In this study, waste product, Tamarind (Tamarindus indica) seeds were utilized to produce an activated carbon to treat dye wastewater. The seeds are processed by acid treatment and heat treatment to obtain the activated carbon. Literature shows activated carbon prepared from palm oil waste (Ahmed et al, 2012), cassava peel (Rajeshwarisivaraj, 2001), bagasse (Tsai, 2001), jute fibre (Senthilkumar et al, 2005), rice husks (El-Shafey, 2007) and seed shells (Thinakaran e al, 2011).

MATERIALS AND METHODS

Adsorbate

Safranin O dye was used as an adsorbate. Safranin O is the cationic dye that is used as a stain in medical field. The Safranin O dye (chemical formula: $C_{20}H_{19}ClN_4$, molecular weight: 350.8511 g mol^{-1}, λ_{max}: 510 nm) was obtained from a chemical store. The chemical structure of Safranin O dye is shown in Fig. 1.The solutions used in the experiments were diluted from the dye solution at concentration 100 mg L^{-1}.

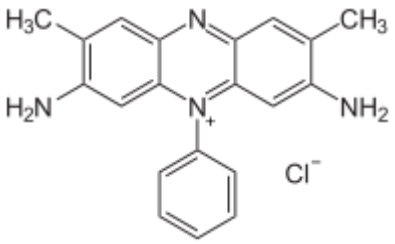

Figure 1. Structure of Safranin O Dye

Preparation of Tamarind seed activated carbon (TSAC)

Tamarind seeds were obtained from a local store in Vadodara, Gujarat, India. The seeds were cleaned and washed with distilled water and were dried in oven at 110°C for 24hours. The dried sample was carbonized in a muffle-furnace at 500°C for 1hour. The seeds were immersed in 60% weight of orthophosphoric acid at the ratio of 1:2(wt %). The sample was washed with distilled water till leachate was near to 7. They were then dried in an oven at 110°C for 6 hours. Finally, the sample was crushed and was made to pass through different sieve sizes.

Activated Carbon Characterization

Moisture content of activated carbon was determined using standard test ASTM D 2867-91 (ASTM, 1991). Specific Surface area (m^2 g^{-1}) was determined using Surface area modeling method by Nunes C. A., Guerreiro M.C., 2011.

Experimental procedure

Batch adsorption equilibrium experiments were conducted for the adsorption of and safranin O dye on TSAC as a function of particle size and initial pH. Based on the effect of the particle size, 0.5 gm of adsorbent with different adsorbent

particles of size of 75 µm, 150 µm and 300 µm was added to different conical flasks. These flasks contained 100 ml of adsorbate solution of concentration (100 mg L^{-1}), mixed for 60 mins. For the effect of the pH, pH of dye solution was varied as 3, 5, 7, 9 and 11. For the effectof adsorbent dose, doses of 0.25, 0.5, 1.0, 1.5 and 2.0 gm were taken. The solution was withdrawn from the reaction mixture at a fixed time interval using Centrifuge. The amount of unadsorbed dye in the supernatant solutions was measured with the aid of a visible spectrophotometer at wavelengths of 510 nm for safranin O dye. The % of dye adsorbed was found by equation (1).

$$\% \, adsorbed = [(Co - Ce)/ Co] \times 100 \quad \text{.....(1)}$$

Where;

C_o and C_e are the initial and final dye concentration respectively (mg L^{-1}) at any time (t).

RESULTS AND DISCUSSION

Characterization results of TSAC

The moisture content of TSAC was found to be 1.2 % indicating a low moisture, high pore volume activated carbon adsorbent. The specific surface area of TSAC was found to be 936 m^2g^{-1} which is indicative of an adsorbent offering a high surface area for effective adsorption.

Batch adsorption studies

Effect of particle size

The effect of different three different particle sizesof TSAC, i.e**,** 75µm, 150 µm and 300µm is shown in figure 2. The particle sizes ranging from 75µm to 300µm have percentages of dye adsorbed between the ranges of 76.14% to 60.18%. Maximum dye removal was observed for a particle size of 75 µm. This is because smaller the particle size, larger is the surface area offered by the adsorbent with more active sites for adsorption.

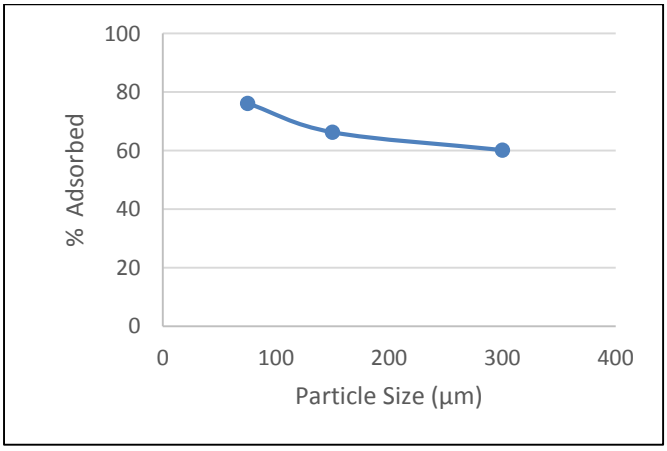

Figure 2. 1Adsorption of Safranin O dye by different particle size of TSAC

Effect of pH

The effect of pH of dye solution on removal of dye is shown in fig.3. Dye removal was observed for pH 3,5,7,9 and 11.The results showed that the amount of dye adsorbed increased with increase in pH value for Safranin O dye. The high pH favourable for the adsorption of Safranin O dye (cationic dye known as basic dye) is due to the fact that as the pH of the system increased, the number of negatively charged adsorbent sites increased and the number of positively charged surface sites decreased. This effect favours the adsorption of the positively charged dye cations due to electrostatic attraction. Maximum dye removal of 88.30% was observed for pH 11.

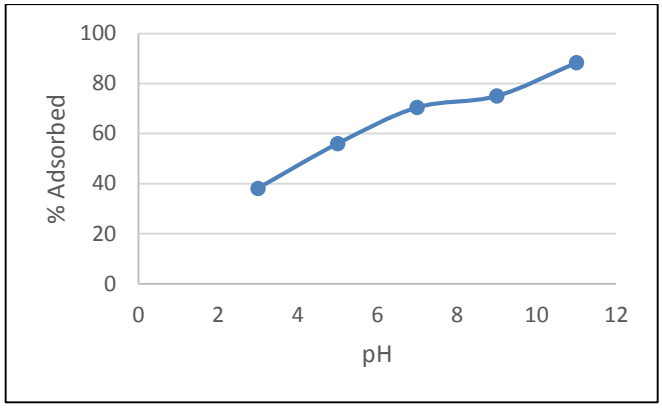

Figure 3. Effect of pH on TSAC using Safranin O dye

3.2.3 Effect of TSAC adsorbent dose

The effect of adsorbent dose on dye removal is shown in figure 4. Adsorbent dosages of 0.25, 0.5, 1.0, 1.5 and 2.0 gm were evaluated for dye removal. The result showed that as the TSAC adsorbent dosage increased the percentage of Safranin O dye adsorbed increased also from 55% to 97%. The percentage of adsorption increased up to 1.0g of TSAC adsorbent after which no significant changes in the percentages of dye was observed with an increasing amount of the adsorbent.i.e, the adsorbent attained equilibrium at around 1.0g of dosage. The adsorption efficiency increased due to the increased number of adsorption sites and surface area.

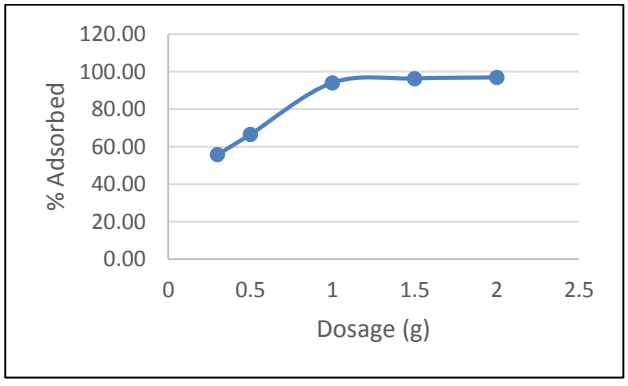

Figure 4. Effect of adsorbent dose on removal of Safranin O dye

CONCLUSION

This paper demonstrates the preparation of activated carbon from a low cost precursor, Tamarind seed. The tamarid seeds were modified by chemical and thermal methods to obtain a high carbon rich activated carbon.The physical characterization of the prepared TSAC showed a low moisture, high surface area adsorbent. The effect of three process parameters, pH, particle size and adsorbent dose was satisfactorily demonstrated by experimental procedure.The TSAC effectively removed Safranin O dye from synthetic wastewater. The use of such low cost adsorbent can be successfully adopted in treating large mount of dye wastewaters.

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