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Adsorptive removal of Orange G dye from an aqueous solution by Activated Carbon prepared from Coconut shell

Dr. Kosha Shah[1], Amit Parmar[2]

[1] Civil Engineering Department, Faculty of Technology & Engineering, The M. S. University of Baroda, Vadodara, Gujarat, India

[2] Civil Engineering Department, Faculty of Technology & Engineering, The M. S. University of Baroda, Vadodara, Gujarat, India

Abstract

The discharge of the wastewaters into rivers arising from textile, food, cosmetic and paper industries leads to addition of dye to natural water bodies causing severe environmental issues. The effects of dye in water results in the photosynthetic processes of aquatic plants to be affected by their high coloration, change in pH and addition of salt and aesthetic concerns in waters. Some dyes have carcinogenic effect on humans and animals. Adsorption by activated carbon is one of the simple, effective and feasible methods for dye removal. In this study, activated carbon is prepared from dry coconut shells. The resulting Coconut shell activated carbon (CSAC) is characterized for X-ray diffraction analysis, Fourier transform infrared spectroscopy, moisture content, ash content and bulk density. CSAC is tested for its effectiveness from the removal of Orange G dye from an aqueous solution. The effect of three variables on adsorption was evaluated, namely particle size, pH and adsorbent dose. The percentage of dye removal was 67.13%, 63.11 % and 53.91 % for particle size of 75µm, 150 µm and 300µm respectively. A pH of 3 showed a maximum dye removal of 88.42%. An adsorbent dose of 2.0 gm dose yields maximum dye removal of 96.94%.

Keywords: *Adsorption, coconut shell activated carbon, dye removal, activation*

1. Introduction

Commercial activated carbon is effective for adsorption of dyes from wastewater. However, there are cost constraints for use of commercial activated carbon for large scale industrial wastewater treatment. In this study attempt has been made to derive activated carbon from a low –cost, waste material, coconut shell which is high in carbon content. The coconut shell activated carbon (CSAC) is evaluated to assess its suitability as an adsorbent. Various studies have been carried out using low-cost adsorbents for dye removal. Activated carbon has been derived from bagasse (Tsai et al., 2001), orange peel (Khaled et al., 2009), coffee husk (Ahmad and Rahman, 2011), coconut tree (Senthilkumaar et al., 2006), Coal (Karaca et al. 2004), rice husk (Kannan and Sundaram ,2001),wood saw dust (Ho and McKay (1998), fly ash (Janos et al., 2003) and orange peel (Annadurai et al., 2002).

2. Materials and methods

2.1 Adsorbate

The adsorbate used in the present study was Orange G dye. Orange G is a azo dye used in the staining of paper and wood, textile and leather industry and as a biological stain. The Orange dye (chemical formula: $C_{16}H_{10}N_2Na_2O_7S_2$, molecular weight: 431.389 g mol^{-1}, λ_{max}: 480nm) was obtained from a chemical store. The chemical structure of Orange dye is shown in Fig. 1.The solutions used in the experiments were diluted from the dye solution at concentration 100 mg L^{-1}.

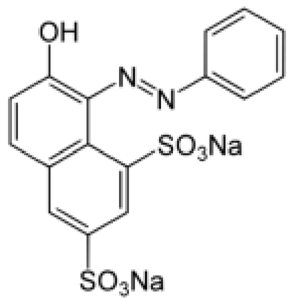

Fig.1 Structure of Orange G Dye

2.2 Preparation of Coconut shell activated carbon (CSAC)

Coconut shells were obtained from a temple in Vadodara, Gujarat, India. The shells were dried impurities were removed and then cleaned with distilled water. The shells were soaked in orthophosphoric acid in ratio of 1:2(wt %). They were dried in an oven at 200^{o}C for 15 minutes. The dried shells were carbonized in a muffle-furnace at 400^{o}C for 45 minutes. They were washed with distilled water until the leachate was between a pH of 6-7. They were then dried in an air-drying oven at 110^{o}C for 12 hours. The dried shells were crushed and was made to pass through different sieve sizes and stored in separate bottles.

2.3 Coconut Shell Activated Carbon Characterization

Moisture content of activated carbon was determined using standard test ASTM D 2867-91 (ASTM, 1991). The ash content was determined using ASTM E1755-01 (ASTM, 2003). The X-ray diffraction analysis (XRD) was carried out in a diffractometer. The Fourier Transform Infrared spectroscopy analysis (FTIR) was carried out using KBr pellets.

2.4 Experimental procedure

Batch experiments were performed for the adsorption of Orange G dye on CSAC. Three parameters, particle size, pH and adsorbent dose were varied in experiments to test their effect on adsorption process. 100 ml of dye solution of 100 mg L^{-1} concentration was taken in flasks. A dose of 0.5 gm CSAC was added with different particle sizes as 75 µm, 150 µm and 300 µm. Another set of flasks were prepared with varying pH of 3, 5, 7, 9 and 11 containing 0.5 gm dosage of adsorbent and 100 mg L^{-1} concentration of dye. Lastly, a set of flasks with varying adsorbent dose of 0.25, 0.5, 1.0, 1.5 and 2.0 gm were added in 100 mg L^{-1} dye solution with pH as neutral. All flasks were mixed for 60 minutes in shaker. The sample was filtered and amount of unadsorbed dye in the filtrate was measured with the aid of a visible spectrophotometer at wavelengths of 480 nm for Orange G dye. The % of dye adsorbed was found by Eq. (1).

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

Where;

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

3. Results and discussion

The moisture content of CSAC was 2% showing a low moisture, less diluted activated carbon. The ash content of CSAC was found to be 10.7% which is indicates the activated carbon has low inorganic content and high fixed carbon. The bulk density of CSAC was 0.5 g/cm^3 which indicates a high the mass of carbon. The X-ray diffraction pattern for CSAC obtained is shown in fig. 2.

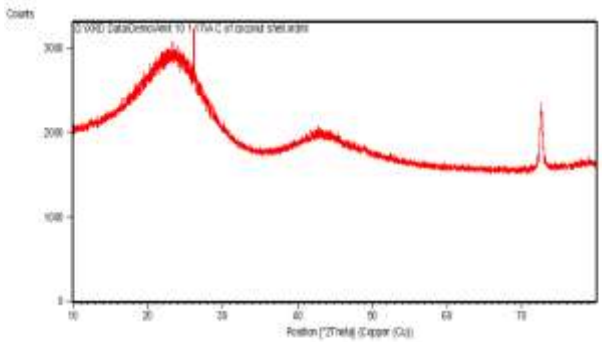

Fig. 2 XRD Measurement for CSAC

The X-ray diffraction pattern of CSAC show high intensity peaks as well as some low intensity peaks which are evidence of good crystallinity of the sample.

The Fourier Transform Infrared Spectroscopy (FTIR) study was carried out to identity the functional groups present in the adsorbents ranging from 400cm^{-1} to 4000cm^{-1}. The FTIR spectrum obtained for CSAC is shown in fig. 3.

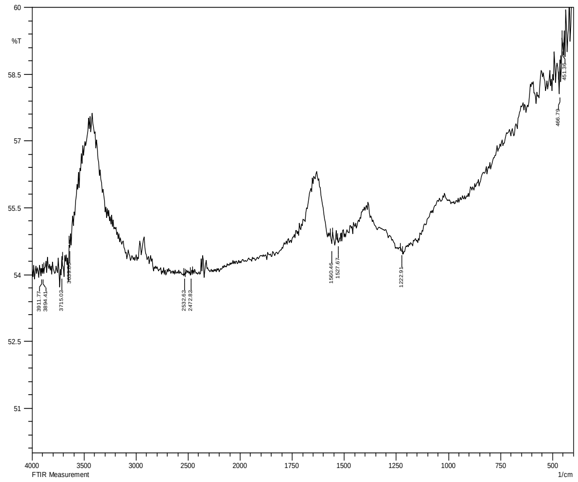

Fig. 3 FTIR Spectrum for CSAC

FTIR indicates the functional groups present in the sample. The FTIR spectrum of CSAC shows the presence of alkanes (C-H stretch), alkenes (=C-H stretch), alkynes (-C≡C-), carboxylic acids (O-H bend), aromatics amines (C-N), nitrites (C≡N stretch), aromatics (C-H stretch),C-O stretch Ester, and alkyl halides groups.

3.2 Batch adsorption studies

3.2.1 Effect of particle size

The effect of different three different particle sizes of CSAC on adsorption of Orange G dye is shown in fig. 4. The particle sizes ranging from 75µm to 300µm have percentages of dye adsorbed between the ranges of 67.13% to 53.91%. Maximum dye removal was observed for a particle size of 75 µm. The smallest particle size yields higher specific surface area for adsorption of dye molecules.

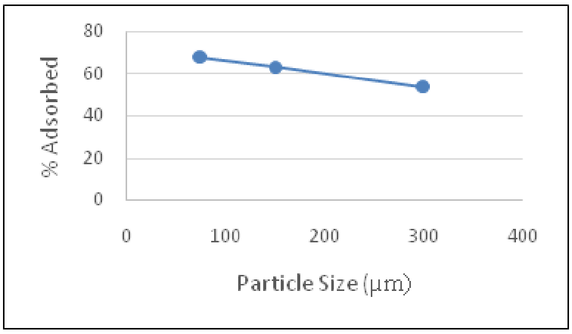

Fig. 4 Effect of1 particle size of CSAC

3.2.2 Effect of pH

The effect of different pH of dye solution on removal of Orange G dye is shown in fig. 5. This is due to the fact that as the pH of the system decreased, the number of negatively charged adsorbent sites decreased also, while the number of positively charged surface sites increased. These effects favoured the adsorption of the negatively charged dye anions due to electrostatic attraction. Maximum dye removal of 88.42% was observed for pH 3.

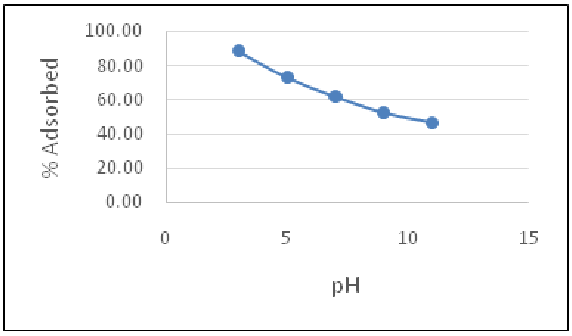

Fig. 5 Effect of pH on adsorption

3.2.3 Effect of CSAC adsorbent dose

The effect of adsorbent dose on dye removal is shown in figure 6. The result showed that as the CSAC adsorbent dosage increased the percentage of Orange G dye adsorbed increased from 39% to 97%. The percentage of adsorption increased up to 1.0g of adsorbent after which equilibrium was achieved.

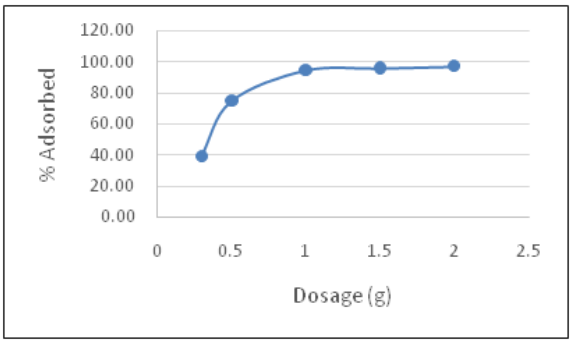

Fig. 6 Effect of CSAC adsorbent dose

4. Conclusion

This paper demonstrates the use of a waste material, Coconut Shell for treatment of dye wastewater. The activation process of Coconut shell activated carbon is demonstrated. The physic-chemical characterization of the prepared CSAC indicated a low moisture, low ash, high bulk density carbon, effective for adsorption. The XRD analysis of the CSAC indicated different crystal phases of carbon found in the sample. The FTIR analysis showed the effective functional groups present in the sample. The effect of three process parameters, pH, particle size and adsorbent dose was studied by experiments. The CSAC was found to be effective for removal of Orange G dye from wastewater. The CSAC can find its application in commercial treatment of similar wastewaters.

References

[1] Ahmad, M.A., Rahman, N.K., Equilibrium, kinetics and thermodynamic of Remazol Brilliant Orange 3R dye adsorption on coffee husk-based activated carbon. Chem. Eng. J. 170 (1), 154–161, (2011).

[2] American Society for Testing and Materials: Standard Method for the Determination of Ash in Biomass, Philadelphia, P.A.: 11, (05), (2003).

[3] American Society for Testing and Materials: Standard for Method for Moisture in Activated Carbon ASTM D 2867-91, Philadelphia, PA: ASTM Committee on Standards, (1991).

[4] Annadurai, G., Juang, R.S., Lee, D.J., Use of cellulose-based wastes for adsorption of dyes from aqueous solutions. J. Hazard.Mater. B92, 263–274, (2002).

[5] Ho, Y.S., McKay, G., Kinetic models for the sorption of dye from aqueous solution by wood. Trans. IChemE B 76 (1), 183–191, (1998).

[6] Janos, P., Buchtova, H., Ryznarova, M., Sorption of dyes from aqueous solutions onto fly ash. Water Res. 37(1), 4938–4944,(2003).

[7] Kannan, N., Sundaram, M.M., Kinetics and mechanism of removal of methylene blue by adsorption on various carbons - a comparative study. Dyes Pigments 51 (1), 25–40, (2001).

[8] Karaca, S., Gurses, A., Bayrak, R., Effect of some pretreatments on the adsorption of methylene blue by Balkaya lignite. Energy Convers. Manage. 45 (1), 1693–1704, (2004).

[9] Khaled, A., El Nemr, A., Ei-Sikaily, A., Abdelwahab, A., Treatment of artificial textile dye effluent containing direct yellow 12 by orange peel carbon. Desalination 238 (1), 210–232, (2009).

[10] Senthilkumar, S., Varadarajan, P.R., Porkodi, K., Subbhuraam, C.V., Adsorption of methylene blue onto jute fiber carbon: kinetics and equilibrium studies, J. Colloid Interface Sci., 284(1), 78–82,(2005).

[11] Tsai, W.T., Chang, C.Y., Lin, M.C., Chien, S.F., Sun, H.F., Hsieh, M.F., Adsorption of acid dye onto activated carbons prepared from agricultural waste bagasse by $ZnCl_2$, Chemosphere 45(1), 51–58, (2001).