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Adsorption of Rhodamine-B Dyefrom Waste Water by using Kamugu Nut Shell Carbon

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Abstract : An activated carbon produced from low cost agricultural waste is utilized for the removal of Rhodamine-B dyefrom waste water. Batch studiesare carried out for the adsorption of dye molecules onto Kamugu Nut Shell Carbon(KNSC). The structural and morphological studies of activated carbon are characterized by SEM with EDAX. The factors influencing the rate processes involved in the removal of dye for particle size, adsorbent dosage, initial dye concentration, contact timeandpH.To evaluate the irreversibility of the adsorption process, three consecutive runs of desorption are conducted by contacting the dye loaded activated carbon with acid. The results of the present study substantiate that agricultural waste KNSC are promising a better adsorbent for the removal of the Rhodamine-B from waste water.

Keywords : Kamugu Nut Shell Carbon, Rhodamine-B, Adsorption.

Introduction

The main source with severe pollution problems worldwide is the textile industry and its unused dyes containing wastewaters. So far 10,000 different textile dyes with an estimated annual production of 7.1 metric tonnes are commercially available worldwide[1]. 30% of these dyes is used in excess of 1,000 tonnes per annum, and 90% of the textile products is used at the level of 100 tonnes per annum[2]. 10-25% of dyes are waste during the textile dyeing process, and 2-20% is directly discharged as binary compound effluents in several environmental elements. specifically, the discharge of dye-containing effluents into the water surroundings is undesirable, not solely as a result of their color, however additionally as a result of several dyes discharged and their breakdown products are toxic, carcinogenic to life forms mainly because of carcinogens, such as benzidine, naphthalene and other aromatic compounds[3].Without adequate treatment these dyes willstaywithin thesurroundings fora long period of time.

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Experimental

Rhodamine-B

RB supplied by Sigma–Aldrich (M) SdnBhd, Malaysia is used as an adsorbate and is not purified prior to use. Distilled water is employed for preparing all the solutions and reagents.

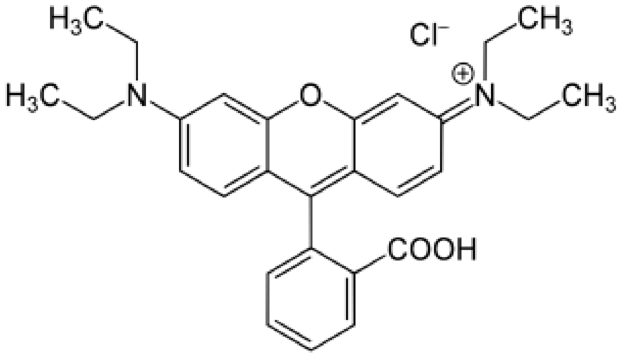

Figure 1: Chemical structure of Rhodamine B

RBhas a molecular weight of 479 g $mol^{-1.}$ Chemical structure of the dye is shown in Figure 1.

Preparation of activated carbon

One part by weight of each powdered raw material is chemically activated by treating with two parts by weight of concentrated sulphuric acid with constant stirring and is kept for 24 hours in a hot air oven at 75°C, the carbonized material is washed well with plenty of water several times to remove excess acid, surface adhered particles, water soluble materials dried at 200°C in hot air oven for 24 hours[4]. The adsorbent thus obtained are powdered well and kept in air tight containers for experimental purposes.

Analysis of Rhodamine B

The concentration of RB in the supernatant solution after and before adsorption is determined using a double beam UV spectrophotometer (Shimadzu, Japan) at 580 nm. It is found that the supernatant from the activated carbon did not exhibit any absorbance at this wavelength and also that the calibration curve is very reproducible and linear over the concentration range used in this work.

Batch equilibrium studies

Batch experiments are carried out by shaking 100 ml of dye solution with 100 mg of adsorbent in a glass stoppered conical flask at a room temperature at the rate of 120 rpm. After agitation the solution centrifuged. Then the dye concentration in the supernatant solution is analyzed using a spectrophotometer by monitoring the absorbance changes at a wavelength of maximum absorbance (580 nm)in these sorption experiments, the solution pH is used without adjusting.

Each experiment is carried out and average results are presented. Calibration curves are obtained with standard RB solution using distilled water as a blank. Mass capacity of adsorption q_e, is calculated from the difference between the initial and final concentration of RB.

$$\mathbf{q_e} = \frac{(\mathbf{C_o} - \mathbf{C_e})}{\mathbf{W}}\mathbf{V} \qquad (\mathbf{1})$$

whereC_0 and C_e (mg L^{-1}) are the liquid-phase concentrations of dye at initial and equilibrium respectively. V is the volume of the solution (l), and W is the mass of dry adsorbent used (g).

Results and Discussion

SEM Morphology

Surface morphology of adsorbents are analysed by SEM. By using high magnification imaging capabilities, it has been used to determine the particle shape, porosity, morphology, nature of the surface of the adsorbent. From the figure 2 it is revealed that the KNSC has a rough and uneven surface with more porous, it seems to be like cave structure. The distribution of pores within the activated carbons is varied considerablyrelyingupon the raw materials used for the preparation. Several shapes of these pores with the different of raw materials. The potency and selectivity of surface assimilation dependon the nature and distribution of pores with volumes. A consideration of the dimensions of some pollutants shows that activated carbon will feasibly be used to remove the toxic dyes present in water.

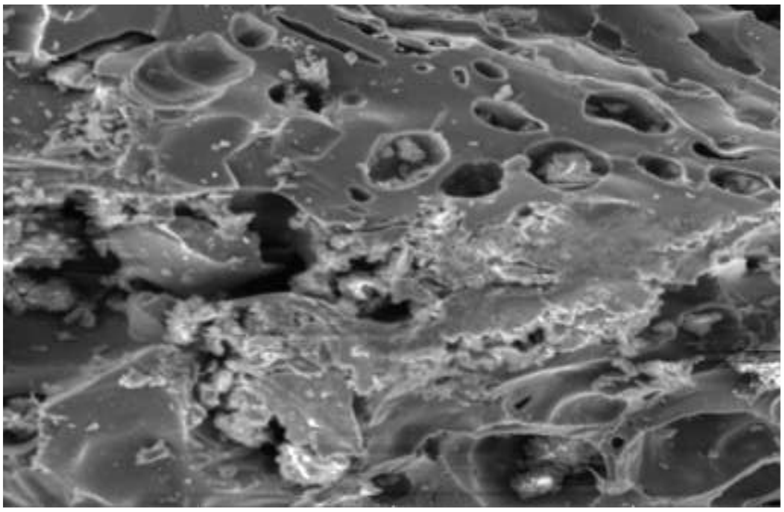

Figure 2:SEM image of kamugu nut shell carbon

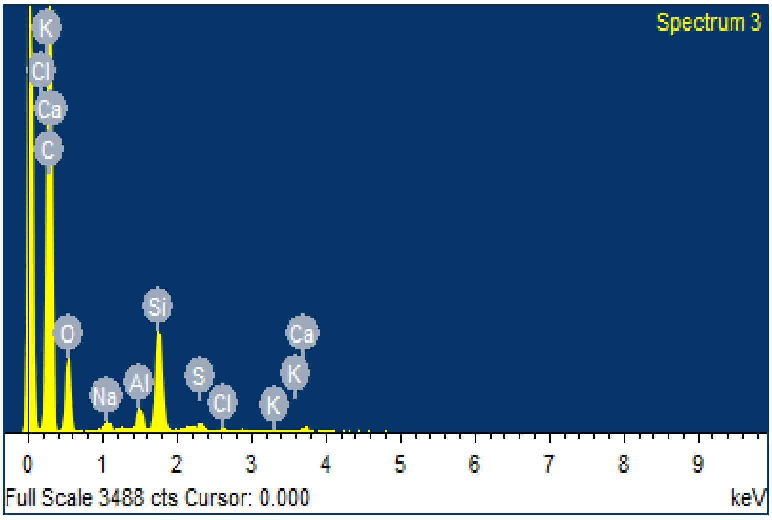

Figure 3:EDAX image of kamugu nut shell carbon

Effect of Adsorbent dosage

Dosage study is important parameter because it determines capacity of adsorbent for a given initial concentration of dye solution[5]. Adsorbent dosage has been determined, the adsorption capacity of an adsorbent for a given initial concentration of the adsorbate at the operating conditions. The effect of variation of adsorbent dosage on percentage removal of RB onto KNSC is graphically shown in figure 4. It clearly indicates that the dye removal increased with increase in adsorbent dosage. The adsorbent dosage increased from 50 to 250 mg with respect to the fixed dye concentration, 10 mg/L. This is because of fixed initial dye concentration increases the total adsorbent dosage which provides a greater surface area or active sites thus it increases the adsorption potential. However, it is observed that after the higher % removal of dyes, there is no significant change in the percentage removal of dyes. It may due to overlapping of active sites at higher adsorbent doses. So, there is no appreciable increase in the adsorptions because of saturation of the effective surface area and the results a conglomeration of exchange particles[6].

Effect of particle size

The adsorption of smaller particles is higher than larger particles. This is due to larger surface area associated with smaller particles[7]. Experiments are carried out at the appropriate equilibrium time limits to assess the variations on the amount of dyes adsorbed on the adsorbent of different particle sizes like 250, 150, 100 BSS mesh numbers are selected the initial dye concentration being 10mg/100ml. From the experimental trails various a set of graphs are obtained by plotting the % Removal against the adsorbent dosages are shown in figure4. It is revealed from the plots that the adsorption process is found to be rapid for the particle size 250 BSS mesh number and a considerable fraction of dye is removed in the initial 30 minutes duration.

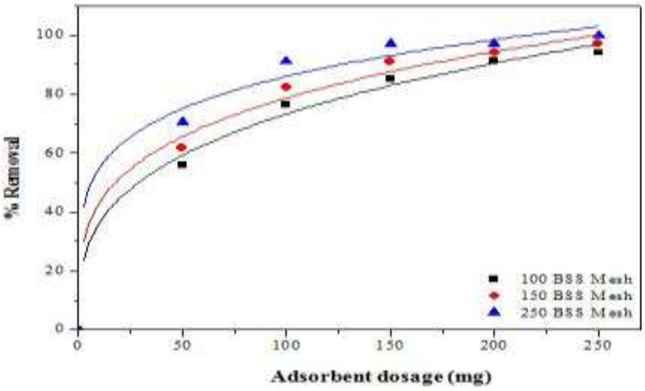

Figure 4: Effect of Adsorbent dosage and particle size on the removal of RB

Effect of contact time

From figure 5 it can be seen that the rate of adsorption is very rapid at initial period of contact time. Thereafter, it decreased gradually with time until adsorption is reached at the equilibrium point. This trend of adsorption kinetics is due to the adsorption of dye on the exterior surface of adsorbent at the initial period of contact time. When the adsorption on the exterior surface reached saturation point, the dye diffused into the pores of the adsorbent and is absorbed by the interior surface of the adsorbent. The contact time curve shows that the dye removal is rapid in first 30 min. The curves of contact time are single, sleek and continuous resulting in saturation.

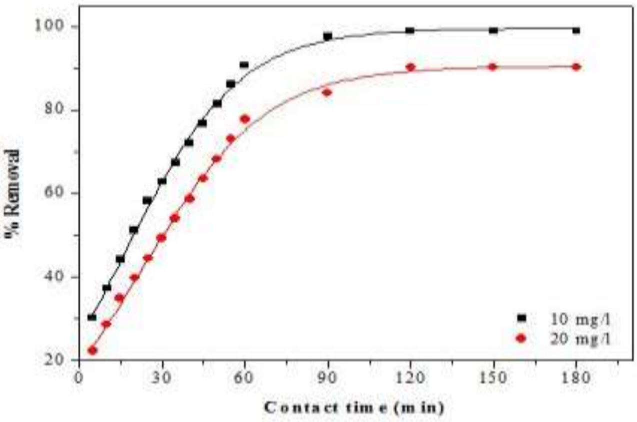

Figure 5: Effect of contact time on the removal of RB

Effect of Initial dye concentration

The effect of initial dye concentrations for their removal of RB is investigated in the range of 5 to 20 mg/L on the adsorption process as shown in Figure 6. Along with pH all other parameters are kept constant in this study. It is evident from the Figures that, as the concentration of dyes are increased, the amount adsorbed is increased, but there is a decrease in % removal. It is because, the initial dye concentration provides the necessary driving force to overcome the resistances to the mass transfer of dye molecules between the aqueous phase and the solid phase resulting in higher probability of collision between adsorbent and the active sites[8].

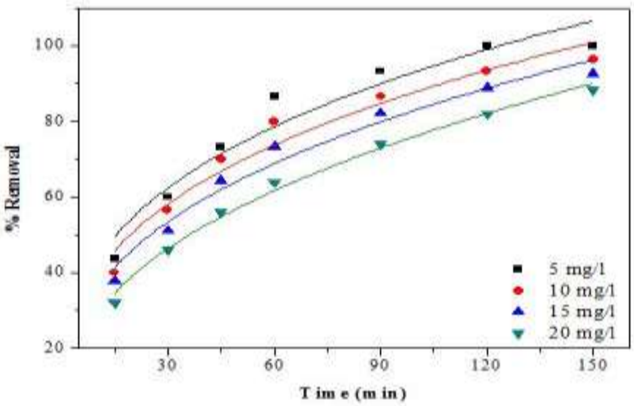

Figure 6:Effect of dye concon the removal of RB

Effect of pH

From Figure7shows the effect of pH on the adsorption of dye molecules by mesoporous carbon. It can be seen that dye adsorption is unfavourable at pH < 4. The decrease in the adsorption with a decrease in pH may be attributed to two reasons. As the pH of the system decreased, the number of negatively charged adsorbent sites decreased and the number of positively charged surface sites increased, which did not favour the adsorption of positively charged dye cations due to electrostatic repulsion[9]. While, the lower adsorption of dyes at acidic pH is due to the presence of the excess H^+ ions competing with dye cations for the adsorption sites of mesoporous carbon. It is known that pH can affect the structural stability of dyes and consequently its colour intensity[10]. It may be due to the structural changes of dye molecules at high pH. On the contrast, the surface of the KNSC acquires a negative charge at a high pH, OH^- on the surface of the adsorbent favours the adsorption of cationic dye molecules.

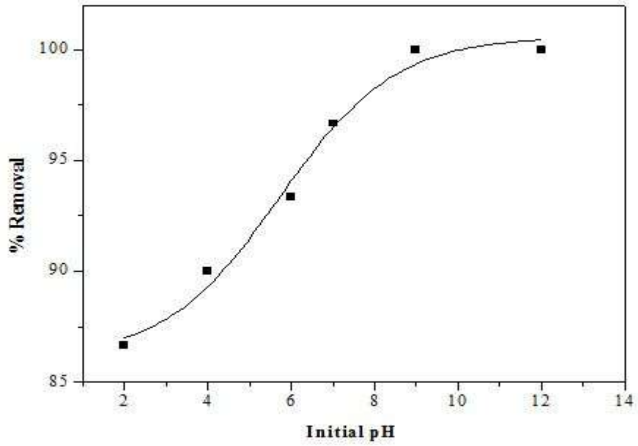

Figure 7: Effect of pH on the removal of RB

Desorption studies

Desorption studies help to elucidate the nature of adsorption and recycling of the spent adsorbent and dye. If the adsorbed dye can be desorbed using water (neutral pH) then the attachment of the dye on the adsorbent is by weak bonds. If the acid or alkaline medium are used for desorption, then the adsorption is ion exchange. If organic acids (namely acetic acid etc.,desorb the dye then the dye is held by activated adsorption. This converted to chemisorption at increased temperatures. In order to evaluate the irreversibility of the adsorption process, three consecutive runs of desorption are conducted by contacting the dye loaded carbon with acetic acid to see how many dye molecules could be desorbed the RB from the exhausted KNSC. Figure 8 presents the percentage of dye desorbed by three runs of the desorption process. It is found that the desorption efficiency is low, as only a small amount of dye (around 40%) could be desorbed from the carbon by running desorption process three times. Amount of dye desorbed found to be 40%. It is also noted that about 1/3 part of the weakly adsorbed dye molecules is desorbed in the first desorption cycle. The tiny amount of dye desorbed in the second and third desorption cycles is negligible.

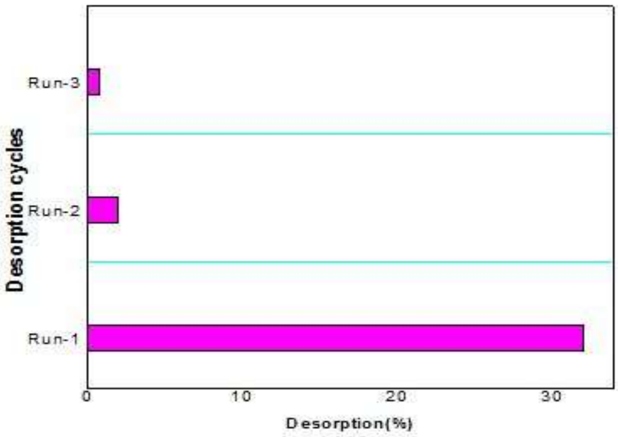

Figure 8: Desorption cycles of RB from KNSC

4. Result

Activated carbon prepared from Kamugu Nut Shellis effectively employed as an adsorbent for the removal of RB from aqueous solution.The surface morphology studies using SEM prove that, it contains more pores, that leads to develop more adsorption sites.Effect of weight of activated carbon is attributed to the increase of surface area and availability of active sites. The adsorption capacity of the adsorbent is considerably affected by initial concentration, adsorbent dose, particle size, contact time, temperature and initial pH.The efficiency of rhodamine B removal on KNSCis about 80-90% . Therefore agricultural waste like KNSC replace the commercial activated carbon

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