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Application of Activated Carbon Towards the Repeal of Coomassie Brilliant Blue

S. Sivakumar, R. Brindha
Post Graduate Department of Chemistry, Hajee Karutha Rowther Howdia College, Uthamapalayam, Tamilnadu, India

Abstract: This study illustrate the preparation of Activated carbon from Arecanut shell and its application towards the repeal of Coomassie brilliant Blue (CB) dye from aqueous solution. The optimum initial concentration (5 ppm), optimum contact time (30 minutes), optimum amount of Areca nut shell Carbon ($2gL^{-1}$) and optimum pH were determined. The percentage removal of CB was increased at low concentration and at low pH. When the amount of Arecanut shell Carbon (AC) was increased, the percentage removal of CB also increased. Freundlich and Langmuir isotherms were tested and they proved the feasibility of adsorption process. The adsorption capacity of Areca nut shell Carbon (AC) was found to be 18.40. The result shows that Areca nut shell Carbon (AC) has the potency to remove Coomassie brilliant Blue (CB) dye and hence used as an adsorbent to eliminate dye from waste water.
Keywords: Arecanut shell Carbon, Coomassie brilliant Blue, isotherm, contact time, pH

I. INTRODUCTION

Dyes are used in many industries such as textile, cosmetics, paper and leather *etc.* The waste water emerged from these industries causes water pollution. When the dyes containing waste water enters the waterbodies contaminate fresh water to become coloured and make it unsuitable for usage. This will produce adverse effect on human beings, cattles and aquatic organisms. Hence it is primary need to remove dyes from waste water. Many researchers have tried for the removal of dyes by preparing activated carbons from agro waste like mango seed shells [1], pine apple stem waste [2], palm flower [3], rice husk [4], Tapioca Peel [5], tobacco residues [6], Thespesia populnea pods [7], cashew nut shell [8], corncob [9] and tamarind shell [10] *etc.* In this study, activated carbon was prepared from Arecanut shell and applied to remove Coomassie brilliant Blue dye from aqueous solution by adsorption method.

II. MATERIALS AND METHODS

A. Adsorbate

The sample of Coomassie brilliant Blue (CB) R 250 (C.I.No.42660) dye was used as an adsorbate. The structure of the dye is given in Fig. 1. The measuring maximum absorbance of Coomassie Brilliant Blue (CB)) dye (Fig. 2) was analysed in UV-visible double beam spectrophotometer (model name: V-630, JASCO, Japan).

The λmax value for Coomassie Brilliant Blue (CB) is 598.8 nm. The dye CBB sample was purchased from Thomas Baker chemicals Mumbai. The other chemicals and reagents employed in the present work were laboratory reagent supplied by SD fine chemicals and E Merck, India.

B. Adsorbent

The raw material for the preparation of activated carbon was Areca nut (Areca Catechu) shell. This agro waste was selected as an adsorbent due to its abundance and easy availability and to provide an economical method of waste management.

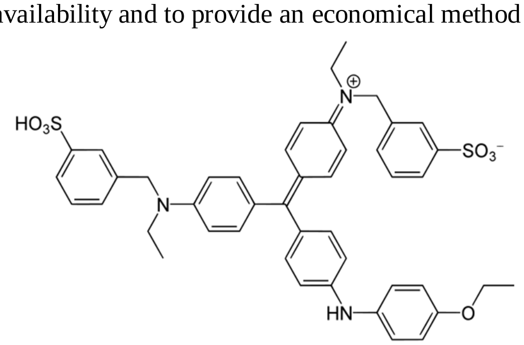

Fig. 1 Structure of Coomassie Brilliant Blue

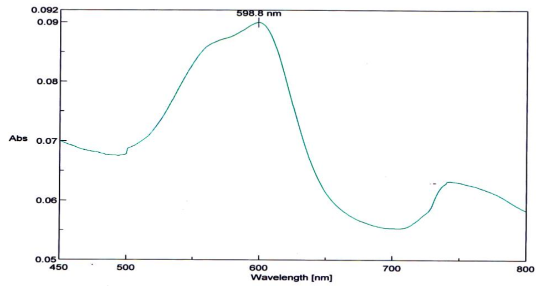

Fig. 2 UV Spectrum of Coomassie Brilliant Blue

C. Preparation of Activated Carbon

The dried raw material Areca nut (Areca Catechu) shell was cut into small pieces and carbonized at the temperature range of 300 – 400^{0}C, in a muffle furnace (Neolab, AUS-101, India) in the absence of air. The residue remaining after pyrolysis was activated by acid digestion and then it was thoroughly washed with distilled water and finally with double distilled water until the washing was free from acid and other ions (tested with litmus paper and Eriochrome Black T indicator). The adsorbent material was then subjected to thermal activation by heating them at 120^{0}C for 2 hr in an air-oven and stored in separate brown bottles.

Experimental Parameters for the Adsorption of Coomassie brilliant Blue (CB) on Arecanut shell Carbon (AC).

D. Initial concentration of dye

Initial Concentration of dye (5-50ppm), Contact time (30 minutes), Amount of adsorbent (2g L^{-1}), Initial pH (6.7) and Particle size 90 micron at 26^{0}C.

E. Contact time

Initial concentration of dye (5ppm), Contact time (5-60 minutes), Amount of adsorbent (2gL^{-1}), Initial pH (6.7) and Particle size 90 micron at 26^{0}C.

F. Amount of adsorbent

Initial concentration of dye (5ppm), Contact time (30 minutes), Amount of adsorbent (1.4-2.6 gL^{-1}), Initial pH (6.7) and Particle size 90 micron at 26^{0}C.

G. pH of the solution

Constant initial concentration of dye (5ppm), Contact time (30 minutes), Amount of adsorbent (2gL^{-1}), pH (2-11) and Particle size 90 micron at 26^{0}C.

H. Batch Type Adsorption Experiment

A Stock solution of dye Coomassie brilliant Blue (CB) (1000 ppm) was prepared and suitably diluted to the required initial concentration with distilled water. 50 ml of the dye solution of known initial concentration (C_i) was taken in six different 250 ml leak-proof reagent bottles. Required amount (2gL^{-1}) of adsorbent Areca nut shell Carbon (AC) were exactly weighed and then transferred into each of these bottles. These bottles were then placed in a mechanical shaker and shaken vigorously for a required period of contact time at room temperature. The dye solutions after equilibrium for required period of contact time was filtered and then the final equilibrium concentration (C_e) was measured. In all the batch adsorption experiments, the extent of removal of dye in terms of the values of percentage removal of dye and amount adsorbed (q in mg g-1) have been calculated using the following relationships.

Percentage of removal = $C_i – C_e/C_i$ x 100 ----------- (1)

Amount of adsorbed = x/m = $C_i – C_e/m$ ------------ (2)

C_i =Initial concentration of dye (ppm), C_e = Equilibrium concentration of dye (ppm), x = Concentration of dye adsorbed (mg L^{-1}), m=Mass of adsorbent (g L^{-1})

III. RESULTS AND DISCUSSION

A. *Effect of Initial Concentration*

The percentage of removal of dye was found to decrease with increase of initial concentration of dye (Fig. 3). At an optimum initial concentration of dye (5 ppm), the percentage removal was found to be optimum (60%). The result shows that after the formation of monolayer of dye molecules on the surface of Areca nut shell Carbon (AC), the formation of second layer of dye molecule is highly hindered at higher initial concentration of dye Coomassie brilliant Blue (CB).

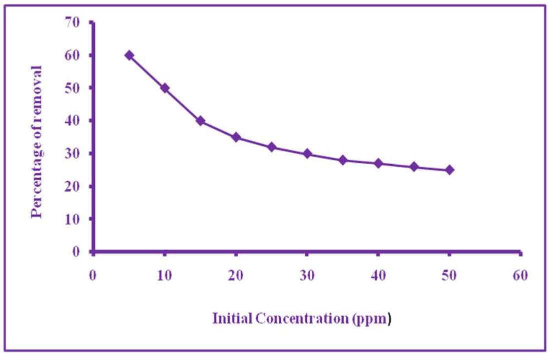

Fig. 3. Effect of Initial Concentration

B. *Adsorption Isotherm*

The study of adsorption isotherm gives adsorption capacity of adsorbent AC. The adsorption data were applied in the isotherm models.

Freundlich isotherm: $\log (x/m) = \log K + (1/n) \log C_e$ ----------- (3)

Langmuir isotherm: $(C_e/q_e) = (1/Q_0 b) + (C_e/Q_0)$ ------------(4)

Where, K and (1/n) are the measure of adsorption capacity and intensity of adsorption respectively, q_e or (x/m) is the amount of dye adsorbed per unit mass of adsorbent (in mg g^{-1}) and b is the Langmuir constant related to energy of adsorption (in mg g^{-1}).

The two isotherm plots are shown in Fig. 4 and 5.

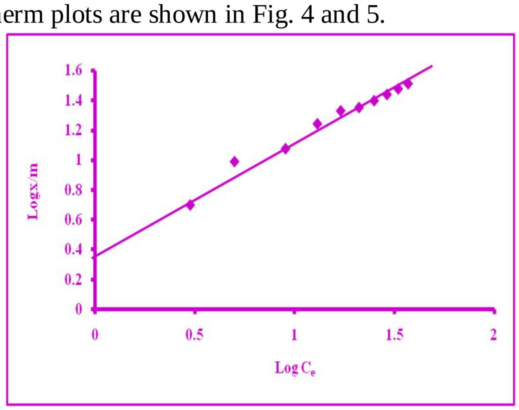

Fig. 4. Freundlich isotherm

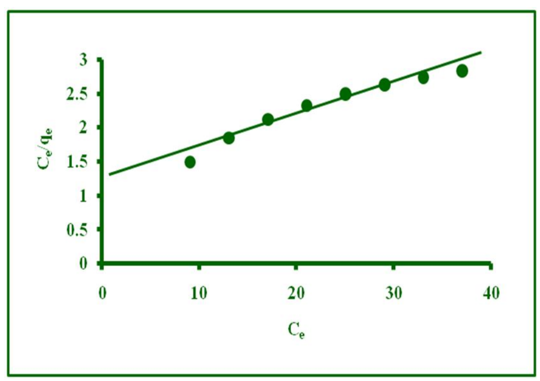

Fig. 5. Langmuir isotherm

Their values computed along with isotherm constants are given in Table 1. Further the essential characteristics of the Langmuir Isotherm is the prediction of possibility of the adsorption process, which are expressed in terms of the dimensionless constant, R_L described by Weber and Chakravorty. The separation factor or equilibrium factor R_L, is defined by the Equation (5).

$R_L = [1/ (1+bci)]$.................................. (5)

Where, b is the Langmuir constant and C_i is the optimum initial concentration of the dye (5 ppm) employed in the adsorption studies .The separation factor R_L indicate the nature of isotherm and the feasibility of adsorption process as, unfavourable (R_L>1), linear (R_L=1), favourable (0<< R_L<<1) and irreversible. The adsorption capacity (Q_0 Value) of AC was 18.40. The Q_0 value shows that the Areca nut shell Carbon (AC) has the adsorption capacity in the removal of CB dye from waste water.

Table –I
Results of correlation analysis of Isotherm for the adsorption of CB on AC

Isotherm Models	Parameters	CB on AC
Freundlich Isotherm	Slope 1/n	0.6374
	Intercept	0.5238
	Correlation coefficient (r)	0.9643
Langmuir Isotherm	Slope ($1/Q_0$)	0.0555
	Intercept ($1/Q_0b$)	0.9937
	Correlation coefficient (r)	0.9512
	Q_0(mgg^{-1})	18.36
	b ($g L^{-1}$)	0.0529
	R_L	0.7906

C. *Effect of Contact Time*

In the adsorption system, contact time plays a vital role irrespective of the other experimental parameters affecting the adsorption kinetics. In order to study the kinetics and dynamics of adsorption of CBB on AC, adsorption experiments were carried out at different contact time (5 to 60 min) at constant optimum initial concentration of dye (5ppm) with 2 gL^{-1} of AC. The values of percentage removal and amount of dye adsorbed exponentially increased with increase in contact time for CB on AC (Fig. 5).

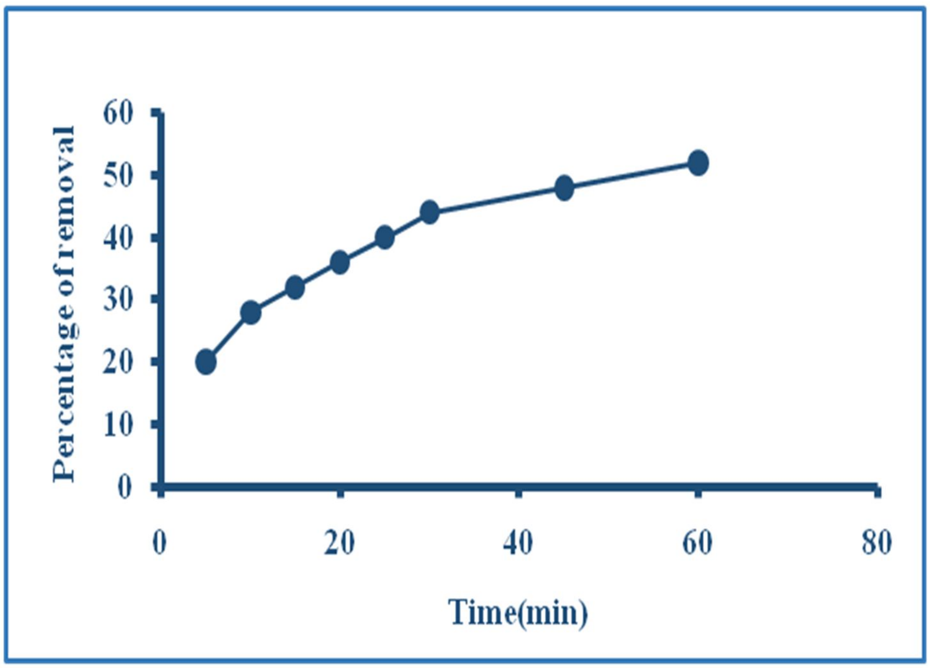

Fig. 5 Effect of Contact Time

D. *Effect of Amount of Adsorbent*

The Effect of Amount of Adsorbent was studied by varying the amount of adsorbent AC range from 1.4gL^{-1} -2.6gL^{-1}. The percentage of removal of dye Coomassie Brilliant Blue (CB) by adsorption on Areca nut shell Carbon (AC) was increased with increase the in the amount of adsorbent AC. This may be due to the increase in the availability of the active sites on the surface of adsorbent AC. The optimum amount of AC was fixed as 2gL^{-1}. The plot of the percentage removal of dye CB versus amount of AC was found to be linear (Fig. 6). The percentage removal of CB at the optimum amount of AC was found to be 32%.

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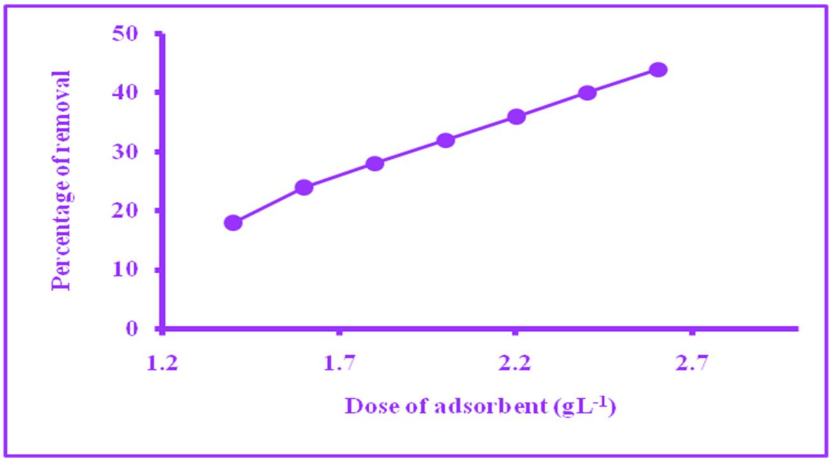

Fig. 10. Effect of amount of adsorbent

E. Effect of pH

The effect of initial pH on adsorption process for Coomassie Brilliant Blue (CB) dye on adsorbent Areca nut shell Carbon (AC) was studied at different pH values range from 2-11. The percentage of removal of CB was increased with decrease in pH (Fig. 11). At acidic pH, the surfaces of activated carbon may become positively charged due to excess of H^+ ions in solution. The electrostatic attraction between CB and surface of adsorbent AC increased the amount of CB adsorbed. The maximum percentage removal of CB by AC was found to be 40% at pH 2.

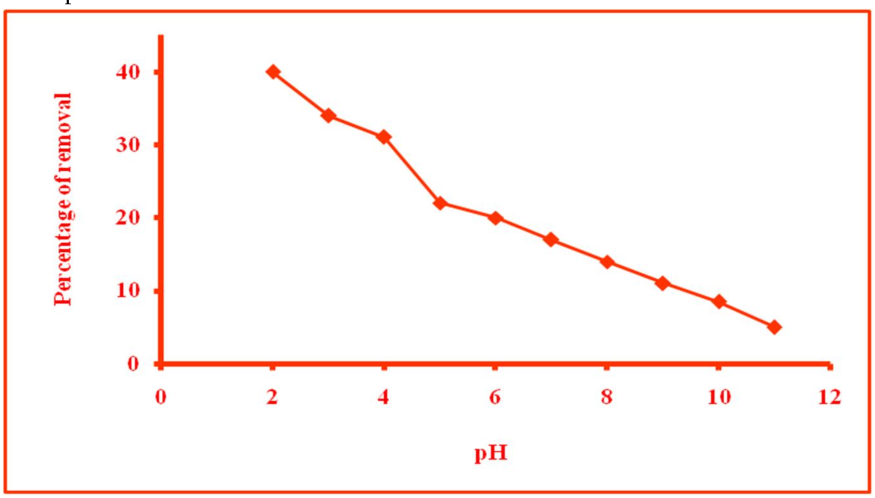

Fig. 11- Effect of pH

IV. CONCLUSION

The percentage removal of dye Coomassie Brilliant Blue (CBB) on AC was found to increase with the decrease in initial concentration and pH of dye. Langmuir and Freundlich adsorption isotherms were tested and found to be applicable. The percentage of removal of dye CBB was found to increase with the increase in contact time and amount of adsorbent AC. it is concluded that Areca nut shell Carbon (AC) can be used as an adsorbent for the removal of Coomassie Brilliant Blue (CBB) dye in particular and in general, dyes from waste water.

V. ACKNOWLEDGEMENT

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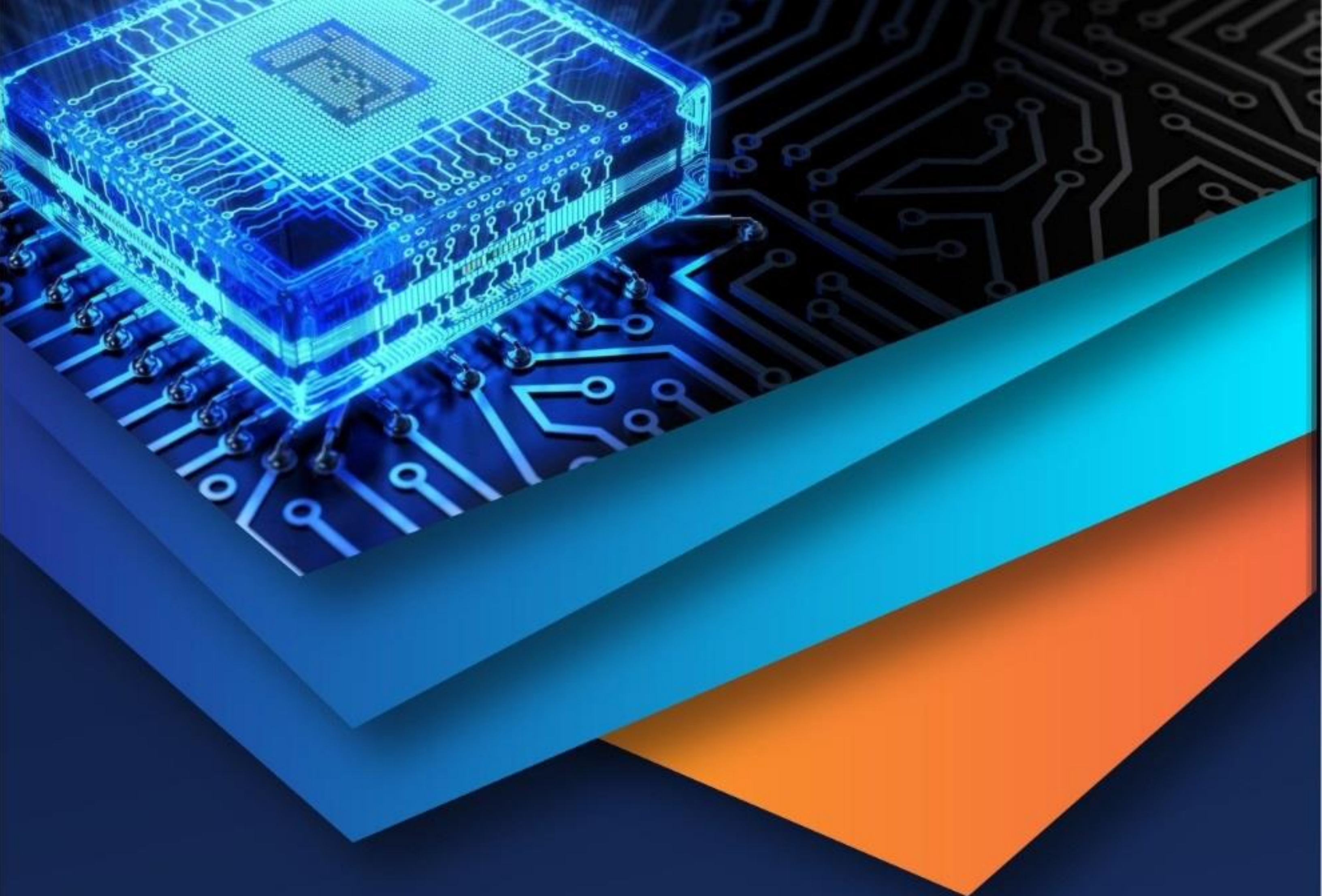

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