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CRYSTAL VIOLET DYE REMOVAL USING ACTIVATED CARBON *LEUCAENE LEUCOCEPHALA* BY ADSORPTION METHOD

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***Abstract**:*
A low- cost and eco- friendly activated carbon was prepared from the pods of Leucaene leucocephala and treated as a carbon material for the removal of Crystal Violet (CV) dye from aqueous solution. Batch adsorption studies were carried out by varying the initial concentration of dye solution, initial pH of the solution, adsorbent dosage and temperature. The results obtained from this study were interpreted in terms of Langmuir adsorption isotherm and Freundlich adsorption isotherm. Scanning Electron Microscopy (SEM) image of activated carbon Leucaene leucocephala was monitored before and after adsorption of CV dye molecules. The percentage removal of CV dye molecules was found to be increases with decreasing initial concentration of dye solution, increasing initial pH of the solution, increasing adsorbent dosage and increasing temperature. Thus, activated carbon Leucaene leucocephala can be employed as a good carbon material for the removal of Crystal Violet dye from an aqueous solution.

***Keywords**: adsorbent, activated carbon, Crystal Violet dye, adsorption isotherm.*

I. Introduction

Water is vital for all living creatures and nowadays its gets contaminated due to release of harmful dye molecules from dyeing industries. The industries like textiles, plastics, pharmaceutical, foodstuffs, cosmetics, paints, detergents and leather use synthetic dyes to colour their products [1]. As a result, the effluents coming out from these industries contain dye molecules which cause danger to marine and non- marine organisms. Various methods like flocculation, chemical precipitation, coagulation, ozonation, oxidation, nano-filtration, ionexchange, reverse osmosis and ultra-filtration are used to remove dyes, but they are expensive and create large amount of sludge [2]-[4]. Thus, the most efficient and simplest method followed is the adsorption method [5]. Adsorption process is a surface phenomenon and a promising technique for waste water treatment [6]. Many researchers have used agricultural waste materials as adsorbents such as sawdust [7], [8], rice husk [9]-[11] and fruit shell [12]. In this work, a low- cost adsorbent as activated carbon prepared from the pods of *Leucaene leucocephala* was used to remove Crystal Violet (CV) dye molecules from aqueous solution.

II. Materials and Methods

A. *Preparation of the adsorbent*

The pods of *Leucaene leucocephala* (White lead tree) shown in the figure 1 were collected from Palakkad district, Kerala and they were made into small pieces. After that dried in sunlight for one week and further desiccated in hot air oven at 60^0 C for 24 hours. The completely dried material was powdered well and chemically activated by treating it with conc H_2SO_4 with constant stirring, kept for 24 hours. The carbonized material thus obtained was washed well with distilled water for several times to remove the excess of acid present and dried at 100^o C-120^o C in a hot air oven to take away water molecules. The adsorbent thus obtained was ground well and sieved through a 250 mesh, kept in an air tight container for further use.

B. *Preparation of Crystal Violet (CV) Dye Solution*

Crystal Violet (CV) dye is a cationic triaryl methane dye having molecular formula $C_{25}H_{30}N_3Cl$ was purchased from a local market in Coimbatore and CV dye solution was prepared by dissolving 5 g of CV dye in distilled water and diluted to 1000 ml. This prepared solution was taken as stock solution which was then diluted to appropriate concentrations. The equipments used were Elico pH meter, photo colorimeter, orbital shaker and incubator orbital shaker.

Figure 1 Pods of *Leucaene leucocephala*

III. Results and Discussion

A. *Effect of Variation of Initial Concentration of CV Dye Solution*

Batch experiments for the adsorption of CV dye with the adsorbent *Leucaene leucocephala* was conducted by varying the initial concentration of CV dye solution.100 ml of dye solution containing 15, 20, 25 and 30 mg of CV dye were prepared from the stock solution and taken in pyrex bottles containing 200 mg of the adsorbent. Then these bottles were agitated at 150 rotation per minute (rpm) on an orbital shaker at room temperature for time intervals (10, 20, 30, 40, 50, 60, 90, 120, 150 and 180 minutes). These solutions were filtered and the dye concentrations of the filtrates were estimated colorimetrically at 590 nm using photo colorimeter.

Figure 2 Effect of Initial Concentration of CV Dye Solution for the Adsorption of CV Dye from an Aqueous Solution onto Adsorbent

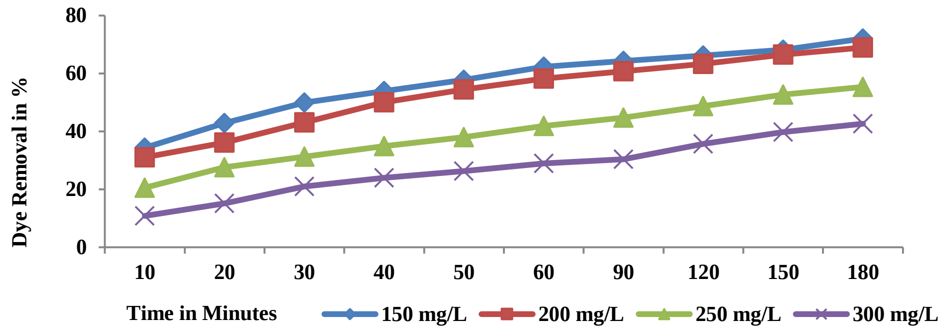


Figure 2 shows the percentage removal of CV dye increases from 42.61 to 72.07 with the adsorbent *Leucaene leucocephala* in 180 minutes of contact time, when the initial concentration of CV dye solution used was varied from 300 to 150 mg/L respectively. The amount of adsorbent kept constant and so the number of adsorption sites is also constant. Therefore, by increasing the amount of CV dye initial concentration, the percentage removal decreases due to limitation of the adsorption sites.

B. *Effect of Variation of pH on the Adsorption of CV Dye*

Batch experiments were performed by varying the initial pH from 5.0 to 9.0 using 0.1 N HCl or 0.1 N NaOH solution and pH measurements were carried out using Elico pH meter. 100 ml of dye solution containing 30 mg of the CV dye were prepared from the stock solution and treated with 200 mg of the adsorbent taken in pyrex bottles. The pH of the above solution was adjusted to desired pH from 5.0 to 9.0 and batch studies were conducted. These solutions were shaken using an orbital shaker at room temperature for various time intervals (10, 20, 30, 40, 50, 60, 90, 120, 150 and 180 minutes).These solutions were filtered and the filtrates obtained were analyzed colorimetrically to find out the percentage amount of CV dye adsorbed.

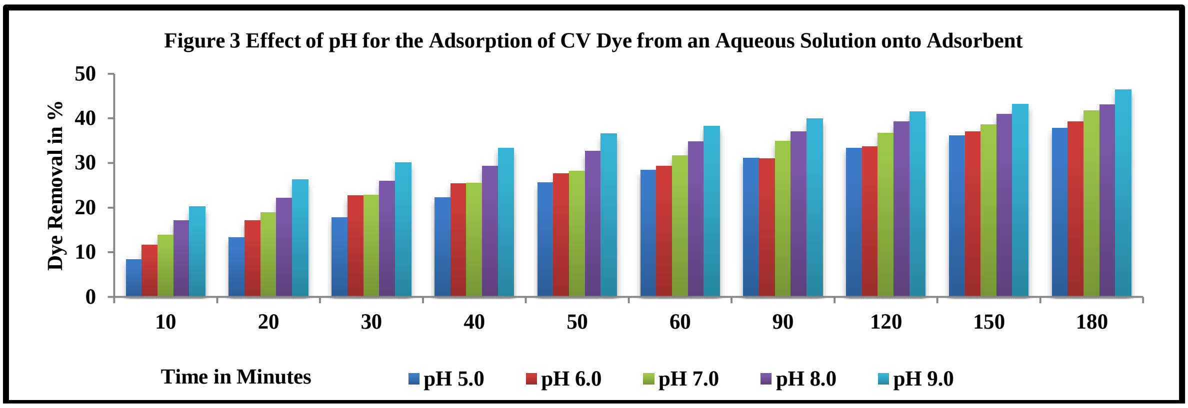


Figure 3 shows the percentage removal of CV dye increased from 37.80 to 46.45 with the adsorbent as the pH varied from 5.0 to 9.0 in 180 minutes of contact time. Generally, at lower pH the percentage removal of cationic dye gets decreased [5]. CV dye is a cationic dye and lower adsorption takes place at acidic pH is due to presence of excess of H^+ ions [8], [13].

C. Effect of Variation of Adsorbent Dosage on the Adsorption of CV Dye

The effect of adsorbent dosage on the adsorption of CV dye was studied at pH 9.0 ± 0.02. 100 ml of dye solution containing 30 mg of the CV dye were taken in pyrex bottles and batch adsorption studies were conducted by varying the adsorbent dosage (200, 300, 400 and 500 mg) of the adsorbent. The pyrex bottles containing the adsorbent and adsorbate were shaken in a orbital shaker for various time intervals and similar procedure have been followed.

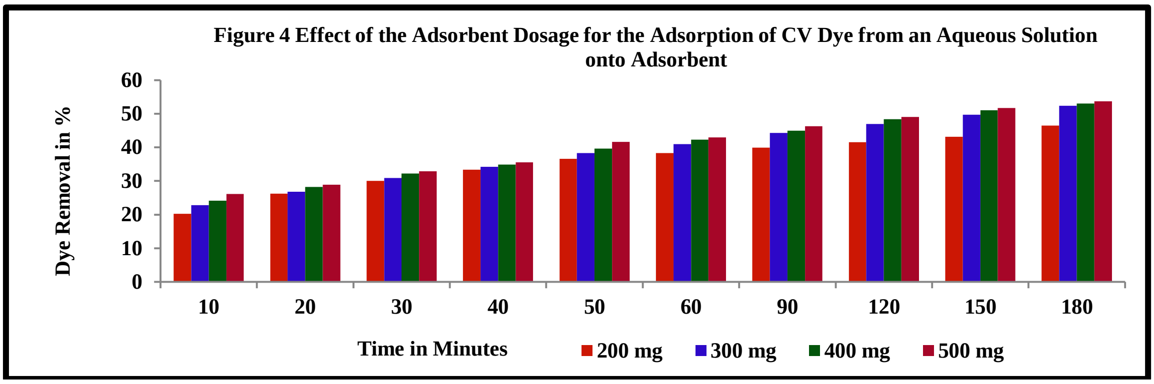


Figure 4 shows the percentage removal of CV dye increased from 46.45 to 53.70, when the adsorbent dosage was varied from 200 to 500 mg due to availability of more adsorption sites in the latter case.

D. Effect of Variation of Temperature on the Adsorption of CV Dye

The effect of temperature on the adsorption process was studied at 295, 305 and 315 K. 100 ml of dye solution containing 30 mg of the CV dye were taken in pyrex bottles and batch adsorption studies were conducted by using the adsorbent dosage 200 mg and at pH 9.0 ± 0.02. Similar procedure has been followed.

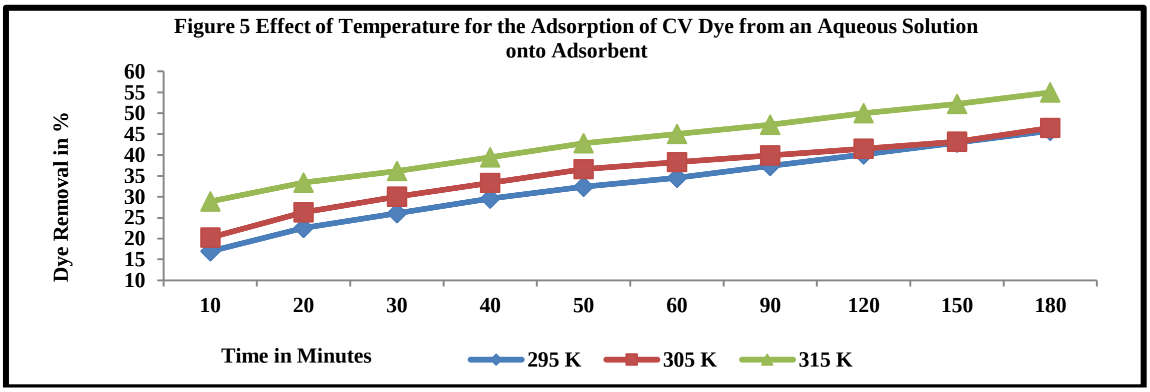
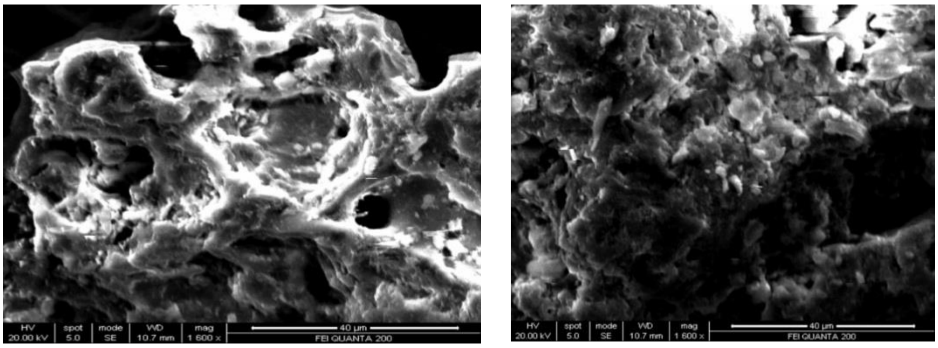


Figure 5 shows the percentage removal of CV dye increased from 45.79 to 55.01 as the temperature was varied from 295 to 315 K using 200 mg of the adsorbent. As temperature increases, there is an increase in mobility of dye molecules and the number of active sites also gets increased. Simultaneously, the pore size gets enlarged due to rise in temperature [5].

E. Characterization of the Adsorbent

Surface morphology of adsorbent *Leucaene leucocephala* was studied using SEM (Scanning Electron Microscopy). Figure 6 shows SEM image of adsorbent *Leucaene leucocephala* before and after adsorption of CV dye molecules respectively. The difference in SEM image clearly indicates that the CV dye molecules get adsorbed to the pores of adsorbent.

Figure 6 SEM Image of Adsorbent *Leucaene leucocephala* before and after Adsorption



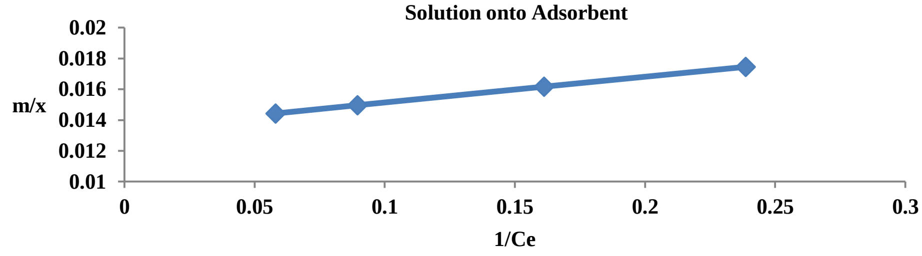
F. Langmuir Adsorption Isotherm

Langmuir adsorption isotherm used to describe the monomolecular adsorption on energetically homogeneous surfaces is given by the equation $\mathbf{(x/m) = k_1^1Ce / (1 + k_1Ce)}$ where the term ‘x’ denotes the amount of CV dye adsorbed in mg/L, ‘m’ is weight of adsorbent in mg, ‘Ce’ is concentration of CV dye at equilibrium, $k_1^1$and k_1 are the Langmuir constants which are the measure of adsorption capacity and energy of adsorption respectively. On rearranging, the above equation becomes $\mathbf{(m/x) = (1/ k_1^1Ce) + (k_1/ k_1^1)}$. The linear plot of 1/Ce Vs m/x shown in the figure 7 indicates that the adsorption followed Langmuir isotherm model for the adsorbent Leucaene leucocephala. The data are given in the table 1 at 180 minutes of contact time.

Table 1 Interpretation of Results of Langmuir Adsorption Isotherm for CV Dye Adsorption from an Aqueous Solution onto Adsorbent

Initial Concentration of CV Dye in mg/L	1/Ce	m/x	Intercept k_1/ k_1^1	Slope $1/ k_1^1$
150	0.2386	0.0174	0.0134	0.0167
200	0.1612	0.0161		
250	0.0895	0.0149		
300	0.0580	0.0144		

Figure 7 Langmuir Adsorption Isotherm for CV Dye Adsorption from an Aqueous Solution onto Adsorbent



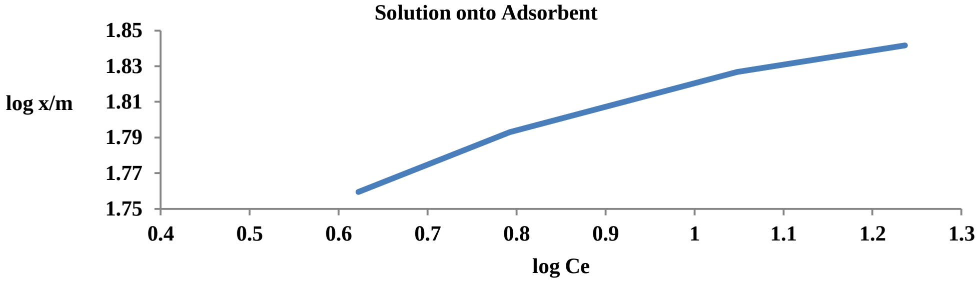
G. *Freundlich Adsorption Isotherm*

Freundlich adsorption isotherm indicates that the adsorption process occurs on a heterogeneous surface. The linear form of Freundlich adsorption isotherm equation is **log x/m =log K_F+ 1/n log Ce** where the term 'x' denotes the amount of CV dye adsorbed in mg/L, 'm' is weight of adsorbent in mg, 'Ce' is concentration of CV dye at equilibrium, K_F and 1/n are the Freundlich constants related to the adsorption capacity and intensity of adsorption respectively. The value of 1/n (less than 1 obtained in this study) indicates the applicability of Freundlich adsorption isotherm for CV dye adsorption. The data are given in the table 2 at 180 minutes of contact time. Graphically, it is shown in the figure 8.

Table 2 Interpretation of Results of Freundlich Adsorption Isotherm for CV Dye Adsorption from an Aqueous Solution onto Adsorbent

Initial Concentration of CV Dye in mg/L	logCe	logx/m	Intercept	Slope 1/ n
150 **200** **250** **300**	0.6223 0.7926 1.0481 1.2365	1.7594 1.7931 1.8268 1.8416	1.6821	0.1331

Figure 8 Freundlich Adsorption Isotherm for CV Dye Adsorption from an Aqueous Solution onto Adsorbent



IV. Conclusion

In this work, batch experiments for the removal of CV dye from an aqueous solution were conducted by varying the parameters such as initial concentration of CV dye, initial pH, adsorbent dosage and temperature. From these studies, we can conclude that activated carbon *Leucaene leucocephala* can be used as a low- cost and eco-friendly carbon material for the removal of CV dye from an aqueous solution.

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