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Removal of Methylene Blue by Activated Carbon from Indian Borage (Plectranthus amboinicus)

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Abstract: *Many organic and inorganic pollutants are discharged by various industries into the water bodies. One of the most important pollutants is dye materials that have adverse effect on human health. In this study, Indian Borage, waste –based activated carbon was used as low cost sorbent for the removal of methylene blue as a textile dye from liquid medium. Activated carbon was prepared from Indian Borage wastes and used asa low cost sorbent for the removal of methylene blue from synthesized waste water. The influences of various parameters such as contact time, pH, sorbent dosage, and initial concentration of pollutants on adsorption were evaluated*

Keywords: *pollutants*

I. INTRODUCTION

Water pollution due to discharging of colored waste waters from the textile industries is an important environmental problem, especially in developing countries. Discharging these colored waste waters into water bodies can causeadverse effects on aquatic life as well as human health. Dyes can be categorized to anionic, cationic and non-ionic dyes, Methylene Blue (MB) or basic blue 9 is one of the commonly cationic dyes used for various purposes in industries especially in the textile industry. Activated carbon due to simplicity, high surface area, and high sorption capacity has been used as a common adsorbent toremove dye pollutants, but it is expensive and inflexible to regenerate. Activated carbon was prepared from Indian Borage wastes and used asa low cost sorbent for the removal of methylene blue from synthesized waste water. In addition to activated carbon, other adsorbents such as montmorillonite nanocomposite montmorillonite , spent tea , Moroccan clay, regenerated clay, diatomite , chitosan hydrogel , durian leaf powder , neem saw dust, and fly ash can also have been employed for this purpose.

II. EXPERIMENTAL SECTION

2.1 MATERIALS AND METHODS

2.1.1 Preparation of the adsorbent

After separation of the gel of Indian Borage wastes, the remaining wastes were carefully washed with deionized water to remove impurities and surface adhered particles andthen were dried in an electrical oven until constant weight at 150°C for 24 hours. Thedried wastes were crushed by a laboratory mill to obtain a particle size in the range of300 to 600 μm. Besides, particles were carbonized in a furnace at 550°C for 20 minutes. Finally, activated carbon was dried in an electrical oven at 105°C for 12 hours and was crushed and sieved to obtain a uniform particle size of 40-mesh for sorption experiments.

2.1.2 Preparation of the dye solutions

In this study, Indian Borage wastes were collected from suburban farms. Chemical substances including methylene blue, sulfuric acid and sodium hydroxide were purchased from Market. The pH of the solution was adjusted with diluted and concentrated sulfuric acid and sodium hydroxide solutions using a digital pH-meter. The other chemicals used in this study were analytical grade reagents. The stock solution of 1000 mg/L MB was prepared and the working concentrations

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were obtained with dilution of the stock solution. The solutions of the adsorbent and adsorbate were mixed using an orbital shaker at 150 rpm.

2.1.3 Characterization and Analysis

The surface morphology of activated carbon before and after the sorption process was characterized under a vacuum of a scanning electron microscope. Elemental analysis of Indian Borage wastes- based activated carbon (AV-AC) was performed using a Heraeus elemental analyzer. The concentrations of MB in the solution phases were determined by a UV-Vis spectrophotometer at maximum wavelengths of 665 nm.

2.1.4 Determination of pHzcp

The pH at the zero point charge (pH_{zcp}) for the activated carbon synthesized from Indian Borage wastes was determined by preparation of 50 mL of 0.01 M NaCl solution in a series of 100mL Erlenmeyer flasks. The initial pH values of the NaCl solution were adjusted, as initial pH (pH_i), between 2 to 12 by adding H_2SO_4 (0.1 M) or NaOH (0.1 M) solution. Then, sufficient amounts of adsorbent were poured into each flask and the suspensions were mixed by a mechanical shaker for 24 hours at 200 rpm. After this period, the solutions pH was measured as final pH (pH_f). The pH_{zcp} was determined by plotting the difference between pH_f and pH_i values ($pH_{zcp}=pH_f - pH_i$) versus pH_i . The contacting local of the resulting curve with abscissa given the pH_{zcp}, the point at which pH is equal to zero.

2.1.5 Batch Adsorption Study

The batch sorption system was applied to identify the influence of different parameters including contact time (0 - 80 minutes), pH (2 - 12), adsorbent dosage (1 - 10 g/L), and initial content of pollutants (30 - 110 mg/L) on the sorption of MB by AV-AC from synthesized wastewater. All of the adsorption experiments were carried out at room temperature (25°C) and agitated at 200 rpm with 100 mL pollutant solution in a 250 mL Erlenmeyer flask. After the adsorption process, the mixture of adsorbate and AV-AC was filtered using a fiberglass paper. The sorption experiments were carried out in duplicates and the average amounts were considered. The uptake capacity and percentage of MB was computed by Equations 1 and 2.

Equation 1.

$$q_e = \frac{(C_0 - C_e) \times V}{m}$$

Equation 2.

$$Sorption\,(\%) = \frac{C_0 - C_e}{C_0} \times 100$$

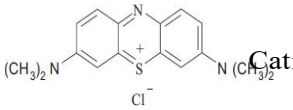
Generic Name	Scientific Name	Chemical Formula	Chemical Structure	Nature	λ max(nm)
Methylene Blue	Basic Blue 9	$C_{16}H_{18}N_3C_1S$		Cationic	665

Figure 1 The Physical and Structural Characteristics of Methylene Blue

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Where q_e (mg/g) is the equilibrium uptake capacity per gram AV-AC. The parameters of C_0 and C_e (mg/L) are the initial and equilibrium concentrations, respectively (19). Also, V (L) is the volume of the solution and m (g) is the adsorbent mass (21).

III. RESULT & DISCUSSION

3.1 Characterization

Figure 2 are show the surface morphology of the sorbent before and after the MB sorption from liquid effluent. As indicated, the original activated carbon hascavities that are more irregular, have fine open pores, uneven structure and a relatively uniform pore size distribution.

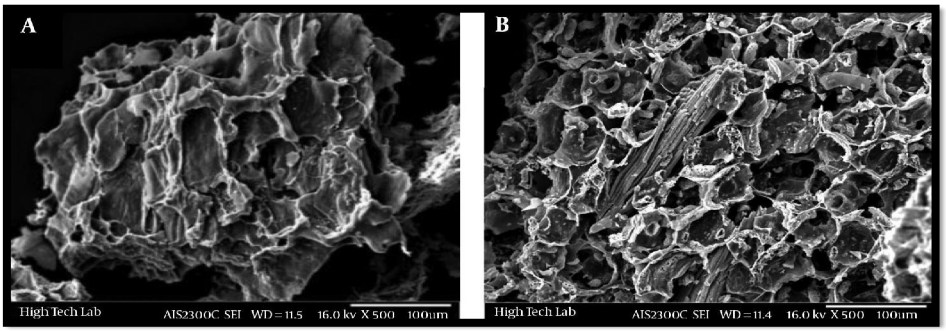

Figure 2. Scanning Electron Microscopy Image of Adsorbent (A) Before and (B)After the Sorption

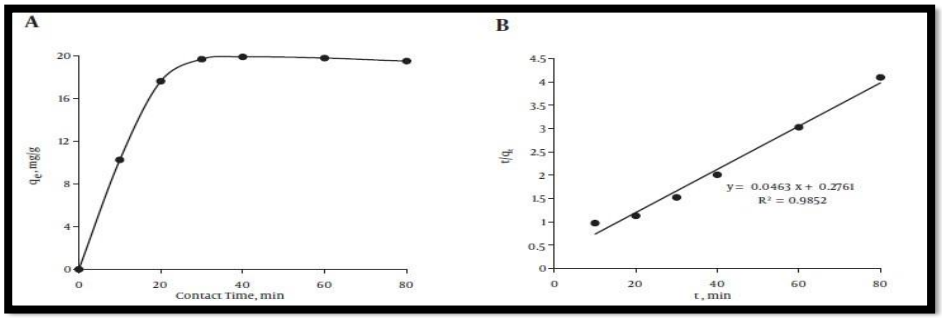

Figure 3. A, Effect of contact time on sorption capacity (dye concentration = 50mg/L, adsorbent dose = 2 g/L, and ph = 7) and; B, pseudo-second-order kinetics

Table 2. Parameters of Langmuir and Freundlich Isotherms Obtained From thePresent Study

Adsorbate	Langmuir Isotherm				Freundlich Isotherm		
	Q_m, mg/g	B, l/mg	R^2	R_L	K_f, l/g	n	R^2
MB	129.87	0.014	0.981	0.58	3.16	1.56	0.984

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Table 3. Comparison of Maximum Uptake Capacity of Methylene Blue by Indian Borage Wastes-Based Activated Carbon and Other Adsorbents.

Adsorbent	Qmax	Ref.
Neem saw dust	3.62	(30)
Fly ash	5.71	(31)
Coir pith carbon	5.87	(32)
Silk fibroin powder	20.8	(29)
Modified-RH	66.66	(5)
Cetylpyridinium-modified montmorillonite	80.67	(33)
Carbonaceous adsorbent	92	(34)
AV-AC	129.87	This study

IV. CONCLUSION

The effect of various parameters such as contact time, pH, adsorbent dosage, and initial dye concentration was assessed on sorption. The optimum contact time in the sorption process was achieved after 40 minutes. Furthermore, the optimum pH was also obtained at pH 12. The experimental data were well fitted by pseudo- second-order kinetic and Freundlich isotherm models. The maximum monolayer adsorption capacity of MB was 129.87. The results illustrated that AV-AC as a low cost, eco-friendly, non- toxicity, and high capacity sorbent towards other sorbents can be used as an effective material for the removal of MB from aqueous solution.

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