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Research Paper Engineering

# Studies on The Removal of Blue 4 Dye from Textile Effluents Using Cotton Stem

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ABSTRACT

*Cotton stems are abundantly available and are usually discarded as an agricultural waste. Here, we describe the use of modified cotton stem as an efficient sorbent for Blue 4 dye. The amount of adsorbent and concentration of adsorbate are studied using modified cotton stem. The main objective of this study was to investigating the removal of Blue 4 dye from textile effluents by the adsorption using cotton stem. All the experiments were carried out at room temperature and neutral pH. Experimental tests were conducted in a batch process. The experimental isotherms data were analyzed using Langmuir and Freundlich isotherm models. The data was found that Langmuir isotherm model fits the data very well for the dye. The calculated dimensionless separation factor, RL indicated that the adsorption of the dye onto the adsorbent were favourable.*

Keywords : Blue 4 dye - cotton stem - adsorption- wastewater treatment

**INTRODUCTION**

Decolourization of wastewater has become one of the major issues in wastewater pollution. Most of the dyes are harmful to aquatic life in rivers where they are discharged. Since, the dye can reduce light penetration into the water thereby decreasing the efficiency of photosynthesis in aquatic plants and hence having adverse impact on their growth. Dyes also can cause severe damage to human beings, such as dysfunction of kidney, reproductive systems, liver, brain and central nervous system. The occupational exposure of workers in the textile industry is linked to a higher bladder cancer risk.(1-5) The removal of such compounds at such low levels consist a difficult problem. Among the methods employed are the adsorption onto sludge of waste water treatment plant, as well as other physico-chemical techniques as coagulation, flocculation, ozonation, reverse osmosis and adsorption on activated carbon.

Activated carbon is extensively used as efficient and versatile adsorbent for purification of water, air and many chemical and natural products. The application of high-surface carbons in gas separation, medicine and catalysis is also well known. The activated carbon produced from coconut shells and pine wood wastes have shown good mechanical strength and high adsorption capacities towards various gaseous compounds (6-7). Olive stones and almond shells are also suitable raw materials for activated carbons with high adsorption capacities, sufficient mechanical strength, and low ash contents. The narrow range of the pore size distribution in these carbons makes them suitable for selective gas adsorption.(8-9).

**METHODOLODY:**

Cotton stems were collected in clean plastic bags. These were washed in distilled water 3-4 times, dried in sunlight for a day and then kept in oven at an elevated temperature of about 65°C for 24 hr. It was later treated with sulphuric acid in the ratio 1:1 and kept at room temperature overnight and stored in a tight lid container for further studies. It was then screened through a mesh sieve with a particle size range of 180-300 μm.

**Preparation of activated carbon from adsorbents**

The adsorbent was treated with concentrated sulphuric acid in the weight ratio of 1:1 and kept for 24 hours. The so obtained black product was then kept in an air-oven at a temperature of 550°C for 12 hours. This was then rinsed with NaHCO3 and water to remove the excess acid. Washed mass was later dried at about 150°C to obtain cotton stem activated carbon (CSAC). The so obtained adsorbent was crushed to reduce the carbon size and sieved to get the product of size lower that 125 nm.

**Preparation of dye solution**

Blue 4 solution was prepared by dissolving 1g of dye in 1000mL of doubled distilled water. This solution was further diluted with double distilled water to obtain the required standard solution. Adsorption studies were performed at room temperature.

**Experimental Procedure**

Adsorption studies were performed in batch manner. Carbon was agitated with the dye solution of different concentrations. The pH of the solution was made 7. Samples were taken at specific time intervals and were centrifuged and the supernatant solution was analyzed for residual dye concentration using a UV-Visible spectrophotometer at λ = 500nm. The amount of equilibrium adsorption, qe (mg/g), was calculated by:

$$q_e = (C_o - C_e)\, v/w$$

where, Co and Ce (mg/L) are the liquid phase concentrations of dye at initial and the dry sorbent used (g).

**Calculations**

A. Initial concentration of the sample is calculated as follows

$$q_e = (C_o - C_e)\, v/w$$

Where,

qe = amount of equilibrium adsorption, (mg/g)
C0 = liquid phase concentration of dye at initial concentration, (mg/l)
Ce = liquid phase concentration of dye at equilibrium, (mg/l)
V = volume of solution, (ml)
W = mass of dry sorbent, (g)

**B. Percentage of colour removal**

$$\%\ of\ colour\ removal = \frac{C_o - C_e}{C_e}\ \text{X}\ 100$$

Where,
C0 = liquid phase concentration of dye at initial concentration, (mg/l)
Ce = liquid phase concentration of dye at equilibrium, (mg/l)

## RESULTS AND DISCUSSIONS

### Adsorption isotherms

It is important to have a satisfactory description of the equilibrium state between the two phases in order to successfully represent the dynamic behaviour of any adsorbate from solution to the solid (adsorbent) phase. Adsorption isotherm can be defined as a functional expression for the variation in adsorption of the adsorbate by the adsorbent in the bulk solution at constant temperature. The equilibrium isotherm is of fundamental importance for the design and optimization of the adsorption system for the removal of dye by adsorption. In the present study, two of the most commonly used models, namely Langmuir and Freundlich isotherms are studied for the adsorption of Blue 4. The distribution of adsorbate between the adsorbent and the bulk solution when the system is in equilibrium is important to establish the capacity of the adsorbent for adsorbing the adsorbate.

### Langmuir adsorption isotherm

The Langmuir equation correlates the amount of adsorbate adsorbed with the equilibrium aqueous concentration. The linear transformation of the Langmuir adsorption isotherm is given as,

$$\frac{C_e}{q_e} = \frac{1}{bQ_o} + \frac{1}{Q_o} C_o C_e$$

where, Ce is the equilibrium concentration of the adsorbate (mg/L), qe is the amount of adsorbate adsorbed per unit mass of adsorbent (mg/g), Q0 and b are Langmuir constants related to adsorption capacity and rate of adsorption respectively.

The Langmuir plots obtained by plotting Ce Vs Ce/qe are linear showing the applicability of Langmuir adsorption isotherm for Blue 4 dye adsorption using the adsorbent in this study. This is also evident by the best fit of the linear equation as seen from the correlation co-efficient values 'r'. The essential characteristics of Langmuir adsorption isotherm can be expressed in terms of a dimensionless constant, separation factor or equilibrium parameter 'RL' which is defined by,

$$R_L = \frac{1}{1 + bC_o}$$

where, Co is the initial concentration of the dye in mg/L and b is the Langmuir constant.

The values of the dimensionless equilibrium parameter RL, reveal that the Langmuir adsorption isotherm is favorable for the adsorption of blue 4 with the adsorbent throughout the adsorption study time.

### Freundlich adsorption isotherm

The Freundlich adsorption isotherm equation is used for determining the applicability of heterogeneous surface energy in the adsorption process. The empirical Freundlich equation is

$$\log q_e = \log K_f + n \log Ce$$

Where, Ce is the equilibrium concentration of the adsorbate (mg/L), qe is the amount of adsorbate adsorbed per unit mass of adsorbent (mg/g), Kf and n are freundlich constants.

**RL value Type of isotherm**

- RL > 1 Unfavourable
- RL = 1 Linear
- RL = 0 Irreversible
- 0 < RL < 1 Favourable

**ADSORPTION ISOTHERMS**

**Table 1 : Langmuir Isotherm Model**

Dye concentration : 10 - 1000 mg / l
Dose concentration : 0.2 g

| Sl. No | Equilibrium concentration, Ce (mg/l) | Equilibrium adsorption, qe (mg/l) | Ce/qe |
|---|---|---|---|
| 1. | 0.001 | 0.45 | 0.0022 |
| 2. | 0.002 | 0.40 | 0.0050 |
| 3. | 0.003 | 0.35 | 0.0085 |
| 4. | 0.004 | 0.30 | 0.0160 |
| 5. | 0.005 | 0.25 | 0.0250 |

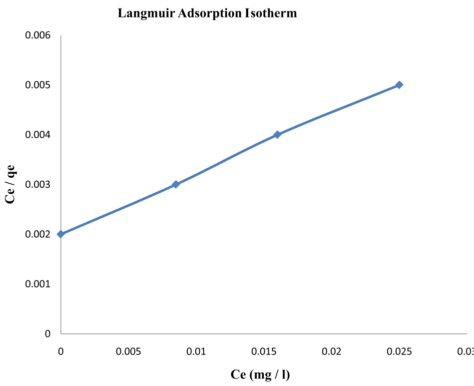


Fig:1 Langmuir isotherm for Blue 4 sorption onto the modified cotton stem at room temperature(23oC)

**ADSORPTION ISOTHERMS**

**Table 2 : Freundlich Isotherm Model**

Dye concentration : 10 - 1000 mg / l
Dose concentration : 0.2 g

| Sl. No | Log qe | Log Ce |
|---|---|---|
| 1. | -0.346 | -3.00 |
| 2. | -0.397 | -2.69 |
| 3. | -0.522 | -2.52 |
| 4. | -0.602 | -2.39 |
| 5. | -0.690 | -2.30 |

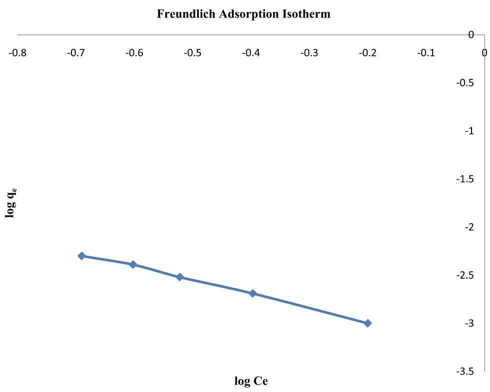


Fig:2 Freundlich isotherm for blue 4 sorption onto the modified cotton stem at room temperature

**Table 3 : Langmuir and Freundlich isotherm constants and correction coefficients for the sorption of blue 4**

| Isotherm | Cotton Stem |
|---|---|
| Langmuir | |
| B | 0.0022 |
| R2 | 0.9900 |
| Freundlich | |
| N | 0.1580 |
| R2 | 0.9720 |

## CONCLUSION

The present work establishes that cotton stem is highly efficient in the adsorption of Blue 4 dye. Values of the equilibrium parameter (RL) from Langmuir isotherm and n values from the Freundlich isotherm indicate that the adsorption process is favourable for the dye. The equilibrium data also fit well with the Freundlich adsorption isotherm for the adsorbent and adsorbate (dye) studied. The amount of blue 4 sorbed was above 90%. Cotton stems are very cheap, easily available and renewable. This study revealed that this biosorbent could be used as a tool for the development of low-cost biomaterial for the treatment of coloured dye.

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