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Studies on the Removal of Red Industrial Dye Using Teak Leaf, Maize Corn and Babool Tree Bark Carbons –A Comparison

N. KANNAN*, A. VIJAYAKUMAR and P. SUBRAMANIAM

*Department of Chemistry,
ANJA College (Autonomous), Sivakasi – 626 124, India.
Department of Chemistry,
Aditanar College of Arts and Science, Tiruchendur – 628 216. India.
dr_n_kannan@yahoo.co.in

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Abstract: Activated carbons prepared from teak leaf (TLC), maize corn (MCC) and babool tree bark (BTBC) were used to study adsorption of red industrial dye under various experimental conditions. Effect of various experimental parameters such as initial concentration, adsorbent dosage, particle size, contact time and initial pH of solution was studied. Batch adsorption studies were carried out at room temperature (30$\pm$1^{o}C). Adsorption parameters were modeled by Freundlich and Langmuir isotherm models. Adsorption data were fitted with the Natarajan and Khalaf, Lagergren and Bhattacharya -Venkobachar equations. The high value of 21.28 was obtained from Langmuir plot indicates maize corn carbon (MCC) is the best low cost adsorbent. The adsorption process followed first order kinetics, with intra-particle diffusion as one of the rate limiting steps

Keywords: Red industrial dye, Teak leaf carbon, Maize corn carbon, Babool tree bark carbon, Langmuir, Fruendlich isotherms, Adsorption kinetics.

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Introduction

Dyes are widely used by textile industries to color their products. One of the major problems concerning textile wastewater is colored effluent. This wastewater contains a variety of organic compounds and toxic substances, which are harmful to fish and other aquatic organisms. Therefore, the treatment of effluent containing such dye is of interest due to its esthetic impacts on receiving waters.

Adsorption processes using activated carbons are widely used to remove pollutants from wastewaters. However, commercially available activated carbon which is widely used as adsorbent is expensive. The advantage of using agricultural by-products as raw materials for manufacturing activated carbon is that these raw materials are renewable, potentially less expensive to manufacture and has large percentage of carbon. Researchers have studied the production of activated carbon from plum kernels[1], cassava peel[2], bagasse[3], jute fiber[4], rice husks[5], olive stones[6], rice bran[7], date pits[8], fruit stones and nutshells[9].

Critical reviews of low cost adsorbents used for waste and waster water treatment also reported[10-12]. The main objective of the present study was to develop a low cost and efficient adsorbent for waste water treatment technology by studying the capacities of activated carbons prepared from teak leaf (TLC), maize corn (MCC) and babool tree bark (BTBC) for adsorptive removal of red industrial dye by adsorption.

Experimental

The red dye material was collected locally from a match industry (λ_{max} 554 nm). Concentrated sulphuric acid (LR; specific gravity: 1.82) was used. Dried teak leaf, maize corn and babool tree bark were collected locally (Tamilnadu), cleaned, dried, cut into small pieces, carbonized and kept at ambient temperature (30 $\pm$ 1 ^{o}C) for 24 h and heated to 363 K in a hot air-oven for 6 h washed with distilled water several times free of acid and then dried at 80 ^{o}C, sieved and preserved for further studies. Batch adsorption experiments were carried out. The amount of dye present in the solution after the adsorption was obtained from the calibration curve.

Results and Discussion

The effect of initial concentration of dye on the percentage removal of dye was studied (Table 1). It was observed that the percentage removal of dye exponentially decrease with increase in the concentration of dye solution. This is because at lower concentration, the ratio of dye molecules to the available surface area is low, subsequently, the adsorption is high[10].

The effect of dose on the adsorption process was studied (Table 1). It was observed that the amount of dye adsorbed exponentially increase with an increase in adsorbent dosage. The increase in the percentage removal of dye is obvious due to increase in adsorbent surface area[10].

The effect of initial pH of the medium on the percentage removal of dye was studied (Table 1). The dye removal was found to be maximum in acidic medium. This may be due to the surface functional groups and nature of dye[10].

Table 1. Extent of removal of dye by TLC, MCC and BTBC at 30 $\pm$ 1 ^{o}C.

Adsorbent	TLC	MCC	BTBC
Adsorbate variation	68.94-58.17	95.87-75.51	88.23-71.92
16.0 – 24.0 ppm	(0.0110-0.0093)	(0.0153-0.0121)	(0.0141-0.0115)
Adsorbent variation	43.25 – 77.68	70.75-97.65	68.60-85.80
0.06 – 0.14 g	(0.0086-0.0155)	(0.0141-0.0195)	(0.0137-0.0171)
pH variation	92.78-77.05	100.00-81.35	98.33-75.35
4.0 – 11.0	(0.0186-0.0154)	(0.0200-0.0163)	(0.0197-0.0151)
Particle size variation	64.25-21.25	91.20-49.50	75.50-68.75
< 75µ – < 250 µ	(0.0128-0.0042)	(0.0182-0.0099)	(0.0151-0.0138)
Time variation	50.60-73.25	58.00-91.58	60.75-78.55
5-180 min	(0.0101-0.0146)	(0.0116-0.0183)	(0.0122-0.0157)

** Amount adsorbed (q) value is given in the parenthesis*

The effect of particle size on the percentage removal of dye was studied (Table 1). From the data observed it is clear that the percentage removal of dye was maximum in <75 µ of adsorbent particle size. But, very low particle size of adsorbent leads to other problems like clogging *etc*[10].

The effect of contact time on the adsorption process was studied (Table 1). The uptake and unadsorbed dye concentrations at the end of 60 min., are given as the equilibrium values[10].

Adsorption isotherms

In order to analyse adsorption data, the Freundlich and Langmuir adsorption isotherms[11] were employed.

A plot of (C_e/q_e) *vs.* C_e was found to be linear with (1/ab) value as the intercept and (1/a) value as the slope. The applicability of Langmuir isotherm indicates the formation of mono-layer and also nature of adsorption process.

Further the essential characteristics of the Langmuir isotherm can be described in terms of a dimensionless constant *viz.*, separation factor or equilibrium parameter, R_L, which is defined by the equation[10]:

$$R_L = [1/ (1+ bC_i)]$$

where, b is the Langmuir (L mg^{-1}) and C_i is the optimum initial concentration of dye (ppm).

The fractional value of R_L (0.089, 0.031 and 0.020) indicates the adsorbtion process is favourable. (Table 2) The 'a' value obtained is maximum (21.28) for maize corn carbon (MCC). Therefore maize corn carbon (MCC) is the best low cost adsorbent.

Table 2. Adsorption isotherm data estimated for the removal of dyes from waste water

Adsorbent	TLC	MCC	BTBC
Fruendlich isotherm			
1/n	0.300	0.228	0.167
K	0.102	0.029	0.132
r	0.983	0.967	0.934
Langmir isotherm			
1/ab	0.130	0.030	0.025
1/a	0.067	0.047	0.055
a	1.092	21.28	18.18
R_L	0.089	0.031	0.020
r	0.989	0.999	0.997

Kinetics of adsorption

For the kinetic study of the adsorption process under consideration, the following equations such as Natrajan and Khalaf Lagergren, and Bhattacharya Venkobacher were employed:

The linear graphical plots between the values of (i) $\log C_i/C_t$ and time (ii) log (q_e- q_t) and time and (iii) log (l-U(t)) and time, indicate the applicability of the above kinetic equations and the first order nature adsorption process. The correlation co-efficient values (0.989-0.996) and k values obtained are given in Table 3.

The possibility of intra-particle diffusion was explored by using the following intra-particle diffusion model[14].

$$q_t = k_p\, t^{1/2} + C$$

The k_p values are calculated and given in Table 3. The results indicate the presence of intra-particle diffusion process[14] as rate determining step.

Table 3. Kinetics of adsorption of dye by TLC, MCC and BTBC.

Adsorbent	TLC	MCC	BTBC
Natrajan and Khalaf equation			
10^3 k_{ad}	9.489	8.420	7.116
r	0.992	0.993	0.996
Lageren equation			
10^2 k_{ad}	2.340	6.607	2.901
r	0.994	0.996	0.994
Bhattacharya and Venkobachar equation			
10^2 k_{ad}	2.314	6.606	2.904
r	0.991	0.989	0.994
Intra Particle Diffusion model			
10^1 k_p	0.175	0.339	0.116
r	0.993	0.997	0.998
log (%Removal) *vs.* log (Time)			
Slope			
Intercept	0.152	0.029	0.065
r	1.590	1.069	1.735
	0.992	0.996	0.974

The correlations of the values of log (% removal) and log (time) also resulted in linear relationships, as evidenced by r-values close to unity (Table 3). The divergence in the value of slope from 0.5 indicates the presence of intra-particle diffusion process as one of the rate limiting steps, besides, many other processes controlling the rate of adsorption, all of which may be operating simultaneously[14].

Conclusion

Results showed that the adsorbent TLC, MCC and BTBC could be used for the removal of dye over wide range of concentrations. In acidic medium the extent of dye removal was maximum. Adsorption data obtained were well correlated with Fruendlich and Langmuir isotherms. The kinetic equations showed that the adsorption obey first order kinetics, with intra particle diffusion as one of the rate determining steps.

References

1. Wu F C, Tseng R L and Juang R S, *J Hazard Mater.*, 1999, **B69,** 287-302.
2. Rajeshwarisivaraj S, Sivakumar S, Senthilkumar P and Subburam V, *Bioresour Technol.*, 2001, **80,** 233-235.
3. Tsai W T, Chang C Y, Lin M C, Chien S F, Sun H F and Hsieh M F, *Chemosphere* 2001, **45,** 51-58.
4. Senthilkumar S, Varadarajan P R, Porkodi K and Subbhuraam C V, *J Colloid Interf Sci.*, 2005, **284,** 78-82.
5. Yalcin N and Sevinc V, *Carbon*, 2000, **38,** 1943-1945.
6. Sheikh A H and Newman A P, *J Anal Appl Pyrol.*, 2004, **71,** 151-164.

7. Hashemian S, Dadfarnia S, Nateghi M R and Gafoori F, *Afr J Biotechnol.,* 2008, **7(5),** 600-605.
8. Girgis B S and Hendawy A A, *Micropor Mesopor Mater.,* 2002, **52,** 105-117.
9. Aygun A, Yenisoy-Karakas S and Duman I, *Micropor Mesopor Mater.*, 2003, **66,** 189-195.
10. Kannan N and Meenakshisundaram M, *Dyes and Pigments,* 2002, **51,** 25-40; *Water Air Soil Pollut.*, 2002, **138**, 289-305.
11. Pollard S J T, Fowler G D, Sollars C J and Perry R, *Sci Total Environ.*, 1992, **116,** 31.
12. Mall I D, Upadhyay S N and Sharma Y C, *Int J Environ Stud.,* 1996, **51,** 77.
13. Adamson A W, Physical Chemistry of Surface, Inter Science Publ. Inc., New York, 1960, p777.
14. Deo N and Ali M, *Indian J Environ Protec.*, 1993, **13(7)** 496-508; *ibid.* **13(8),** 570-576.