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Studies on the Removal of Basic Red 29 Dye by Activated Carbon obtained from Neem Leaves (*Azadirachta indica*)

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ABSTRACT

Activated carbon was prepared from leaves of Azadirachta indica by H_3PO_4 impregnation method. The adsorption properties of activated carbon prepared from Neem precursor were evaluated by treating the dilute solutions of basic red 29 of different concentrations. Batch mode adsorption studies of activated carbon obtained from Neem on basic red 29 indicated that it could be effectively used as a low cost adsorbent. The amount of dye adsorbed per unit mass of adsorbent was found to increase from 47.58 to 143.68 mg/g on increasing the initial dye concentration from 25 to 100 mg/L. Maximum percentage of dye removal was 95.16% at equilibrium time & at an initial dye concentration of 25 mg/L. This treatment method may be used to recycle the maximum possible amount of spent sorbent for further use.

Keywords: *activated carbon, adsorbent, adsorbate, chromophores, auxochromes, desorption.*

I. INTRODUCTION

Air, water and food are the important natural resources necessary for the survival of humans on earth. Due large number of contaminants present in fresh water bodies, most of the water is not suitable for human consumption. Due to rapid growth of population, there is huge demand of industries. The industrial effluents released directly or indirectly into the fresh water bodies cause huge pollution problems. The lack of environmental awareness also leads to an increase in water pollution. The industrial wastewaters are also characterized by non-biodegradable materials including dyes, metals, aerosols, surfactants, phenols, phosphates and high BOD and COD concentrations[1]. The dyes used are mainly aromatic compounds with color imparting polar groups. The dyes are usually difficult to degrade due to their complex structures[2,13].

The color of dyes is due to the presence of chromophore groups. The most important chromophores are –N=N–,–C=C–, –C=O–, –NO2, –NO groups. Auxochromes are the electron

donating groups that can intensify the color of chromophore and increase the solubility and adherence of the dye with the fibre. Some important auxochromes are –NH2, –NHR, –NR2, –COOH, –OH, –SO3H and –OCH3 groups[3]. The conventional bio-treatment methods are not efficient to treat the dyed effluents. However, adsorption of dyes by the activated carbon is one of the most promising and convenient treatment techniques for the removal of the dyes from dyed effluents.

II. MATERIALS AND METHODS

Activated carbon was prepared from the leaves of Neem (*Azadirachta indica)*. The leaves were washed, dried and cut into small pieces of 2-3 cm size. The carbonized material was sieved into fine 300-850 μm particles. The precursor material was impregnated with boiling solution of 10 % H_3PO_4 for nearly 2 hrs and then kept for 24 hrs. At the end of 24 hrs, the supernatant was removed by decantation. The residual matter was dried and carbonized at 400 ^{0}C for half an hour in muffle furnace. The material was powdered and activated in muffle furnace at 800 ^{0}C. The activated carbon obtained was finally washed with excess of water to remove any residual acid present and then dried[4]. The activated carbon obtained from Neem leaves by H_3PO_4 impregnation method is designated as NAC_2.

ADSORPTION STUDIES OF BR29 BY NAC_2

The dye basic red 29 (BR29) was dissolved in 1000 ml of distilled water to prepare a stock solution of 1000 mg/L. Appropriate concentrations of the stock solution were obtained by dilution method.

Table1.1 Details of selected dye (BR29) for the adsorption studies

Selected Dye	Molecular formula	Molecular weight, g/mol	λ_{max} nm
Basic Red 29	$C_{19}H_{17}ClN_4S$	**368.88**	**511**

Batch Adsorption Studies For Br29

The batch mode adsorption studies were carried out by varying the initial dye concentration, initial pH and temperature. 100 mg of adsorbent was agitated with 200 mL of aqueous dye solution. The agitation was carried out by keeping the contents of flask in a temperature controlled orbital shaker. The mixture was then withdrawn at specified time intervals and centrifuged at 5000 rpm for 10 minutes. The un-adsorbed supernatant was further analyzed for the residual dye concentrations using UV-visible spectrometer (Elico: BL-198) by fixing λ_{max} at 548 nm as the absorption wavelength.

Batch Desorption Studies

At the end of adsorption experiments, the activated carbon loaded with dye was washed with distilled water to remove any un-adsorbed dye from it. 500 mg of dye loaded activated carbon was centrifuged with 50 mL of distilled water at 300 rpm. The supernatant liquid was removed at several pH values. The desorbed dye solution was estimated by the adsorption studies[6].

III. RESULTS AND DISCUSSION

Batch Mode Adsorption Studies

Effect of agitation time and initial dye concentration on adsorption of BR 29 by NAC_2

Tables 2.1 to 2.4 show the data for the adsorption of BR29 on NAC_2 as a function of contact time. Figure 1 shows the effect of initial dye concentration & contact time on the removal of BR29 by NAC_2. Due to the availability of more number of adsorption sites on the surface of adsorbent, rapid uptake of the dye was seen during the initial 30 minutes of contact time. The adsorption reached the equilibrium at around 80 minutes for the ranges of concentrations studied. The uptake of dye increased from 47.58 to 143.68 mg/g due to the increase in its concentration from 25 to 100 mg/L. Maximum percentage of dye removal was 95.16% at equilibrium time & at an initial dye concentration of 25 mg/L. The reason for the increased adsorption of dye may be the minimum competition of solute molecules at lower dye concentration[7,8].

The smooth adsorption curves obtained suggest the possible monolayer coverage of dye molecules on the surface of the activated carbon. Similar behavior has been reported for the adsorption of Malachite Green by mango bark & Neem bark powder[8-10].

Effect of temperature on the adsorption of Basic Red 29 by NAC_2

The adsorption of BR29 on NAC_2 at temperatures of 30, 40 and 50°C with a fixed initial dye concentration of 50 mg/l is represented in Figure 2. The percentage of BR29 adsorption by NAC_2 increased from 84.76 to 89.54 % as the temperature was increased from 30 to 50°C. This increase in uptake with increase in temperature indicates that adsorption of BR29 by NAC_2 is endothermic in nature. The increase in temperature may increase the ionic mobility of large sized dye cation. Further, the increase in temperature may cause a swelling effect in the internal structure of the carbon which makes the large dye to penetrate more[11]. Similar results were reported for the adsorption of Malachite Green dye on rubber seed coat based activated carbon.

Table 2.1: Effect of agitation time & initial dye concentration on adsorption of BR29 dye

Time (min)	Final Concentration, C_t (mg/L)	Dye adsorbed (%)	Amount of dye adsorbed q_t, mg/g
0	25.0	0.0	0.0
5	16.98	32.08	16.04
10	11.79	52.84	26.42
15	8.68	65.28	32.64
20	7.52	69.92	34.96
30	6.31	74.76	37.38
40	5.16	79.36	37.68
50	4.55	81.80	40.90
60	3.63	85.48	42.74
70	2.78	88.88	44.44
80	1.21	95.16	47.58
90	1.21	95.16	47.58
100	1.21	95.16	47.58

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110	1.21	95.16	47.58

Initial concentration of dye= 25 mg/L pH=8.58 Temperature= 30 ^{o}C

Table 2.2: Effect of agitation time & initial dye concentration on adsorption of dye

Time (min)	Final Concentration, C_t (mg/L)	Dye adsorbed (%)	Amount of dye adsorbed q_t, mg/g
0	50.0	0.00	0.00
5	35.72	28.56	28.56
10	31.10	37.80	37.80
15	25.25	49.50	49.50
20	23.46	53.08	53.08
30	17.83	64.34	64.34
40	15.16	69.68	69.68
50	13.32	73.36	73.36
60	11.69	76.62	76.62
70	10.71	78.58	78.58
80	8.56	82.88	82.88
90	7.62	84.76	84.76
100	7.62	84.76	84.76
110	7.62	84.76	84.76

Initial concentration of dye= 50 mg/L pH=8.54 Temperature= 30 ^{o}C

Table 2.3: Effect of agitation time & initial dye concentration on adsorption of dye

Time (min)	Final Concentration, C_t (mg/L)	Dye adsorbed (%)	Amount of dye adsorbed q_t, mg/g
0	75.0	0.0	0.0
5	58.23	22.36	33.54
10	47.95	36.07	54.10
15	43.63	41.83	62.74
20	38.56	48.59	72.88

30	31.73	57.70	86.54
40	27.92	62.78	94.16
50	26.64	64.48	96.72
60	23.72	68.37	102.56
70	20.53	72.63	108.94
80	19.21	74.39	111.58
90	19.21	74.39	111.58
100	19.21	74.39	111.58
110	19.21	74.39	111.58

Initial concentration of dye= 75 mg/L pH=8.54 Temperature= 30 ^{o}C

Table 2.4: Effect of agitation time & initial dye concentration on adsorption of BR29 dye

Time (min)	Final Concentration, C_t (mg/L)	Dye adsorbed (%)	Amount of dye adsorbed q_t, mg/g
0	100	0.00	0.00
5	78.24	21.76	43.52
10	69.12	30.88	61.76
15	62.72	37.28	74.56
20	58.91	41.09	82.18
30	52.03	47.97	95.94
40	45.21	54.79	105.58
50	42.26	57.74	115.48
60	36.62	63.35	126.76
70	32.52	67.48	134.96
80	29.22	70.78	141.56
90	28.16	71.84	143.68
100	28.16	71.84	143.68
110	28.16	71.84	143.68

Initial concentration of dye= 100 mg/L pH=8.54 Temperature= 30 ^{o}C

Table 4.2.9: Effect of agitation time & temperature on adsorption of BR29 dye

Time (min)	Final Concentration, C_t (mg/L)	Dye adsorbed (%) 30^0C	Dye adsorbed (%) 40^0C	Dye adsorbed (%) 50^0C
0	50.0	0.00	0.00	0.00
5	25.96	28.56	39.58	48.08
10	18.89	37.80	49.54	62.22
15	17.76	49.50	56.88	64.48
20	15.63	53.08	60.56	68.74
30	13.21	64.34	66.90	73.58
40	10.75	69.68	74.44	78.50
50	8.82	73.36	77.18	82.36
60	7.53	76.62	80.66	84.94
70	6.56	78.58	83.16	86.88
80	5.23	82.88	85.96	89.54
90	5.23	84.76	85.96	89.54
100	5.23	84.76	85.96	89.54

Initial concentration of dye= 50 mg/L pH=8.54

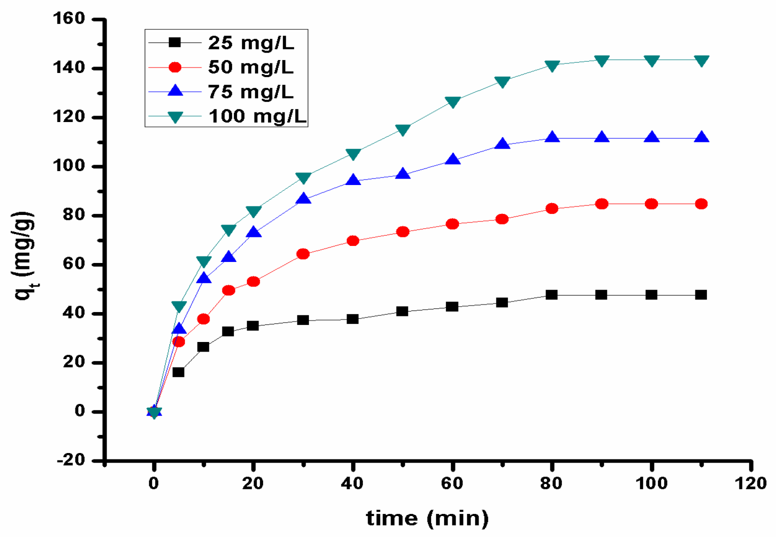

Fig 1: Amount of dye (BR29) adsorbed versus time at different initial concentrations.

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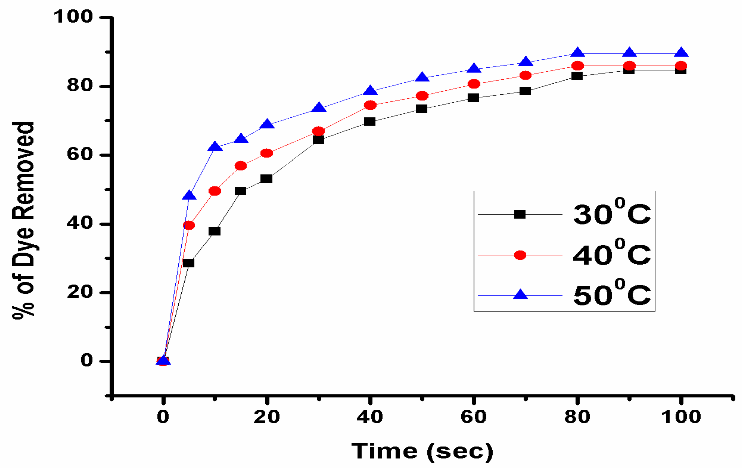

Fig 2: Amount of dye (BR29) adsorbed versus time at different temperatures.

Desorption studies of Activated Carbon

Sufficient amount of dye could be desorbed from the dye loaded carbon because the adsorption process mainly involved is physi-sorption[12]. Maximum desorption was observed at a pH range of 2 to 5. High percentage of desorption observed at lower pH was due to the presence of more number of competitive H^+ ions. Desorption decreases on increasing the pH. The higher percentage of desorption at low pH helps in recycling the used adsorbent. From the desorption studies, it has been found that the dilute acid with a pH range of less than 4.0 could be effective for the regeneration of adsorbed BR29 onto NAC_2 surface.

IV. CONCLUSION

The batch mode adsorption studies of Neem activated carbon (NAC_2) prepared by H_3PO_4 on basic red 29 indicates that NAC_2 could be effectively used as a low cost adsorbent and could serve as better alternative to the commercial activated carbon. The dyed industrial effluents of textile and paper industries could be effectively treated by neem activated carbon and thus the pollution problem arising due to color could be addressed effectively. This teatment method also enables us to recycle the maximum possible amount of spent adsorbent for further use.

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