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Sorption of Reactive and Acid Dyes from Aqueous Solutions Onto Sawdust

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Abstract

The capability of sawdust for removal of Reactive Yellow (RY 1) and Acid Orange (AO2), from aqueous solutions was studied. The effect of various experimental parameters such as different treatments of sawdust, sorbent dose and pH of solution were studied. The saw dust a relatively abundant and inexpensive material was found to be effective absorbent for the removal of reactive and acid dyes from their aqueous solutions. It was found that the sawdust activated with acid have higher adsorption capacity. It has been found that at initial pH of 2 and at higher sorbent dose reactive and acid dyes were removed more effectively.

Key words : Sawdust, Adsorption, Dye removal, Sorbent dose.

Introduction

Large amount of water and chemicals were used for dyeing process in textile industries. The waste water of this process usually consist of number of contaminants including acids, bases, dissolved soliods, toxic compounds and organic dyes. The dye compounds not only esthetically are displeasing but also impede light penetration in the pans, thus upsetting the biological treatment processes within the treatment plants. In addition many dyes are toxic to some micro organisms and may cause direct destruction or inhibition of their catalytic capabilities.

Water soluble dyes such as reactive dyes and acid dyes are not easily removed in conventional physico-chemical coagulation methods, and are not biodegradable (Mohan *et al.*, 1999). A number of materials such as natural clay and activated carbon have been used as sorbent for dye removal (Acemioglu, 2004). Activated carbon is the most popular and widely used absorbent but it is expensive and its cost increase with the quality. In addition its regeneration with refractory techniques results in a 10-15% loss of the sorbent and its uptake capacity. Therefore there is a growing interest in finding low cost easily available materials for the dye removal for industrial waste (Gong *et al.,* 2007; Namasivayam *et al.*, 1998; Namasivayam *et al.*, 1996; Montanher *et al.,* 2005 and Hashemian, 2007).

Numerous studies on adsorption properties of naturally occurring and low cost adsorbents such as agricultural by products or natural fibers have been documented. Namely barley straw, tree bark, peanut hulls, human hair, waste tire rubber and moss peat (Gong, *et al.*, 2005) etc. have been reported in recent years. Studies shows that saw dust, among the low cost adsorbents mentioned, is the most promising adsorbent for removing organic dyes and some other unwanted materials from waste water. Not only is sawdust abundant but also it is actually an efficient adsorbent that is effective to many types of pollutants such as dyes, oil, salts heavy metals etc. Many agricultural by products are little or no economic value and some, such as sawdust, which are available in large quantities in lumber-mills, are often present a disposal problem. The use of sawdust for removing dyes would benefit both the environment and agriculture.

In this work we investigated the adsorption of reactive yellow and acid orange by sawdust pretreated with formaldehyde (SDF) and sulphuric acid (SDA). The influences of dye conc., adsorbent dose and pH were investigated.

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Materials and Methods

Dyes

Acid Orange (C.I = 15510; molecular weight = 328 and λ_{max} = 486) and reactive yellow dye (C.I = 18971; molecular weight = 744 and λ_{max} = 415) were used in this study. Chemical structures of dyes are shown in figure 1.

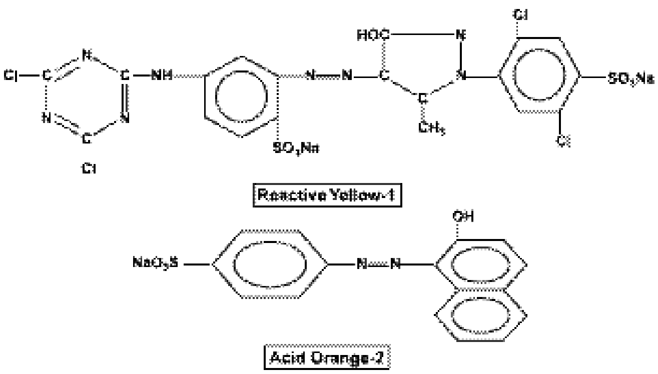

Fig. I. Structires of Dyes used in the study

Treatment of biosorbent

Sawdust collected from a local saw mill was dried in sunlight until all the moisture evaporated and then it was ground to a fine powder, which was used for adsorption experiments.

Formaldehyde treated sawdust

To polymerize and immobilize the colour and water soluble substances the ground saw dust was treated with 1% formaldehyde in the ratio of 1:5 (SD: Formaldehyde, w/v) at 50^{O}C for 4 h. The SD was filtered out with buchner funnel, washed with distilled water to remove free formaldehyde and activated at 80^{O}C in an air oven for 24 hours. The material was placed in an air tight container for further use.

Acid treated sawdust

One part of SD was mixed with one part of sulfuric acid heated in a muffle furnace for 24 hours at 150^{O}C. The heated material was washed with distilled water and soaked in 1% sodium bicarbonate solution overnight to remove residual acid. The material was dried in an oven at 105^{O}C for 24 hours and used for further study.

Preparation of dyes solution

An accurately weighed quantity of each dye was dissolved in double distilled water to prepare stock solution (500mg/lit). Experimental solutions of the desired concentrations were obtained by successive dilutions. Acid and reactive dye concentrations were determined using absorbance values measured before and after treatment at 415 and 486 nm respectively with a uv/visible spectrophotometer (Helios alpha, Spectronic unicam). Experiments were carried out at initial pH values ranging from 2 to 11; initial pH was controlled by addition of dilute HCI or NaOH solutions.

Adsorption experiments

In each adsorption experiment 100ml of dye solution of known concentration and pH was added to 400mg of SDF and SDA in a 250ml quick fit conical flask at room temperature and the mixture was stirred on an orbital shaker and 150 rpm. The samples were withdrawn from the shaker after 4 hours and absorbent was separated from the solution by centrifugation at 4500rpm for five minutes. The absorbance of the supernatant solution was estimated to determine the residual dye concentration. The experiments were done, by varying the amount of adsorbents (1 to 10g/100ml); concentration of dye solution (10 to 100mg/lit) and initial pH 2 to 11 at fixed time. The percent of sorbed dye was calculated form the following equatiopn.

$$\% \text{ sorption} : \frac{Ci - Ce}{Ci} x100$$

Where,

Ci is the absorbance of sample before addition of the sorbent. Ce is the absorbance of sample after treatment with saw dust.

Results and Discussion

Effect of pH

As the initial pH of solution can significantly influence biosorption of dyes, the effects of pH on dye sorption by the sawdust was studied first. The value of pH used ranges from 2 to 11. As elucidated in Figure 2, for both dyes, the dye removal ratio was maximum at initial pH 2. The ratios of dyes sorbed decreased as the initial pH was increased from 2 to 5, and, the dye removal ratio remained constant at pH 5. For this reason pH 2 was selected for all other experiments.

Effect of dye concentration

Result shows that Acid Orange 2 (AO) up to 60 ppm concentrations when treated with acid treated saw dust (SDA) could

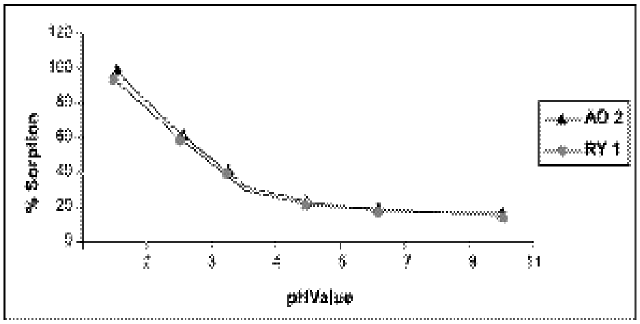

Fig. 2. Effect of pH on biosorption of AO_2 and RY 1 by acid treated sawdust (dye concentration : 100mg/lit; sorbent dose: 5g/1; contact time 24 h.

effectively remove 86.8% dye from aqueous solutions. Wheres in case of reactive yellow the adsorption capability is found 78.4% Similarly formaldehyde treated saw dust (SDF) shows 57.2% results in same concentration of Acid Orange and 48.6% in reactive yellow. Results are shown in Table I and II for acid orange and reactive yellow dyes respectively.

Effect sorbent dose

The effect of sorbent dose on the removal of dyes is shown in Fig. III. The percentages of dye sorbed increased as the

Table I. Sorption of different conc. of acid orange (AO_2) by sawdust

Sr.#	(Ci) ppm	Abs.before treatment	Abs. after treatment		(*Ce) ppm		%Sorption= $\frac{Ci-Ce}{Ci}$ x100	
			SDA	SDF	SDA	SDF	SDA	SDF
1	10	0.234	0.058	0.182	2.48	5.48	75.2	45.2
2	20	0.461	0.103	0.245	4.48	10.66	77.6	46.7
3	30	0.688	0.134	0.358	5.88	15.63	80.4	47.9
4	40	0.915	0.157	0.459	6.88	20.08	82.8	49.8
5	50	1.142	0.177	0.496	7.75	21.75	84.5	56.5
6	60	1.369	0.180	0.585	7.92	25.68	86.8	57.2
7	70	1.488	0.233	0.706	10.99	33.25	84.3	52.5
8	80	1.607	0.274	0.797	13.68	39.68	82.9	50.4
9	90	1.726	0.340	0.876	17.73	45.72	80.3	49.2
10	100	1.845	0.380	0.948	20.60	51.40	79.4	48.6

Ci:initial dye concentration (ppm); Ce: equilibrium dye concentration (ppm) in liquid phase; biosorbents: SDA, SDF sorbate: acid orange; sorbent dose: 5g; volume of acid orange dye taken: 100ml

Table II. Sorption of recative yellow (RY 1) by sawdust

Sr.#	(Ci) ppm	Abs.before treatment	Abs. After treatment		(*Ce) ppm		%Sorption= $\frac{Ci-Ce}{Ci}$ x100	
			SDA	SDF	SDA	SDF	SDA	SDF
1	10	0.234	0.076	0.151	3.25	6.46	67.5	35.4
2	20	0.461	0.138	0.291	6.32	12.64	68.4	36.8
3	30	0.688	0.207	0.420	9.03	18.33	69.9	38.9
4	40	0.915	0.248	0.544	10.88	23.80	72.8	40.5
5	50	1.142	0.293	0.648	12.85	28.40	74.3	43.2
6	60	1.369	0.325	0.703	12.96	30.84	78.4	48.6
7	70	1.488	0.334	0.781	15.75	36.75	77.5	47.5
8	80	1.607	0.395	0.861	19.68	42.88	75.4	46.4
9	90	1.726	0.445	0.995	23.22	51.93	74.2	42.3
10	100	1.845	0.496	1.081	26.90	58.60	73.1	41.4

Ci: initial dye concentration (ppm); Ce: equilibrium dye concentration (ppm) in liquid phase; biosorbents; SDA, SDF, sorbate: reactive yellow 1; sorbent dose: 5g; volume of reactive yellow I dye taken: 100 ml.

sorbent dose was increased over the range 1-10g/lit. The sorption of dyes increased from 55.7% to 98.4% for AO_2 and 54.3% to 92.6% to RY-1. Increase in biosorption with the sorbent dose attributed to increased surface area and availability of more sorption sites.

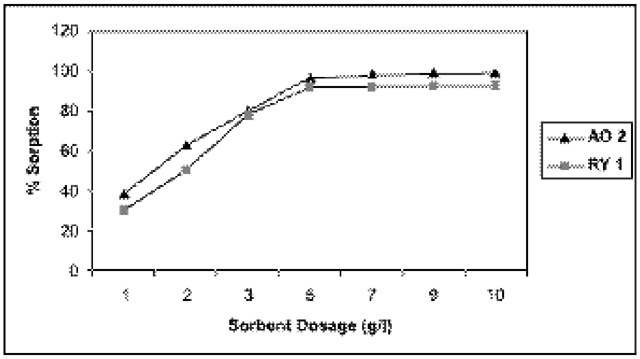

Fig. 3. Effect of sorbent dose on biosorption of AO_2 and RY 1 by powdered sawdust (dey concentration: 100mg/lit; contact time: 36 hours

Conclusion

From the above experiments it can be concluded that the adsorption capacity of acid treated sawdust is more than formaldehyde treated one for both AO_2 & RY 1. pH of the particular conc. of dye in aqueous solutin also effects significantly on the adsorption capacity of dyes. From the experimental results it is concluded that low pH is favorable for dye adsorption. Similarly sorbent dose also effects on dye adsorption and greater the sorbent dose more will be the adsorption of dye. Observation showed that sawdust is more adsorbent for the removal of acid and reactive dyes which is locally available.

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