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Removal of Congo Red (Dye) by Using Chemically Modified Sawdust

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Removal of Congo Red dye from an aqueous solution has been studied using sorbent prepared from sawdust treated with HCHO and dil. H_2SO_4. The effects of pH, contact time, sorbent dose and initial dye concentration have been studied. Effect of diverse ions has also been studied. The optimum removal is obtained at pH = 6, 90 min time of contact, 1 g of sorbent dose and low dye concentration. The amount of dye adsorbed per g of sorbent increases with increasing initial concentration. Different light metals and other ions do not affect the system.

Key Words: Congo red dye, Adsorption, Sawdust.

INTRODUCTION

Dyeing and finishing are some of the important processes in textile, paper making and leather manufacture. The effluent from dyestuff manufacture and certain other industries, like textile, pulp and paper dyeing, printing and leather, contain small proportions of dyes. Dyes find wide application in carpet and wool industries, which discharge large volumes of dye bearing effluents into natural streams.

Residual dyes are the major contributors to colour in wastewaters generated from textile and dye manufacturing industries. These dyes, though present in only small amounts, are visually detectable. Discharge of coloured wastes into natural bodies is not desirable as they are not only aesthetically displeasing but also prevent reoxygenation in receiving waters by cutting off penetration of sunlight, thus upsetting biological activity in water bodies. In addition, many dyes used as colouring materials may be toxic to some organisms.

The textile dyeing and printing industrial wastes contains a variety of organics, various kinds of basics (cationic), dispersed dyes, vinyl sulphur reactive dye and azo dispersed dyestuff, organic solvents, dye carriers like biphenyl, orthophenyl phenol, polymers, acids, alkalis and toxic metals[1]. These are the major constituents responsible for the hazardous nature of waste. Besidesues certain organic chemicals like dye carriers in the dyeing of synthetic textiles are quite stable and are non-biodegradable. They have a tendency for concentration in the tissues of aquatic animals. Also large number of carcinogenic, mutagenic and tetratogenic substances are present in this waste. The textile industrial effluent in particular has high COD, BOD and temperature. It has a bad colour due to dyeing operation and alkaline in nature[2].

In fact, most of the commercially used dyes are resistent to biodegradation[3], photodegradation[4] and even oxidising agent[5]. Unless properly treated, these dyes can significantly affect photo-synthetic activity due to reduced light penetration and may also be toxic to certain forms of aquatic life due to presence of substituent metals and chlorine[6]. Dyes have also been known to interfere with certain municipal wastewater treatment operations such as ultraviolet disinfection[7].

Various treatment methods for removal of dyes from industrial effluents like coagulation using alum, lime, ferric chloride, ferric sulphate; chemical oxidation methods using chlorine and ozone; and membrane separation methods are in vogue. Many of them do not operate at low concentrations of coloured compounds in the effluents. Many attempts have been made to remove dyes from dye effluent through chemical treatment, ozonization, electrochemical methods, filtration, etc.[8] Adsorption on alumina and carbon has been extensively studied as a waste treatment method for removal of different classes of dyes from wastewater[9–12]. Various workers worked for removal of coloring matters from dye industry effluents by using various low cost adsorbents[13, 14] and other different methods[15–19].

However, there is no single economically accepted and feasible method for removing different types of dyes. Among the various methods of colour removal adsorption currently appears to offer good potential. Commercial activated carbon (CAC) has been widely used as an adsorbent in food, beverage, pharmaceuticals, chemical and other industries as well as in municipal water supply and has become the standard adsorbent for water industries. The main drawback with the use of activated carbon seems to be its initial high cost, recharging and regeneration expenses. Conventional regeneration methods include steam heating or incineration in hot air stream. Carbon losses could be very high, due to combustion of the material. Further it is difficult to procure CAC in developing countries like India. Therefore the sawdust obtained from the local coir industry for the adsorption of congo red dye which is widely obtained from the various kinds of textile dyeing industrial wastes has been used.

EXPERIMENTAL

Preparation of sorbent: The sawdust is obtained from local coir industry was cleaned by removing various kinds of contaminants like odd shaped wood pieces, some dried leaves, small pieces of metal and dust. Initially sawdust was washed with tap water to remove the maximum possible lignin from it. Distilled water washing was made until water remains colourless. The sawdust is heated to 60°C so that moisture gets evaporated. It was ground in order to increase the surface area and sieved to 80 + 230 mesh size. This sawdust is used for the adsorption procedure.

Adsorption studies: Adsorption studies were carried out by batch adsorption process at room temperature. Synthetic samples containing the required amount of congo red were prepared by dissolving the desired amount of congo red in double distilled water and adjusted the required pH. 50 mL of the solution containing the required amount of dye was taken in 100 mL glass stoppered conical flasks for the purpose of the experimental work. To these conical flasks suitable doses of adsorbent was added and shaken thoroughly on electric shaker for the required period. The suspension was then allowed to settle, supernant solution was decanted and analyZed on UV-Vis spectrophotometer (model-118) for concentration of dye. The effect of pH, contact time, adsorbent dose, initial concentration were studied and optimiZed. Initial pH of samples was adjusted by adding 0.1 N HCl or 0.1 N NaOH. All the experiments were conducted at room temperature (30 ± 1°C).

RESULTS AND DISCUSSION

Effect of pH: The pH of the aqueous solution is an important controlling parameter in the adsorption process. The changes in pH affect the adsorptive process through changes in the extent of functional groups on the adsorbate and adsorbent. The role of hydrogen ion concentration was observed at different pH 2–10. The adsorption of dye is minimum at lower pH 2 (13%), it increases with increase in pH up to 6 (13%–5.5%). After pH 6 it gradually decreases (pH 8 = 71% and pH 10 = 67%) up to alkaline pH. However, no drastic decrease is observed from pH 6 onwards.

Effect of various adsorbent dosages: The results of experiments on the optimiZation of dosage of adsorbents are presented in Fig. 1. When the amount of adsorbent increases from 0.2 to 1.2 g/50 mL of solution, the percentage removal increases from 43% to 83.39%. The data reveal that the increase in amount of adsorbent added increases the amount of dye adsorbed and the percentage removal of dye. The increase in the amount of acid adsorbed with an increase in the dosage of adsorbent is mainly due to the enhanced total surface area of the adsorbents.

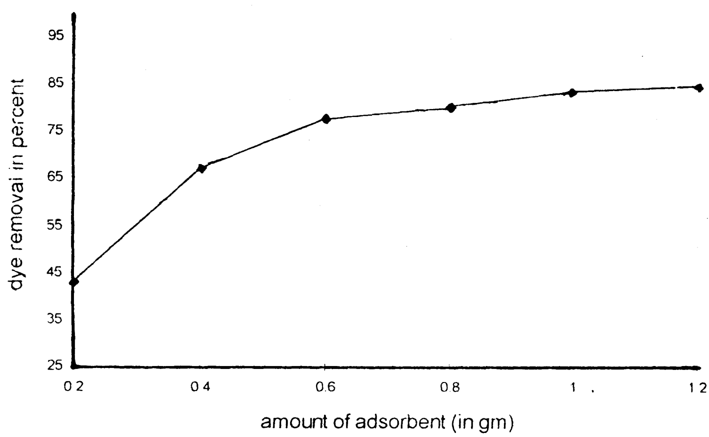

Fig. 1. Removal of congo red at different adsorbent doses.

Effect of contact time: The kinetics of adsorption of dye with sawdust was studied by estimating the effect of contact time on the percentage removal of dye. The data REVEALS that the rate of uptake of dye by the adsorbent is rapid at the initial period of contact time (30 min—67.36% removal), gradually decreases (60 min—78.35% removal) and finally becomens almost constant after 1.5 h (per cent removal from 85.39% to 86.4%). It is noted that an increase in contact time increases the percentage removal of dye from aqueous solution.

Effect of initial dye concentration: The effect of initial dye concentration on adsorption is presented in Fig. 2. The percentage of removal of dye decreases from 89.12 to 80.00 when the initial concentration increases from 5 to 25 ppm. Panday *et al.*[20, 21] have reported that the Freundlich and Langmuir adsorption isotherms applied to adsorbents for the removal of metal ions. This indicates that the adsorptoin mechanisms operating for the components are almost similar. Hence, the amount adsorbed exponentially increases while the percentage removal exponentially decreases with the increase in initial concentration of dye. This indicates that there is a reduction in the immeidiate sorption of solute owing to the lack of available active sites on the adsorbent surface, compared to the relatively large number of active sites when the initial concentration of the dye is high.

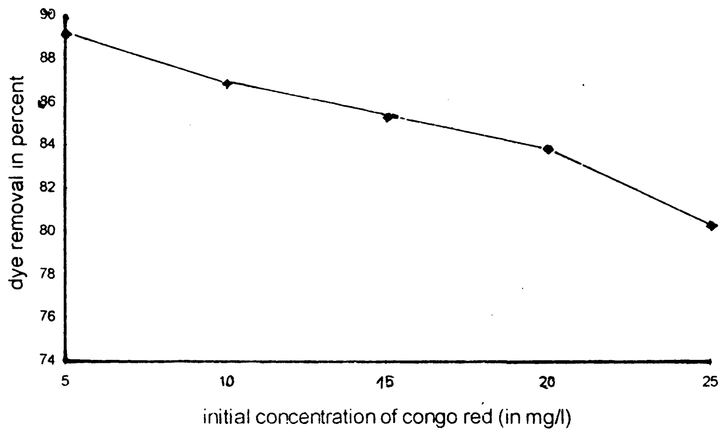

Fig. 2. Removal of congo red at different initial concentrations.

Freundlich adsorption equation and Langmuir adsorption equation have been applied to the adsorption of congó red dye by sawdust at different amounts of adsorbent. The values of Freundlich and Langmuir equation constants are shown in Table-1 and Freundlich adsorption plot for adsorption of dye by sawdust is shown in Fig. 3.

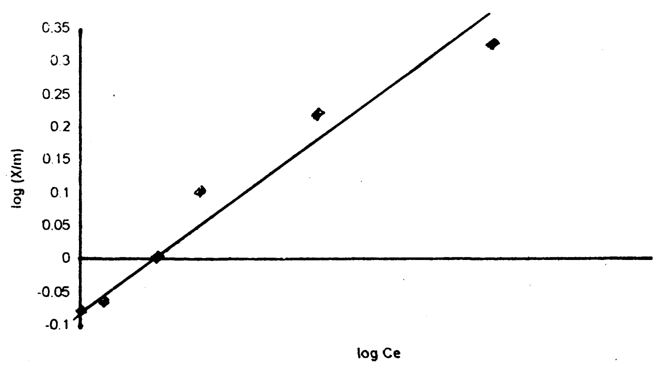

Fig. 3. Freundlich isotherm plot for adsorption of dye by sawdust.

TABLE-1
FREUNDLICH AND LANGMUIR ADSORPTION CONSTANTS

Freundlich constant				Langmuir constant			
k	n	r	r^2	b	V_m	r	r^2
5.011	0.9689	0.967	0.936	2.162	3.7	0.877	0.769

The correlation coefficient and coefficient of determination ($r = 0.967$ and $r^2 = 0.936$) for Freundlich equation are higher than those for Langmuir equation ($r = 0.877$ and $r^2 = 0.769$). Therefore for the present adsorption study it can be stated that Freundlich adsorption equation is found to be a better fit than the Langmuir adsorption equation.

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