ISSN-1680-9955

Pak. J. Anal. & Envir. Chem. Vol. 7, No. 2, (2006) 112 – 115

Tuberose Sticks as an Adsorbent in the Removal of Methylene Bluefrom Aqueous Solution

AHSAN HABIB*, ZAHIDUL HASAN, A.S.M. SHAJEDUR RAHMAN AND A.M. SHAFIQUL ALAM
Department of Chemistry, University of Dhaka, Dhaka 1000, Bangladesh
E-mail: mahabibbit@yahoo.com

Abstract
The use of low-cost and ecofriendly adsorbents has been investigated as an ideal alternative to the current expensive methods of removing dyes from wastewater. Methylene Blue was used as model compound. The effects of contact time, initial dye concentration (20, 30, 40, 50 mg/L), pH and adsorbent dosages have been studied at 25 °C. The equilibrium time was found to be 30 min for all the dye concentrations. A maximum removal of 80% was obtained at pH 11.0 for an adsorbent dose 50 mg/50 mL of 40 mg/L dye concentration. Adsorption increased with increase in pH. Maximum desorption of 50% was achieved in water medium at pH 2.0..

Keywords: Waste tuberose stick, Methylene Blue, Adsorption, Desorption.

Introduction

Dyeing industry wastewater is one of the major environmental problems in greater Dhaka district, Bangladesh. There are almost 400 dyeing industries in and around the Dhaka city and their number is constantly increasing. In the dyeing industries, above 30 – 60 L of water are consumed per kg of cloth dyed and large quantities of the effluents are released during processing. It amounts to about 16% of the total water consumed in the mills [1,2].

Color is one of the characteristics of an effluent which is easily detected and readily traced back to source. Most of the dyes are stable to biological degradation. Color affects the nature of the water and inhibits sunlight penetration into the stream and reduces photosynthetic action. Some of the dyes are carcinogenic and mutagenic [3]. The presence of chemicals like hydrogen sulphide, sulphide and sulphur dyes causes rapid depletion of dissolved oxygen, affecting aquatic life adversely [4]. Various chemicals are present in the effluent, such as phenols, benzene, toluene and other hydrocarbons, many of which are potential carcinogens [5]. Toxicity of various azo dyes especially benzidine based dyes are well known because of their mutagenicity and carcinogenicity [6]. It is rather difficult to treat dye effluents because hot and strongly colored textile dyeing wastewater is notoriously known to contain a large amount of suspended solids, high COD concentration and with a highly fluctuating pH. Hence there is a need to remove dyes from dyeing wastewater before it mixes with water bodies.

The conventional methods for removal of dyes using alum, ferric chloride, activated carbon, lime etc are not economical in the Bangladesh context. Pollard et al [7] have reviewed low cost conventional adsorbents for the treatment of industrial wastewaters. Namasivayam [8] has also reviewed non-conventional adsorbents used for the removal of dyes and heavy metals. Some works of low cost, non-conventional adsorbents have been carried out. Adsorbents used include agricultural solid wastes such as coir pith [20], banana pith [9], coconut husk [10], sawdust [11], biogas residual slurry [12], peat moss and rice hulls [13], bagasse and paddy straw [14] and industrial solid wastes

such as fly ash and coal [15], red mud [16] and Fe/Cr(III) hydroxide [17].

The objective of the present study is to explore the feasibility of wastes tuberose stick as an adsorbent for the removal of dyes present in industrial effluents. Methylene blue was selected as a model dye as an attempt to use waste tuberose sticks as an adsorbent for the removal of dye from wastewaters.

Materials and Methods

Adsorbent

Waste tuberose sticks were collected from the local flower market in Dhaka city. The collected sticks were washed with distilled water and dried in the sunlight for 4-5 days. Then the dried sticks were cut into small pieces and powered well using a crusher. The powered tuberose stick was sieved with 425 mμ sieve. The powder was then used as adsorbent. The methylene blue was obtained from E. Merck (Germany).

Batch sorption

Batch sorption studies were carried out by agitating 50 mL of dye solution of the desired concentration and 50 mg of the powder in 250 mL reagent bottole. Agitation was performed at room temperature (25 ºC) with manual shacking at different time intervals. The dye solution was separated from the adsorbent by centrifuging. The dye removal was determined spectrophoto-metrically (UV-160A, Shimadzu, Japan)) by monitoring absorbance changes at the λ_{max} (665.0 nm) of Methylene Blue. 20, 30, 40 and 50 mg/L dye concentrations were used for the adsorption studies.

Desorption studies

50 mL of 50 mg/L of dye was agitated with 200 mg of the tuberose stick powder for the equilibrium time (30 min). After centrifuging, the supernatant dye solution was discarded and the adsorbent was separated and allowed to agitate with 100 mL of distilled water at different pH (2-11) for the predetermined equilibrium time of adsorption. The desorbed dye solution was separated by centrifuging and estimated as before.

Deionized water was used through out the experiment. pH of the dye solutions was adjusted upon addition of requisite volume of sodium hydroxide (E. Merck, India) and hydrochloric acid (E. Merck, India).

Results and Discussion

Effect of agitation time and initial dye concentration

Figure 1 shows that the uptake of dye from water was concentration dependent and increased with initial concentration of Methylene Blue. The equilibrium time is the time taken for the maximum adsorption of dye onto the adsorbent surface, above which the adsorption remains constant. The equilibrium time was found to be 30 min for 20, 30, 40 and 50 mg/L of the dye concentration. The removal of dye is rapid in the initial stages of contact time and gradually decreases with lapse of time until saturation.

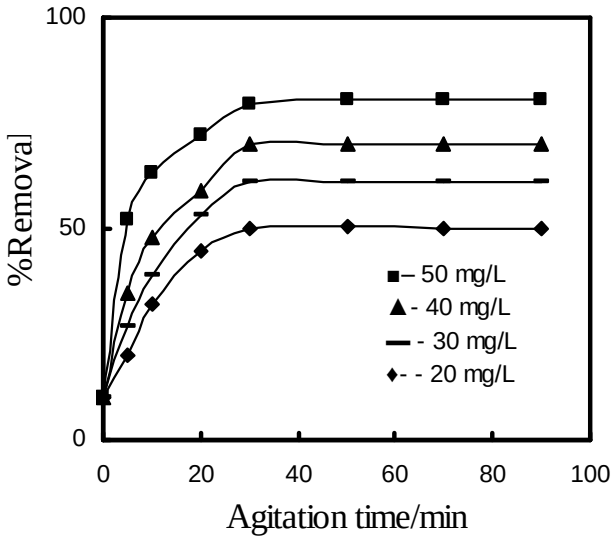

Fig. 1. Effect of agitation time on removal of Methylene Blue by tuberose sticks powder.

Effect of adsorbent dosages

Figure 2 shows the removal of dye as a function of adsorbent dosage. Increased in adsorbent dose increased the percentage removal of dye. For quantitative removal of dye from 50 mL of 30 mg/L, a maximum dosage of 200 mg is required.

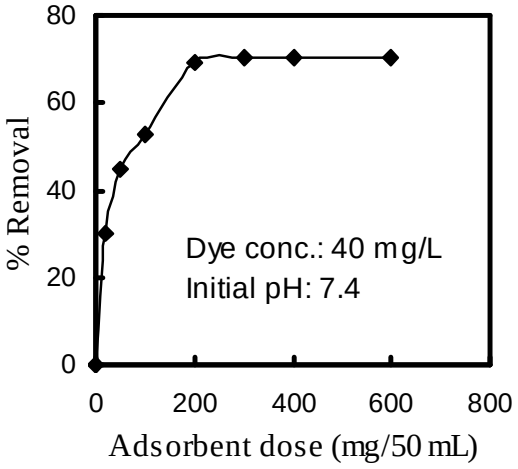

Fig. 2. Effect of adsorbent dosage on Methylene Blue removed by tuberose stick powder.

Effect of pH

Figure 3 shows the effect of pH on the removal of Methylene Blue. When initial pH of the dye solution was increased from 2 to 11, the percent removal increased from 35 to 70. With increase in pH from 2 to 6, the percent removal increased from 35 to 70. With further increase in pH to 11 there was a slight increase in percent removal (80%). Lower adsorption of Methylene Blue, a cationic dye, at acidic pH is due to the protonation at the oxygen atom of hydroxyl of cellulose since tuberose sticks contains a significant amount of cellulose. On the other hand, adsorption increases with increasing pH. This is due to deprotanation of cellulosic hydroxyl groups. Deprotonation favors the interaction of the cationic dye with the oxygen of cellulosic hydroxyl.

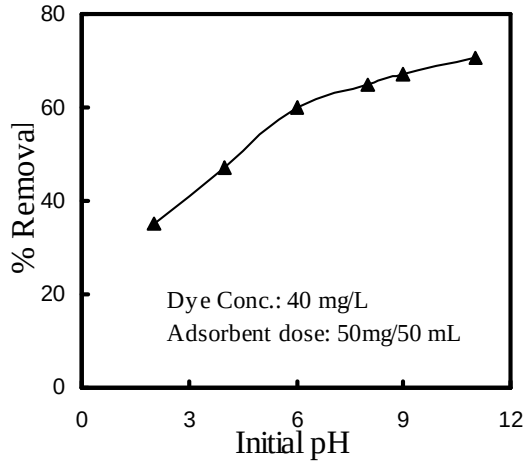

Fig. 3. Effect of pH on the removal of Methylene Blue by tuberose stick powder.

Desorption studies

Desorption studies helps to elucidate the mechanism of adsorption and recovery of the adsorbate and adsorbent. The regeneration of the adosrbent may make the treatment process economical. The percent desorption decreases with increase in pH of aqueous medium (Figure 4). This is just opposite to the pH effect since proton (H^+) has high exchange capacity compared to the large molecule Methylene Blue.

Therefore, it is concluded that tuberose stick has a suitable adsorption capacity for the removal of cationic dyes present in the industrial effluents. Moreover, the desorption study shows that the recycling of adsorbent and adsorbate may be possible.

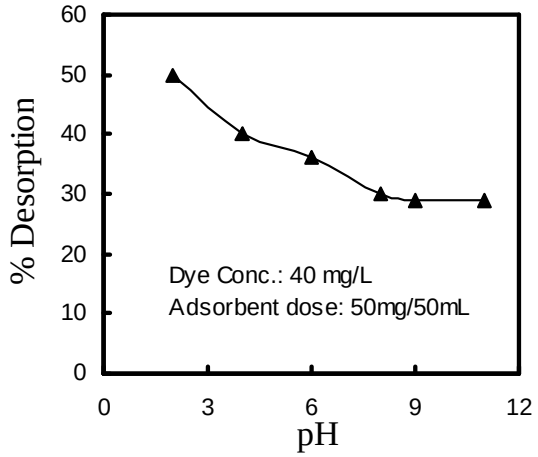

Fig.. 4. Desorption studies for Methylene Blue removal.

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