Dye Removal From Aqueous Solution by using Treated Sugarcane Bagasse at Various pH

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Abstract

The use of low cost, recycled waste and ecofriendly adsorbents has been investigated as an alternative method for replacement of currently expensive method for removing dyes from wastewater. In this study, sugarcane bagasse - an agro industry waste were used to remove the dyes from the aqueous solution in a batch reactor. The formaldehyde treated (PCSB) and sulphuric acid treated (PCSBC) sugarcane bagasse were used to adsorb methyl red at a various pH value at room temperature. Similar experiment were conducted using commercially used powder activated carbon (GAC), in order to evaluate the performance of PCSB and PCSBC. It was found that, GAC is very effective in the dye removal at any given pH. While, for both PCSB and PCSBC the initial pH value range from 6 to 10 was favorable. This study had shown that the PCSB and PCSBC could be employed and have a potential for low cost alternative in the wastewater treatment for dyes removal.

Keywords : dyes removal, adsorption, formaldehyde, sulphuric acid

Introduction

Dyes are used in a various industries, namely food, paper, carpet and others. Among these, textile industries rank first in the usage of dyes. Nowadays, about 9000 types of dyes have been incorporated in the colour index. Due to low biodegradability of dyes, the discharge of coloured wastewater from these industries had caused many significant problems, such as increasing the toxicity and COD (chemical oxygen demand) of the effluent [1].

Most of the dyes are very stable, either to photo-degradation, bio-degradation or oxdizing agents. Currently, several physical and chemical processes are used for dyes wastewater treatment. However, these processes are highly cost and not efficient for the treatment of wide range of dye wastewater [2].

The adsorption process had been proven to be the most effective method in the dyes removal. Also, the adsorption is very simple process and offers sludge free operation. Activated carbon (powdered or granular) is widely used as an adsorbent because it has excellent adsorption efficiency for organic compounds. But, it is very expensive. Furthermore, regeneration using solutions produces a small addition effluent while regeneration by refractory technique results in a 10-15% loss of adsorbent and it uptake capacity [3].

This had lead to the further studies for cheap substitution. Consequently, numerous low costs alternatives have been carried out including; waste coir pith [4], wood [5], perlite [6], flyash [7], pumice powder [8], orange peel [9], agro industrial waste [10] and Indian Rosewood (SD) [11]. The low cost, biodegradable, easily available and highly effective adsorbent are still needed.

Sugarcane bagasse is an agro-waste from the sugar production industries, which used as a fuel for the boiler, to generate heat to the factory. In this study, sugarcane bagasse is pretreated with formaldehyde and sulphuric acid. The treated sugarcane bagasse adsoprtion on the methyl red is investigated for the various initial pH at room temperature.

Approach and Method

Preparation of adsorbents

Powdered activated carbon (PAC) was supplied by BHD Laborotary Supplies, Poles England. The adsorbents was used directly without any further grinding and sieving.

Formaldehyde Treated Bagasse

The bagasse obtained was dried under the sunlight until all of the moisture evaporated. Then, it was ground to a fine powdered and sieved to a size of -80 to +230 mesh size. The ground bagasse is then treated with 1% formaldehyde (w:v) ratio of 1:5 at 50°C for 4 hour. Then, this bagasse was filtered out by using Buchner funnel. It was washed

with distilled water and was activated at 80 °C in the air oven for 24 hour.

Sulphuric Acid Treated Bagasse

One part of the bagasse was mixed with one part of the concentrated sulphuric acid and then heated in a muffle furnace for 24 hour at 150 °C. The heated bagasse was washed with distilled water and soaked in 1% sodium bicarbonate solution overnight. The bagasse then was dried in an oven at 105 °C for 24 hour and sieve to a sizeof -80 to +230 mesh unit.

Dye Solution Preparation

A stock solution of 500 mg/L methyl red was prepared by dissolving 500 mg methyl red in 1 litre of double distilled water. Experimental solution of the desired concentration was obtained by successively dilution. Table 1 shows the physico-chemical properties of methyl red. Figure 1 shows the structural formula of methyl red.

CAS No.	493-52-7
C.I. No.	13020
Chemical Formula	$C_{15}H_{15}N_3O_2$
Molecular Weight	269.31
Melting Point	179- 182 °C
Dye Content	95%
Absorption Max (pH 4.5)	523 – 526 nm
Adsorption Min (pH 6.2)	430 – 434 nm
Absorptivity (1%, 1 cm) pH 4.5	> 1330
Absorptivity (1%, 1 cm) pH 6.2	> 700
Transition Range	pH 4.2 – 6.2 Red - yellow

Table 1 shows physico-chemical properties of Methyl Red

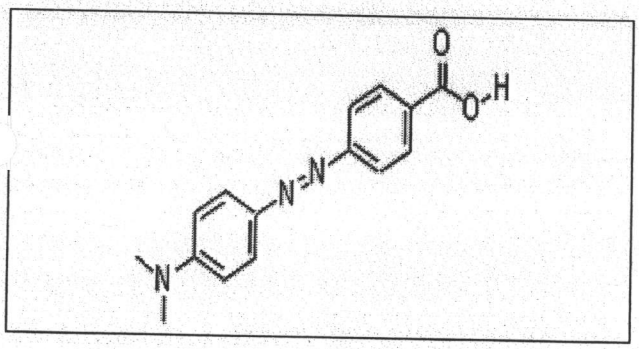


Figure 1 shows structural formula of Methyl Red

Adsorption Experiment

In each adsorption experiment, 250 mL of dyes solution of known concentration and initial pH was added to 400 mg of adsorbents in 250 mL round bottom flask at room temperature and the mixture was stirred on a rotary orbital shaker set at 160 rpm.

The sample was withdrawn from the shaker after 2 hour and saperated from the solution by centrifugation at 4500 rpm for 5 minutes.

Dyes concentration was determined by using adsorbance value measured before and after the treatment at 617 nm with UV Visible Spectrometer.

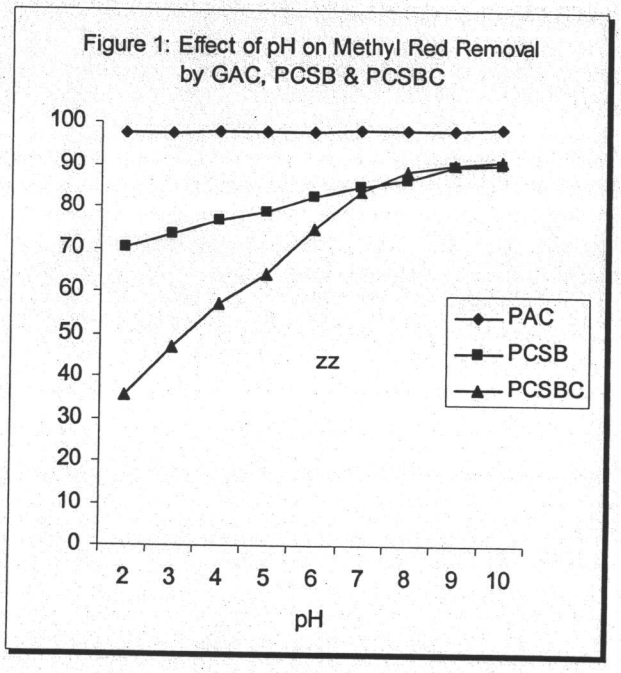
The experiment were carried out at initial pH values ranging from 2 to 13, initial pH was controlled by the addition of sodium hydroxide, NaOH or hydrochloric acid, HCl.

Result and Discussion

For the powdered activated carbon, it was found that the percentage of dye removal was not affected by pH variation. The uptake of the dyes was nearly 100% for all pH values.

For the sulphuric acid treated bagasse (PCSB), the dyes adsorption was significantly change over the pH value of 4 to 7. The lowest percentage of dye removal was recorded at pH 2 (52.2%). At the pH range 7 to 10, the percentage of removal was almost remains constant. As the pH of the solution decrease (more acidic), the number of negatively charged adsorbents site increased. This will not flavour the adsorption of the positively charge dyes cation [4]. This, however didn't applied to PAC, as it was remained almost 100% for all pH values. There might be another mode of adsorption, such as ion exchange. As the pH value increased from 9 to 13, the efficiency of the dyes removal is slightly become lessen [1]

The nearly same pattern was obtained for the formaldehyde treated sugarcane bagasse (PCSBC). The minimum percentages of removal was recorded at pH 2 (78.5) and the highest percentage recorded at pH 10. (98.7%) Figure 2 shows the variation of dyes removal for different adsorbents at various pH values.



Conclusion

The removal of methyl red from simulated wastewater by using PAC, PCSB and PCSBC has been investigated for a various pH values.

This study had shown that PCSB and PCSBC had a lower adsorption efficiency compared to GAC at any given p H value. Initial dyes concentration over the range of 2 to 6, decreased the efficiency of the dyes removal. While, the pH range 7 to 10 is optimum for the dyes removal for both adsorbents, PCSB and PCSBC.

As sugarcane bagasse is easily available in the countryside, it has potential to be used for the small scale industries which produced dyes as their effluent, after it was being pretreated with formaldehyde and sulphuric acid.

The data maybe useful for designing and fabrication of an economically cheap treatment process using batch or stirred tank flow reactors for the removal of methyl red from diluted industrial effluent.

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