Removal of Methylene Blue by Adsorption onto Activated Carbon Developed from Bristle Coir Fibre

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Abstract

The progressive increase of industrialization in Sri Lanka and other countries has resulted in continuous increase of pollution of both surface and ground waters. Methylene Blue (MB) is an acid dye that is utilized for dyeing fabric, clothing (in the batik industry), paper and leather. There is rapid increase in the amount and the dye that is thrown into the natural water bodies leading to hazardous water contamination. Traditional methods of purification have found to be not efficient in eliminating the hazardous waste found in the effluent. However, recent studies conducted using activated carbon, as an adsorbent, has proved to be successful. However, commercially available activated carbon is expensive and this study looks at the possibility of using naturally available low cost materials such as coir fibre as an activated carbon precursor.

Coconut trees are widely grown in Sri Lanka and coir, the natural vegetable fibre, is extracted from the outer husk of the coconut. Coir fibre has higher amount of lignin and its internal structure is excellent for the production of activated carbon.

The objective of this study is to prepare activated carbon from chemically treated bristle coir fibres and characterize it and to investigate the equilibrium and kinetics model of adsorption of MB dye by thus prepared activated carbon from the coir fibre.

Bristle coir fibres were collected from the coir mill from a coastal area in the North Western Province of Sri Lanka. Before subjecting the raw coir fibre to heat treatment, they were scoured (with alkaline-bio) thoroughly and washed ultrasonically (Rocker Soner 203 H / Taiwan) with distilled water to remove excess chemicals and dried at 105 ^{0}C in electrical muffle oven for 5 hours. Scoured coir fibers were grinded by using ball mill machine (Fritsch supreme line Pulverisette 7/German) at 400 rpm for 10 minutes to produce coir micro level particles. The particle size was determined by particle analyzer (Fritsch Analysette 22 Nano Tec plus / German). Bristle coir micro level particles were leached with 0.5 M KOH for one hour and coir pulp was separated by filtering. Activated carbon was prepared by one step pyrolysis by chemical treatment with 0.1 M of

Potassium Hydroxide (KOH). Scoured coir fiber particles pulp was fed in to tube furnace (Carbolite's / German) at 380 ^{0}C for fifty minutes in a nitrogen atmosphere. In order to understand the proximate analysis of adsorbent, properties such as pH, bulk density, moisture content, ash content, volatile content, and iodine number were determined using ASTM standard test methods. Activated carbon was characterized and the morphological features on the surface were observed with the Scanning Electron Microscope (SEM) and Fourier Transform Infra-Red (FTIR) (Shimatzu IR affinity- 01) spectroscopy analysis. Ultimate analyses of active carbon were done by EDX (ZEISS EVO LS 15 SEM with Oxford EDX). Adsorption studies were carried out batch wise and adsorption measurements were obtained by UV- spectro -photo meter (Shimadzu1800, Japan) at 645 nm.

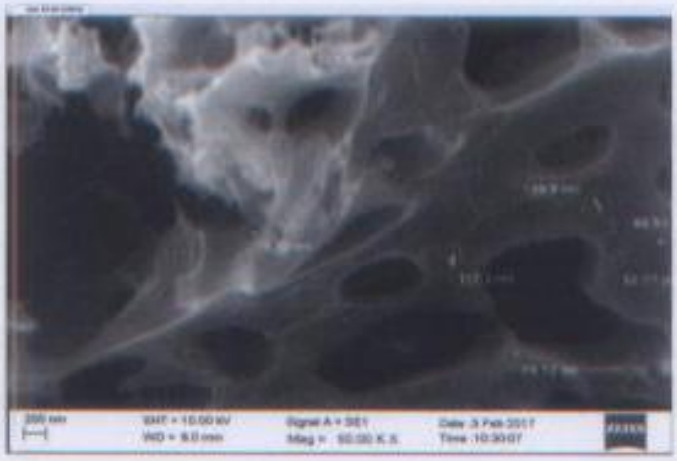

Figure 1 : SEM image of coir activated carbon

The Figure shows the micrograph of coir fibre activated carbon. From the figure it can be clearly seen that micro size pore have developed evenly in the activated carbon particles. This helps in enhancing the adsorption of Methylene blue dye. Further, dye adsorption capability depends on the number of functional groups on the surface of the activated carbon.

Presence of strong adsorption peaks in the FTIR spectra thus indicates higher number of functional groups on the surface of the activated carbon obtain from coir fibres.

Adsorption data were modeled using Langmuir - Freundlich equation. The equilibrium data was best described by Langmuir model. The kinetic data were also applied to the pseudo first-order and pseudo second-order and intra-particle diffusion models. The kinetic data followed the two kinetic models but pseudo second-order model best described the kinetics of the adsorption process. The adsorbent capacities of coir activated carbon was compared with that of the commercial coconut shell activated carbon and the results show that coir activated carbon can be effectively used for first time as a low-cost renewable adsorbent alternative to commercially available Activated carbon in effluent treatments for the removal of excess dye materials.

Keywords: Activated carbon; Adsorption; Coir; Effluent treatment; Methylene blue