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Adsorptive removal of Cyanosine from waste water using coconut husks

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ABSTRACT

A waste material – coconut husk has been used as a low cost adsorbent and its efficiency in Cyanosine sorption was compared with activated carbon. The influence of various factors such as adsorbent dose, adsorbate concentration, particle size, temperature, contact time and pH was studied. The adsorption of the dye over both the adsorbents was found to follow Langmuir and Freundlich adsorption isotherm models. Based on these models, different useful thermodynamic parameters have been evaluated. The adsorption of Cyanosine over activated carbon and activated coconut husks follows first order kinetics and the rate constants for the adsorption processes increase with temperature in the case of AC and decrease in the case of ACH.

1. Introduction

Color removal from textile effluents has been the target of great attention in the last few years, not only because of its potential toxicity, but mainly due to its visibility problems [1,2]. Among the several currently known physical, chemical and biological methods used for wastewater treatment, adsorption still continues to be most widely used and economical process [3,4]. Other advantages of adsorption are its ability to separate a wide range of chemical compounds, easy operational procedures and facilitation of recovery of costly organic and inorganic materials [5,6]. Because of these facts, the adsorption technique is being widely used for wastewater treatment. The adsorption by activated carbon, has become the water industry's standard for the reclamation of municipal and industrial wastewater to a potable water quality [7]. However due to its high cost, several workers have tried low cost materials for dyes removal [8–15]. Rice husks [16,17], fruit stones [18,19], coconut shells [20,21], fertilizer waste [22,23], fly ash [24,25], peat moss [26,27], maze cobs [28] and red mud [29] are some of the waste materials which have been fruitfully tried for this purpose.

Water-soluble reddish brown Cyanosine dye is an acid dye which is applicable to all kind of natural fibers like wool, cotton and silk as well as to synthetics like polyesters, acrylic and rayon. This is also used in paints, inks, plastics and leather. The object of the present investigation has been to evaluate the efficiency of removal of Cyanosine dye using activated coconut husks and activated carbon. Activated coconut husks are an agricultural waste material, which is easily available, cheap and economically advantageous. In the present study application of activated coconut husks for the removal of dyes from aqueous solution has been studied and activated carbon was used as a conventional adsorbent to compare the results.

2. Materials and methods

Cyanosine (Fig. 1) (2,4,5,7-tetra bromo-4,5,6,7-tetra chloro fluoresceine disodium salt) was obtained from M/s Merck and its 0.01 M stock solution was prepared in double distilled water.

Doubly distilled water was used for necessary dilutions. All reagents used in the present work were of analytical grade.

Activated carbon (AC), was from M/s Merck and used as received. All pH measurements were carried out with a decibel DB 1011 digital pH meter, fitted with a glass electrode and COD digestion apparatus (Spectra Lab-2015 S) was used for determining COD of the solutions. Absorbance measurements were recorded on a Spectronic 20D+ Thermospectronic spectrophotometer over the wavelength range 200–800 nm.

2.1. Material development

The coconut husk (CH) was cleaned, thoroughly washed with distilled water, and then dried in an oven. This dried material was then treated with hydrogen peroxide solution for 24 h to oxidize adhering organic impurities and dried at 110 °C for 1 h under vacuum. The material was grounded and sieved to desired particle sizes such as <106, 106–125, 125–180, 180–212, 212–250,

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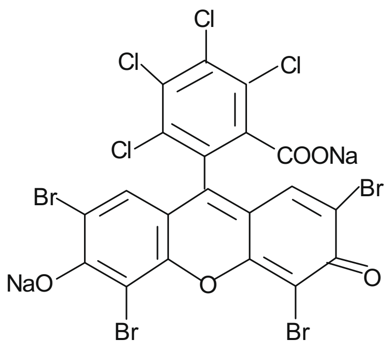

Fig. 1. Structure of Cyanosine.

250–300, >300 BSS mesh. Finally, granules of activated coconut huks (ACH) thus obtained were stored in separate vacuum desiccators until required. The activated carbon (AC) was also separated into similar particle sizes and also kept in desiccators.

2.2. Adsorption studies

Adsorption studies for both the adsorbents AC and ACH were performed by the batch technique at 30, 40 and 50 °C. For every adsorption isotherm study, a series of volumetric flasks containing equal volumes (30 ml) of adsorbate solutions at varying concentrations were employed at desired pH. These concentrations were decided after considerable preliminary investigations. An optimized amount of adsorbent of particle size 125–180 BSS mesh was then added into each flask and was intermittently agitated. When the equilibrium was thought to be established, supernatant was carefully filtered through Whatmann filter paper (No. 41) and analyzed spectrophotometrically at λ_{max} 538 nm.

2.3. Kinetic studies

Batch technique was also applied for the kinetic measurements. In airtight 100 ml conical flasks, a known amount of AC or ACH was added into 30 ml of dye solution. The flasks were then kept in a water bath maintained at a desired temperature and agitated mechanically. After a fixed time interval, the adsorbent was separated by filtration and the filtrate was analyzed spectrophotometrically to determine the equilibrium concentration of the dye. The kinetic studies were also carried out under different adsorbate concentrations.

3. Results and discussion

3.1. Characterization of adsorbent material

The AC and ACH were characterized by scanning electron microscope (SEM) shown in Fig. 2. SEM is widely used to study the morphological features and surface characteristics of the adsorbent materials which reveals surface texture and porosity of both the adsorbents.

3.2. Effect of pH

To study the influence of pH on the adsorption capacity of AC and ACH for Cyanosine dye, experiments were carried out using different initial solution pH values, varying from 3.6 to 9.2. The obtained results are presented in Fig. 3, which shows that the adsorption capacity increases significantly with a decrease in the pH. Cyanosine dye releases colored dye anions in solution. A higher sorption capacity of the adsorbents obtained at a lower pH may be due to electrostatic attraction between these negatively charged dye anions and the positively charged adsorbent surface thereby, increasing the dye adsorption [30]. The maximum removal of Cyanosine dye with AC and ACH was observed at pH 3.6.

3.3. Effect of adsorbent dose

Adsorption was carried out with different adsorbent dosage at different temperatures. The amount of the dye removal by adsorption on AC and ACH are presented in Figs. 4 and 5. The dose of adsorbent was varied from 0.06 to 0.4 g/l for AC and from 3.3 to 23.3 g/l for ACH, at fixed pH, temperature and adsorbate

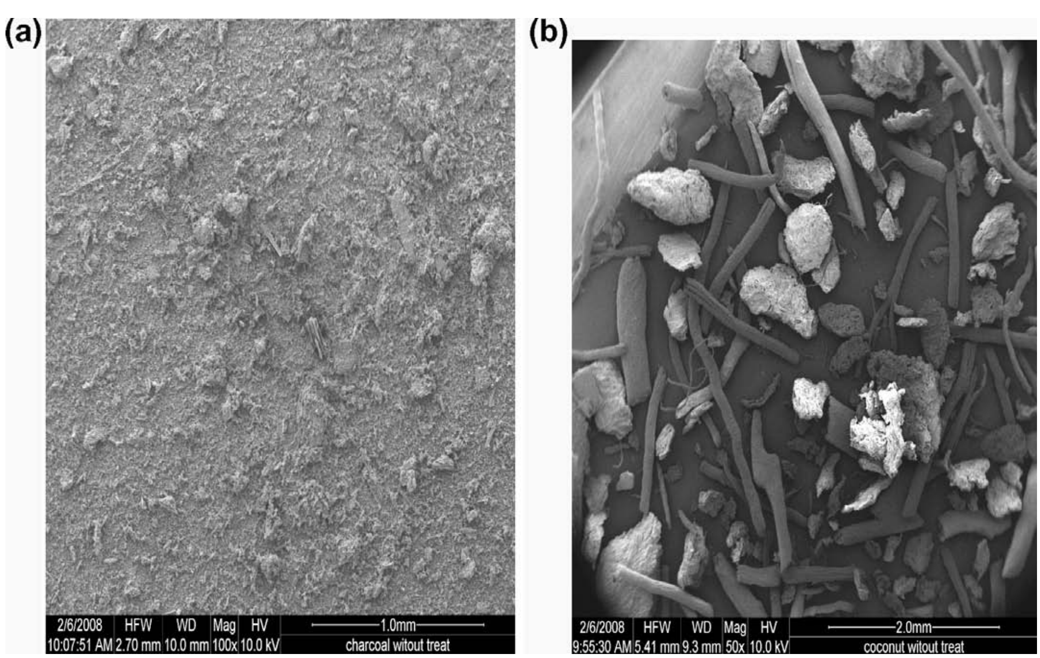

Fig. 2. SEM micrographs: (a) of AC and (b) of ACH.