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Assessment of activated carbon prepared from corncob by chemical activation with phosphoric acid

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ABSTRACT

Corncob, which is the main waste from corn agricultures in Egypt, has been used as a raw material for the preparation of different activated carbons. Activated carbons (ACs) were prepared by chemical activation with concentrated H_3PO_4 acid; followed by pyrolysis at 400, 500 and 600 °C. Different ACs have been used for the removal of methylene blue (MB) dye from aqueous solutions. Batch adsorption experiments were performed as a function of initial dye concentration, contact time, adsorbent dose and pH. Adsorption data were modeled using the Langmuir and Freundlich adsorption isotherms. Adsorption of MB on AC1 (R^2=0.9868) and AC2 (R^2=0.9810) followed Langmuir model with maximum monolayer sorption capacity of 28.65 and 17.57 mg/g, respectively. Adsorption onto AC3 was better fitted to Freundlich isotherm model (R^2=0.9823).

1. Introduction

The world-wide high level of production and use of dyes generates colored wastewaters, which give cause of environmental concern. Textile companies, dye manufacturing industries, paper and pulp mills, tanneries, electroplating factories, distilleries, food companies and a host of other industries discharge colored wastewater [1]. As a matter of fact, the discharge of such effluents in the

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environment is worrying for both toxicological and esthetical reasons. The methods of color removal from industrial effluents include biological treatment, coagulation, floatation, adsorption, oxidation and membrane filtration. Among the treatment options, adsorption appears to have considerable potential for the removal of color from industrial effluents. It has been found that the performance of the adsorbents depends on their textural properties as porosity and surface area [2]. Adsorption onto activated carbons is a well known process for micro-pollutants removal [3]. It has many advantages over several other conventional treatment methods for wastewater treatment. These include (i) less land area (half to quarter of what is required in a biological system); (ii) lower sensitivity to diurnal variation; (iii) not getting affected by toxic chemicals; (iv) greater flexibility in the design and operation and (v) superior removal of organic contaminants [4]. Activated carbon is perhaps the most widely used adsorbent for the removal of many organic contaminants which are biologically resistant. Adsorption with activated carbon is usually an expensive treatment process and this promoted a growing search to prepare economical activated carbon. Many kinds of plant biomasses are natural renewable resource that can be converted into activated carbon, either by physical or chemical activation. The advantage of using agricultural by-products as raw materials for manufacturing activated carbon is that these raw materials are potentially less expensive to manufacture [5]. The technology to manufacture activated carbon of good quality is not fully developed in developing countries; therefore, there is a need to produce activated carbon from cheaper and readily available materials, which can be used economically on a large scale. According to what was mentioned, providing an adsorbent, which is cost-effective and environmentally comparative, for the removal of dyes from aqueous solutions seems to be so vital. The activated carbon has been produced from variety of biomass i.e., agricultural wastes [6], date stone [7], peanut shells [8], marigold straw [9], oil palm shell [10], cotton wove waste [11], and almond shell [12].

In this work, three different ACs were prepared from corncob by chemical activation using phosphoric acid followed by pyrolysis at different temperatures. They were used as adsorbents to remove methylene blue dye from aqueous solution. The kinetic data and equilibrium data on batch adsorption studies were carried out to understand the adsorption process. The effect of adsorption parameters such as pH, adsorbent concentration, contact time and initial dye concentration is also reported.

2. Materials and methods

2.1. Adsorbate

Methylene blue, a basic dye is a product of LOBA Company, Egypt. It was used as received without further purification. A stock solution of methylene blue (50 mg/l) was prepared and suitably diluted to the required initial concentration. All chemicals were of analytical reagent grade.

2.2. Adsorbent preparation

The corncob collected from agriculture lands near Benha city were washed several times with distilled water and left to dry, and then it was cut into small pieces, grained and sieved to an average particle size (0.05 mm). The raw material was subjected to chemical treatment followed by pyrolysis. The activation was carried out by impregnation of the corncob samples with phosphoric acid in a ratio of 1:2 (w/w) for 24 h, and then washed with distilled water several times until pH reached 4. After that, the samples were dried at 100 °C then pyrolysed in a muffle furnace in absence of air at 400, 500 and 600 °C for 2 h. After pyrolysis, the resulting samples were washed with distilled water until the pH of the washing solution reached 6–7. The activated carbon samples were dried at 100 °C and kept dry till use. The resulting AC samples produced are abbreviated as AC1, AC2 and AC3 according to the activation temperatures (400, 500 and 600 °C, respectively).