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Super Dye Adsorption Capability of Natural Superfine Down Particles for Organic Contaminant from Binary Dye Mixture ⋆

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Abstract

Reuse of waste resources is still a challenging issue for public health and ecosystem protection. Herein, natural superfine down particles (NSDP) were successfully prepared from the wasted down fibers and investigated for the removal of methylene blue (MB) and methyl orange (MO) dyes from the binary dye solution. The adsorbent was characterized by scanning electron microscopy (SEM) and N_2 adsorption. The adsorption behavior of NSDP for these two dyes was investigated as a function of pH. The results showed that the NSDP surface has surface area of 7 277 cm^2/g and an abundance of functional groups (carboxyl, hydroxyl and amine-groups). The adsorption capacity of NSDP was strongly pH-dependence. The results indicated that NSDP can be used as an efficient and economic adsorbent to remove dyes in the textile effluents.

Keywords: Natural Superfine Down Particle; Textile Wastewater; Dye Adsorption; pH

1 Introduction

As an important chemical products, organic dyes are widely used in various fields, including paper, leather, printing, food, cosmetics, paint, pigment, and so on [1]. However, their highly toxic nature have led to a series of environmental pollution problem. Discharge of wastewater containing organic dyes into the aquatic ecosystem without proper treatment poses a severe threat

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to the environment, because these dyes affect the nature of the water, inhibit sunlight penetration into the stream and hinder photosynthetic reactions. In addition, some of these dyes are highly cytotoxic, mutagenic and carcinogenic to humans [2].

So far, the textile industry is the major contributor to aquatic pollution, and hence, the elimination of dyes from textile effluents is crucial. Attributed to these harmful impacts, much attention have been paid to remove the synthetic dyes from the printing and dyeing wastewater [3]. Various methods, including chemical oxidation [4-5], ion exchange [6], coagulation/flocculation [7-8], electrochemical treatment [9], photochemical treatment [10-11], biodegradation [12-13], and physical adsorption [14-17] have been explored for the decoloration of dyeing wastewater. Among these reported abatement methods, adsorption is considered useful for treating of industrial effluents because of its simplicity, efficiency, low operation cost and selectivity [18]. Therefore, it is vital to design an exceptional adsorbent include high selectivity and adsorption capacity, fast kinetics and good recycling properties

Down fibre, which are natural protein fibres, have long been used as high quality textile materials by virtue of their moderate moisture absorption and retention ability [19]. Poultry farms in China produce about 0.2 billion kg of down fibres every year. Much of the used fibre is processed into a low-quality protein supplement for animal feed, which leads to a huge waste of energy resources [20]. The possibility of using hen feathers as a potential adsorbent to remove organic dyes from textile effluents has been demonstrated [21-25], but the low adsorption capacity of this materials limits its commercial application.

Herein, we prepared natural superfine down particles (NSDP), which had a 14-fold larger Brunauer-Emmett-Teller surface area (S_{BET}) and the greater number of surface hydrophilic (hydroxyl, carboxyl, and amino) groups, compared to goose down fibres. The main aim of our study was to explore the possibility of utilizing the prepared NSDP for the removal of organic dyes from aqueous solutions. Methylene blue (MB, λ_{max} = 660 nm) and methyl orange (MO, λ_{max} = 465 nm) were chosen as the adsorbates. These two dyes are commonly used in textile/dyeing industries and are often discharged into water bodies without purification/treatment.

2 Materials and Methods

2.1 Materials

Down fibers of ducks were collected from a local poultry farm in Wuhan, China. The dyes, including MB and MO were purchased from Tianjing Jiedi Co. Ltd. (Tianjing, China), used without further purification.

2.2 Preparation and Characterization of NSDP

The details of our laboratory-scale NSDP preparation process have been described in an earlier publication [19, 26]. Briefly, the collected down fibres were washed thoroughly with deionized water for 3-4 times for removal of mixed dirt and any other granular impurities. Then, the cleaned down fibres were dried in an oven at 105 °C for 3 h. The dried fibres were cut into short pieces with a specialized rotary blade and soaked for 24 h in a mixed solution with the 20% (v/v) aqueous ethanol and 30% (v/v) hydrogen peroxide at room temperature. The soaked fibres were