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Fabrication of spherical cellulose/carbon tubes hybrid adsorbent anchored with welan gum polysaccharide and its potential in adsorbing methylene blue

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HIGHLIGHTS

- A kind of tentacle-type cellulose-based adsorbent was prepared in the study.
- The entrapped carbon nanotubes endowed the adsorbent with high mechanical strength.
- The welan gum was grafted onto the support for large adsorption capacity.
- The novel adsorbent was evaluated in detail by adsorbing dye molecules in water.

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ABSTRACT

A high performance adsorbent was performed by emulsification of carbon nanotubes (CNTs) entrapped cellulose solution, and followed by grafting welan gum onto the support as tentacle-type polysaccharide ligands. The morphology and mechanical properties of the adsorbent were characterized with optical microscopy, scanning electron microscopy, and flow hydrodynamics. The well-dispersed CNTs throughout the support as nanofillers were proved to effectively enhance both the structure stability and the mechanical strength of support. Moreover, the tentacle-type adsorbent was further investigated carefully for its efficiency in adsorbing methylene blue from water in a batch system. It demonstrated that higher pH and longer adsorption time contributed to larger adsorption capacity since the adsorbent provided more adsorption sites available for the dye adsorption at such conditions. Fitting the isotherm data to Langmuir and Sips models gave the conclusion that the adsorption behavior matched best with Sips model, proving a multilayer adsorption at lower concentration and monolayer adsorption at higher concentration. The equilibrium adsorption capacity onto the adsorbent was determined to be 302.1 mg g^{-1} at pH 6.0 from Sips model. Combined with the advantages of mechanical strength and adsorption performance, the novel adsorbent would be considered to a top-priority adsorbent for separation field.

1. Introduction

The treatment of wastewater from industrial process has been considered a challenge as a result of the increased strict regulation for controlling the water pollution [1,2]. In the wastewater, the dye pollutant occupies the main contribution on the environmental hazard. It is reported that about twelve percent of total dyes produced annually are discharged into the wastewater from the manufacturing and textile industries [3]. The discharge of dyes into environment even in a small amount is still harmful for ecological system and human health [4]. For example, these dye pollutants possess high biochemical oxygen demand that causes the water eutrophication and then jeopardize seriously the common growing for aquatic flora and fauna [5,6]. On human health, they can also give rise to nausea, profuse sweating, mental confusion, allergic dermatitis and skin irritation [7–9]. In this context, the removal of dissolved dye pollutants is environmentally necessary in the field of wastewater treatment.

However, there is still a challenge to eliminate these dye pollutants satisfactorily by current techniques since most of them belong to recalcitrant organic compounds, which are resistant to aerobic digestion and stable to heat, light and oxidizing agents [6]. As far as the environment-friendly, easy recovery and high adsorption efficiency are concerned, the dye removal by adsorption enjoys more advantages over other methods and is considered an ideal method for removing dyes or other pollutants [10]. In view of this technique, the adsorbent is the heart component that relates significantly to the adsorption efficiency. In the context, varied adsorbents have been developed and utilized to meet the strict standard of wastewater treatment [11]. As for the adsorbent, the support and its ligands are two key points and should be taken into consideration. In terms of support, cellulose biopolymer is considered an important support

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