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Preparation and characterization of multi-walled carbon nanotubes/chitosan nanocomposite and its application for the removal of heavy metals from aqueous solution

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ABSTRACT

Multi-walled carbon nanotubes (MWCNTs) were modified with chitosan, and a homogenous nanocomposite was obtained. The morphological properties of the MWCNTs/chitosan nanocomposite were studied with scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FT-IR), and thermal gravimetric analysis (TGA). The morphological results indicate the successful modification and the formation of MWCNTs/chitosan nanocomposites. The MWCNTs/chitosan nanocomposite was packed inside a glass column and used for the removal of copper, zinc, cadmium, and nickel ions from aqueous solution. The MWCNTs/chitosan nanocomposite showed a great efficiency for the removal of the target metal ions from the aqueous solution. The results suggested that this novel MWCNTs/chitosan nanocomposite could be used for different environmental applications.

1. Introduction

Carbon nanotubes (CNTs) have captured much attention worldwide since the discovery of CNTs in 1991 [1]. Significant work has been done to reveal the unique structural, mechanical, electrical, electromechanical and chemical properties of CNTs and to explore the key applications of these novel materials. CNTs have unique size distributions, novel hollow-tube structures, high specific surface areas, electrical conductivity and semiconductivity. Carbon nanotubes have a wide range of length scales and are capable of being oxidized and forming carboxylic groups on their surfaces [2]. Different diameters and chiralities of carbon nanotubes give rise to various chemical, physical and mechanical properties [3–5]. These characteristics allow applications of CNTs in many fields such as photocatalysis [6], medicine [7], nanoscale electronics [8], hydrogen storage [9,10], mechanical systems [11], SEM probes [12] and electron field emission tips [13]. Many research studies have shown the capability of CNTs in the adsorption and removal of different pollutants such as virus from water [14], dichlorodiphenyltrichloroethane and its metabolites at trace level in water samples [15], organophosphorous pesticides in wastewater sludge [16], nicosulfuron, thifensulfuron-methyl and metsulfuron-methyl in water samples [17], atrazine from aqueous solution [18–20], polyhalogenated organic pollutants in environmental water samples [21–25], tetrabromobisphenol A [26], pharmaceuticals in spiked water samples [27], drugs in urine [28], ionizable organic compounds [29], poly aromatic hydrocarbons [30], thiamethoxam, imidacloprid, acetamiprid [31], polycyclic aromatic hydrocarbons in environmental water [32], different pesticides [33] and metal ions [34–39] from different environments. Recently, modification of CNTs with polymers has been of significant interest due to their exceptional properties and applications [24,25,40–42]. One of the common polymers that is used for the modification of carbon nanotubes is chitosan [43–45]. Chitosan, a polysaccharide biopolymer obtained from the deacetylation of chitin, has been widely used in medical applications because it can not only be economically processed from chitin but is also nontoxic, biocompatible, and biodegradable [46,47]. Chitosan is known to have good complexing ability through specific interactions of its amino groups with heavy metals from various waste waters [48–52]. Carbon nanotubes were modified with chitosan and used for different applications such as the adsorption of congo red [53], the determination of copper (II) by anodic stripping voltammetry [54], and biosensors for different molecules such as hydrogen peroxide [55] and cholesterol [56].

Both carbon nanotubes and chitosan can adsorb and remove heavy metals from aqueous environments, but, to the authors' knowledge, there are no studies exploring the potentiality of com-

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