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Extraction and characterization of chitin and chitosan: applications of chitosan nanoparticles in the adsorption of copper in an aqueous environment

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Abstract: The main objective of the present work is to develop and characterize a new generation of adsorptive gelled porous bead supports made from nanoparticles of chitosan, bentonite and alginate. There were subsequently used in the purification of water synthetically polluted with cupric ions. The multiple experiments carried out on the adsorption of copper resulted in an equilibrium time reached after 10 min with an elimination percentage of 86%. Adsorption kinetics is better described by the expression of the second-order model whereas the adsorption isotherm is satisfactorily described by the Freundlich model. The different results showed the high affinity of the nanoparticle composite beads of chitosan/bentonite/alginate to cupric ions in an aqueous solution which is probably due to the presence of various chelating agents such as "NH, OH, COO^-, and O" in their structure.

Keywords: adsorption; alginate; bentonite; chitosan nanoparticles; copper.

1 Introduction

Chitosan is a polysaccharide that deserves special attention due to its net cationic character and to the presence of multiple reactive functional groups (OH and NH_2) on its chains. The use of chitosan in acid conditions to remove heavy metals is limited due to its tendency to dissolve in acid effluents. To overcome this problem, chitosan was stabilized by crosslinking in acid conditions (1–3).

Furthermore, chitosan adsorption efficiency could be improved by switching to the nano form. The nanoparticles were obtained by ionic crosslinking using tripolyphosphate considered as a non-toxic polyanion (4). This modification, resulted in various changes to chitosan properties, such as a hindrance of the dissolution of chitosan in acidic environments, an improvement of the mechanical strength and an increase of the amorphous nature and the specific surface. These changes theoretically increase the absorption capacity of chitosan nanoparticles compared to the chitosan capacity (5–9).

Alginate is also a natural polymer that can form salts with metal ions. Sodium alginate is a linear polyuronate which contains varying amounts of D-mannuronic and L-guluronic acids and can easily be crosslinked using calcium ions (10). Such a polymer plays an important role in water treatment technologies. The absorption of the heavy metals takes place by ion exchange between Ca (II) and the metal ion in aqueous solution (11–13).

Bentonite is an aluminum phyllosilicate mainly composed of montmorillonite (smectite) with other inorganic clays and minerals. There are several types of bentonite that depend on their dominant elements (K, Na, Ca and Al) (14). The use of bentonite as an adsorbent is of interest in the treatment of industrial effluents. This is justified by the importance of negative charges on the surface of this material and also, by the possibility of cation exchange and especially its wide availability in nature (15–18).

In order to improve the possibilities of recovery and disposal of pollutants, little research has focused on the combined use of chitosan nanoparticles, alginates and bentonite.

2 Materials and methods

2.1 Materials

All products used in this work were of analytical grade from Fluka, Panreac and Sigma-Aldrich sources (Prochima

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