Journal of Fiber Bioengineering and Informatics 12:3 (2019) 103–128
doi:10.3993/jfbim00301

A Review on Chitosan for the Removal of Heavy Metals Ions

Qasim Zia [a], Madeeha Tabassum [b], Hugh Gong [a], Jiashen Li [a,*]

[a] *The University of Manchester, Department of Materials, M13 9PL, Manchester, UK*
[b] *Queen Mary University of London, School of Engineering and Materials Science, London, UK*

Abstract

There has recently been an increasing interest in water treatment methods as a result of growing concerns over shortages of clean water. This paper aims to review the past and present researches on chitosan for the adsorption of heavy metals from the wastewater. Adsorption is considered to be the most efficient method for the removal of metal impurities from drinking water. Chitosan, a deacetylated derivative of chitin, has many commercial applications due to its biocompatibility, nontoxicity, and biodegradability. Moreover, amine groups are present on the backbone of chitosan. For this reason, chitosan has been used for the adsorption of heavy metals. To begin with, mechanism of adsorption of heavy metal ions on chitosan and disadvantages of heavy metal ions were reviewed. Further, a detailed review had been done on the adsorption capacities of crosslinked chitosan, chitosan nanofibers, chitosan nanoparticles, chitosan composites, modified/pure chitosan, and porous chitosan. Lastly, research gaps and future recommendations were given for further development and accurate results of adsorption.

Keywords: Chitosan; Heavy Metals; Adsorption; Crosslinked Chitosan

1 Introduction

1.1 The Chemical Construction of Chitosan

Chitosan is linear amino polysaccharide consisting of two basic units, glucose amine and N-acetyl glucosamine, acquired from the deacetylation of chitin in the alkaline environment [1]. Chitin is a natural polymer discovered 200 years ago. It is mainly extracted from cell walls of fungi as well as from the exoskeleton of crustaceans such as shrimp and crabs [2-6]. The structure of chitosan is composed of (1,4)-linked 2-amino-2-deoxy-β-D-glucan as shown in Fig. 1, its chemical name is poly [-(1, 4)-2-amino-2-deoxy-D-glucopiranose] [2, 7, 8]. The structures of chitosan contain amine (NH_2) groups, and as a result have good medical properties for instance biodegradability, biocompatibility and excellent antibacterial activity. It is the only cationic natural occurring

*Corresponding author.
Email address: `jiashen.li@manchester.ac.uk` (Jiashen Li).

Sep. 2019

polymer [9, 10]. Furthermore, chitosan is extensively used for the adsorption of heavy metal ions due to the presence of amine and hydroxyl groups [11-13].

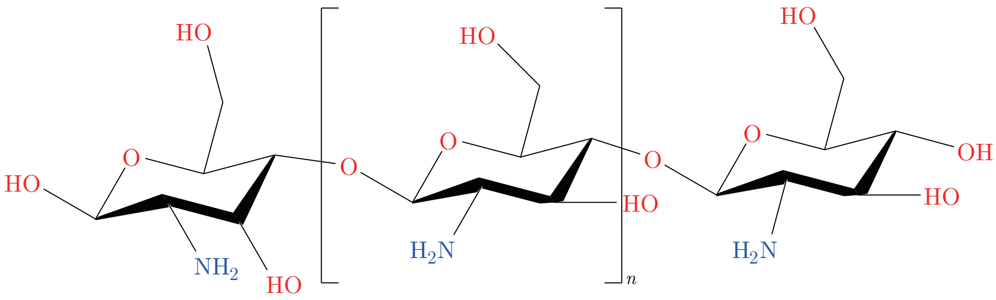

Fig. 1: Chemical construction of chitosan

1.2 Adsorption at Solid/Liquid Interface

Solids and many solvents which do not dissolve in solution and has the tendency to form bonds with the ions present in solution are called ion exchangers; and the process of ion exchange that occurs at solid/liquid interface is known as ion exchange adsorption. Fig. 2 shows the schematic representation of adsorption solid/liquid interface. Various ion exchange minerals exist in nature such as: alumina silicates from zeolite group and clays of bentonite and montmorillonite.

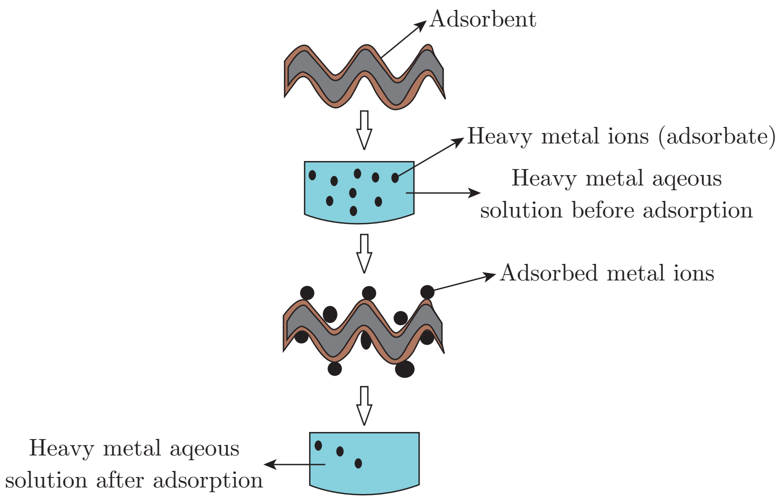

Fig. 2: Schematic representation of adsorption at solid/liquid interface

There are three main types of ion exchanger's i.e. natural, semisynthetic and synthetic ion exchangers. Natural ion exchange materials were the first which found the applications in the purification of water. Bentonite clay and zeolites are common ion exchange materials. An example of zeolite structure is aluminate AlO_4 in which Al^{3+} ions are surrounded in tetrahedral by double negative charge of oxygen ions or OH^- groups with single negative charge. These excess negative charges are balanced with alkali metals or alkaline earth metal ions which are loosely bound with the crystal lattice. These metal ions can be displaced or substituted with the ions present in solution [14].