Removal of Heavy Metals from Aqueous Solution by Hydroxyapatite/Chitosan Composite

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Abstract: Hydroxyapatite/chitosan (HApC) composite has been prepared by precipitation method and used for removal of heavy metals (Cr$^{6+}$, Zn$^{2+}$ and Cd$^{2+}$) from aqueous solution. The HAp and 3H7C composite with HAp:chitosan ratio of 3:7 (wt%) were characterized by Fourier transform infrared spectroscopy, X-ray diffraction and scanning electron microscopy-energy dispersive X-ray spectroscopy. The SEM results showed that HAp is spherical-shaped and crystalline, while chitosan has a flat structure. SEM micrograph of 3H7C composite reveals crystalline of HAp uniformly spread over the surface of chitosan. The crystal structure of HAp is maintained in 3H7C composite. Chitosan affects the adsorption capacity of HAp for heavy metal ions; it binds the metal ions as well as HAp. The kinetic data was best described by the pseudo-second order. Surface adsorption and intraparticle diffusion take place in the mechanism of adsorption process. The binding of HAp powder with chitosan made the capability of composite to removal of Cr$^{6+}$, Zn$^{2+}$ and Cd$^{2+}$ from aqueous solution effective. The order of removal efficiency (Cr$^{6+}$ > Cd$^{2+}$ > Zn$^{2+}$) was observed.

Introduction

Industrial developments cause a lot of water pollution by heavy metal ions such as copper, lead, zinc, cobalt, nickel, chromium and mercury [1]. Heavy metal that contained in water can be separated with many methods such as reduction, membrane process, ion exchange, solvent extraction, and adsorption [1,2]. Among them, many industries choose adsorption process to remove heavy metals from their wastewater because adsorption is more efficient and economical than other methods [1].

Hydroxyapatite (HAp) is a compound with molecular formula Ca$_{10}$(PO$_4$)$_2$(OH)$_2$. HAp can be used as adsorbent for removal of toxic heavy metal ions such as Co, Ni, Cu, Zn, and Cd [3, 4]. However, it has been known that HAp only has high removal capacity for divalent heavy metal ions [3] and it is not easy to separate from solution after adsorption [1]. To overcome this problem, HAp can be incorporated with polymer to improve the HAp removal capacity. Chitosan is well-known as bioadsorbent for removal of metal ions because the large content of NH$_2$ groups [5–7]. Composite of HAp/chitosan as adsorbent for removal of Pb$^{2+}$, Co$^{2+}$ and Ni$^{2+}$ has been reported, but chitosan did not affect the adsorption capability [1].

The present paper deals with the synthesis of hydroxyapatite/chitosan (HApC) composite with concentration of HAp:chitosan in 3:7 (wt%) and its application for the removal of Cd$^{2+}$, Zn$^{2+}$ and Cr$^{6+}$ ions. Evaluation of HAp and its composite as adsorbent for the removal of heavy metal ions (Cd$^{2+}$, Zn$^{2+}$ and Cr$^{6+}$) in simulated wastewater has been carried out. Effect of various physical-chemical parameters was studied. The sorption dynamic was also investigated.