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Removal of Cu(II) from aqueous solution using APTES-GA modified magnetic iron oxide nanoparticles: kinetic and isotherm study

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Abstract

In this work the surface modification of iron oxide magnetic nanoadsorbents (MNP-APTES-GA) prepared by functionalizing magnetic iron oxide nanoparticles (MNPs) with (3-aminopropyl) triethoxysilane (APTES) and glutaraldehyde (GA) was used for the removal of Cu(II) from aqueous solution. The solvothermally prepared MNPs were characterized by x-ray diffraction, transmission electron microscopy, Fourier transform infrared spectroscopy and vibrating sample magnetometer. The batch adsorption experiments were carried out to study the adsorption behaviour of Cu(II) on MNP-APTES-GA by optimizing different parameters such as contact time, adsorbent dose, initial Cu(II) concentration and pH. The adsorption behaviour of Cu(II) on MNP-APTES-GA follows pseudo first order kinetic model. The adsorption isotherm of MNP-APTES-GA for Cu(II) fitted well for the Langmuir model with the adsorption capacity of 19.26 mg g^{-1}. Kinetic and isotherm study of MNP-APTES-GA suggested that these nanoadsorbents could be a promising candidate for the removal of Cu(II) from the wastewater.

1. Introduction

Rapid industrialization and urbanization have resulted into water contamination by toxic heavy metals, which is affecting human health and also ecosystem [1, 2]. The industries like metallurgical, tannery, chemical manufacturing, mining, pesticides, and battery manufacturing etc are the main sources of wastewater containing one or more toxic heavy metals [3]. Many metals are essential in very low concentrations for various biochemical and physiological functions in living organisms, but becomes harmful when their certain threshold concentration exceeds. It has been widely accepted that heavy metals have many adverse health effects. Still water pollution by heavy metals is increasing in many parts of the world [4, 5]. Toxic heavy metals of environmental concerns are copper, arsenic, cadmium, mercury, lead, chromium, cobalt, nickel, and zinc etc [6]. All of these metals are very reactive at low concentrations and can cause severe public health concerns. Thus, it is vital to remove heavy metal contamination from water in order to prevent the possibility of uptake by humans [1].

Many technologies have been developed for the removal of heavy metals from the metal-contaminated wastewater such as filtration, chemical precipitation, ion exchange, membrane separation, electrochemical, reverse osmosis, and adsorption etc [7, 8]. Among these methods, adsorption is an effective and popular method due to its simplicity, easy operational conditions, and high-efficiency [9]. For efficient removal of heavy metal pollutants, the adsorbent should have large specific surface area, numerous adsorption sites, biocompatibility and ability for functionalization [10]. Several adsorbents have been developed such as activated carbon [11], carbon nanotubes [10], chitosan [12], functionalized polymers [13], graphene oxide nanosheets [14], Fe-Fe_3O_4/graphene oxide [15], and so on. But, these adsorbents shows unsatisfied adsorption capacity due to diffusion limitation, lack of active surface sites, difficulties of separation, and regeneration of adsorbents from