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Study on the adsorption of Cu(II) by EDTA functionalized Fe_3O_4 magnetic nano-particles

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HIGHLIGHTS

- Prepared the EDTA functionalized magnetic nano-particles (MNPs-EDTA) by a simple one-pot method.
- MNPs-EDTA were used for Cu(II) adsorption firstly and show high adsorption capacity.
- The adsorption equilibrium could be achieved within 5 min.
- MNPs-EDTA could remove nearly 100% Cu^{2+} from tap water and river water.

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ABSTRACT

The EDTA functionalized magnetic nano-particles (MNPs-EDTA) as a novel magnetic nano-adsorbent have been prepared by a simple one-pot method for the removal of Cu(II) from aqueous solution. Factors affecting the adsorption of Cu(II) on MNPs-EDTA, such as contact time, temperature, pH, salinity, and initial concentration of Cu(II), were investigated. The studies on the adsorption revealed that the adsorption process obeyed the pseudo-second order kinetic model, the determining step might be chemical sorption and the adsorption equilibrium could be achieved in 5 min. Among the various isotherm models, the experimental data for the adsorption of Cu(II) followed the Langmuir isotherm best and the maximum adsorption capacities was 46.27 mg g^{-1} at pH 6.0 and 298 K. Thermodynamic parameters declared that the adsorption process was endothermic and spontaneous. The removal efficiencies of Cu(II) were over 98.3% and inappreciably influenced by the water matrix. In addition, the adsorption–desorption studies indicated that MNPs-EDTA had a high stability and good reusability.

1. Introduction

Heavy metals, though essential for industry, have also been recognized as major pollutants to plants, animals and human beings for their highly toxic, non-biocompatible traits. Within such heavy metals, copper (Cu(II)) has been considered as one of most harmful ions due to its poisonousness to human body and its abundant and naturally-occurring in the environment especially in wastewaters. Ingestion of excessive copper may lead to vomiting, cramps, convulsion, and even death [1]. And the major source of copper pollution in aquatic systems is the discharge of untreated effluents from different industries, such as electroplating, paint, metal finishing, mining operations, chemical manufacturing, fertilizer, and pigment industries [2–4]. Therefore, it is necessary to explore methods to effectively remove Cu(II) from water or various industrial effluents before their discharge.

Up to now, numerous technologies have been developed for the removal of Cu(II) from wastewater such as chemical precipitation [5], ion exchange [6], liquid–liquid extraction [7], membrane filtration [8], biosorption [9], electrodialysis [10], and electro-coagulation [11]. However, the application of these methods have been impeded by some inherent limitations, involving high capital and maintenance cost, expensive equipment, high sensitivity to operational conditions, significant energy consumption, incomplete metal removal or sludge generation, etc. [12,13]. Beyond these methods, adsorption has been received increasingly attention in recent years owing to its high efficiency, cost-effectiveness and easy handling. Various adsorbents have been reported for the removal of Cu(II) from aqueous solutions, including activated carbon [14], zeolite [15], diatomite [16], kaolinite [17], chitosan [18], alumina [19], functionalized polymers [20] and zero-valent iron [21]. But, most of these adsorbents are not the ideal choices for their unsatisfied adsorption capacity, insufficient adsorption efficiencies, difficulty of separation from the solution, or high price in application. Presently, the application of nano-materials has emerged as a fast-developing, fascinating area of interest for removal of Cu(II)

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