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Removal of Cu(II), Zn(II) and Pb(II) from water using microwave-assisted synthesized maghemite nanotubes

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HIGHLIGHTS

- ▶ Maghemite nanotubes were synthesized by template free rapid microwave irradiation.
- ▶ Maghemite nanotubes were used for adsorption of Cu(II), Zn(II) and Pb(II).
- ▶ The experiments were carried out to consider the effect of adsorption parameters.
- ▶ All experimental data was analyzed using isotherm and kinetic models.
- ▶ Maghemite nanotubes have no significant effect of pH on heavy metal ions adsorption.

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ABSTRACT

Magnetic maghemite (γ-Fe_2O_3) nanotubes were synthesized by microwave irradiation method and were used for the removal of Cu^{2+}, Zn^{2+} and Pb^{2+} from water. The properties of this magnetic adsorbent were characterized by XRD, FESEM, HRTEM, zeta potential, BET surface area measurements and magnetization curves. Magnetic saturation of synthesized nanotubes was found to be 68.7 emu g^{-1} and BET specific surface area was 321.638 $m^2\ g^{-1}$. Adsorption experiments were carried out systematically by batch experiments to investigate the influence of different factors, such as contact time, initial concentration of metal ions, and pH of the solutions. The adsorption equilibrium study exhibited that the heavy metal ions adsorption of maghemite nanotubes followed a Langmuir isotherm model. The kinetic data of adsorption of heavy metal ions on the synthesized nano-adsorbents were best described by a pseudo-second-order equation, indicating their chemical adsorption. From the Langmuir isotherms, the maximum adsorption capacities of tubular maghemite adsorbents towards Cu^{2+}, Zn^{2+} and Pb^{2+} were 111.11, 84.95 and 71.42 mg g^{-1}, respectively. This work demonstrates that synthesized maghemite nanotubes can be considered as potential magnetic nano-adsorbent.

1. Introduction

Water pollution by toxic heavy metal ions occur globally [1]. Strict environmental regulations on the discharge of heavy metal ions and rising demand for clean water with extremely low level of heavy metal ions make it greatly important to develop different efficient technologies for heavy metal ions removal. The conventional technologies for the removal of heavy metal ions from aqueous solution include chemical precipitation, ion exchange, reverse osmosis, electrochemical treatment and adsorption [2]. Among the different treatments described above, adsorption technology, on the other hand, is one of the most recommended physicochemical treatment processes that is commonly used and applied for heavy metal ions removal from water samples and aqueous solutions. In addition, adsorption process is well recognized as one of the most efficient methods for removal of heavy metal ions from their matrices. Adsorption is attractive due to its merits of efficiency, economy and simple operation [3]. The common adsorbents primarily include activated carbons, zeolites, clays, biomass and polymeric materials [4]. However, these adsorbents described above suffer from low adsorption capacities and separation inconvenience. Therefore, efforts are on to discover new promising adsorbents. Adsorption is mainly based on the utilization of solid adsorbents from either organic, inorganic, biological or low cost materials [5,6].

Magnetic separation can be one of the promising ways for a novel environmental purification technique because of producing little or no flocculants and having capability of treating large amount of wastewater within a short time. Moreover, this approach can particularly be adopted when the problem of separation is complex, i.e., when polluted water contains solid residues which

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