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Novel self-assembled 3D flower-like magnesium hydroxide coated granular polyurethane: Implication of its potential application for the removal of heavy metals

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ABSTRACT

Novel nanostructured three-dimensional flowerlike $Mg(OH)_2$-incorporated granular polyurethane (designated as gPU-FMH) was prepared using a simple hydrothermal method, for which commercial MgO, water, and granular polyurethane (gPU) were applied. Interestingly, it is found that gPU and the hydrothermal process are the key factors for the assembly of the flowerlike structures of the $Mg(OH)_2$, as its hexagonal nanosheet petals provide a high surface area. Temperature significantly controlled the morphologies of the flowerlike $Mg(OH)_2$, and the granular gPU-FMH showed the superb adsorption capacities of 472, 1050, and 1293 mg g^{-1} (maximum adsorption capacities, q_m, from Langmuir model) for Cu(II), Cd(II), and Pb(II), respectively. The proposed hypothesis for the synthesis of gPU-FMH and the removal mechanism of the heavy metals has been proved through various spectroscopic analyses. In the result of the continuous-flow column study, gPU-FMH showed a long breakthrough and a high removal capacity (184 mg g^{-1}) of Cu(II).

1. Introduction

The discharging of heavy metals into the environment results in hazardous impacts on the health of human beings, animals, and plants. The remediation of heavy metals from industrial effluents and discharges is of great importance. Among the numerous reported mechanisms for the removal of heavy metals, adsorption has attracted much attention due to its simplicity and cost-effectiveness (Park et al., 2016). Since conventional adsorbents such as low-cost adsorbents (Salam et al., 2011), waste materials (Bhatnagar and Sillanpää, 2010), and especially nanosized metal oxides (Cao et al., 2012) have been reported with low adsorption capacities, a practical adsorbent with a high removal capacity is in huge demand.

In association with a water-treatment demand, much attention has been paid to the evolution of metal oxides with three-dimensional (3D) flowerlike nanostructured materials that use nanosized building blocks to remove heavy metals (Zhang et al., 2012). It is believed that compared with the traditional adsorbents, the specific surface areas of the 3D flowerlike nanomaterials are much larger, which could improve its heavy-metal adsorption capacities (Ma et al., 2018; Nasiri et al., 2018). Among all of the metal oxides, magnesium oxide (MgO) and magnesium hydroxide [$Mg(OH)_2$] have been considered since they are not only cheap, innocuous, and environmentally friendly, but their adsorption properties for heavy-metal removal are also excellent (Cao et al., 2012). However, the synthesis of the 3D flowerlike metal oxide

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