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Phosphate Capture from Sewage by Hafnium-Modified Fe_3O_4@SiO_2 Superparamagnetic Nanoparticles: Adsorption Capacity, Selectivity, Reusability Analysis and Mechanistic Insights

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Abstract : With global increasing demand for phosphorus and intensively depleting reserves, it is urgent need to explore innovative approaches towards capturing phosphate from sewage, which is also an effective way to reduce phosphate contamination and avoid eutrophication of water bodies. In the present article, the superparamagnetic nano-sorbents containing Fe_3O_4 core and hafnium-modified MgAl/MgFe layered double hydroxides shell (abbreviated as MgAlHf-NP and MgFeHf-NP) was developed using a simple and low-cost synthesis protocol. The obtained Hf-coated nano-materials showed well-defined crystal structure and sufficient saturation magnetization and exhibited higher adsorption capacity for phosphate. Meanwhile, high selectivity was also confirmed since coexisting foreign anions and biomacromolecules showed little competitive effect on phosphate adsorption. The enhancement via doping with Hf should be explained by the stronger ligand complexation built by the pair of hard acid Hf ion and hard base phosphate that matched up the bonding preferences. Sufficient OH^- concentration and clear pH shift during the desorption/regeneration allowed for regeneration rate of higher than 90% after 5 cycles of adsorption desorption. This article attempts to provide a competitive candidate for phosphate-capture, which is highly effective, easily separable and repeatedly usable.

Keywords : phosphate recovery, nanoparticles, superparamagnetic, adsorption, reusability
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