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RESEARCH ARTICLE

Controllable synthesis of Fe_3O_4-wollastonite adsorbents for efficient heavy metal ions/oxyanions removal

Jelena D. Rusmirović[1] · Nina Obradović[2] · Jovana Perendija[3] · Ana Umićević[4] · Ana Kapidžić[4] · Branislav Vlahović[5] · Vera Pavlović[6] · Aleksandar D. Marinković[7] · Vladimir B. Pavlović[2,8]

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Abstract

Iron oxide, in the form of magnetite (MG)–functionalized porous wollastonite (WL), was used as an adsorbent for heavy metal ions (cadmium and nickel) and oxyanions (chromate and phosphate) removal from water. The porous WL was synthesized from calcium carbonate and siloxane by controlled sintering process using low molecular weight submicrosized poly(methyl methacrylate) as a pore-forming agent. The precipitation of MG nanoparticles was carried out directly by a polyol-medium solvothermal method or via branched amino/carboxylic acid cross-linker by solvent/nonsolvent method producing WL/MG and WL-γ-APS/MG adsorbents, respectively. The structure/properties of MG functionalized WL was confirmed by applying FTIR, Raman, XRD, Mössbauer, and SEM analysis. Higher adsorption capacities of 73.126, 66.144, 64.168, and 63.456 mg g^{-1} for WL-γ-APS/MG in relation to WL/MG of 55.450, 52.019, 48.132, and 47.382 mg g^{-1} for Cd^{2+}, Ni^{2+}, phosphate, and chromate, respectively, were obtained using nonlinear Langmuir model fitting. Adsorption phenomena were analyzed using monolayer statistical physics model for single adsorption with one energy. Kinetic study showed exceptionally higher pseudo-second-order rate constants for WL-γ-APS/MG, e.g., 1.17–13.4 times, with respect to WL/MG indicating importance of both WL surface modification and controllable precipitation of MG on WL-γ-APS.

Keywords Calcium metasilicate ceramic · Magnetite functionalization · Solvent/nonsolvent method · Polyol-thermal method · Heavy metals · Adsorption; Fe_3O_4

Introduction

Rapid global industrialization increases the amount of effluent consisting chemical wastes such as volatile organic compounds (industrial solvents), heavy metals and oxyions, and pharmaceutical drugs and their metabolites. Industrial effluents are one of the prime sources of environmental toxicity that deteriorates water quality (Paul 2017). Long-term

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✉ Jelena D. Rusmirović
jrusmirovic@tmf.bg.ac.rs

[1] Innovation Center of the Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, Belgrade 11120, Serbia

[2] Institute of Technical Sciences of SASA, Knez Mihailova 35/IV, Belgrade 11000, Serbia

[3] Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Njegoševa 4, Belgrade 11000, Serbia

[4] Vinča Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia

[5] Department of Mathematics and Physics, North Carolina Central University, Durham, USA

[6] Faculty of Mechanical Engineering, University of Belgrade, Kraljice Marije 16, Belgrade 11120, Serbia

[7] Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, Belgrade 11120, Serbia

[8] Faculty of Agriculture, University of Belgrade, Nemanjina 6, Belgrade-, Zemun 11080, Serbia