Chemical Engineering Journal

Zero valent nickel nanoparticles decorated polyaniline nanotubes for the efficient removal of Pb(II) from aqueous solution: Synthesis, characterization and mechanism investigation

Madhumita Bhaumik[a], Arjun Maity[bc], Hendrik G.Brink[a]

[a] Chemical Engineering Department, University of Pretoria, South Africa

[b] DST/CSIR, Centre for Nanostructure and Advanced Materials (CeNAM), Council for Scientific and Industrial Research (CSIR), Pretoria 0001, South Africa

[c] Department of Chemical Science, University of Johannesburg, Doornfontein, 2028 Johannesburg, South Africa

https://www.sciencedirect.com/science/article/pii/S1385894720340298

Abstract

Zero valent nickel nanoparticles (Ni0 NPs) have exhibited potential applicability in various fields including, chemical cells, fuel cells and catalysis. Alike zero valent iron NPs, Ni0 NPs and their composite nanostructures would have great prospect in remediating heavy metal pollutants from water bodies. To establish this fact composite nanotubes (CNs) of naphthalene sulfonic acid doped polyaniline (PANI-NSA) and Ni0 NPs (PANI-NSA@Ni0 CNs) were synthesized by immobilization of Ni0 NPs onto the PANI-NSA surface and effectively used for the removal of Pb(II) ions from aqueous solution. Morphological and structural characterization established that aggregation of ferromagnetic Ni0 NPs was greatly diminished by immobilization onto the matrix of PANI-NSA. Improved specific surface area and greater reactivity of the PANI-NSA@Ni0 CNs enabled superior removal performance towards Pb(II) ions in comparison with its constituents. The highest removal efficiency (90.9%) was observed using 0.5 g/L CNs at pH 5.0. Pb(II) sorption kinetics was very rapid and equilibrium was reached within 30–90 min for 50–150 mg/L concentrations at pH 5.0. The Langmuir isotherm model provided the best description of the isotherm data, with a deduced maximum Pb(II) removal capacity of 414.6 mg/g at 25 °C. Thermodynamic analysis revealed exothermic and spontaneous adsorption onto the adsorbent surface. Co-existing heavy metal ions had slight impacts on Pb(II) removal performance of the PANI-NSA@Ni0 with associated implications for the treatment of industrial wastewater. XRD and XPS analyses allude that Pb(II) adsorption onto deprotonated surface sites followed by reduction to Pb0 were the leading removal mechanism associated with the current CNs structure.