Defence Seminar

on

Synthesis and utilization of novel materials for adsorptive treatment of mercury and lead in aqueous medium

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by

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ABSTRACT

Mercury (Hg) and lead (Pb) are two gravely threatening substances wreaking havoc on global ecosystem. They are found predominantly in water bodies due to their exorbitant discharge from various anthropological sources. In that context, adsorption is a simple, cost effective technology that is capable of removing these toxic heavy metals from wastewater and addresses the global concern of freshwater availability and usage.

The present research work introduces seven novel materials (nanoparticles or composite), namely, NH_2-UiO-66-SH_C, PBS2, APAN5-BS0.75, FE-TA, Fe-LAA1, aHAp-S and C-aHAp-S, which were designed specifically for Hg and Pb adsorptive purposes with tuned sulfur or nitrogen functionalities due to their targeted affinity for these heavy metals. These adsorbents belong to different categories, such as, metal organic frameworks (NH_2-UiO-66-SH_C, Fe-TA and Fe-LAA1), chalcogenides (PBS2), hydroxyapatite (aHAp-S), polymeric mixed matrix media (APAN5-BS0.75) and charcoal based composite (C-aHAp-S). The synthesis strategies employed to produce these materials included hydrothermal, solvothermal, co-precipitation, anti-solvent induced polymeric phase inversion methods thereby, creating a diverse, flexible and versatile approach to material design and application studies. Leading edge techniques, viz., X-ray diffraction (XRD), Fourier Transform Infrared (FTIR) spectroscopy, transmission electron microscopy (TEM), field emission scanning electron microscopy (FESEM), energy dispersive X-ray (EDX), Brunauer-Emmett-Teller (BET) method, X-ray photoelectron spectroscopy (XPS) and zeta potential analysis, were used to characterize the physical as well as chemical intricacies of the produced adsorbents.

The performance of the synthesized materials was investigated through elaborate adsorption experiments (conducted in batch mode) which demonstrate the influence of adsorbent dose, initial contaminant concentration, solution pH, time and temperature to facilitate the optimization of these factors and quantification of the uptake capacities along with the kinetic and thermodynamic parameters using standard isotherm models (Langmuir and Freundlich models), kinetic models (pseudo-first order and pseudo-second order) and associated equations. Furthermore, the composite macro-adsorbents were used in fixed bed adsorption column analysis to highlight their scope of real field application. A systematic model for solute mass transfer (based on pore diffusion kinetics) was utilized to provide the breakthrough analysis and estimate long-term behaviour of these columns using relevant batch and column parameters, such as, effective pore diffusivity (D_p), and axial dispersion coefficient

(E_z). The maximum Langmuir adsorption capacities (Q_L) for the nanomaterials range from 830 mg/g to 1370 mg/g for Hg (includes NH_2-UiO-66-SH_C, PBS2 and FE-TA) whereas, it lies between 508 mg/g and 1285 mg/g for Pb (includes Fe-LAA1 and aHAp-S). The hybrid composites demonstrated Q_L of 130 mg/g for Hg (APAN5-BS0.75) and 200 mg/g for Pb (C-aHAp-S). The enhanced capacity of these materials was induced with functional modifications which inevitably established them as superior adsorbents compared to several contemporary counterparts. Additionally, their high selectivity (in presence of interfering co-ions and counter ions) and effective reusability emphasized their remarkable performance.

These novel adsorbents, therefore, offer considerable promise in the field of wastewater treatment. The impact in the area of heavy metal (Hg and Pb) remediation provides them with a significant prospect for application.

Keywords: *Mercury adsorption; Lead adsorption; Metal organic framework; Chalcogenide; Sulfonated aluminium substituted hydroxyapatite; Iron thiomalate; Iron asparate; Chemisorption; Mixed matrix beads; Carbon composite; Pore-diffusion model; Breakthrough performance.*