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Achieving Controllable MoS2 Nanostructures with Increased Interlayer Spacing for Efficient Removal of Pb(II) from Aquatic Systems

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Abstract

The development of new synthesis approaches for MoS2 is necessary to achieve controlled morphologies and unique physicochemical properties that can improve its efficiency in particular applications. Herein, a facile one-step hydrothermal route is proposed to prepare controllable MoS2 micro/nanostructures with an increased interlayer using sodium diethyldithiocarbamate trihydrate as the new S source at different pH values. To investigate the morphology, chemical composition, and structure of the MoS2 micro/nanostructures, various characterization techniques were used. The obtained microrods, microspheres, and microrods with hairlike structures (denoted as MoS2-N-H) were composed of MoS2 nanosheets with increased interlayer spacing (~1.0 nm) and utilized for the removal of Pb(II) from aquatic systems. Among the structures, MoS2-N-H demonstrated the highest adsorption capacity (303.04 mg/g) for Pb(II) due to the existence of -S/–C/–N/–O-comprised functional groups on its surface, which led to strong Pb–S complexation and electrostatic attractions. The uptake of Pb(II) onto MoS2-N-H followed pseudo-second-order kinetics and Freundlich isotherm. To evaluate its practical applicability, the adsorbent was employed in real mine water analysis; it was found that MoS2-N-H could adsorb almost 100% of the Pb(II) ions in the presence of various coexisting ions. Additionally, after Pb(II) adsorption, MoS2-N-H was transformed into PbMoO4-xSx spindlelike nanostructures, which were further used for photodegradation of an antibiotic, viz., ciprofloxacin (CIP), to avoid secondary environment waste. Thus, this investigation provides an effective one-pot approach to fabricate controllable MoS2 micro/nanostructures with increased interlayer spacing for water treatment. The utility of these nanostructures in related supercapacitor/battery applications may also be envisaged because of their unique structural properties.