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Self-Tunable, Exfoliated Oxygen-Rich Flower-like MoS_2 Nanosheets for Arsenic Removal: Investigations on Substitution, Stability, and Sustainability (3S) for Maxi-Sorption

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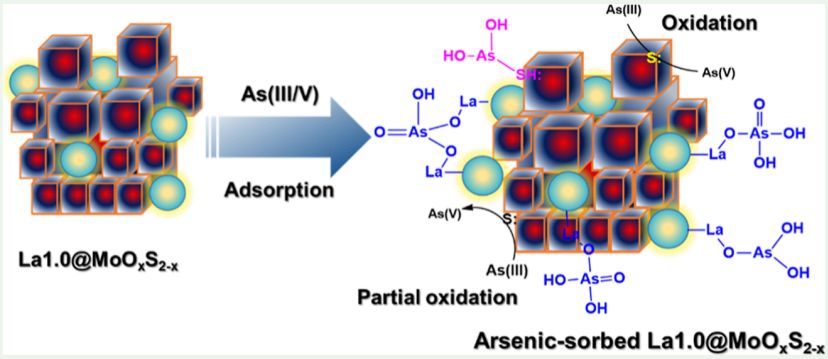

ABSTRACT: In this study, we synthesized La-incorporated O-rich defective MoS_2 nanosheets by a simple, inexpensive, in situ hydrothermal reaction to self-exfoliate the bulky MoS_2 layers themselves so that they can readily trap hard base anions, arsenic (arsenite and arsenate), from water. Attempting to modify MoS_2 surfaces by incorporating O allows for more active sites, which is confirmed by powder XRD patterns where the exfoliated layers have a *d*-spacing of 0.63 nm, while the spacing for the bulky layers is 0.60 nm. The substitution of La at different equivalent ratios on the interlayer/surface improves the adsorption properties of arsenite and arsenate in simple solutions, as shown by the Langmuir adsorption density values of 0.7760 and 1.4363 mmol g^{-1}, respectively. When the O-rich MoS_2 layers were loaded with La, the adsorption densities improved, with La1.0 equiv showing the best values among the materials studied. The presence of O and S was more responsible for the removal of arsenite ions, and La and O, together with a small amount of N, were able to remove arsenate ions from water according to the well-known Pearson's Lewis acid−base principle. The stability of the materials was characterized after the experiments, and it was found that there was no leaching of the materials by ICP-OES and the stability was maintained after 6 regeneration cycles. With the exception of phosphate, which behaves chemically similar to arsenic, the adsorption densities were not significantly affected by the mono- and divalent anions, indicating the selectivity of the prepared materials. The synthesis cost of MoO_xS_{2-x} was 2 times lower than that of bulky MoS_2, and its adsorption properties were 10 times higher than those of the latter. The results suggest that La-substituted O-rich MoS_2 is a potential candidate for the removal of soft and hard base metals from water.

KEYWORDS: *defective MoS_2, La-incorporation, layered structure, arsenic removal, adsorption*

1. INTRODUCTION

Arsenic exists in two oxidation states of arsenite (As^{3+}, As(III)) and arsenate (As^{5+}, As(V)) in nature.[1] Arsenite is more toxic than arsenate due to its nonionic form of H_3AsO_3 species and low affinity for many adsorbents.[2] The maximum level of arsenic in drinking water recommended by the World Health Organization (WHO) is 10 μg/L.[3] A recent report indicated that arsenic has been found in groundwater in 209 districts in 25 states and union territories in India. Although several methods have been adopted for the removal of toxic arsenic from water,[4] adsorption is the most effective due to its simplicity, ease of implementation, user-friendly nature, and low cost.[4,5]

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