

Hybrid Magnetic Activated Carbon–Polyaniline Nanocomposite for Superior Lead Removal from Aqueous Media

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Lead (Pb) contamination in water poses a significant threat to both human health and the environment, as it is toxic even at very minimal concentrations. In the scope of this study, a novel magnetic composite material as AC/Fe₃O₄/PANI-SDS, was synthesized to efficiently eliminate Pb²⁺ ions from polluted water. Each component in the composite has a significant impact: the activated carbon provides a large surface area for adsorption, the magnetic iron oxide (Fe₃O₄) allows the material to be easily magnetic recovery from water systems using a magnet, and the polyaniline (PANI) and sodium dodecyl sulfate (SDS) improve the capability of the material to attract and hold onto Pb²⁺ ions. To assess the surface, magnetic, and structural properties of the prepared material, several characterization techniques were applied, such as FTIR, XRD, SEM-EDS, BET analysis, VSM, and zeta potential measurements. These tests confirmed that the composite has the right structure, and functional groups to work as a capable and efficient adsorbent. Batch adsorption studies were used to evaluate the effect of pH, interaction time, initial Pb²⁺ ions concentration, and temperature on removal efficiency. The findings highlight the composite's remarkable adsorption efficiency after 220 minutes at optimal conditions, specifically at pH 6. Adsorption kinetic studies demonstrated strong agreement with the pseudo-second-order model, while isotherm analysis showed that the Langmuir model provided the highest correlation coefficient within the investigated concentration range. This fitting suggests apparent Langmuir-type adsorption behavior with a maximum adsorption capacity of 348.39 mg/g. Thermodynamic assessment demonstrates that the elimination of Pb²⁺ ions is an endothermic and spontaneous process. In addition, the composite can be reused and recycled repeatedly without significantly reducing its effectiveness, offering an economical and ecologically sustainable approach. The findings of this research highlight the potential of AC/Fe₃O₄/PANI-SDS composite as new, efficient, and eco-friendly adsorbents for the elimination of Pb²⁺ ions from solutions. In real-world applications, its high capacity for adsorption, ease in separation, and reusability make it a promising treatment for heavy metal contamination.

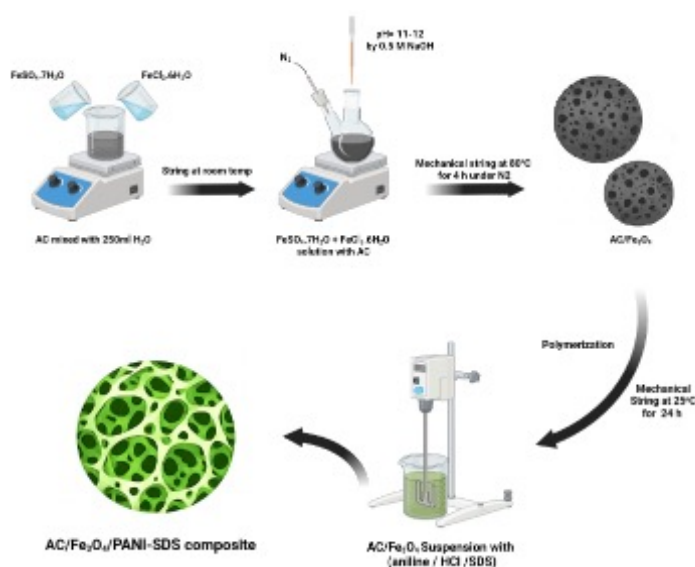


Fig 1. Synthesis process for AC/Fe₃O₄/PANI-SDS composite.