Phase transformed iron oxide – iron (oxy) hydroxide composite nanoflorets grown on foam-like graphene as a high performing adsorbent

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ABSTRACT

Functional surfaces and interfaces play a dominant role in advancing physical and chemical properties exploitable for various applications. Herein, a unique material architecture, viz. foam-like three-dimensional (3D) graphene on nickel foam has been used as a substrate to grow iron oxide (Fe_3O_4) – iron (oxy) hydroxide (FeOOH) nanocomposites with the dandelion-like (labelled as iron nanoflorets) structure. The 3D graphene and the iron nanoflorets have been grown by chemical vapour deposition and electrochemical deposition, respectively. The composite phase is shown to be vital in providing the necessary binding sites for electrostatic interaction for adsorption process in chemical engineering processes. A detailed Raman spectroscopy and X-ray photoelectron spectroscopy analyses reveal the phase changes of FeOOH from lepidocrocite to goethite on the graphene foam substrate. This transformation of lepidocrocite to its more stable polymorph goethite is assisted by the Fe^{2+} ions in a ferrous sulphate solution. The usefulness of hybrid iron nanoflorets as an adsorbent is demonstrated through adsorption of Congo red dye; adsorption capacity as high as ~1553 mg g^{-1} is achieved. The adsorbent is easily recovered by direct lifting due to its sturdy structure, which is an added advantage as the recovery of nanomaterials after adsorption from water remains a great challenge. Experiments suggest that the adsorption of Congo red is found to follow pseudo-first-order kinetics for the first 60 min and followed by pseudo-second-order kinetics. The adsorption isotherm is found to fit both Langmuir and Freundlich isotherms due to the presence of multiple active sites. The present material system is expected to further advance the industrial wastewater remediation.

KEYWORDS

Process engineering; Composite nanostructures; Heirarchical graphene structures; Dye degradation; Iron nanoflorets

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