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Phosphate adsorption on hydroxyl–iron–lanthanum doped activated carbon fiber

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HIGHLIGHTS

- Successful preparation of ACF-LaFe by SolmeteX for effective phosphate removal.
- Phosphorus adsorption capacity of ACF-LaFe is 29.44 mg/g.
- The adsorption mechanisms were investigated by SEM, FT-IR and pH analysis.
- Anions had adverse effect on adsorption with the order of $F^- > SO_4^{2-} > NO_3^- > Cl^-$.

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ABSTRACT

Rare earth, typical lanthanum, has attracted significant attention due to its high phosphate adsorption capability, but the high price and scarcity of the resources hinder its practical application. In this study, Lanthanum(III) was mixed with Iron(III) to obtain the composite metallic (hydr)oxide which are doped onto activated carbon fiber (ACF), named as ACF-LaFe, for phosphate adsorption. Single-factor and response surface methodology (RSM) were used to optimize the preparation. The phosphate adsorption capacity of ACF-LaFe was calculated to be 29.44 mg/g, which is much higher than that of ACF-LaOH or ACF-HFO in our previous reports. Adsorption kinetics and isothermal adsorption studies showed that the pseudo-first-order model and the Langmuir isotherm fitted the experimental data quite well, indicating that the phosphate adsorption onto ACF-LaFe should be monolayer and chemical adsorption with the surface reaction. The phosphate adsorption mechanism was investigated by means of pH study, scanning electron microscope (SEM), Fourier transform infrared spectroscopy (FT-IR). Ionic competition study showed that the presence of concomitant anions had profounder adverse effect on phosphate adsorption onto ACF-LaFe with the order of $F^- > SO_4^{2-} > NO_3^- > Cl^-$. The present study demonstrated that ACF-LaFe would achieve the dual aims of high phosphate removal and low running cost.

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1. Introduction

The presence of dissolved phosphate in surface waters has become a worldwide environmental issue because of its marked negative impacts to water quality that cause eutrophication problems [1,2]. Enhanced removal of phosphate from waste effluents is thus of considerable significance before their discharge into the environment [3]. Various techniques have been used for phosphate removal, including chemical precipitation, biological treatment, ion exchange and adsorption, etc. Among them, adsorption is one of the most attractive approaches with the advantage of operation simplicity, low operation cost and having effective removal without yielding harmful by-products.

Many types of adsorbents for phosphate removal have been investigated, which include aluminum and aluminum (hydr)oxide [4,5], poly-meric ligand exchanger [6], iron oxides [7,8], dolomite [9], red mud [10], zeolite [11], furnace slag [12], mesoporous silicates [13,14] and so on. However, most of these adsorbents would be very difficult to be reused since they are in powder and will sink down to the bottom of the water bodies which may cause environmental secondary pollution. To further improve the recyclability and adsorption efficiency, it is necessary to develop some novel phosphate-specific adsorbents which would be easily available for the water bodies.

In our previous study, lanthanum (hydr)oxide-doped activated carbon fiber (ACF-La) has been prepared for phosphate removal [15,16]. Lanthanum (hydr)oxides are the active component by its

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