



Phosphorus removal from wastewater using nano-particulates of hydrated ferric oxide doped activated carbon fiber prepared by Sol–Gel method

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HIGHLIGHTS

- The preparation of ACF-NanoHFO using Sol–Gel method is investigated.
- Sol–Gel is quoted to be a simple and effective method for ACF-NanoHFO preparation.
- The performance and mechanisms of ACF-NanoHFO for phosphate removal are studied.
- Ligands exchange, electrostatic interactions become weaker with pH increasing.

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ABSTRACT

Sol–Gel method is used to immobilize nano-particulates of hydrated ferric oxide (HFO) within macroporous activated carbon fibers (ACFs), and the phosphate removal behavior and its mechanisms of the new hybrid phosphate adsorbent named as ACF-NanoHFO are studied. The surface structure of ACF-NanoHFO is characterized by scanning electron microscopy (SEM), showing Sol–Gel method to be a reliable method for improving performances of depositing iron nano-particles on the ACF. The Freundlich and Langmuir models are used to simulate the sorption equilibrium, indicating that the Langmuir model is more suitable than the Freundlich model for well elucidation of the experimental data. The maximum adsorption capacity is calculated to be 12.86 mg/g. The kinetic data from the adsorption of phosphate are discussed in a framework of the pseudo second-order model, indicating that the adsorption of phosphate is a chemisorption process. The phosphate adsorption is highly pH dependent. The coexistence of other anions in solutions has an adverse effect on phosphate adsorption. A decrease in adsorption capacity follows the order of exogenous anions, i.e., $F^- > NO_3^- > Cl^- > SO_4^{2-}$. The ligands exchange and electrostatic interactions are manifested to be two main mechanisms for phosphate adsorption of ACF-NanoHFO revealed by Fourier transform infrared (FT-IR) spectroscopy and change of pH values associated with the adsorption process. All the results indicate that the ACF-NanoHFO has a considerable potential for the phosphate removal from contaminated waters.

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1. Introduction

Superfluous phosphorus contained in wastewater from municipal, industrial and agricultural activities can cause eutrophication and hence deteriorate water quality [1,2]. Enhancement of the phosphate removal in waste effluents is thus of considerably significant before their discharge into the environment [3,4]. Nowadays, the treatment technologies applied to phosphate removal mainly include biological removal [5], chemical precipitation by

ferric or aluminum salts [6,7], ion exchange [8], and adsorption [9,10], etc. However, these technologies usually cannot perfectly follow the increasingly stringent regulations on the phosphate discharge in a cost effective manner. Moreover, as an important non-renewable natural resource, the inexpensive phosphorus in the world is estimated to be depleted by 2050 [11]. Therefore, it is worthwhile to explore feasible technologies to capture, recover and reuse the phosphorus in wastewater.

Adsorption seems to be attractive for the phosphate removal due to its simplicity of operation, low cost and the possibility of phosphate recovery [10]. Various materials have been studied as the phosphate adsorbents including dolomite [12], zeolites [13], blast furnace slag [14], banana stems [15], mesoporous silicates [16], iron oxides [17], aluminum salts [18], and so on. However, the

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