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An electrochemically modified novel tablet porous material developed as adsorbent for phosphate removal from aqueous solution

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HIGHLIGHTS

- A low cost novel tablet porous material (TPM) was developed for phosphate removal.
- TPM was modified by an electrochemical surface modification process (ECTPM).
- The adsorption capacity of ECTPM (5.36 mg g^{-1}) was higher than TPM (3.61 mg g^{-1}).
- TPM and ECTPM were of high selectivity on phosphate adsorption.

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ABSTRACT

In the present study, a novel tablet porous material (TPM) was developed from Kanuma clay (K-clay), corn starch, iron powder, white cement and calcium oxide. It was prepared through an electrochemical surface modification (ESM) method. Laboratory-scale batch experiments were conducted to evaluate the phosphate adsorption capacity of TPM and ESM modified TPM (ECTPM) from aqueous solution. The adsorption isotherms, adsorption kinetics and major factors such as temperature and pH were investigated. The phosphate adsorption results fitted the Freundlich isotherm model very well, and the adsorption process was an endothermic and spontaneous reaction which could be described by a pseudo-second-order kinetic model. The maximum phosphate adsorption capacity was 3.61 mg g^{-1} onto TPM and 5.36 mg g^{-1} onto ECTPM, respectively, and equilibrium could be attained in 2 h. The solution pH had little effect on TPM phosphate removal when pH varied from 5.0 to 9.0. ECTPM and TPM are of high selectivity on phosphate adsorption. This novel developed TPM is a more promising adsorbent than other clay mineral materials for phosphate removal from wastewater.

1. Introduction

Food production requires diverse fertilizers such as phosphorus and nitrogen. In past decades, the accelerating growth of the world population resulted in a large consumption of natural resources and increased the burden of food shortage [1]. Phosphorus is an essential element and of irreplaceable in agriculture; it is an unrenewable resource and conclusive evidence reports that current global reserves of P may be depleted in 100 years [2]. Further, the wide utilization of P-fertilizers in agriculture and industry enhances the nutrient element load when P residual and waste discharged into water bodies without any treatment. It causes many environmental issues [3,4], one of the most severe problems is eutrophication in surface water bodies [5]. It causes the deterioration of aquatic ecosystems and the death of aquatic animals [6]. In most cases, phosphorus content is the limiting factor in eutrophication [7]. In a word, the removal of phosphorus has become the focus of investigation by many researchers.

Many techniques were developed for phosphorus removal such as biological phosphorous removal processes [8], chemical precipitation [9], crystallization [10], electrochemistry [11] and membrane bioreactor (MBR) [12]. Among these technologies, Electrochemistry (coagulation) is one worth mentioning because of its high removal efficiency [13], more than 90% of phosphate can be removed under optimum conditions. With regard to electrochemistry, defects are also obvious: such as the difficulty in utilizing it for large amounts of wastewater treatment and the problems of in situ treatment. In this situation, adsorption can be regarded as a good method for phosphate removal [14]. During past years, diverse adsorbents were developed and utilized to promote phosphate removal, such as fly ash [14], bentonites [15],

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