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Kinetic and thermodynamic aspects of arsenate adsorption on aluminum oxide modified palygorskite nanocomposites

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HIGHLIGHTS

- ▶ A novel adsorbent was prepared by modifying palygorskite with aluminum oxide.
- ▶ Characterization of the adsorbent was performed.
- ▶ Adsorption of arsenate in water was achieved.
- ▶ Thermodynamics and kinetics were studied.

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ABSTRACT

Nanocomposed aluminum oxide modified palygorskite was prepared and some of methods such as X-ray diffraction (XRD), N_2 adsorption technique surface area and pore size, and scanning electron microscopic (SEM) with energy dispersive X-ray spectroscopy (EDS) were used to characterize analysis. Compared with aluminum oxide particles, acid activated palygorskite and natural palygorskite clay, aluminum oxide modified palygorskite shows better arsenate adsorption capacity. The effects of adsorption time, temperature, acidity and co-existing anions such as fluorine, bromide, chloride, sulfate, phosphate, nitrite and nitrate on the removal of arsenate from water were investigated. The adsorption thermodynamics was conducted, which shows that the adsorption of arsenate on aluminum oxide modified palygorskite can be better simulated by Redlich–Peterson model and the adsorption is an endothermic and spontaneous process. Kinetics studies show the adsorption is a pseudo-second-order process, which is controlled by surface diffusion at the beginning and then controlled by intraparticle diffusion.

1. Introduction

With the development of modern industries, heavy metals released from industrial, agriculture and domestic wastes are high toxic to human health. Among them, arsenic is the most common toxic substance in the environmental contamination which ranking first on the superfund list of hazardous substances [1,2]. In order to protect public health, the US Environmental Protection Agency, the World Health Organization and the European Commission have decided to lower the maximum contaminant level of arsenic in drinking water from 50 to 10 μg/L [3–5]. This stringent arsenic standard will inevitably require many utilities to upgrade their present systems or consider new treatment options. Various arsenic treatment methods have been developed, including precipitation–coagulation, membrane separation, ion-exchange, coprecipitation and adsorption [4–9]. Most of these removal technologies were expensive, therefore, the focus of research has been on the development of cheap and easy-to-handle removal technologies, especially for decentralized use in rural areas in developing countries.

Adsorption has a comparatively low cost and easily separates a small amount of toxic elements from large volumes of solutions. Some of the common adsorbents used for the Arsenic treatment include activated alumina, manganese green sand, granular ferric hydroxide, soil, and mud [10–14]. However, these techniques have inherent limitations in application (such as complicated treatment process, high cost and energy requirement) or have a danger of secondary pollution. Clay minerals have great potential as inexpensive and efficient sorbents owing to their large quantities, chemical and mechanical stability, high surface area and structural properties. Adsorption by activated alumina (AA) proved recently as one of the best available technologies for arsenic removal. It has an advantage over other adsorbents in that AA used during the removal process is nonhazardous and could be safely disposed of in landfills.

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