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A novel bentonite-based adsorbent for anionic pollutant removal from water

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HIGHLIGHTS

- ▶ We modified the bentonite with CaO to produce a novel adsorbent.
- ▶ Modified bentonite can adsorb anionic contaminants.
- ▶ The novel adsorbent shows superior adsorption capacities.
- ▶ The adsorption mechanism is anion/OH^- exchange reaction.

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ABSTRACT

A novel adsorbent, HO-CaBen, was prepared by the modification of bentonite, which shows good potential as a cheap and effective adsorbent for anionic contaminants removal from aqueous solutions. The adsorbent HO-CaBen was characterized by XRD and FTIR. The effects of equilibrium time, pH and temperature on adsorption some typical anionic contaminants were studied by the batch adsorption process. The adsorption capacities for fluoride, phosphate, Orange II, and SDBS are 50.07, 29.1, 239.5, and 298.5 mg g^{-1}, respectively. These values are higher than those reported for low-cost adsorbents. The adsorption mechanism of the anion on HO-CaBen is anion/OH^- exchange reaction and is verified by theoretical calculation results. These results indicated that HO-CaBen was a promising adsorbent for anion removal from wastewater treatment by bentonite.

1. Introduction

Adsorption is a widely used technique for removing contaminants owing to economical and environment-friendly reasons. The cost of an adsorption process mainly depends on the cost of the adsorbent and its regeneration. Activated carbon is currently the most widely used adsorbent. However, the use of activated carbon is restricted by its high cost. Many low-cost adsorbents are being developed worldwide to replace activated carbon. Clays are some of such low-cost alternatives because of their abundance. Bentonite, a very rich clay mineral, is one of the most extensively used adsorbents.

Bentonite consists of layers of two tetrahedral silica sheets sandwiching one octahedral alumina sheet. Bentonite has a permanent negative charge caused by the isomorphous substitution of Al^{3+} for Si^{4+} in the tetrahedral layer and Mg^{2+} for Al^{3+} in the octahedral layer. This negative charge is balanced by the presence of exchangeable cations (Na^+, Ca^{2+}, etc.) in the lattice structure, which enables its good performance in adsorbing cationic contaminants by cationic exchange [1–3]. Besides cation adsorption, bentonite is easily organo-modified to adsorb nonionic pollutants by partition method [4,5].

However, bentonite weakly adsorbs anionic pollutants because of repulsion between the anion and the negative charge on the edge of the bentonite sheet [6,7]. Some studies have reported the use of organobentonite, bentonite modified with a cationic surfactant, for anionic dye removal with high loading amount of surfactant (200% of the cationic exchange capacity, CEC) [8–10]. Our previous study has revealed that the main mechanism of the adsorption involved in anionic dye removal is the anionic exchange between contaminants and excessive anions from the surfactant [11]. Thus, to obtain a high adsorption capacity, modifications require surfactants at double the CEC. Consequently, the cost escalates.

Anionic contaminants such as fluoride, phosphate, acid dyes (Orange II), and anionic surfactants (sodium dodecyl benzene sulphonate, SDBS) are very common in the industry and domestic wastewater. Some attempts have been made to remove these anionic pollutants using modified bentonite. For example, the adsorption capacity of fluoride on acid-activated bentonite is as high as

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