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Ultrasound assisted synthesis of Ca–Al hydrotalcite for U (VI) and Cr (VI) adsorption

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HIGHLIGHTS

- ▶ Ca–Al LDHs is synthesized in a modified co-precipitation method.
- ▶ Ultrasonic time and temperature have a significant effect on the material synthesis.
- ▶ Ca–Al LDHs exhibits high adsorptive capacity of chromium and uranium.
- ▶ Desorption efficiency of chromium and uranium are below 50%.

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ABSTRACT

Adsorption of chromium (VI) and uranium (VI) nitrate on Ca–Al hydrotalcite (Ca–Al LDHs) compounds is investigated. The powdered materials are synthesized in a modified co-precipitation method under the ultrasonic treatment with different conditions for Cr (VI) and U (VI) adsorption. Factors that affect the compounds synthesis such as temperature, reaction time, calcination and aging conditions are reported. The effects of various parameters on adsorption process including adsorption/desorption kinetics, isotherms and influencing factors such as contact time, solution pH and effect of competing ions are studied. It is found that Ca–Al LDHs has the largest capacity for both Cr (VI) and U (VI), adsorbing 104.82 ± 0.02 mg/g and 54.79 ± 0.02 mg/g, and highest rate of adsorption up to $98.78 \pm 0.02\%$ and $90.28 \pm 0.02\%$ respectively. Cr (VI) and U (VI) adsorption decreased obviously with pH levels outside the range of 7–11. Adsorption/desorption kinetics of Cr (VI) and U (VI) shows that desorption K values of U (VI) are larger than Cr (VI) while adsorption K values U (VI) are smaller than Cr (VI), suggesting that Ca–Al LDHs efficiency for the removal of U (VI) is fast adsorption and slow release compare to Cr (VI). The effect of competing ions such as nitrate radical and chloridion was negligible.

1. Introduction

Layered double hydoxides (LDHs), also known as anionic clays or hydrotalcite (HT)-like materials have been widely investigated in recent years because of their promising applications in areas such as water treatment, nuclear waste treatment/storage, anion scavengers, neutralizers (antacids), filtration, polymer stabilizers, catalysts and catalyst supports, anion exchangers, adsorbents, electroactive, photoactive materials and pharmaceutics [1–18]. Recently, significant interest has been devoted to the synthesis of LDHs with new compositions by various kinds of modified method allowing improved applications, such as ion-exchange method [1,4,11,19], melt intercalation [5], sol–gel method [8], situ growth method [9,13,14] and co-precipitation method [20,21]. For the preparation of LDHs by co-precipitation inorganic salts in alkaline media either at constant or at increasing pH, the method of pH variation is frequently used. Expectative product cannot be prepared if the pH is too low or too high, so the pH value must be chosen carefully. Another important point to take note of is that the pH value needed for the precipitation of LDHs is not necessarily equal to the pH of the precipitation of the most soluble metal hydroxide.

In this study, we improved the co-precipitation method to prepare Ca–Al-LDH that significantly shortens the reaction time and reduced the reaction conditions. The improved ultrasound technique method applied to the synthesis of layered double hydroxides is simpler, easier to control, and consumes less energy and materials than traditional methods [16–18,22–25].

The removal of heavy metals (HMs) from wastewater is a matter of great interest in the field of water pollution, because it may

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