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Synthesis and application of magnetic graphene/iron oxides composite for the removal of U(VI) from aqueous solutions

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HIGHLIGHTS

- A novel Fe_3O_4/GO was synthesized by chemical co-precipitation method.
- The Fe_3O_4/GO showed high sorption capacity towards U(VI) ions.
- Fe_3O_4/GO could be easily separated with ease using an external magnet.
- Fe_3O_4/GO exhibited high regeneration and repeated reversibility in aqueous solution.

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ABSTRACT

Graphene has been extensively concerned in multidisciplinary research fields due to its remarkably physicochemical characteristics. Herein, magnetic graphene/iron oxides composite (Fe_3O_4/GO) which was synthesized from graphene using a chemical reaction approach had been employed as a novel adsorbent for the preconcentration and solidification of U(VI) ions from aqueous solutions. The sorption behavior of U(VI) on the surface of Fe_3O_4/GO was carried out under ambient conditions such as contact time, pH and ionic strength according to concentration of $C_{U(VI)initial} = 1.12 \times 10^{-4}$ mol/L. The Langmuir and Freundlich models were adopted to simulate sorption isotherms of U(VI) at three different temperatures relying on the concentration of $C_{U(VI)initial} = 2.25 \times 10^{-5}$ to 2.24×10^{-4} mol/L, the experimental results suggested that the sorption reaction was favored at higher temperature. The pH-dependent and ionic strength-independent U(VI) sorption on Fe_3O_4/GO demonstrated that the sorption mechanism of U(VI) was inner-sphere surface complexation at low pH values, whereas the removal of U(VI) was achieved by simultaneous precipitation and inner-sphere surface complexation at high pH values. The maximum sorption capacity of U(VI) on Fe_3O_4/GO at T = 293 K and pH = 5.5 ± 0.1 was about 69.49 mg/g higher than majority of materials and nanomaterials reported. Magnetic separation has been considered as an effective and quick technique for separating magnetic particles, without filtration and centrifugation. The Fe_3O_4/GO can be favorably separated from aqueous solution under an applied magnetic field from large volumes of aqueous solutions. The experimental results show that the Fe_3O_4/GO is a promising adsorbent for the removal of radionuclides and heavy metal ions from large volumes of aqueous solution.

1. Introduction

Contamination of the environment with radionuclides and heavy toxic metal ions has been concerned throughout the world due to application of nuclear weapons, exploiting of nuclear energy, coal combustion, application and production of phosphoric fertilizer, etc. [1]. Uranium is commonly present in the hexavalent oxidation state in wastewater under the aerobic condition [2,3]. The predominantly radiological detriment from uranium is alpha radiation. Uranium is one of toxic radioactivity elements due to its carcinogenic and mutagenic characteristics [4]. Uranium released into the environment can be hazardous to human health, and reach the top of food chain eventually be inhaled by persons leading to detrimental impacts of human health, such as kidney damage, liver damage and even death [5,6]. Therefore, it is significant to remove uranium from wastewater before it is discharged into the environment. Traditional methods have been employed for the elimination of radionuclides and toxic heavy metal ions such as electrodeposition, solvent extraction, coagulation, electro chemical treatment, sorption, membrane processing and reverse osmosis [7–10]. Among these approaches, sorption has been

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