Preparation of Phosphorylated Graphene Oxide-Chitosan Composite for Highly Efficient Removal of U(VI)

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Uranium is not only a strategic resource for the nuclear power but also a highly toxic contaminant in the environment.[1] Although a series of traditional capturing materials including zeolite, metal-organic framework, mesoporous silica, and carbon-based nanomaterials have been developed, the combined advantages of decent stability, ultrafast removal kinetics, high sorption capacity, great selectivity, and potential recyclability have yet to be integrated into a single material.[2-6] Herein, a new synthesis strategy was developed to synthesize a novel phosphorylated graphene oxide (GO)-chitosan (CS) composite (denoted as GO-CS-P) for U(VI) removal. Batch experiments and spectroscopic analysis were performed to explore the removal performance and mechanism of GO-CS-P towards U(VI). The results showed that with the presence of the GO-CS-P composite, the concentration of U(VI) in the aqueous solution can be reduced to an extremely low level within a short time of 15 min. In addition, the maximum sorption capacity of U(VI) on GO-CS-P was calculated to be ~779.44 mg/g, which is higher than those on GO, GO-CS and a series of currently reported adsorbents. Moreover, GO-CS-P also exhibited high selectivity in capturing U(VI) from a mixture containing multiple competing metal ions. According to the desorption experiments, Fourier transform infrared spectroscopy (FTIR), X-ray absorption spectroscopy (XAS) and X-ray photoelectron spectroscopy (XPS) analysis, the highly efficient immobilization of U(VI) in GO-CS-P was predominantly controlled by inner-sphere surface complexation with a minor contribution of surface reduction. These observations indicate that the GO-CS-P composite can be used for nuclear fuel partition and uranium-bearing wastewater remediation.

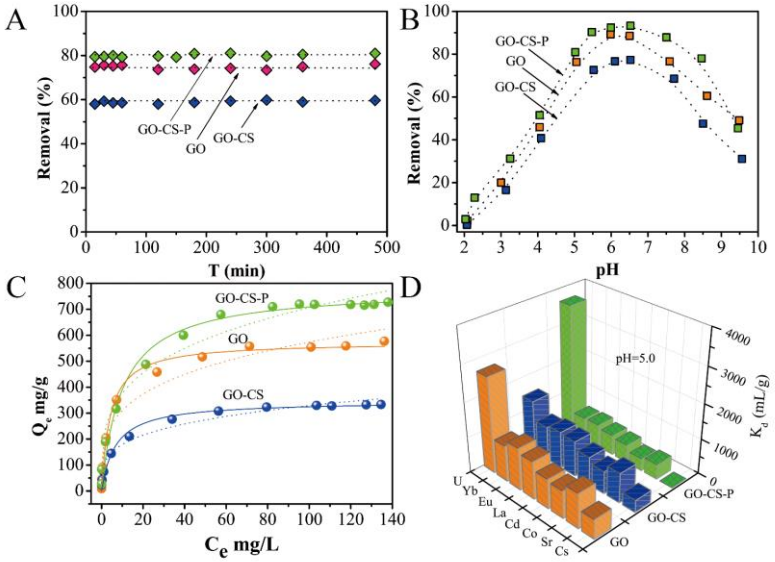

Fig.1. (A) Time-dependent sorption behaviors of U(VI) onto GO, GO-CS and GO-CS-P. T = 293 K, pH = 5.0, m/V = 0.05 g/L, $C_{U(VI)initial}$ = 5.0×10^{-5} mol/L, I = 0.01 mol/L $NaNO_3$; (B) Effect of solution pH on the removal of U(VI) by GO, GO-CS and GO-CS-P. T = 293 K, m/V = 0.05 g/L, $C_{U(VI)initial}$ = 5.0×10^{-5} mol/L, I = 0.01 mol/L $NaNO_3$; (C) Sorption isotherms, Langmuir and Freundlich model fits of U(VI) on GO, GO-CS and GO-CS-P. T = 293 K, pH = 5.0, m/V = 0.05 g/L, I = 0.01 mol/L $NaNO_3$. Symbols represent the experimental data, solid lines represent Langmuir model fits and dash lines represent Freundlich model fits; (D) Sorption selectivity of GO, GO-CS and GO-CS-P towards multiple metal ions. T = 293 K, pH = 5.0, m/V = 0.05 g/L, I = 0.01 mol/L $NaNO_3$, C_0 = 5.0×10^{-4} mol/L for a single metal ion.

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