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Adsorption of uranium(VI) by humic acids isolated from two China uranium-rich lignite deposits

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Due to human activities such as uranium mining, processing nuclear materials and nuclear power generation, excessive amounts of uranium have been discharged into the soils, surface water and groundwater. Humic acids(HAs) isolated from lignites have demonstrated beneficial impacts on immobilize radionuclide contaminants in water. The aims of this study is to explore the adsorption and desorption behavior of uranium(VI) on HAs derived from uranium-rich lignites and find out whether the high content of uranium present in these HAs can affect the reaction system. HAs(XZ-HA and BM-HA) were extracted from two uranium-rich lignites from XinZhai and BangMai villages in Yunnan province, China. The properties of obtained HAs were characterized by FTIR, element analysis, determination of HAs acidity and UV-Vis. Different operating conditions of pH, ionic strength, time, initial uranium concentration, and adsorbent amount were investigated. The results showed that HAs were particularly effective for adsorbing uranium(VI) and the optimum pH ranged from 5.0–8.5. The ionic strength(0.001, 0.01 and 0.1 M NaCl) can influence the adsorption behavior by affecting the HAs molecular structure, the adsorption efficiency decreased with increasing of ionic strength. The maximum uranium(VI) adsorption capacity of XZ-HA and BM-HA were 2.9 mg g^{-1} and 3.7 mg $g^{-1}$with adsorption efficiency of 72.5% and 92.0% respectively, the chemical characterization of HAs suggested that the carboxylic and phenolic hydroxyl groups were responsible for controlling the adsorption capacity. The pseudo-second-order model was found to explain the adsorption kinetics most effectively, and the adsorption isotherms were fitted well by the Langmuir and Freundlich models. Based on the desorption experiments, the main adsorption mechanism was complexation effect between the organic ligands of HAs and uranium(VI). The uranium present in XZ-HA and BM-HA(9.6 mg kg^{-1} and 55.2 mg kg^{-1}) were released into the solution at the pH values between 1.0–3.0, when the BM-HA dosage was 2.5 g L^{-1}, the maximum concentration of uranium to be 50.4 μg L^{-1}, which exceed WHO guideline value for uranium(30 μg L^{-1}) in drinking water. This shows that uranium-rich lignite-derived HAs may present a potential environmental risk when used in acidic aqueous media.