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Effective, rapid and selective adsorption of radioactive Sr^{2+} from aqueous solution by a novel metal sulfide adsorbent

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Abstract: A novel metal sulfide (KZTS) adsorbent has been synthesized using a simple one-step hydrothermal method for radioactive Sr^{2+} removal from aqueous solutions. XRD and TG analyses indicated that KZTS was chemically and thermally stable. SEM-EDS and TEM images showed that KZTS possessed both flake-like and polyhedral structure with the formula of $\text{K}_{1.67}\text{Zn}_{0.67}\text{Sn}_{2.17}\text{S}_{6.00}$ and $\text{K}_{5.84}\text{Zn}_{3.47}\text{Sn}_{5.04}\text{S}_{16.99}$, respectively. The average formula was determined to be $\text{K}_{1.87}\text{ZnSn}_{1.68}\text{S}_{5.30}$ using ICP-OES. The adsorption ability of KZTS for Sr^{2+} was evaluated in detail by batch experiments. The kinetics studies showed that Sr^{2+} was rapidly removed from the aqueous solution within the equilibrium time of 10 min. According to Langmuir isotherm, the maximum adsorption capacity of KZTS was 19.3 mg/g at 298 K and the high value of the Langmuir constant indicated the high affinity of KZTS for Sr^{2+} . The adsorption mechanisms involved ion exchange and surface Sr–S bonding interactions, with the former dominating. High adsorption performance was observed over a broad pH range of 3–11, although it could be inhibited by co-existing ions, especially Ca^{2+} and Mg^{2+} . The adsorbent showed a high distribution coefficient ($K_d = 1.26 \times 10^6$ mL/g) and negligible adsorbate leaching at low Sr^{2+} concentrations, indicating the strong and irreversible adsorption of Sr^{2+} on KZTS. Further, KZTS exhibited high selectivity for Sr^{2+} in alkaline and tap water. These remarkable features suggest that KZTS is a highly desirable adsorbent to remove radioactive strontium from radioactive wastewater.

Keywords: Radioactive wastewater; Radioactive strontium; Adsorption; Ion exchange; Metal sulfide

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