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PII: S1385-8947(18)31107-0
DOI: https://doi.org/10.1016/j.cej.2018.06.069
Reference: CEJ 19280

To appear in: *Chemical Engineering Journal*

Received Date: 23 April 2018
Revised Date: 5 June 2018
Accepted Date: 12 June 2018

Please cite this article as: M. Zhang, P. Gu, Z. Zhang, J. Liu, L. Dong, G. Zhang, Effective, rapid and selective adsorption of radioactive Sr^{2+} from aqueous solution by a novel metal sulfide adsorbent, *Chemical Engineering Journal* (2018), doi: https://doi.org/10.1016/j.cej.2018.06.069

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 $K_{1.67}Zn_{0.67}Sn_{2.17}S_{6.00}$ and $K_{5.84}Zn_{3.47}Sn_{5.04}S_{16.99}$, respectively. The average formula was determined to be $K_{1.87}ZnSn_{1.68}S_{5.30}$ 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 = 1.26×10^6 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