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Sequestration of radionuclides and heavy metals by hydroxyapatite doped with Fe, Cu and Sn

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Apatite, $Ca_5(PO_4)_3(F,OH,Cl)$ ($P6_3/m$, Z=2), is the most abundant phosphate mineral on Earth. The end-member hydroxyapatite, $Ca_5(PO_4)_3OH$ ($P2_1/b$), is the primary mineral component in bones and teeth and tends to scavenge and sequester heavy metals in the human body. Hydroxyapatite has also been shown to be effective at sequestering radionuclides and heavy metals in certain natural systems (Dybowska et al., 2004). Hydroxyapatite has been the focus of many laboratory studies and is utilized for environmental remediation of contaminated sites (Moore et al., 2002). The crystal structure of apatite tolerates a great deal of distortion caused by extensive chemical substitutions. Metal cations (e.g. REE, actinides, K, Na, Mn, Ni, Cu, Co, Zn, Sr, Ba, Pb, Cd, Fe) substitute for Ca, and oxyanions (e.g. AsO_4^{3-}, SO_4^{2-}, CO_3^{2-}, SiO_4^{4-}, CrO_4^{2-}) replace PO_4^{3-} through a series of coupled substitutions that preserve electroneutrality. Owing to the ability of apatite to incorporate "impurities"(including actinides) gives rise to its proposed use as a waste form for radionuclides. Recent work at Sandia National Laboratory demonstrated that hydroxyapatite has a strong affinity for U, Pu, Np, Sr and Tc reduced from pertechnetate (TcO_4^-) by $SnCl_2$ (Moore et al., 2002). Based on these earlier promising results, an investigation was initiated into the use of apatite-type materials doped with aliovalent cations including Fe, Cu and Sn as Tc-scavengers. Synthetic Fe and Cu-doped hydroxyapatite samples were prepared by precipitation of Ca, from Ca-acetate, and P, from ammonium phosphate. The Fe and Cu were introduced as chlorides into the Ca-acetate solution. Stannous chloride was used as a reducing agent and was apparently incorporated into the crystal structures of the hydroxyapatite samples in small, as yet undetermined quantities.

References

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