Utilization of Al-/Fe-/Si- Ceramic Matrices for Cadmium Detoxification in Wastes

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Abstract: Waste sludge containing cadmium (Cd) presents serious risks to the environment and public health. The stabilization and detoxification of cadmium-laden sludge is thus of great significance. The sintering of metal-containing waste with various ceramic precursors forming various crystalline structures has been proved to be a capable technique of metal stabilization. To simulate the process of stabilization, cadmium oxide (CdO) was alternatively mixed with three types of easy attainable ceramic precursors (i.e., amorphous SiO_2, α-Al_2O_3, α-Fe_2O_3) at various molar ratios. The mixtures were subjected to a well-controlled thermal treatment scheme and heated at desired temperatures in the range of 600-1000 ℃ for 3 h. The phase transformation during the sintering process was monitored by X-ray diffraction (XRD), and the cadmium incorporation efficiency was quantified through Rietveld refinement method. Results showed that cadmium was able to be crystallochemically incorporated into various crystalline structures, including $CdSiO_3$, Cd_2SiO_4, Cd_3SiO_5, $CdAl_4O_7$ and $CdFe_2O_4$. It was found that the sintering temperature and the types of precursor greatly affected the cadmium incorporation reactions. According to the weight fractions of crystalline phases in the sintered products, the cadmium incorporation efficiency was further expressed as a transformation ratio. Constant-pH leaching tests were used to assess the cadmium stabilization effect. A substantial reduction in Cd leachability was achieved by forming different Cd-hosting crystalline products, particularly for $CdFe_2O_4$ spinel phase. The results derived from this study suggested a promising strategy for the stabilization and detoxification of cadmium laden sludge by sintering with Al/Fe/Si-rich ceramic precursors.