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P-31 Nuclear Magnetic Resonance as a Probe of Plutonium Incorporation and Radiation Damage in Phosphates

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Plutonium doped YPO4 was prepared to test the extent of solid solution and the effect of radiation damage over several years. Y0.92 238Pu0.08PO4 showed the presence of a Pu substituted xenotime phase and a 238PuP2O7 phase by X-ray diffraction (XRD). The 31P magic-angle spinning nuclear magnetic resonance (MASNMR) spectrum showed peaks for PuP2O7 and peaks assigned to phosphorus coupled to Pu3+ substituted randomly into Y3+ sites. A time series of 31P MASNMR and XRD measurements observed the loss of the reflections due to the 238PuP2O7 phase in the XRD pattern of the Y0.92238Pu0.08PO4 sample within 4 weeks. The MASNMR spectra obtained at longer times in both the Y0.92 238Pu0.08PO4 and Y0.96 238Pu0.04PO4 samples showed an additional broadened and shifted 31P resonance assigned to amorphised xenotime with a chemical shift consistent with Q0 orthophosphate. Thus, the amorphised local structure is assigned to a predominantly Q0 phosphate arrangement subject to local densification.

Summary

This paper is about understanding the solid solubility of Pu in crystalline phosphates and the effect of its alpha decay on the local structure of the crystal. We use novel actinide enabled magic angle spinning nuclear magnetic resonance to elucidate the nature of bonding in the amorphised phase.

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