Phase transformation kinetics in U-Mo-Pt alloys

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Introduction

Alloys of U, Mo, and Pt are candidate fuels of interest to the Reduced Enrichment for Research and Test Reactors (RERTR) program. This program operates to reduce the threat of nuclear proliferation worldwide by eliminating the use of highly enriched uranium (HEU) in research and test reactors. A major facet of this program is the development of high-density, low-enrichment-uranium fuel to replace the HEU-based fuel currently used in many of the world's high-power research reactors. Unwanted phase transformations in U-Mo alloys are inhibited by additions of Pt. This study is designed to investigate the role of Pt in those phase transformations.

Methods and Materials

A series of U-Mo alloys containing varying amounts of Pt have been prepared. The alloys contain depleted uranium, about 20 atomic percent Mo, and concentrations varying from about 0 to 2 atomic percent of Pt. These alloys were annealed for various times and temperatures and then quenched. The alloy samples (approximately 5 mm in diameter and 1 mm thick) were given thin epoxy coatings and sealed in an aluminum sample holder with a Kapton window. Each sample contained roughly 0.3 g of depleted uranium. Alloy samples were examined at MR-CAT with a study of Pt L_{III} edge and Mo K edge x-ray absorption fine structure (XAFS).

Since the samples consisted of only a few grains, measuring the fluorescence from a static sample resulted in large contamination of the XAFS signal due to diffraction peaks. A sample spinner was employed to broaden the diffraction lines (in energy) and enable collection of a clean signal (Figure 1).

Results

Preliminary analysis shows that the Pt coordination environment consists of 4–5 uranium atoms at 2.95 ± 0.03 Å with a Debye-Waller factor of 0.010 ± 0.002 Å^2, a fairly large disorder. Surprisingly, adding 20% Mo does not improve the fit. A contribution of between 3% and 10% Mo in the first shell results in the best fit, depending on the sample. There is not a strong second coordination shell around the Pt atoms (Figure 2). Annealing the sample apparently has only a small effect on the Pt near-neighbor environment, even though the uranium undergoes a phase change. There is a small decrease (<1%) in the Pt-U distance, and some increase in the Mo coordination number in the first shell is apparent.

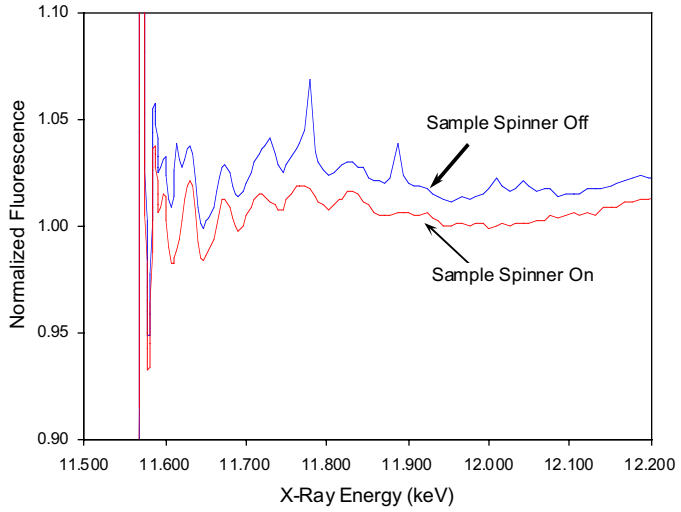

Figure 1: X-ray absorption spectrum above the Pt L_{III} edge for the 2% Pt sample with sample spinner on (bottom) and off (top). In the top spectrum the diffraction peaks are already reduced by more than one order of magnitude by a filter and soller slits in the Stern-Heald geometery.

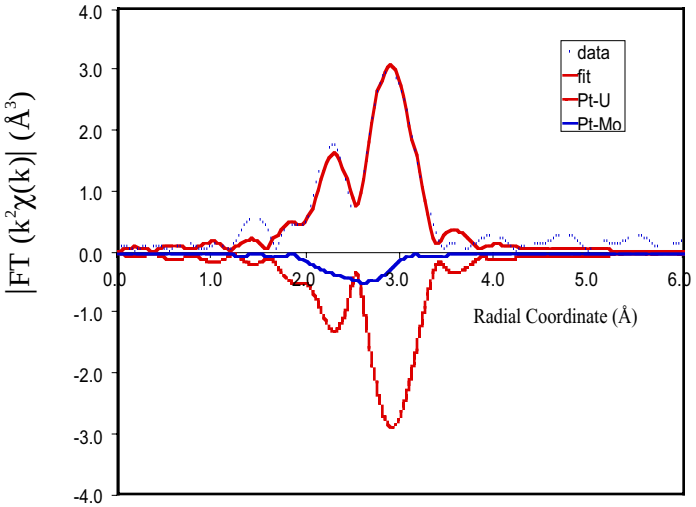

Figure 2: Magnitude of the Fourier transform of $k^2\chi(k)$ for U-Mo-Pt (1%) sample annealed for 100 hours. Individual scattering path contributions are shown in negative y direction.

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