MATERIALS ENGINEERING
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"Irradiation Behaviors in U-10Mo Alloys from the Atomistic Scale to the Microscale"

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ABSTRACT

Low enriched uranium (LEU, < 20 % ^{235}U)-molybdenum (U-Mo) alloy is the primary nuclear fuel candidate for research and test reactors, and it is also considered one of the fuel candidates for fast reactors. Furthermore, U-Mo monolithic fuel is currently undergoing a qualification process to replace highly-enriched uranium (≥ 20 % ^{235}U) fuel for high-performance research and test reactors. As part of the fuel qualification process, it is critical to examine the microstructural evolution of U-Mo fuel under irradiation. This study determines: 1) radiation behavior of U-10Mo alloy at the microscale subjected to different fuel fabrication techniques and 2) species diffusion and diffusion mechanisms of U, Mo, and Xe under irradiation to understand fission gas bubble behavior. There is a lack of knowledge of the microstructural evolution of the rolled U-Mo alloy foil, which is a proposed geometry for high-performance research and test reactors, as well as the U-Mo alloy fuel that is cast into a slug form without rolling, which is a more suitable geometry for advanced reactors. The effects of the fabrication methods, specifically arc-casting and cold-rolling, on the phase decomposition in U-10Mo alloy subjected to low neutron fluence are characterized using synchrotron X-ray diffraction and scanning electron microscopy. During the nuclear fuel qualification process, it is also important to understand and predict the behavior of fission gas bubbles in U-Mo fuel under irradiation, which affects fuel swelling and fuel failure. Mechanistic fuel models are being developed that can reproduce the existing experimental data for fuel swelling and be further applied to irradiation conditions which cannot be achieved experimentally. Diffusion of species under irradiation conditions is an important parameter in the mechanistic fuel models; however, no temperature-relevant experimental diffusion data exists. Diffusion of U, Mo, and Xe in γU-10wt.%Mo under irradiation, calculated via rate-theory models, parametrized using molecular dynamics simulations, are presented.

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