

Corrosion characteristics of zirconia coated zirconium alloy in lithiated water

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Abstract After the Fukushima-Daiichi accident, the development of accident tolerant fuel cladding materials to improve reactor safety has become a hot topic in the field of nuclear industry. ZrO_2 has a satisfactory neutron economy and can guarantee the fission chain reaction process, which enables it to be a promising coating for zirconium alloy cladding. Maintaining a good corrosion resistance in primary coolant loop during normal operations of Pressurized Water Reactors is a prerequisite for ZrO_2 as a protective coating on zirconium alloy cladding. Research on corrosion performance of ZrO_2 coating in nuclear water chemistry is relatively scarce, and existing reports failed to provide an in-depth explanation for failure causes of ZrO_2 coating. Herein, a detailed corrosion process of ZrO_2 coating in lithiated water at 360 °C and 18.5 MPa was proposed based on experimental research and molecular dynamics simulation. The protective effect and failure mechanism of ZrO_2 coating on Zry-4 under varied LiOH concentrations was further revealed. ZrO_2 coating provided a favorable corrosion protection with the occurrence of localized corrosion at low LiOH concentrations. Factors influencing corrosion resistance mainly include pitting corrosion extension, enhanced Li^+ permeation, short-circuit diffusion of O^{2-} and ZrO_2 phase transformation. In highly-concentrated LiOH solutions, intergranular corrosion, internal oxidation and perforation resulted in coating failure. Zr ions were released to coating surface to form flocculent ZrO_2 and ZrO_2 clusters due to the strong diffusion and dissolution tendency of α -Zr in the Zry-4 substrate. This work can provides some references to understand service behavior of nuclear coatings under variable water chemistry conditions and promote in-pile application of ZrO_2 coating.

Keywords coating, zirconium alloy, corrosion, LiOH concentration