Effect of pre-exposure on corrosion behaviors of FeNiCrAl high entropy alloys in liquid lead-bismuth eutectic with different oxygen concentrations at 550 °C

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Abstract The fuel cladding materials of lead-cooled fast reactors (LFRs) are subjected to fast neutron irradiation, high temperature, liquid lead-bismuth eutectic (LBE) corrosion and mechanical degradation during service, which require very high comprehensive properties of materials. Therefore, candidate materials such as FeCrAl alloy, advanced stainless steel and high entropy alloy (HEA) are designed. Among them, the HEA is expected to be applied in LFRs due to its diversity of composition design and unique four-core effects, but the corrosion data of HEA in liquid LBE is still lacking. The corrosion behavior of four FeNiCrAl HEAs exposed to liquid LBE at different oxygen concentrations at 550 °C was investigated in the present work. After 500 h of pre-exposure to oxygen-saturated LBE, none of the four HEAs had dissolution corrosion, among which $Fe_{45}Ni_{30}Cr_{15}Al_{10}$ and $Fe_{50}Ni_{25}Cr_{15}Al_{10}$ HEAs had slight nodular corrosion. After 500 h of pre-exposure to low-oxygen (1.93×10^{-7} wt.%) LBE, all four HEAs suffered severe dissolution corrosion. After 500 h of pre-exposure to oxygen-saturated LBE followed by 500 h of exposure to low-oxygen LBE, due to the formation of protective Al-rich oxide film, dissolution corrosion still did not occur and the reduction of Fe-rich oxides in the outer layer of the nodular corrosion was observed in the four HEAs. After 500 h of exposure to low-oxygen LBE followed by 500 h of exposure to oxygen-saturated LBE, a continuous oxide film formed on the surface, the dissolution corrosion was inhibited. The corrosion mechanism and oxidation kinetics of FeNiCrAl HEAs exposed to liquid LBE at different oxygen concentrations at 550 °C are discussed.

Keywords: Alloy; TEM; Oxidation; High temperature corrosion