8–3 Life Prediction of Material in Nuclear Reprocessing Plants

— Corrosion Characteristics of Stainless Steel in Boiling Nitric Acid Solution Including Np —

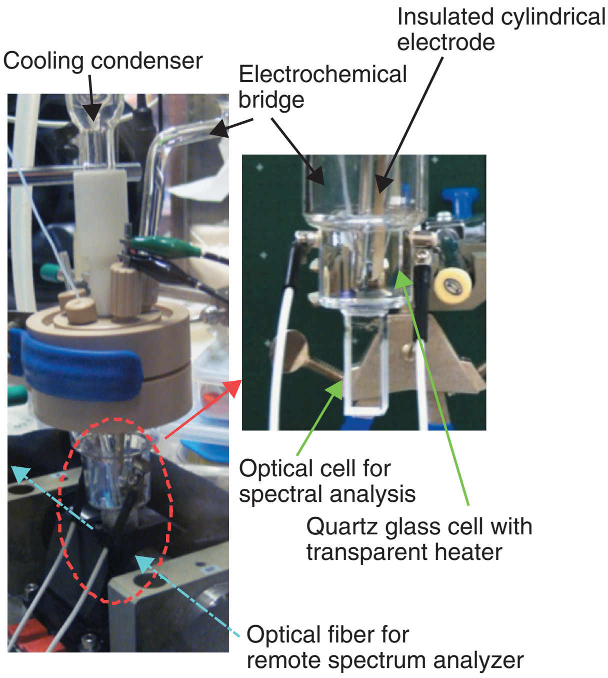

Fig.8-7 Appearance of developed electrochemical cell including optical cell for spectral analysis
The test cell is combined with a transparent heater, a potential probe, and an optical cell. It is operated remotely. The amount of solution is approximately 15 cm³.

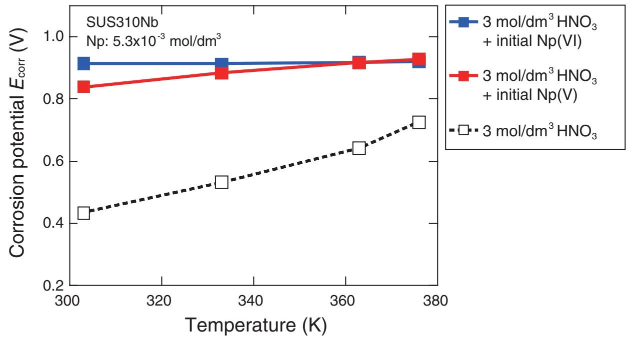

Fig.8-8 Effect of temperature on corrosion potential of stainless steel (SUS310Nb)
The increasing corrosion potential caused by a slight amount of Np accelerates corrosion; the behavior depends on the valence of the Np and the temperature.

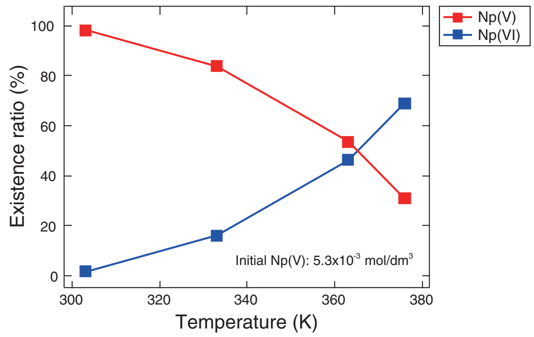

Fig.8-9 Effect of temperature on valence change in Np
Pentavalent Np(V) is oxidized to hexavalent Np(VI) by increasing the temperature of the solution. This suggests that the oxidized Np(VI) ions accelerate corrosion.

Nuclear reprocessing has been promoted for the reuse of uranium (U) and plutonium (Pu) in spent reactor fuels worldwide. A corrosive nitric acid solution is used in nuclear reprocessing, which involves materials containing metallic ions that accelerate corrosion. Therefore, accelerated corrosion of stainless steel, one of the component materials, is an issue in nuclear reprocessing plants.

It is well known that among metallic ions, Pu and neptunium (Np), which are oxidized in boiling nitric acid solution to metallic ions in higher oxidation states, accelerate corrosion the most. Furthermore, the amount of Pu and Np that can be handled in an experiment is restricted because they are radioactive elements.

We developed a specially designed small electrochemical test cell integrated with an optical cell for spectroscopic analysis in order to concomitantly evaluate the oxidation states of Np ions and the polarization curves of stainless steel in boiling nitric acid solution. The goal of this study is to understand the corrosion acceleration mechanism of stainless steel.

The test cell shown in Fig.8-7 enables (1) the handling of a small amount (ca.15 cm³) of test solution, (2) simultaneous spectroscopic characterization and electrochemical monitoring of the solution, and (3) stable electrochemical measurements in a boiling nitric acid solution.

Fig.8-8 shows that the corrosion potential E_{corr} of the stainless steel increases with increasing temperature when the solution contains Np ions. The presence of Np ions accelerates the corrosion of stainless steel by increasing the corrosion potential. Further, the corrosion potential in the solution containing Np(VI), in a higher valence state, does not change with increasing temperature, whereas that of a solution containing Np(V), in a lower valence state, increases.

Fig.8-9 shows the existence ratios of Np(VI) and Np(V) in 3 mol/dm³ HNO_3 with initial Np(V) ions at various temperatures. The existence ratio of Np(VI) increases with increasing temperature.

In conclusion, Np(VI) oxidized by nitric acid was found to raise the corrosion potential and accelerate the corrosion of stainless steel.

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Reference

Kato, C. et al., Electrochemical Measurements in Boiling Nitric Acid Solutions Containing Radioactive Elements by using Small Cell with a Portion for Spectral Analysis Function, Zairyo to Kankyo, vol.60, no.2, 2011, p.69-71 (in Japanese).