

## Nitric Acid Reduction on 316L Stainless Steel in Conditions Representative of Reprocessing

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During the lifetime of a nuclear facility, structural materials are exposed to high concentrations of nitric acid. Due to their high corrosion resistance, steels comprise the largest class of metal-based materials encountered on nuclear sites. A greater understanding of how process steels interact with nitric acid in nuclear plant environments is required in order to enable informed decisions to be made about the design and effective application of different steel types within nuclear environments.

It is widely acknowledged that nitric acid is a complex media. Stainless steels readily form a protective oxide layer in nitric acid. However, increasing the oxidising power of the media tends to shift steel corrosion potentials towards their transpassive domain. This leads to passive film dissolution, resulting in rapid transpassive corrosion.

The corrosion of steels in nitric acid is further complicated by the autocatalytic reduction of  $\text{HNO}_3$  to aqueous nitrous acid ( $\text{HNO}_2$ ) which attacks the steel surface. With increasing  $\text{HNO}_3$  concentration the reduction rate of  $\text{HNO}_3$ , and consequent formation of  $\text{HNO}_2$ , accelerates the corrosion rate due to the oxidation of passive film forming elements, such as Fe and Cr from the steel surface. Consequently Cr, which is important to passive film stability, depletes from the surface.

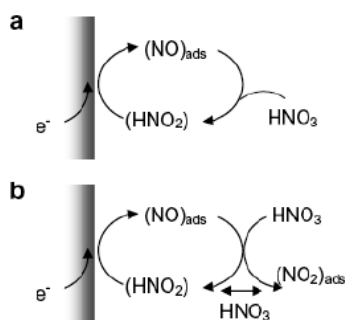


Figure 1 - Sketch of the mechanism of reduction of nitric acid [1]. Where, (a) represents low to moderate  $\text{HNO}_3$  concentrations and (b) represents high  $\text{HNO}_3$  concentrations.

This behaviour has previously been observed electrochemically in static linear sweep voltammetry (LSV) experiments. However, performing LSV experiments at a rotating working electrode appears to slow the rate of nitric acid reduction, decreasing the

corrosion potential, as shown in Figure 2. Most likely, this is due to removal of nitrous acid from the surface of the electrode due to enhanced media flow, which in turn is reducing the oxidising power of the media.

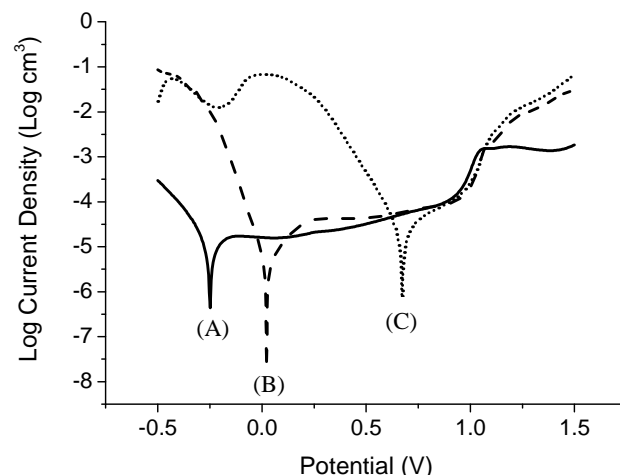


Figure 2 - Potentiodynamic polarisation plots of type 316L SS in 5%  $\text{HNO}_3$  at (A) static working electrode, (C) 25%  $\text{HNO}_3$  at a static working electrode and (B) rotating at 5Hz. Conducted at room temperature ( $20 \pm 2^\circ\text{C}$ ). Plots were measured in the potential range -0.5V to 1.5V (sweep rate,  $10\text{mVs}^{-1}$ ).

With a view to assessing the effect of this behaviour on process steels in stagnant and/or flowing conditions, we present the first theoretical treatment for LSV studies performed on a 316L stainless steel rotating disk electrodes in varying concentrations of nitric acid and at varying rotation speeds. This will allow us to determine for the first time the kinetic parameters of the nitric acid autocatalytic reduction at the surface of process stainless steel.

### References;

- [1] P. Fauvet, F. Balbaud, R. Robin, Q. T. Tran, A. Mugnier, D. Espinoux (2008) 'Corrosion mechanisms of austenitic stainless steels in nitric acid media used in reprocessing plants' *Journal of Nuclear Materials*, 375, 52-64.