



Effect of nitrogen on crevice corrosion in austenitic stainless steel

H. Baba *, Y. Katada

National Institute for Materials Science, 1-2-1 Sengen, Tsukuba-shi, Ibaraki 305-0047, Japan

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Abstract

Corrosion properties of high nitrogen austenitic steels in chloride solutions have been investigated. Nitrogen behavior was evaluated at various electrode potentials, and analysis of the surface film was carried out with XPS. The alloy used for the experiments had a composition of 23%Cr–4%Ni–0–1%Mo–0.7–1%N and was obtained through electro-slag remelting (ESR) under high nitrogen pressure. High nitrogen austenitic steel produced NH_4^+ in the solution by crevice corrosion under a constant potential of 0.2 V (SCE). In the transpassive region and at 0.7 V (SCE), the products in the solution were NH_4^+ , NO_3^- and NO_2^- . The amount of dissolved NO_3^- and NO_2^- increased with the electrode potential. NH_4^+ in the solution suppressed decreases of pH, having a re-passivation effect. For crevice corrosion under a higher electrode potential than 0.4 V (SCE), the number of crevice corrosion points and the corrosion loss decreased as the electrode potential increased. This behavior can be attributed to the corrosion suppressing effect of NO_3^- dissolved in the solution as a product of crevice corrosion. The presence of chromium and iron oxides in the passivation film and crevice corrosion surface film were identified from XPS analysis. N 1s spectra indicated the presence of a nitride (CrN) or NH_3 .

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* Corresponding author. Tel.: +81 29 859 2331; fax: +81 29 859 2301.
E-mail address: BABA.Haruo@nims.go.jp (H. Baba).

1. Introduction

Passivation of the surface of a stainless steel occurs through the formation of a film of chromium oxide that preserves the corrosion resistance characteristics of the material. However, in an environment with the presence of chloride ions, localized corrosion such as pitting and crevice corrosion is still a problem for this type of steel. It is well known that nitrogen dissolved in austenitic steel reinforces the steel, and at the same time, it improves the resistance to pitting and crevice corrosion caused by the presence of chloride ions [1–10]. Several mechanisms have been proposed to explain the suppression effects to localized corrosion. It is believed that nitrogen in the steel dissolves, it consumes protons in the pit to form ammonia, thus preventing a lowering of the pH in the pit, which contributes to the suppression of acidification inside the pit [1,11,12]. It is also speculated that surface films are stabilized through passivation or nitrogen enrichment of the film/metal interface to prevent the attack of chloride anions (Cl^-) [6,13–15].

However, these mechanisms have not been precisely established. One of the reasons for this situation is the fact that the amount of nitrogen added to the stainless steel is limited by its solubility during dissolution under normal pressure. As it was impossible to obtain stainless steel with a nitrogen content as high as 1%, the behaviour of solid nitrogen solution could not be completely clarified. Up to the present, surface analyses of the passivation film on nitrogen containing austenitic steels have been carried out using XPS and AES, but the anti-corrosive properties and the nitrogen behaviour were not perfectly understood [6,13–16].

In the present work, an austenitic stainless steels with a high content of nitrogen in solid solution ($\approx 0.7\text{--}1\%$ N) was produced in an electro-slag remelting (ESR) facility under pressurized nitrogen gas [17]. The effects of electrode potentials on crevice corrosion characteristics and electrochemical behaviour were investigated in a chloride environment. After potentiostatic polarisation, the amount of nitrogen produced by crevice corrosion was measured, and the relationship with the potential was investigated. The surface film was analyzed by XPS, and the mechanism of crevice corrosion was studied.

2. Experimental

2.1. Sample preparation

A high nitrogen content austenitic steels of the composition shown in Table 1 were used for the samples. After melting by an ERS facility, the steel was processed by hot forging, hot and cold rolling, and heat treatment at 1250 °C for 30 min. The material consisted of a single-phase austenite with no grain precipitation of Cr nitrides. Bars of dimensions

Table 1
Chemical compositions of steels (wt.%)

Sample no.	C	Si	Mn	P	S	Ni	Cr	Mo	N	Al (Total)	O
(1) 23Cr–0.7N–1Mo	0.020	0.11	0.06	0.005	0.0002	4.15	22.55	1.02	0.73	0.14	0.0014
(2) 23Cr–0.9N–1Mo	0.024	0.12	0.09	0.006	0.0004	4.23	22.44	1.04	0.93	0.13	0.0019
(3) 23Cr–1.0N–0Mo	0.034	0.11	0.10	0.005	0.0020	4.53	23.30	0.02	0.96	0.018	0.0022

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