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Letter

Evaluation of microbiologically influenced corrosion inhibition using electrochemical noise analysis

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Abstract

Microbiologically influenced corrosion inhibition (MICI) has been observed for Al 2024, mild steel and cartridge brass when an artificial seawater (AS) solution containing growth medium was contaminated by bacteria. Impedance data clearly showed that pitting did not occur under these circumstances for Al 2024. For mild steel corrosion rates were decreased significantly. For brass corrosion rates were also greatly decreased and tarnishing was not observed. Analysis of electrochemical noise data obtained for the three materials in AS with and without growth medium did not reveal significant changes due to MICI except for an increase of the noise resistance R_n and a parallel shift of the current power spectral density plots to lower values for Al 2024 and mild steel. The observed increase of R_n was mainly due to a significant decrease of the standard deviation of the current fluctuations.

Keywords: Aluminum; Mild steel; Brass; Microorganisms; MICI; Seawater; Electrochemical noise analysis

1. Introduction

As discussed elsewhere [1], microbiologically influenced corrosion inhibition (MICI) has been observed for several materials due to contamination of an artificial

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seawater (AS) solution containing growth medium by bacteria. Analysis of EIS data showed that pitting did not occur for Al 2024, corrosion rates were greatly diminished for brass and tarnishing was not observed. For mild steel much lower corrosion rates were obtained due to bacterial contamination. Additional experiments with improved methods of sterilization demonstrated that the growth medium was not responsible for the increased corrosion resistance observed in AS containing growth medium. Since a unique opportunity was presented to evaluate electrochemical noise (EN) data for the same material/solution systems in the active and passive state, a more detailed analysis of the EN data in the time and frequency domains was performed.

2. Experimental approach

Al 2024-T3 (UNS A92024), mild steel 1010 (UNS G10100) and cartridge brass (UNS C26000) were exposed to AS prepared as Vätäänen nine salt solution (VNSS) [2] with and without growth medium. The growth medium was a mixture of peptone, starch, glucose and yeast extract (Table 1). The electrochemical cell consisted of two identical electrodes with a saturated calomel electrode (SCE) as a reference electrode. The exposed area of each electrode was 4.0 cm^2. Electrochemical impedance and EN data were obtained in the two-electrode configuration using a Gamry model PC4/300 system. The sampling rate for collection of EN data was 2 points/s for 1024 s. Software developed at CEEL was used to analyze the EN data in the time and frequency domains [3]. The trend in the EN data was removed using a linear or a polynomial method before this analysis [4]. Contrary to the previous approach [4] the mean values of current or potential were not removed in this process.

The electrochemical cell parts and sealed flasks containing VNSS with growth medium and KCl solution were sterilized in an autoclave at 120°C for 30 min and

Table 1
Composition of VNSS + growth medium

Compound	Concentration (g/l)
NaCl	17.6
$NaHCO_3$	0.08
KBr	0.04
$CaCl_2 \cdot 2H_2O$	0.41
$SrCl_2 \cdot 6H_2O$	0.008
Na_2SO_4	1.47
KCl	0.25
$MgCl_2 \cdot 6H_2O$	1.87
H_3BO_3	0.008
$FeSO_4 \cdot 7H_2O$	0.01
Na_2HPO_4	0.01
Peptone	1.0
Starch	0.5
Glucose	0.5
Yeast extract	0.5