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Corrosion Science 47 (2005) 795–809
CORROSION SCIENCE
www.elsevier.com/locate/corsci

Localized attack of copper and brass in tap water: the effect of *Pseudomonas*

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Available online 13 August 2004

Abstract

The presence of *Pseudomonas fluorescens* in artificial tap water (ATW) affects the composition of the oxide layer and the susceptibility to pitting corrosion of copper and 70/30 brass. The surface layer was investigated by means of a combination of electrochemical and spectroelectrochemical techniques involving cyclic voltammograms, potentiodynamic reduction curves, anodic polarisation curves, weight-loss tests and reflectance spectroscopy.

In the sterile conditions the mass loss is lower in brass than in copper while the presence of bacteria enhances the attack in brass. Dezincification in inoculated electrolyte was revealed by microscopic observation, as well as by potentiodynamic reduction curves. Zn dissolution was also supported by spectroscopic evidence.

Slow-rate voltamperometric curves were used to determine potential values characteristic of localized corrosion. In the presence of bacteria, the pitting potential moves towards more positive values for both materials but the difference between the repassivation and the pitting potential increases. Bigger and deeper pits can be seen in the presence of microorganisms.

Keywords: A. Copper; A. Brass; C. De-alloying; C. Microbiological corrosion; C. Passive films

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doi:10.1016/j.corsci.2004.07.013

1. Introduction

Copper and its alloys belong to the group of materials that are resistant to corrosion thanks to a protective film that grows naturally in certain environments. One of the most frequent problems that appears on copper and copper-alloys is microbiologically induced corrosion (MIC), which can be attributed to the presence of bacteria that changes the condition in the metal/electrolyte interface and promote localized corrosion. The mechanism typical of this kind of attack has been studied in carbon steels [1,2], where the phenomenon is well understood particularly for the case of sulphate-reducing bacteria. This interest has also expanded to other materials such as stainless steels [3,4] and copper-alloys [5–7], which are generally resistant to corrosion. These materials are susceptible to MIC in the conditions mentioned above for carbon steels, as well as in other aqueous aerobic media where different mechanisms have been proposed to explain the potential ennoblement leading to pitting. Among these proposed mechanisms, the production of enzymes that catalyse oxygen reduction [8] or the effect of other metabolites on the metal surface [6,9,10] are worth mentioning. All of them share a common pattern: the important role of the surface film and the changes induced by the presence of bacteria [7].

Copper and brass are materials of widespread use for plumbing purposes. The presence of organic matter is known to have undesirable effects in the quality of the drinking water. This can be manifested by either increasing corrosion by-products release or by decreasing microbial stability [11]. Moreover, potable water installations have frequently found to be affected by pitting of the piping system. In many of these cases, microbiologically influenced corrosion has been found to be the origin of the problem. This investigation describes the study of the first stages of microbiological attack by means of a combination of electrochemical and spectroscopic techniques.

2. Materials and methods

2.1. Electrolyte composition

All the experiments were carried out using artificial tap water (ATW). The mineral base composition was $MgSO_4$ (40 mgl^{-1}), $MgCl_2$ (60 mgl^{-1}), KNO_3 (25 mgl^{-1}), $CaCl_2$ (110 mgl^{-1}), Na_2CO_3 (560 mgl^{-1}) and $NaNO_3$ (20 mgl^{-1}) in distilled water; the pH was adjusted to 7.6 with HCl solution 1 $moll^{-1}$.

In the case of the electrochemical and spectroelectrochemical tests performed to evaluate the effect of the presence of bacteria, pure cultures of *Pseudomonas fluorescens* (ATCC 17552) were grown at 32 °C with continuous shaking in a minimal broth containing 0.06% peptone. Cells were harvested from cultures at the mid-exponential phase of growth by centrifugation for 10 min at 10,000*g* in a Jouan BR4i centrifuge, washed, and suspended in ATW after centrifuging again. This bacterial suspension was labelled as "BATW".

The weight loss tests were done in ATW containing 0.5% peptone.