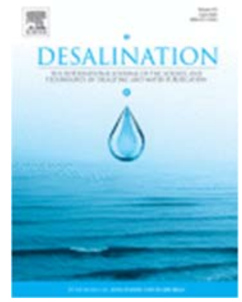
Desalination
Volume 479, 1 April 2020, 114283



Corrosion inhibition effect of a benzimidazole derivative on heat exchanger tubing materials during acid cleaning of multistage flash desalination plants

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Received 25 November 2019, Accepted 11 December 2019, Available online 24 December 2019, Version of Record 7 February 2020.

https://doi.org/10.1016/j.desal.2019.114283Get rights and content

Abstract

A benzimidazole derivative, 2-(2-bromophenyl)-1-methyl-1H-benzimidazole (2BPB) has been studied as a corrosion inhibitor for Cu-Ni 70/30 and 90/10 alloys in 1 mol/dm^3 HCl solution at low and high temperatures using the weight loss, electrochemical (potentiodynamic polarization (PDP), electrochemical impedance spectroscopy (EIS), & cyclic voltammetry (CV)), and surface characterization (scanning electron microscopy (SEM) & Fourier-transform infrared spectroscopy (FTIR)) techniques. The effect of immersion time (up to 72 h) and addition of iodide ions on the inhibition efficiency of 2BPB have also been investigated. At low temperature, 1.0 g/L 2BPB inhibits Cu-Ni 70/30 and 90/10 alloys by 88.9 ± 4.8% and 57.5 ± 1.3%, respectively. The performance of 2BPB improves with increase in immersion time and addition of iodide ions but slightly depreciates with rise in temperature. 2BPB acts as a mixed type corrosion inhibitor and adsorbs on the alloys surfaces through physical adsorption mechanism. SEM and FTIR results confirm the adsorption of 2BPB on the alloys surfaces. 2BPB is a potential low toxic candidate for the formulation of acid corrosion inhibitor for Cu-Ni alloys.

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Keywords

Desalination plant
Cu-Ni alloy
Acid cleaning
Corrosion inhibition
Benzimidazole

1. Introduction

Copper-nickel alloys exhibit good corrosion resistance, excellent thermal and electrical conductivity, good mechanical ductility, and excellent antifouling properties [1,2]. The good corrosion resistance property is due to the formation of a protective passive film, Cu_2O on the surface [1,2]. These unique properties allow copper-nickel alloys to be used as brine heaters and evaporator condensers in the multistage flash (MSF) desalination plants [3].

One of the operational challenges of MSF desalination plants is the formation of inorganic scales on the surface of the alloy components;

a common phenomenon capable of decreasing plant production efficiency and enhancing under deposit corrosion [4,5]. The frequently adopted descaling technique in the MSF desalination plants is acid cleaning [4,5] using hydrochloric or sulfuric acids in the concentration range of 2–5% [6]. The use of hydrochloric acid is usually preferred because of the formation of soluble chloride products in lieu of insoluble sulfates.

During acid cleaning in the absence of a corrosion inhibitor, brine heaters and evaporator condensers in MSF desalination plants usually suffer accelerated corrosion. For instance, the technical report on one of the largest desalination plants in the world revealed that brine heaters and evaporator condensers made of Cu-Ni 70/30 and 90/10 alloys experienced corrosion rate between 53 and 66 mpy during 6 h acid cleaning with 2% HCl solution containing no corrosion inhibitor [6]. Khadom et al. [7] also observed that Cu-Ni 90/10 alloy exposed to 5% HCl solution for 3 days at 55 °C experienced a corrosion rate of 20.83 g/m^2 in the absence of a corrosion inhibitor. The severe corrosion experienced by these Cu-Ni alloys could be due to the impediment to form a stable Cu_2O passive layer during acid cleaning in the absence of a corrosion inhibitor. It therefore becomes imperative for an effective corrosion inhibitor to be added to acid cleaning solution before deployment.

Few research studies have been devoted towards finding effective corrosion inhibitors for the acid cleaning of Cu-Ni alloys (Table 1). These reports reveal that nitrogen–containing organic compounds are, by far, the most investigated corrosion inhibitors for the alloys. Related studies on pure metallic copper have also shown sulfur- and nitrogen–containing compounds to be highly effective corrosion inhibitors [8,9]. The sulfur and nitrogen moieties in the corrosion inhibitor compounds provide lone pair electrons to form coordinate bonds with Cu^0, Cu^+, or Cu^{++} species leading to the formation of protective complexes on the metal surface [8,9]. Obviously, the efficacy of the compounds in Table 1, based on the inhibition efficiencies [7,10,11], provide strong motivation for the development of acid cleaning corrosion inhibitors for Cu-Ni alloys using nitrogen-containing compounds.

Table 1. Some reported organic-based corrosion inhibitors for copper-nickel alloys in acid cleaning solution.