Corrosion Inhibition Evaluation Of Alpha-Beta Brass In Tap Water

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Abstract

The corrosion inhibition of brass (Cu=59.96%, Zn=38% and others=2%) in tap water, in the presence of Benzoate ion (C6H5COO-1) has been investigated using Potentiodynamic polarization scan. It was observed that the open circuit potential (OCP) and corrosion current (ICORR) in plain water, and Sodium benzoate (C6H5COONa) containing water was -263mV, -253.9mV and 489.0×10-9 A/cm2, 77.90×10-9 A/cm2 respectively. It was assumed that benzoate ions (C6H5COO-1) adsorb at the surface of brass and inhibits corrosion. It was concluded that the use of sodium benzoate (C6H5COONa) as corrosion inhibitor is beneficial to protect brass and/or to increase its life by electrochemical test method.

Introduction

Copper and its alloys are widely used in industry because of their excellent electrical and thermal conductivity and are often used in heating and cooling system [1–3]. Brass has been widely used as tubing material for condensers and heat exchangers in various cooling water systems [4–9]. The corrosion resistance of copper alloys has been attributed to the passive Cu_2O layer formed on the surface [10]. The oxide layer formed on brass is composed of Cu_2O and ZnO.

Brass is susceptible to a corrosion process known as dezincification and this tendency increases with increasing zinc content of the brass [11, 12]. In principle, there are four different methods of preventing or minimizing dezincification. Firstly, alpha brass can be used in place of alpha beta brasses which are more susceptible to dezincification.

The second method is derived from Cu–Zn phase diagram [13], is to thermally treat two-phase brasses (Zn, 39%) to transform them to the single alpha-phase. This can be conducted by heating between 400 and 600^{o}C with subsequent quenching to room temperature [14, 15]. The third method to minimize dezincification is to add low levels of suitable elements to the alloy. These include arsenic [14-20], antimony [16], boron [21], phosphorus [22], tin [23] and aluminum [23]. The fourth method is the use inhibitors. The effectiveness of the inhibitor varies with its concentration, the corrosive medium and the surface properties of the alloy. Many inhibitors have been used to minimize the corrosion of brass in different media [24]. The organic materials which act as inhibitors are able to form a protective film on the surface of metal through their functional groups which are adsorbed on copper metal either physically or chemically [25].

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Benzoate ion, being a conjugate base of weak acid, has been frequently studied for prevention of corrosion. Especially for copper-based materials, benzoate ions act as anodic inhibitor [26, 27].

In the present investigation, it is proposed to study the electrochemical behavior of brass in plain water with an inhibitor containing Sodium benzoate. The electrochemical study (Potentiodynamic polarization) was used to assess the inhibition efficiency of sodium benzoate.

Experimental Details

Materials

Brass strips having chemical compositions 59.96% Cu, 38.00% Zn, 0.7% Fe, 0.46% Sn, the remainder being trace amounts of Pb, Ni and Al were used. The inhibitor was prepared by adding 2gms sodium benzoate in 100 ml of distilled water along with ethylene glycol and ethanol amine. The structure of sodium benzoate is shown in Figure:1.

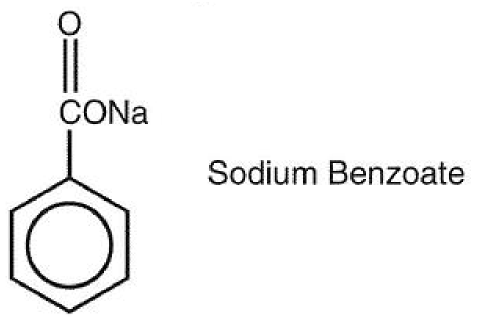

Figure 1: Structure of Sodium Benzoate

2.2. Potentiodynamic Polarization Studies

The Potentiodynamic polarization studies were carried out with brass strips having an exposed surface area of 1 cm2. A copper wire, sheathed in a 4 mm diameter Pyrex tube, was soldered to one face. The cube was mounted in a cold curing epoxy resin to leave one exposed face, which was then mechanically ground to 600 grit, rinsed in water and acetone, and then dried in air.

The cell assembly consisted of brass as working electrode, graphite as counter electrode and a saturated calomel electrode (SCE) as reference electrode with a Luggin capillary probe. 2% inhibitor was used in water as electrolyte. Polarization studies were carried out using Potentiostatic Gamry DC105 and the data obtained were analyzed using the Echem Analyst. The working electrode was immersed in plain water and allowed to stabilize for 30 minutes. The potentiodynamic polarization curve for brass specimen in the test solution with and without inhibitor was recorded at a scan rate of 1 mV/s. The inhibition efficiency of the inhibitor was determined from corrosion current density using the Tafel extrapolation method.

Results and Discussion

The Potentiodynamic polarization curves for brass in water and in sodium benzoate containing water are shown in figures 2 & 3 respectively. The comparison between plain water and sodium benzoate containing water is shown in figure 4.

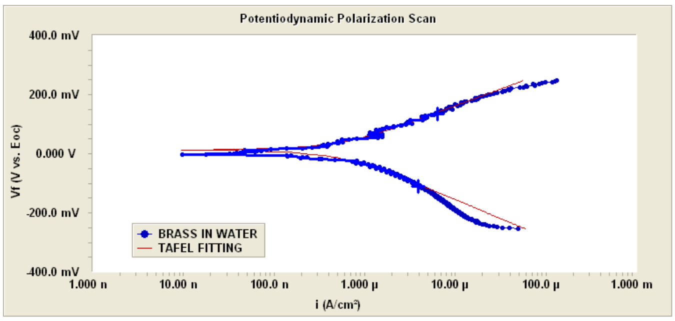

Figure: 2 Polarization curve in Plain Water

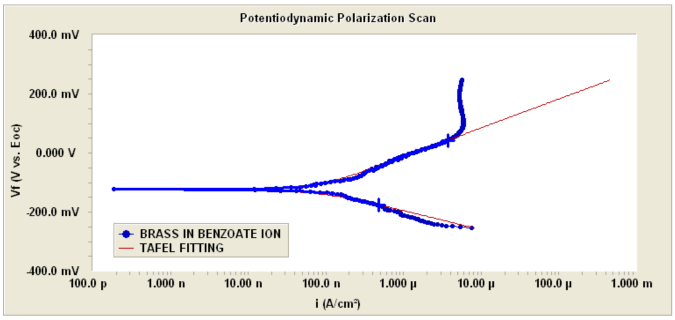

Figure: 3 Polarization curve in Plain Water with inhibitor

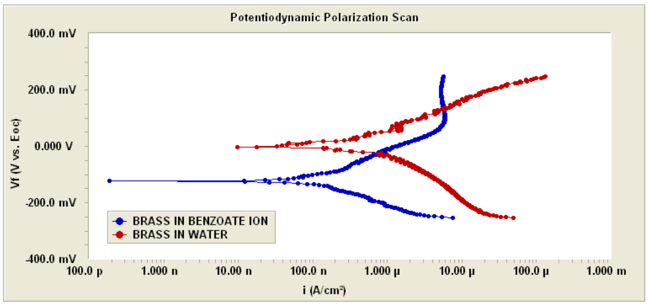

Figure: 4 Polarization curve of Brass with & without inhibitor in water

The values of corrosion current density, corrosion potential, corrosion rate, cathodic Tafel slop and anodic Tafel slop decreases by the addition of inhibitor in water. The values were determined by Tafel Extrapolation and are given in table 1. The efficiency of inhibitor was calculated by the following formula,

$$\mathbf{IE = (I_{CORR} - I_{CORR\,(INH)}) \times 100 / I_{CORR}}$$

Where,

IE is inhibitor efficiency

ICORR is the corrosion current density value without inhibitor

ICORR (INH) is the corrosion current density values with inhibitor

Table 1: Results of Polarization Scans

Parameters	**Brass in Water**	**Brass in Benzoate ion**
Beta A (V/decade)	113.9×10^{-3}	98.10×10^{-3}
Beta C (V/decade)	127.9×10^{-3}	65.40×10^{-3}
Current Density (I_{CORR}) A/cm²	489.0×10^{-9}	77.90×10^{-9}
E_{CORR} (mV)	12.00	-122.0
Corrosion Rate (mpy)	240.9×10^{-3}	38.35×10^{-3}
Open Circuit Potential(mV)	-263	-253.9
Efficiency (%age)	---------------	84.06

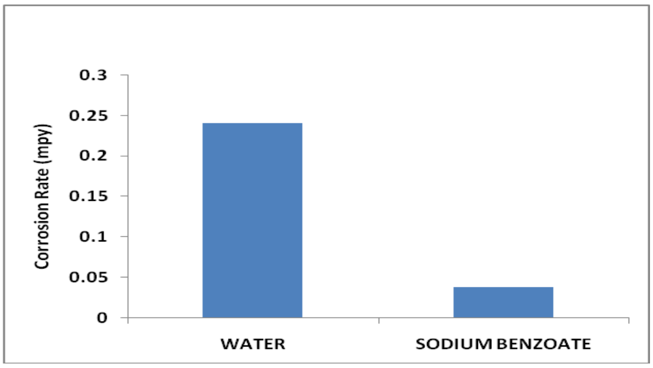

Figure: 5 Comparison of corrosion rate with & without inhibitor in water

Discussion

The efficiency of the benzoate containing inhibitor in water was 84% which indicated higher corrosion resistance of alpha beta brass than in plain water. Benzoate is not an oxidizer. In accordance with its character of anions, it is classed among the anodic inhibitors. In the presence of benzoate containing inhibitor, during anodic polarization, it showed passivity at potential +78.90mV and the passive current was 5.763x10-6 A/cm2. Brass in plain water was active than the brass in benzoate containing inhibitor solution. Corrosion rate of alpha beta brass decreases by the addition of benzoate containing inhibitor in water. Despite this it was not considered as dangerous since too small quantity has no detrimental effect [28].

Conclusion

Sodium benzoate containing inhibitor showed good inhibition efficiency in plain water. Polarization measurements revealed the organic compound investigated acted as anodic type inhibitor, inhibiting the corrosion of brass by blocking the active sites of the metal surface. The inhibitor easily adsorb on the brass surface to provide barrier and control brass corrosion. Efficiency of 2% sodium benzoate containing inhibitor in water was 84%.

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