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ORIGINAL ARTICLE

Corrosion behaviour of 6063 aluminium alloy in acidic and in alkaline media

Deepa Prabhu, Padmalatha Rao *

Department of Chemistry, Manipal Institute of Technology, Manipal University, 576104 Karnataka, India

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EIS

Abstract The corrosion behaviour of 6063 aluminium alloy was investigated in different concentrations of phosphoric acid medium and sodium hydroxide medium at different temperatures. The study was done by electrochemical method, using Tafel polarization technique and electrochemical impedance spectroscopy (EIS) technique. The surface morphology was investigated using scanning electron microscope (SEM) with Energy-dispersive X-ray spectroscopy (EDX). The results showed that the 6063 aluminium alloy undergoes severe corrosion in sodium hydroxide medium than in phosphoric acid medium. The corrosion rate of 6063 aluminium alloy increased with an increase in the concentration of acid as well as with alkali. The corrosion rate was increased with an increase in temperature. The kinetic parameters and thermodynamic parameters were calculated using Arrhenius theory and transition state theory. Suitable mechanism was proposed for the corrosion of 6063 aluminium alloy in phosphoric acid medium and sodium hydroxide medium. The results obtained by Tafel polarization and electrochemical impedance spectroscopy (EIS) techniques were in good agreement with each other.

1. Introduction

Corrosion, which is an inevitable problem faced by almost all industries can be considered as one of the worst technical calamities of our time. Besides from its direct costs in dollars, corrosion is a serious problem because it definitely contributes to the depletion of our natural resources. Corrosion studies have also become important due to increasing awareness of the need to conserve the world's metal resources (Stansbury and Buchanan, 2000). Now-a-days more attention has been paid to control the metallic corrosion, due to increasing use of metals in all fields of technology.

Corrosion studies of aluminium and aluminium alloys have received considerable attention by researchers because of their wide industrial applications and economic considerations (Christian Vargel, 2004; Kosting and Heins, 1931; Badaway et al., 1999; Paul and Sigwalt Juniere, 1964). Aluminium and aluminium alloys have emerged as alternate materials in aerospace and in some chemical processing industries. Due to their wide applications, they frequently come in contact with acids or bases during pickling, de-scaling, electrochemical etching

* Corresponding author. Tel.: +91 9880122680.
E-mail addresses: padmalatha.rao@manipal.edu, drpadmalatharao@yahoo.com (R. Padmalatha).

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and extensively used in many chemical process industries. Most of the reported studies were conducted on corrosion of various metals and alloys in HCl and H_2SO_4 media (Paul and Sigwalt Juniere, 1964; Ating et al., 2010; Umoren et al., 2009; Obi-Egbedi et al., 2012; Nnanna et al., 2011).

Phosphoric acid medium is widely used for acid cleaning and elector polishing of aluminium (Christian Vargel, 2004). Even though dissolution rate of aluminium in phosphoric acid medium is lower, compared to the dissolution of the same in hydrochloric medium or sulphuric acid medium, it does corrode aluminium and its alloys. Phosphoric acid medium is also used in pickling delicate, costly components and precision items where rerusting after pickling has to be avoided. Sodium hydroxide is usually used for degreasing purpose. According to the available literature, not much study has been done regarding the corrosion behaviour of 6063 aluminium alloy in phosphoric acid medium as well as with sodium hydroxide medium. As part of our studies with corrosion behaviour of aluminium and aluminium alloys in phosphoric acid medium and sodium hydroxide medium and corrosion control of the same using green inhibitors (Deepa and Padmalatha, 2013a,b) we report herein the results of corrosion behaviour of 6063 aluminium alloy in phosphoric acid medium and sodium hydroxide medium of different concentrations at different temperatures.

2. Methods

2.1. Material

The experiments were performed with specimens of 6063 aluminium alloy. The composition of the 6063 aluminium alloy specimen is given in Table 1.

Cylindrical test specimens were sealed with Acrylic resin material in such a way that the area exposed to the medium was 1.0 cm^2. It was polished with 180, 280, 400, 600, 800, 1000, 1500, and 2000 grade emery papers. Further polishing was done with disc polisher using levigated alumina to get mirror surface. It was then dried and stored in a desiccator to avoid moisture before using it for corrosion studies.

2.2. Medium

A stock solution of phosphoric acid medium was prepared using analytical grade phosphoric acid medium (85%) and double distilled water. It was standardized by potentiometric method. Phosphoric acid medium of concentrations 1.0 M, 0.1 M and 0.01 M was prepared by appropriate dilution. A stock solution of sodium hydroxide was prepared by dissolving analytical grade sodium hydroxide pellets in double distilled water and standardized by volumetric method using phenolphthalein indicator. Solutions of required strengths 0.05 M, 0.25 M and 0.5 M were prepared by appropriate dilutions as and when required. Experiments were carried out using a calibrated thermostat at temperatures 30 °C, 35 °C, 40 °C, 45 °C and 50 °C (±0.5 °C).

Table 1 Composition of the 6063 aluminium alloy specimen (% by weight).

Element	Composition (%)
Si	0.412
Fe	0.118
Cu	0.0570
Mg	0.492
Al	Balance

2.3. Electrochemical measurements

Electrochemical measurements were carried out by using an electrochemical work station, CH600D-series, U.S. Model with CH instrument beta software. The electrochemical cell used was a conventional three-electrode compartment having glass cell with a platinum counter electrode and a saturated calomel electrode (SCE) as reference. The working electrode was made up of 6063 aluminium. All the values of potential were measured with reference to the saturated calomel electrode. The polarization studies were done immediately after the EIS studies on the same electrode without any further surface treatment.

2.3.1. Tafel polarization studies

Finely polished 6063 alloy specimens with 1.0 cm^2 surface area were exposed to corrosion medium of different concentrations of phosphoric acid (0.01 M, 0.1 M and 1.0 M) and different concentrations of sodium hydroxide (0.05 M, 0.25 M and 0.5 M) separately at a temperature range of 303–323 K. The potentiodynamic current–potential curves were recorded by polarizing the specimen to −250 mV cathodically and + 250 mV anodically with respect to open circuit potential (OCP) at a scan rate of 0.01 V/s.

2.3.2. Electrochemical impedance spectroscopy (EIS) studies

Electrochemical impedance spectroscopy (EIS) measurements were carried out using a small amplitude ac signal of 10 mV over a frequency range of 100 kHz–0.01 Hz.

Both techniques were repeated at least three times. The average value of best three agreeing values was reported.

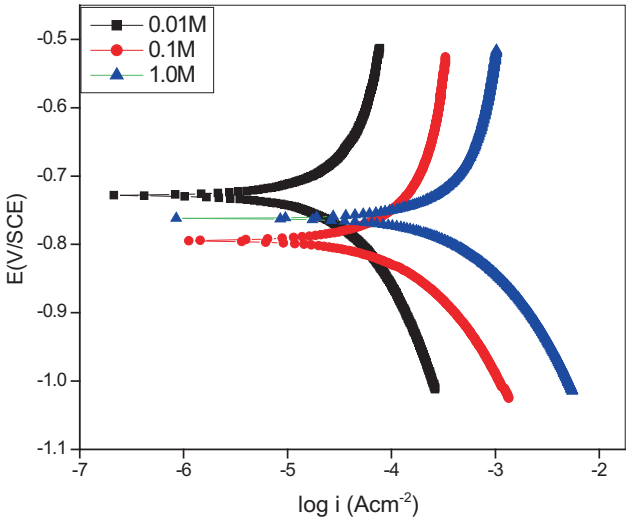

Figure 1 Tafel polarization curves for 6063 aluminium alloy in different concentrations of H_3PO_4 at 30 °C.