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Evaluation of Corrosion Inhibition of Linseed Oil-Based Inhibitors on Aluminum-8088 Alloy

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ABSTRACT

There is a high demand for eco-friendly, effective, and high performance corrosion inhibitors for industrial applications. Thus, the corrosion property of aluminum alloys was studied in linseed oil. Potentiodynamic polarization and weight loss analysis were used to study the corrosion inhibition mechanism of the linseed oil. The linseed oil showed the highest inhibition efficiency of 87.01% at 1000 ppm. A high efficiency of 86.03% was achieved even after 24h of exposure. The potentiodynamic polarization test showed that the linseed oil is a mixed-type inhibitor. The surface morphology of the uninhibited and inhibited specimens examined by a scanning electron microscope.

Keywords: Aluminium 8088, Linseed Oil, Corrosion, Weight loss, Polarization, SEM

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INTRODUCTION

Corrosion is a vital issue that has to be addressed by engineers and scientists working in the field of engineering and corrosion discipline globally because of its hazardous effects in various manufacturing industries. Aluminum is the second most used material for engineering application [1]. The constant growth in consumption of aluminum, particularly in the packaging, transport, and engineering fields, can be ascribed to its outstanding properties: low density, easy recycling, attractive appearance, and so on. Because of the rapid advancement of industrial applications such as offshore platforms and direct current transmission, the aluminum alloy demand is rising [2-3]. Nevertheless, corrosion of aluminum alloys is a serious problem that causes severe environmental risks and economic losses, especially in the cooling systems [1]. The good corrosion resistance of pure aluminum is because of the spontaneous compact formed and adherent oxide films. Nevertheless, the surface layers contain much heterogeneity, such as intermetallic particles in the case of aluminum alloys. These intermetallic particles form local cathodes or anodes in the material microstructure and therefore increase the vulnerability for localized corrosion [2,3] thus, making corrosion protection of aluminum alloys a serious subject. There are two major means of improving the corrosion resistance of aluminum alloys: (i) modification of the surface and (ii) tailoring the microstructure and composition. With notable progress recently, alloying is still a challenge because it does not allow long-lasting improvement in corrosion resistance [4]. Therefore, the use of environmentally friendly and efficient protective schemes is of high importance. Among the various available methods such as anodic/ cathodic protection, corrosion-resistant materials, corrosion inspection, and monitoring tools, protective coatings, and corrosion inhibitors used fiercely for diverse applications in protecting metallic structures from corrosion, one of the most cost-efficient and popular approaches for corrosion control is the use of an inhibitor. [4,5] The inhibitor forms a protective film over the metal surface that separates the metal from destructive solutions and thus inhibits corrosion. The protective actions of the conventional inhibitors are based on the direct metallic surface passivation or interactions with the metal corrosion product, which results in passivation layer formation. For decades, hexavalent chromium has been applied mostly in protecting aluminum alloys from corrosion [6,7] and this has caused pollution of the surrounding ecology of different industries, body implants, and so on. [8−10] thereby, making the replacement of these toxic compounds with environmentally benign substitutes desirable [5-6].

ELECTROCHEMICAL TESTS

Electrochemical tests were carried out at room temperature using three-electrode conventional corrosion cells. The working electrodes (aluminum alloy) were embedded in a resin with 1 cm2 exposed area. A platinum rod was employed as a counter electrode while an Ag/AgCl electrode served as a reference electrode. The electrochemical experiment was conducted using a potentiostat/galvanostat CH-I 608E Series (USA) connected with software. The electrode was first stabilized for 1 h to attain quasi-equilibrium values at an open circuit potential. From the current density vs potential line fitted slope, the polarization resistance (Rp) was determined using the software. Electrochemical corrosion data, corrosion current density (icorr) and potentials (Ecorr), were estimated from the polarization curve by Tafel approximation [7-8].

Weight Loss Test: The cleaned aluminum samples were weighed, before immersion into the chloride solutions, with 0, 200, 400, 600, 800, and 1000 ppm LO, for 24 h. The samples were cleaned following the ASTM standards32 and reweighed. The tests were conducted three times, with approximately 99% reproducibility. The test sample preparation and experimental process for electrochemical, surface, and weight loss techniques were related to the one reported in the literature. Equations 2 and 3 were employed to evaluate the corrosion rate (CR) and percentage inhibition efficiency at different inhibitor concentrations, respectively. W D A T CR 87.6 = × × (2) where T is the exposure time (hour), D is density (g/cm2), A is area (cm2), and W is weight loss (mg). IE (%) CR CR CR 100 (uninhibited) (inhibited) uninhibited = × (3) where CRuninhibited and CRinhibited are the corrosion rate in the absence and presence of an inhibitor, respectively [9].

SURFACE ANALYSIS

Surface analysis was conducted on exposed samples for 168 h immersion in uninhibited and inhibited solutions using the backscattered electron signals recorded with a JEOL JSM-7600F microscope (Peabody, MA, USA) with a probe current of approximately 700 nA and 15 kV accelerating voltage [10-11]. A scanning electron microscope equipped with energy-dispersive X-ray spectroscopy (EDX) was used for determining the elemental compositions on the sample surface.

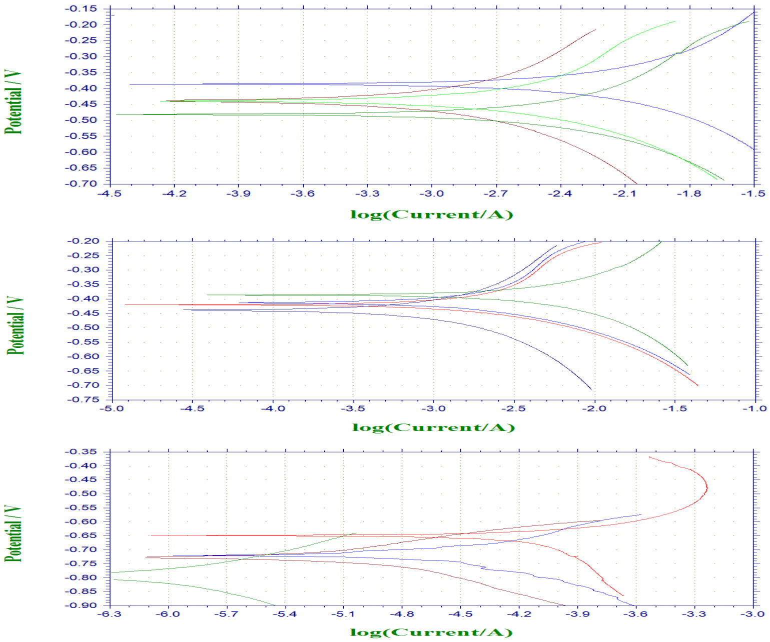

Figure 1: Potential−current curve for aluminum in the LO with and without diverse concentration of PEO (T = 298 K and sweep rate = 0.2 mV/s).[12]

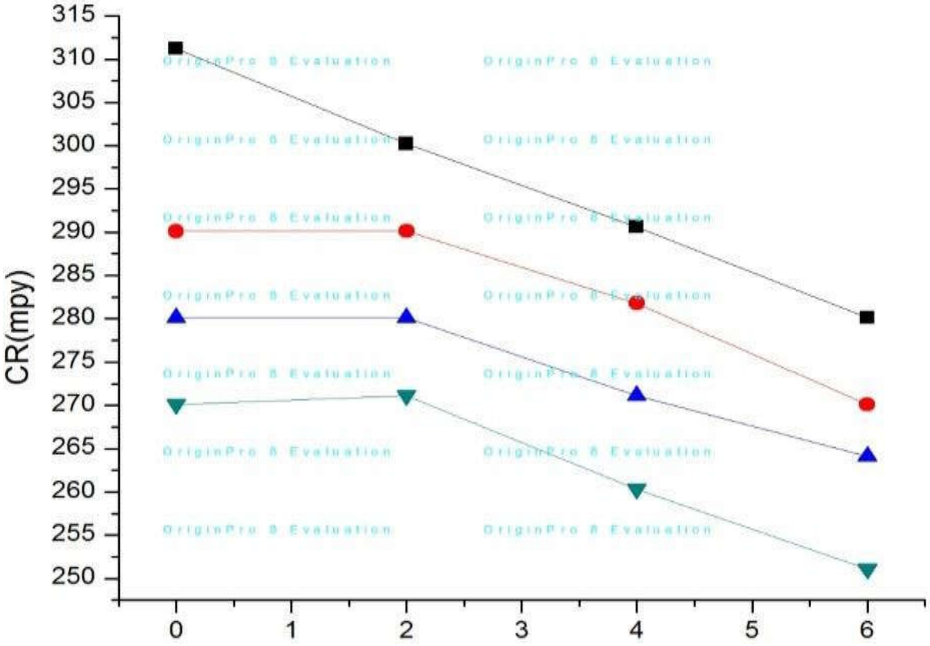

Figure 2: CR vs exposure time for aluminum corrosion in the LO with and without various concentrations of LO at (T = 298 K).

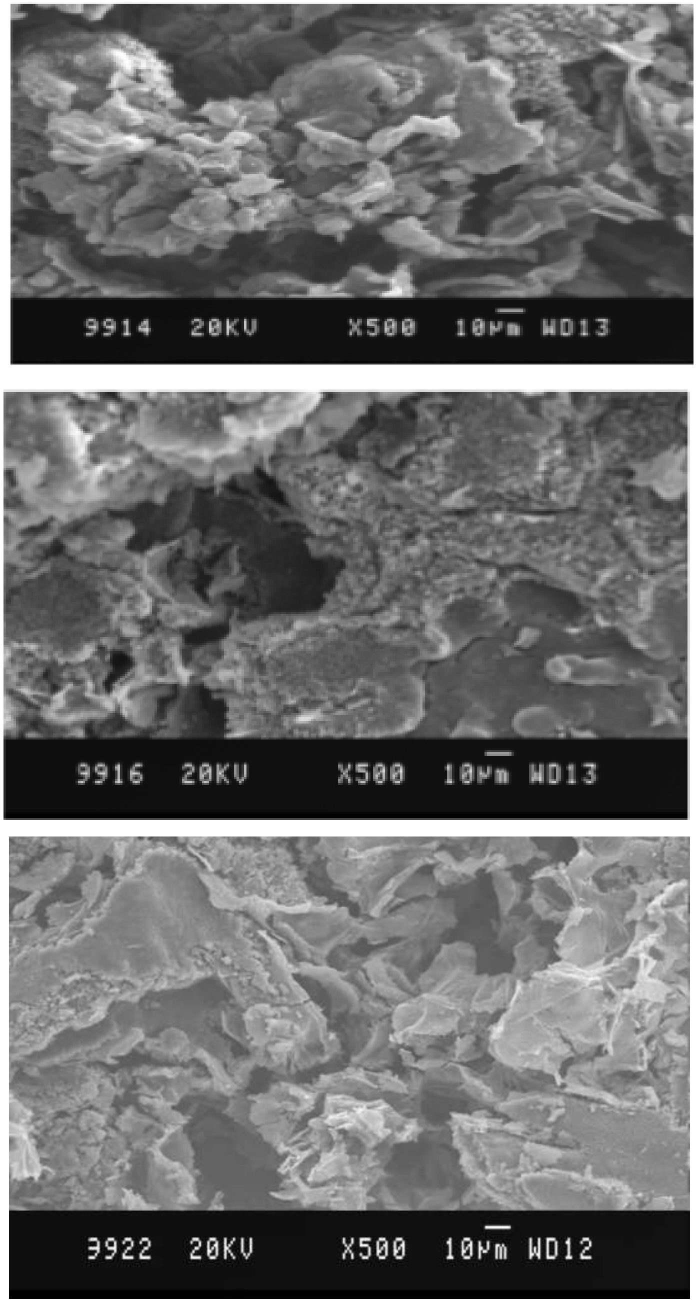

Figure 3: SEM micrographs for aluminum, after 24 h of immersion in LO (a) without LO (b) with 200 ppm LO, (c) with 400 ppm LO, (d) with 600 ppm LO, (e) with 800 ppm LO, and (f) with 1000 ppm LO. [13]

CONCLUSIONS

The corrosion inhibition tendency of parsley essential oil as a cheap sustainable inhibitor for aluminum in LO was shown by weight loss analysis, potentiodynamic polarization, and the SEM technique. The potentiodynamic analysis validates that the LO mitigates the aluminum corrosion via adsorption at the electrolyte/aluminum interface and thus forms protective layers on the aluminum surface. The corrosion inhibitive behavior significantly increased as the inhibitor concentration increased; 87.01% efficiency was achieved after 24 h of immersion with 1000 ppm inhibitor concentration. The obtained results from weight loss analysis, potentiodynamic polarization, and morphological characterization were in good agreement.

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