



## Short Communication

## Influence of surface roughness on the corrosion behaviour of magnesium alloy

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## ABSTRACT

In this study, the influence of surface roughness on the passivation and pitting corrosion behaviour of AZ91 magnesium alloy in chloride-containing environment was examined using electrochemical techniques. Potentiodynamic polarisation and electrochemical impedance spectroscopy tests suggested that the passivation behaviour of the alloy was affected by increasing the surface roughness. Consequently, the corrosion current and the pitting tendency of the alloy also increased with increase in the surface roughness. Scanning electron micrographs of 24 h immersion test samples clearly revealed pitting corrosion in the highest surface roughness (Sa 430) alloy, whereas in the lowest surface roughness (Sa 80) alloy no evidence of pitting corrosion was observed. Interestingly, when the passivity of the alloy was disturbed by galvanostatically holding the sample at anodic current for 1 h, the alloy underwent high pitting corrosion irrespective of their surface roughness. Thus the study suggests that the surface roughness plays a critical role in the passivation behaviour of the alloy and hence the pitting tendency.

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## 1. Introduction

Magnesium alloys have gained significant interest for automotive and aerospace applications for their high-strength-to-weight ratio. However, their wide-spread use is limited by their high corrosion susceptibility, particularly in chloride-containing environment. In recent years, a substantial amount of work has been carried out to improve the corrosion resistance of magnesium and its alloys through alloying and surface coatings for various applications [1–5]. A few researchers have also studied the influence of microstructure on the corrosion behaviour of magnesium alloys [6,7].

Generally, the surface roughness plays a role on the corrosion behaviour of metallic materials. It has been reported that an increase in the surface roughness of stainless steels increases the pitting susceptibility [8–10] and general corrosion rate [11]. A similar trend has been reported for other metals, such as copper [12], and titanium-based alloys [13]. However, the literature on the effect of surface roughness on the corrosion behaviour of magnesium and its alloys is limited. Interestingly, the only work by Alvarez et al. [14] on AE44 magnesium alloy is in contrast to the trend reported for other metallic materials. Based on immersion test results, the authors [14] reported that the general corrosion decreased as the alloy's surface roughness increased. Further they reported that the polished alloy allowed greater initial pitting and higher pitting volume than the semi-polished alloy. Typically, the general and localized corrosion behaviour of alloys would depend on their passivation behaviour. Hence, it is important to know

the passivation behaviour of magnesium alloys with different surface finish to correlate the surface roughness to their general corrosion and pitting tendency.

In this study the corrosion behaviour of AZ91 magnesium alloy was studied using electrochemical techniques, such as potentiodynamic polarisation and electrochemical impedance spectroscopy, especially to understand the passivation behaviour of the alloy with different surface roughness.

## 2. Experimental procedure

Sand-cast AZ91 magnesium alloy was used as the test material in this study. The chemical composition of the alloy is given in Table 1. For obtaining different surface roughness, the samples were grinded/polished with different grits of silicon carbide (SiC) (i.e., 320, 600 and 1200) and 3 µm diamond-paste. The surface roughness was analysed using atomic force microscopy (AFM).

The corrosion behaviour of the alloy was studied using electrochemical techniques, such as potentiodynamic polarisation and electrochemical impedance spectroscopy (EIS). A potentiostat and frequency response analyser (Model VersaSTAT 3) driven by VersaStudio software were used for potentiodynamic polarisation and EIS experiments, respectively. A typical three electrode system consisting of graphite as a counter electrode, Ag/AgCl electrode as a reference electrode and sample (0.75 cm<sup>2</sup> exposed area) as a working electrode were used. The test electrolyte was 0.5 wt.% NaCl solution. Prior to testing, the samples were allowed for 2 h to reach a relatively stable open circuit potential. EIS experiments were performed over the frequency range of 10<sup>5</sup>–10<sup>–2</sup> Hz at AC amplitude of 5 mV. Potentiodynamic polarisation experiments were done at a scan rate of 0.5 mV/s. In addition, immersion tests

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