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Influence of B4C Particles on the Corrosion Resistance of an AA1100 Aluminum Matrix Composite

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1. Introduction

The AA1100 aluminum matrix composites reinforced with B_4C particles (25 vol.%) are attractive materials for spent nuclear fuel storage applications due to their neutron absorption capability, which may contribute to enhanced safety and increased storage capacity in reactor pools [1,2] However, because these materials remain exposed to aqueous environments for prolonged periods, their corrosion behavior must be thoroughly understood [2].

In this study, the influence of B_4C particles on the corrosion resistance of the AA1100 alloy was investigated by combining electrochemical analyses in different media: 0.005 mol.L-1 NaCl solution, 0.005 mol.L-1 NaCl containing 2000 ppm of boric acid, and 2000 ppm of boric acid solution alone. In addition to evaluating the composite, the electrochemical behavior of aluminum and B_4C was also assessed separately to understand their individual and coupled contributions to the corrosion process.

The results show that B_4C cannot be regarded as an electrochemically inert reinforcement. Instead, it can sustain cathodic activity, indicate semiconducting behavior and lead to galvanic interactions with the aluminum matrix. The electrolyte composition also played a decisive role in the corrosion response. Boric acid at the investigated concentration modified the reaction kinetics and contributed to changes in the corrosion resistance of the material. These findings provide a more detailed understanding of the role of B_4C particles in AA1100-based composites, where the electrochemical behavior of both the aluminum matrix and the B_4C particles, together with the kinetics of the anodic and cathodic reactions, are addressed.

2. Methodology

For this study, was used an aluminum matrix composite, with an AA1100 matrix, reinforced with 25 vol. % of boron carbide particles and coated with an aluminum cladding of the same material as the composite matrix, commercially known as BORALCAN™. This material was originally developed by Rio Tinto Alcan for neutron-shielding applications in the nuclear industry. The nominal chemical composition of the composite, expressed in weight percent, was quantified by inductively coupled plasma optical emission spectroscopy (ICP-OES) and for the carbon content, was determined by LECO® combustion analysis, comprises approximately 1.48 wt.% B, 4.77 wt.% C, 5.72 wt.% Fe, 1.53 wt.% Ti, 0.75 wt.% Si, 0.10 wt.% Cu, and minor amounts of Mn, Mg, Co, and Zn, with aluminum as the balance. Figure 1 shows the microstructure of the Al/B_4C composite, obtained using a Hitachi TM3000 tabletop SEM equipped with energy-dispersive X-ray spectroscopy (EDX), operating in both backscattered electron (BSE) and secondary electron (SE) modes at an accelerating voltage of 15 kV.

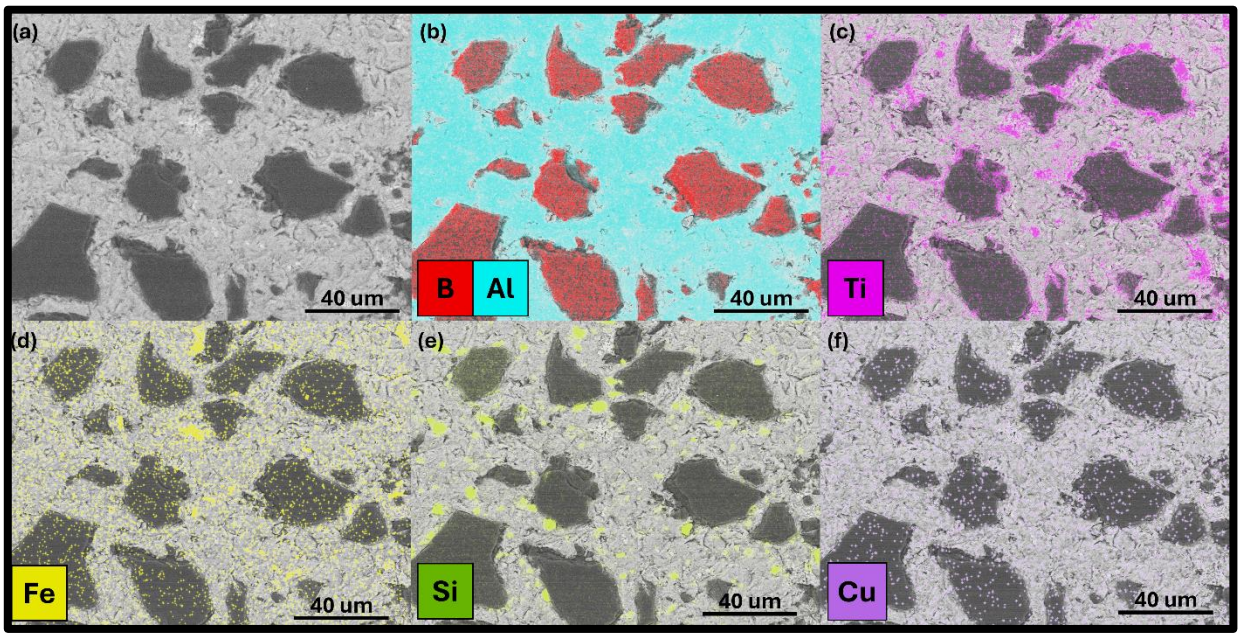


Figure 1. Surface microstructure and topography of the polished AA1100-B4C aluminum matrix composite: (a) scanning electron micrograph. EDX scanning of the region detecting: (a) boron and aluminum; (c) titanium; (d) iron; (e) silicon; (f) copper.

The sample surface was prepared using a sequence of abrasive SiC papers: 100, 220, 320, 400, 600, 800, and 1200 grit sizes, followed by polishing with alumina suspensions of 1.0 µm, 0.3 µm and 0.025 µm particle sizes.

To investigate the influence of the reinforcements on corrosion resistance, was applied electrochemical polarizations in different media: 0.005 mol.L^{-1} NaCl solution, 0.005 mol.L^{-1} NaCl containing 2000 ppm of boric acid, and 2000 ppm of boric acid solution alone.

3. Results and Discussion

Figure 2 shows the electrochemical polarization curve with a 2000 ppm H_3BO_3 solution and with IEA-R1 reactor pool water (IPEN), comparing the AA1100 alone and the AA1100 + 25 vol. % B_4C. The responses of these media are similar.

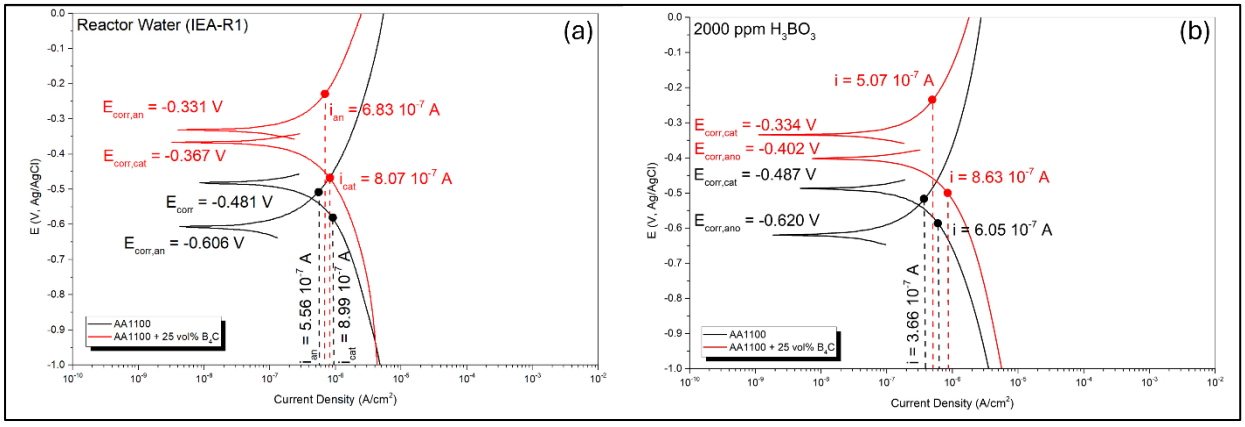


Figure 2. Electrochemical polarization, cathodic and anodic, of AA1100 and AA1100 + 25 vol. % B_4C: (a) reactor water of IEA-R1 (IPEN); (b) 2000 ppm of H_3BO_3 solution.

To evaluate the corrosion resistance of the materials, were used a 0.005 mol.L^{-1} NaCl solution and a 0.005 mol.L^{-1} NaCl + 2000 ppm of H_3BO_3 (figure 3).

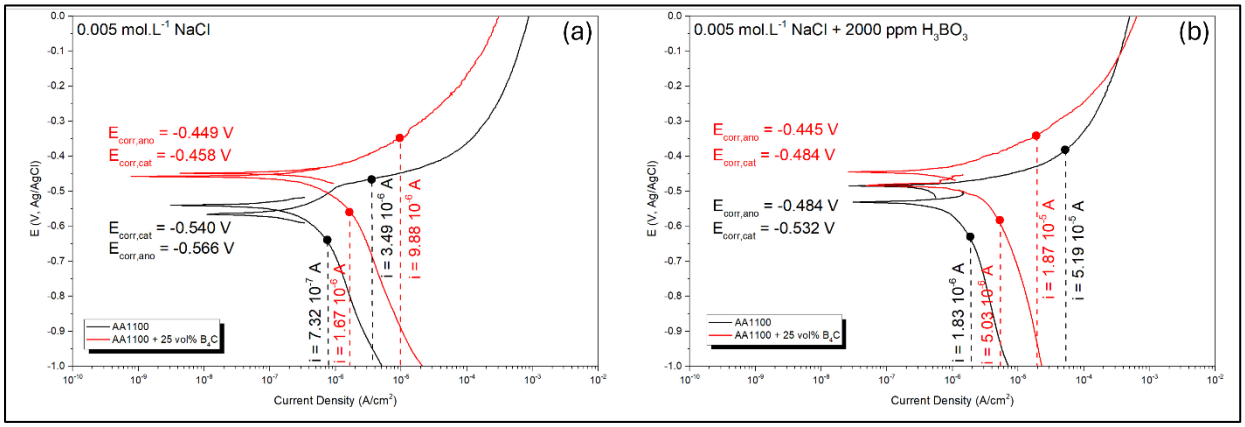


Figure 3. Electrochemical polarization, cathodic and anodic, of AA1100 and AA1100 + 25 vol. % B_4C: (a) 0.005 mol.L^{-1} NaCl solution; (b) 0.005 mol.L^{-1} NaCl + 2000 ppm of H_3BO_3 solution.

4. Conclusions

The results demonstrated that the presence of B_4C particles significantly influences the electrochemical behavior of the AA1100 aluminum matrix. The polarization curves showed that the response of the composite depends on the electrolyte composition, with boric acid modifying the corrosion kinetics, slowing the corrosion current of the Al/B_4C composite.

Acknowledgements

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