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Influence of the Al content on the aqueous corrosion resistance of binary Fe-Al alloys in H_2SO_4

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Introduction

Fe-Al-based alloys attract much attention for high temperature structural applications because of their outstanding physical and chemical properties. They exhibit a lower density of 5.7-6.7 g/cm^3 compared to other iron-base materials such as cast iron and stainless steels, superior high-temperature corrosion resistance, good wear resistance and low material costs [1, 2]. In addition, the equipment for their production and processing is readily available in industry [2]. Due to the practical and scientific importance, the aqueous corrosion behavior of Fe-Al-based alloys should be understood. A number of studies on the aqueous corrosion behavior of binary Fe-Al alloys have been reported so far, but they mainly focused on binary Fe-Al alloys with a limited variation in the Al content, e.g., (in at. %) Fe-28Al [3], Fe-40Al [4, 5], Fe-(8, 10, 22)Al [6] or Fe-Al alloys with additional alloying elements. A systematic investigation on the Influence of the Al content on the aqueous corrosion resistance of binary Fe-Al alloys is still needed. Therefore the aqueous corrosion behavior of binary Fe-Al alloys with Al contents up to 40 at. % was investigated in the present work.

Materials and Methods

A series of binary Fe-Al alloys with 5, 10, 15, 25, 30 and 40 at.% of Al were prepared by induction melting under argon atmosphere. H_2SO_4 with a pH of 1.6 was selected as the electrolyte. The three electrode-method [7] was employed for the electrochemical experiments. The Ag/AgCl reference electrode (3M KCl) was adopted. The open circuit potentials (OCPs) and potentiodynamic polarization curves were determined at 25 and 97 °C, respectively. Post mortem examination of the microstructures of the corroded samples were performed by scanning electron microscopy (SEM). A second series of the binary Fe-Al alloys was pre-oxidized before performing the electrochemical measurements.

Results and Discussion

All the potentials values obtained in the present work were converted into the value against a saturated calomel electrode (SCE).

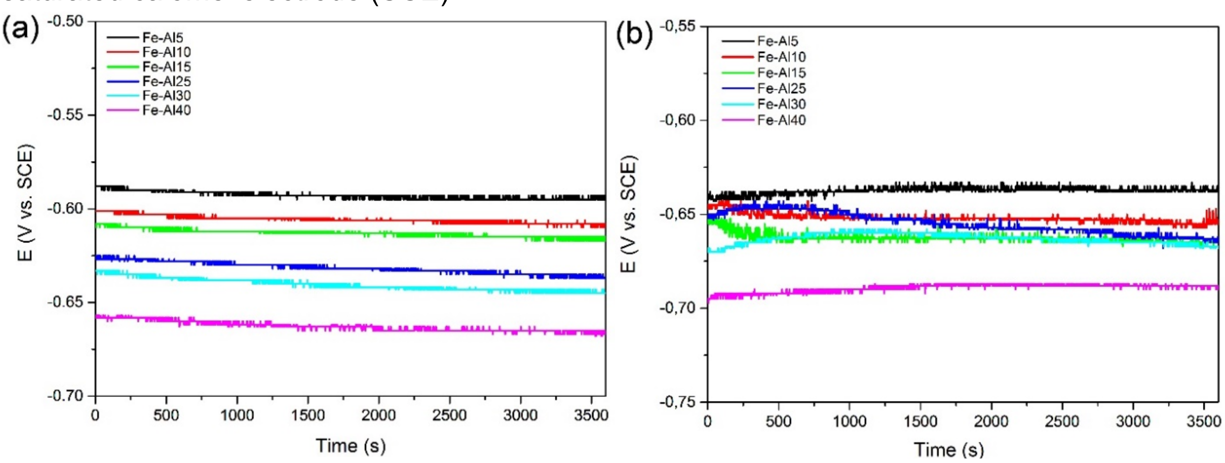

Fig. 1 The OCPs of binary Fe-Al alloys in H_2SO_4 of a pH 1.6 at (a) 25 °C and (b) 97 °C, respectively.

Fig. 1 shows the OCPs of the binary Fe-Al alloys in H_2SO_4 of a pH 1.6 measured for 3600 s at 25 °C and 97 °C, respectively. At both temperatures, the OCPs of the Fe-Al alloys decreased continuously

with increasing Al content, i.e. the Fe-Al alloy with higher Al content is potentially more active in H_2SO_4 of a pH 1.6. At 97 °C, the OCPs of all alloys were lower than corresponding one at 25 °C.
Fig. 2 shows the potentiodynamic polarization curves of Fe-Al alloys in H_2SO_4 of a pH 1.6 with the scan rate of 0.5 mV/s at 25 °C and 97 °C, respectively. At 25 °C (Fig. 2a), the alloys with 5 and 10 at. % Al only exhibited active behavior, while passivation behavior was observed for the alloys with Al contents of 15 at.% and higher. This is consistent with the general observation in oxidation experiments that the minimum Al content for the formation of protective Al_2O_3 scales on binary Fe-Al alloys is 16-18 at.% [1]. Such a correlation between wet corrosion behavior and oxidation resistance has already been found previously in case of Fe-Al-C alloys [8]. Whether the formed passive film on the surface of the alloys is a bilayer [4, 6] consisting of an Al-oxide enriched layer and a Fe/Al oxide layer or a single Fe/Al oxide mixed layer [9] is still under debate. When Al content increased from 15 to 25 at.%, the primary passive potential decreased considerably and the width of the passivation regions increased significantly. As the Al content further increased, both primary passive potentials and the width of the passivation regions almost kept constant, which indicated the increment of Al content only had slight influence on the passivation behaviors of Fe-Al alloys, when the Al content exceeded 25 at.%. At 97 °C (Fig. 2b), none of the alloys showed passive behavior.

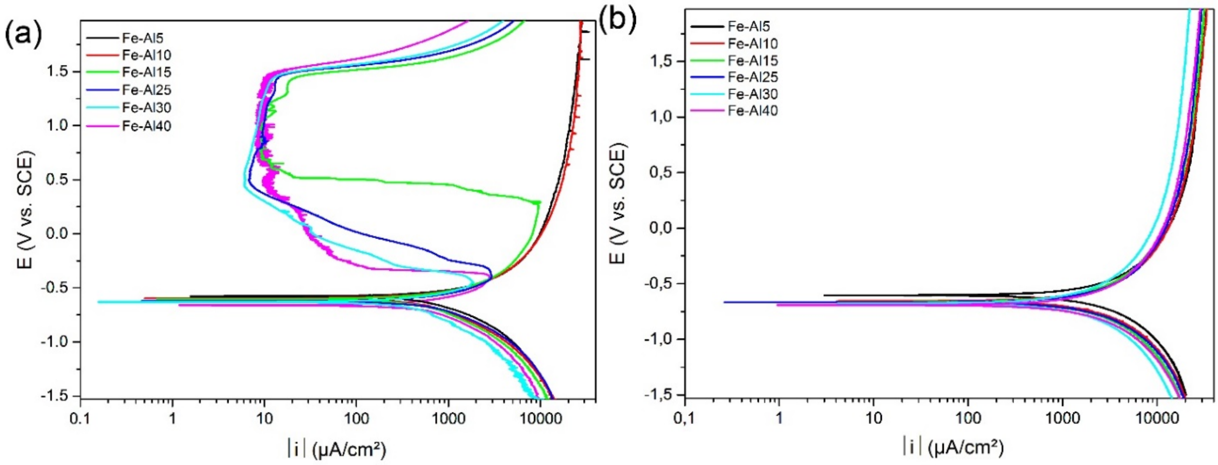

Fig. 2 The potentiodynamic polarization curves of binary Fe-Al alloys in H2SO4 of a pH 1.6 with the scan rate of 0.5 mV/s at (a) 25 °C and (b) 97 °C, respectively.

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