Influence of Al Content and Pre-oxidation on the Aqueous Corrosion Resistance of Binary Fe-Al Alloys in Sulphuric Acid

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Abstract: The influence of Al content and pre-oxidation on the corrosion behavior of binary Fe-Al alloys in 0.0126 M H_2SO_4 was investigated. The minimum Al content for forming a passive film on binary Fe-Al at 25 °C is 15 at.%. Alloys with 25 at.% Al or more show a good and similar corrosion resistance. X-ray photoemission spectroscopy measurements show the passive film on Fe-25Al is enriched in Al and consists of an outer layer of mixed Al and Fe hydroxides and an inner layer of Al oxide. The oxide layer generated at 1000 °C effectively protected against aqueous corrosion in H_2SO_4.

Keywords: Fe-Al alloys; Aqueous corrosion resistance; Pre-oxidation; Sulphuric acid

1. Introduction

Fe-Al-based alloys attract much attention for high temperature structural applications because of their outstanding properties. They exhibit a lower density of 5.7-6.7 g/cm^3 compared to other iron-based materials such as cast iron and stainless steels, superior high-temperature corrosion resistance, good wear resistance and low material costs [1-3]. In addition, the equipment for their production and processing is readily available in industry [2]. Fe-Al-based alloys are mainly developed for high-temperature structural applications [4, 5]. However, due to their lower costs, they are also considered as a potential alternative for replacing conventional stainless steels at low temperatures. Applications that have been looked at in detail are pipes and tubes for sea water desalination [6], Cr- and Ni-free parts used in food industry [7], high-performance brake materials for trucks [8] and as catalysts [9]. For such applications, understanding of the aqueous corrosion behavior is of great importance.

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 of the Al content [10-26] or Fe-Al alloys with additional alloying elements [11, 27-45]. Moreover, these investigations were carried out in a variety of electrolytes. Only two investigations were carried out using H_2SO_4 of low molarity. Masahashi et al. [46] investigated Fe-Al alloys with a wider range of Al content (5, 10, 15, 25 and 30 at.%). However, only the mass changes of the samples after immersion in 5×10^{-3} M H_2SO_4 at 40-100 °C up to 3 h were determined and corroded samples were inspected by scanning electron microscopy (SEM) and evaluated by X-ray photoelectron spectroscopy (XPS). The passivation behavior was not studied. A more extensive study was carried out by Chiang et al. [47] who investigated the passivation behavior of six Fe-Al alloys with Al contents between 3.4 to 41.7 at.% at 25 °C. However, no post