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INFLUENCE OF FLUORIDATION ON THE STRENGTH OF SUPERPLASTIC Zn-21AI-2Cu ALLOY DEFORMED IN A SALINE MEDIUM

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Introduction

The interest in Zn-Al-Cu alloys has intensified in recent years because they possess the highest known yield strengths among the entire series of Zn-Al superplastic alloys. The superplastic materials are generally fine-grained materials and the deformation is associated with the grain boundary processes [1]. Because of this, the superplastic alloys are exposed to a potential danger of intergranular stress corrosion cracking under susceptible service conditions. Consequently, the study of enhancing the strength and increasing the corrosion resistance of the material at room temperature is an important research area.

Fluorine pasivation technology of metal surfaces (fluoridation) has been proved to be very effective in the protection of several metals such as austenitic stainless steel [2] and aluminum [3]. In the present investigation the superplastic Zn-Al-Cu alloy has been studied to evaluate the effects of fluoridation and the stress corrosion damage.

Experimental

The alloy Zn-21AI-2Cu named Zinalco, was prepared by melting high purity Zn, Al, and Cu and homogenizing at 573 K for 20 h. The ingots were extruded [4] to obtain round bars of 10 mm in diameter. The average grain diameter was 2 μm. Tension specimens of 31 mm of gage length and 6.3 mm diameter were machined from extruded Zinalco bars with fine grain structure formed by grains of α phase (Al solid solution) and the η (Zn solid solution). The specimens were polished with diamond paste of 0.5 μm and then washed with acetone in an ultrasonic cleaner.

The tension specimens were placed inside a Monel tube, and then the tube was evacuated to 10^{-3} mbar afterwards filled with high purity (N9-Air products) grade gaseous fluorine. Flowing it through a NaF trap to remove the HF impurities previously purified the fluorine gas. The content of impurities in the fluorine gas was found to be negligible by infrared spectroscopy before and after the corrosion process. The Monel tube containing the samples was pressurized with the fluorine gas at one atmosphere at 250°C, during 50 and 100 Hs. After this treatment the tube was cooled down to room

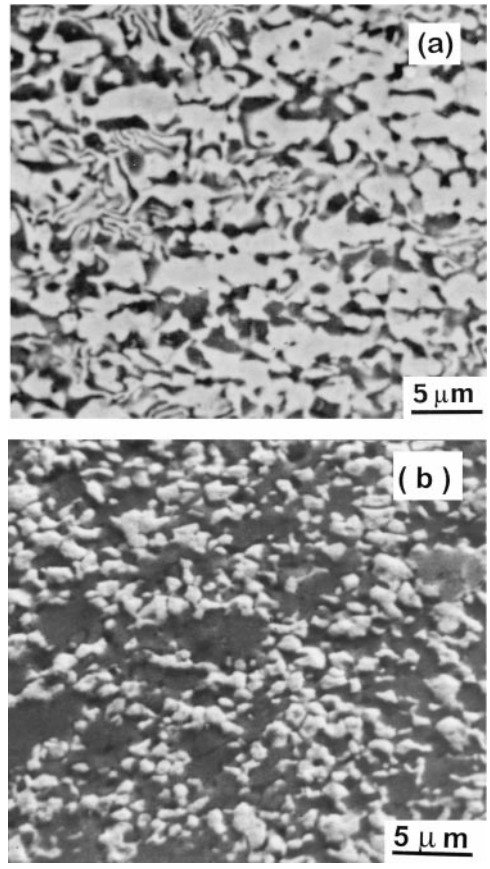

Figure 1. Microstructure of superplastic zinalco alloy (a) Fine grains in the untreated sample (b) exposed to a fluorine atmosphere for 50 h.

temperature and evacuated the fluorine gas. Before removing the tension specimens, the chamber was cleaned with nitrogen gas.

Fluoridated and non-fluoridated tension specimens were tested under conditions of tension stress (International Standard ISO 7539–7) while exposed to the corrosive medium (synthetic seawater) in a CERT (Constant, Extension Rate Test) machine. Another set of fluoridated and non-fluoridated specimens were tested in tension under normal conditions in an Instron machine. In both cases the strain rate used was 10^{-5} s^{-1}. Before tension test, the microstructure of the fluoridated specimens was characterized by scanning electron microscopy (SEM), microanalysis and X-rays diffraction.

TABLE 1
Maximum Strength and Ductility of Specimens Tested Under Ambient Conditions

	UTS (MPa)	Deformation (%)
Non-Fluoridated	370	38
Fluoridated 50 h	296	26
Fluoridated 100 h	307	36

TABLE 2
Maximum Strength and Ductility of Specimens Tested in a Synthetic Sea Water Environment

	UTS (MPa)	Deformation
Non-Fluoridated	248	59
Fluoridated 50 h	119	126
Fluoridated 100 h	122	137

It is interesting to notice that a higher amount of fluor is stored on the surface of the specimen with less fluoridation time (50 h). This reduction of the fluorine content in the specimen after longer fluoridation time, was observed before by Resonant Nuclear Reactions and X-rays [3,4].

Results and Discussion

The microstructure before and after fluoridation is shown in Fig. 1. It is observed that the aluminum phase (dark) is more etched (Fig. 1b) than the zinc phase (bright). The surface becomes rougher as the Zn rich phase is etched at grain boundaries.

Vickers Microhardness (100 grams) measurements shows that the fluoridated surface of the material is softer than the non-fluoridated. The changes go from 120 VH for non-fluoridated specimens to 65 VH for the specimens fluoridated 50 h and 90 for those fluoridated 100 hours. The results of tension test under ambient conditions are shown in Table 1, the fluoridated specimens shows a decrement in the ductility and in the strength in comparison with the non-fluoridated specimens. The specimens with higher amount of fluor (50 h) shows a minimum in ductility and strength.

Another set of fluoridated and non-fluoridated specimens were also subjected to tension whilst exposed to a synthetic sea water environment (ASTM D I 141–90) in a CERT machine with a view to determining stress corrosion susceptibility. The result shows a decrease of the strength and an increase of ductility with respect to the non-fluoridated material, Table 2.

In summary we observed that under ambient conditions, fluoridation reduces the strength of the alloy (Table 1) and ductility remains almost the same. When the specimens are tested under synthetic sea-water environment, the strength, with respect to the material tested under ambient conditions, is reduced and ductility is increased, in both fluoridated and non-fluoridated specimens. The reduction of the strength, in the fluoridated specimens is bigger than 50% and the increase of the ductility is 5 times the ductility found when tension is performed under ambient conditions. The ductility of the non-fluoridated specimen tested under seawater environment becomes 42% bigger, so there is some influence of the synthetic seawater on this property, in absence of fluor. It is possible that some chlorine introduced in the grain boundaries produced weakness of them and facilitates the grain boundary slip, reducing the strength and increasing ductility in a higher grade in the fluorinated specimens than in non-fluorinated.

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