

Effect of heat treatment and chemical processing on the electrochemical behaviour of aluminium alloy AA3102

J. T. B. Gundersen<sup>1</sup>, A. Aytac<sup>1</sup>, S. Ono<sup>2</sup>  
and K. Nisancioglu<sup>1</sup>

<sup>1</sup> Department of Materials Technology and  
Electrochemistry  
Norwegian University of Science and Technology  
N-7491 Trondheim, Norway

<sup>2</sup> Department of Applied Chemistry  
Faculty of Engineering, Kogakuin University  
1-24-2 Nishishinjuku, Shinjuku-ku  
Tokyo 163-8677, Japan

Corrosion resistant aluminium alloys for heat-exchange applications have attracted an appreciable interest during the last decade as a consequence of increasing demand for lightweight automotive structures. In addition to usual functional properties, certain components of the heat-exchanger (*e.g.*, fins) are designed to electrochemically protect the other parts against corrosion (*e.g.*, manifold and tubes). Using alloys with customised electrochemical properties is an important factor in achieving this purpose. The purpose of this work was to study the effect of heat treatment and chemical processing on the electrochemical behaviour of aluminium alloy AA3102, which is typically used as tube material.

## EXPERIMENTAL

The material studied was aluminium alloy AA3102 with a spectrographically determined composition of 0.421% Fe, 0.07% Si, 0.0015% Cr, 0.01% Cu, 0.0075% Ga, 0.2097% Mn, 0.0001% Na, 0.0052% Ni, 0.0025% P, 0.0006% Pb, 0.0139% Ti, 0.0129% V and 0.0003% Zr. The material was extruded as flat profiles using a laboratory extrusion press. A cooling device positioned 1 m below the outlet of the press inhibited the recrystallization process. The width and thickness of the flat profiles were 60 mm and 3.2 mm, respectively.

Samples were studied in the following conditions:

1. As extruded.
2. Heat-treated for 2 h at temperatures in the range 300°C to 600°C in an air circulating furnace and subsequently quenched in distilled water at room temperature.
3. Heat-treated for 5 to 60 min at 600°C in an air circulating furnace and subsequently quenched.
4. Heat-treated for 60 minutes at 600°C in an air circulating furnace, quenched, alkaline etched removing approximately 1 µm metal from the surface and desmuted in nitric acid.
5. Heat-treated as in 4, alkaline etched, desmuted and heat-treated as in 4.
6. Heat-treated as in 4 and Cr-P-acid stripped.

All samples were acetone degreased prior to electrochemical testing.

Time dependent corrosion potential measurements were performed in a SWAAT-solution (artificial sea water according to ASTM D1141) open to air at a controlled temperature of 25 ± 1°C. Potentiodynamic polarization measurements were performed at a sweep rate of 0.1

mV/s in a 5 wt% NaCl solution open to air at a controlled temperature of 25 ± 1°C.

Surface analytical studies were performed by use of a scanning electron microscope (SEM) and a glow discharge optical emission spectrometer (GD-OES).

## RESULTS AND DISCUSSION

Corrosion potential measurements showed deep negative transients for the heat-treated samples, which suggests the presence of an electrochemically active surface [1]. The degree of activation varied depending on the heat-treatment temperature and the heat-treatment time. Alkaline etching removed the electrochemically active surface resulting in a stable corrosion potential near -720 mV<sub>sce</sub>. Heat treatment of etched samples, however, restored the anodic transients. Oxide stripping by Cr-P-acid did not have any significant effect on the anodic transient.

The potentiodynamic polarization measurements also showed a negative shift of the corrosion potential as a result of heat treatment. Furthermore, the anodic current densities became large at a given potential relative to the as-extruded surface, and several anodic oxidation peaks were observed. The sweep curve for the alkaline etched sample did not show any anodic oxidation peaks since the active layer responsible for the peaks was removed. Oxide stripping did not affect the anodic sweep curves.

SEM studies of the samples after exposure to the SWAAT solution under open-circuit conditions revealed uniform etching of heat-treated samples, while pitting corrosion was observed on as-extruded samples. After several hours in the SWAAT solution the heat-treated samples also showed pitting corrosion

Qualitative depth profiles obtained by GD-OES indicated an enrichment of lead and magnesium at the metal-oxide interface as a result of heat treatment. Since the magnesium enrichment probably is in the form of an oxide, it cannot contribute to the electrochemical activation of the surface [2]. The observed lead enrichment, probably in metallic form [3], may therefore be the cause of activation. Lead enrichment of the surface has so far been observed only by GD-OES. The mechanism by which lead activates the surface is not understood. However, the mechanism is probably similar to the well-known activation of aluminium anodes by small additions of Group IIIA and IVA elements to the metal [4,5].

## REFERENCES

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