**A Combined Electrochemical and Microstructural
Analysis of Model AlMgSi(Cu) alloys**

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Abstract

Application prospects in automotive and aerospace industry have led to extensive studies on AA6xxx alloys in recent years because of their attractive combinations of properties. The benefits include formability, weldability, high strength to weight ratio and low cost. The main alloying elements in the commercial AA6xxx are Mg, Si, Fe and Cu. Mg and Si are usually used for strengthening purposes by precipitation hardening treatments at the expense of ductility. Cu is added to AlMgSi alloys to improve its ductility, for enhancement of the peak hardness and the precipitation hardening kinetics and furthermore it reduces the time to reach the peak hardness.

Most AA6xxx alloys are generally considered to have good corrosion resistance compared to other series of aluminum alloys. However, thermo-mechanical treatment, alloying and other factors may introduce susceptibility to localized corrosion, such as pitting and intergranular corrosion (IGC). IGC of aluminium alloys is the result of micro-galvanic cell formation at the grain boundaries (GB), related to GB precipitates, which are either more cathodic or anodic than the surrounding solid solution aluminium matrix. The formation of Cu-rich intermetallic precipitates at GB makes these zones and the zones directly adjacent to the GB depressed in Cu content. As a consequence, the GB becomes more anodic than the grain bulk. Preceding investigations by Svenningsen et al. have reported that α and β phase formation at the GB may result in significant IGC susceptibility [1-3].

In a number of studies model AlMgSi(Cu) alloys with a range of chemical compositions and heat treatment processes have been investigated [1-5].

None of the investigations presented in literature to date have focused on model AA6xxx simulating the industry processing route. In order to elucidate the individual and combined effects of Mg, Si and Cu as well as heat treatment, dedicated model alloys have been designed, simulating automotive industrial AA6xxx alloys. To this aim six series of specific combinations of alloying element content (Si/Mg ratios of 2 and 1.25 and Cu-contents ranging from 0.03, 0.50 to 0.80 wt-%) and heat treatments in line with industrial automotive standard practices were implemented in this model alloy study. The typical compositions of the model alloys are presented in Table 1.

Table 1: Model alloy compositions (wt. %)

	Al	Si	Mg	Cu	Fe	Mn
1	Bal.	1.0	0.5	0.03	0.2	0.1
2	Bal.	1.0	0.5	0.15	0.2	0.1
3	Bal.	1.0	0.5	0.80	0.2	0.1
4	Bal.	1.0	0.8	0.03	0.2	0.1
5	Bal.	1.0	0.8	0.15	0.2	0.1
6	Bal.	1.0	0.8	0.80	0.2	0.1

Dedicated accelerated IGC testing, electrochemical (interrupted) potentiodynamic polarization measurements and microstructural experiments (optical microscopy and AFM/SKPFM analysis) have been designed and combined to obtain in-depth mechanistic information and correlation between microstructure and localized corrosion investigate the alloying element and heat treatment effects. A clear correlation between Cu content and the susceptibility of the model alloy to localized corrosion was found.

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