Chromate Conversion Coatings Formed on 7xxx Aluminum Alloys

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High strength Al alloys containing Cu, such as AA2024 and AA7075, are widely used in aircraft applications, but are extremely susceptible to localized corrosion. Chromate conversion coatings (CCCs) are applied to these alloys to give them sufficient corrosion resistance for use in aircraft. The noble nature of Cu-containing intermetallic particles in the heterogeneous microstructure is thought to account for the poor corrosion resistance of these Al alloys and the relatively poor protection properties of CCC coatings on them. Although many studies have investigated the corrosion of AA7xxx and the protection afforded by CCCs, the effect of Cu content on corrosion and mechanisms of coating formation, and interaction between Cr(VI) species and Cu containing intermetallic particles are still unclear. This work is focused on understanding the effects of Cu content in 7xxx alloys on corrosion resistance and CCC protection.

A series of AA7xxx alloys in the T6 temper, but with Cu content varying from 0.013 to 2.0 wt% was studied. Potentiodynamic polarization and EIS tests were conducted on the untreated alloys. Two breakdown potentials were observed for Cu-containing alloys in deaerated 0.5 M NaCl, and the values of breakdown potential increased logarithmically with increasing Cu content. However, the corrosion resistance of high Cu content alloys, determined by EIS, decreased as the Cu content increased. Metallography and Focused Ion Beam (FIB) cross sectioning in conjunction with potentiostatic polarization were used to show that the first breakdown potential in these alloys was associated with transient dissolution of active particles, while combined IGC and selective grain attack occurred above the second breakdown potential.

CCCs were formed on AA7xxx alloys by a 3 min immersion. Some substrates were pretreated by exposure to HF + H2SO4 solution to artificially enrich Cu at the surface. The coating resistance of CCCs on un-pretreated samples, as determined by EIS, increased with substrate Cu content. In contrast, the coating resistance of CCCs on pretreated alloys first increased with Cu content in the low Cu range and then decreased for higher Cu contents. Cu content was found to play a two-fold role in corrosion and chromate protection.

The CCC formation process on AA7075 was investigated using FIB sectioning and TEM/Nano-EDS line profiling. The thickening rate of the CCC on the matrix was found to follow log-linear kinetics. The coatings formed on the two primary coarse intermetallic particles were much thinner than that on the matrix. On the Al-Fe-Cu particles, the coating was thin, but had a similar composition as the CCC on the matrix. However, the Al-Cu-Mg phase, which underwent selective dissolution of Mg during the immersion in Alodine solution, was coated with a thin Al/Mg/Cr mixed oxide layer. A sol- gel mechanism of CCC formation on heterogeneous substrate of AA7075 is proposed based on morphology and composition of CCC on the matrix and intermetallic particles.