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CORROSION BEHAVIOR OF $Al_7Cu_{0.2}Si_{0.2}Zn_{0.2}Mg_{0.1}$ COMPLEX CONCENTRATED ALLOY, IN 3wt% AND 5wt% NaCl SOLUTION

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Abstract

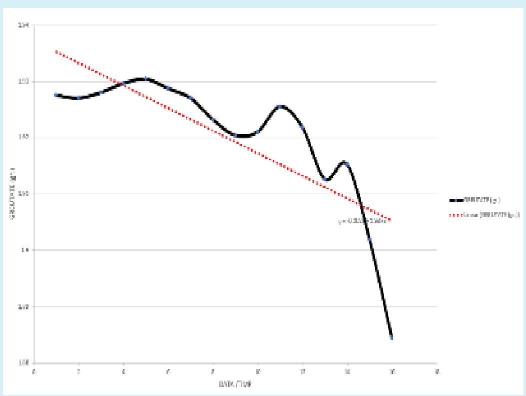
Complex concentrated alloys (CCAs) are new types of materials, where the equimolar rule proposed by high entropy alloys (HEAs) is modified in relation to the potential of the obtained structures. CCAs expend the compositional space of the conventional alloys, revealing new pathways for material design. The $Al_7Cu_{0.2}Si_{0.2}Zn_{0.2}Mg_{0.1}$ alloy was prepared in an induction furnace, in controlled atmosphere and was cast in a copper ingot mold. Specimens for heat treatment and rapid solidification processes were provided. The resulted samples of $Al_7Cu_{0.2}Si_{0.2}Zn_{0.2}Mg_{0.1}$ alloy, obtained through the three different methods, were characterized by chemical, structural, and corrosion methods. The corrosion immersion tests, were performed in 3wt% and 5wt% NaClsolution, and corrosion indices were measured periodically. The obtained corrosion film was analized by SEM-EDS to determine the composition and structural behaviour. Depending on the adhesion level, the corrosion film remained stable or partially broken and separated in the solution. The sample weight loss presented large variations between the various experimental conditions, but the general tendency was the decrease in the weight of the samples during the corrosion tests. The formation of oxide and chloride layers, during the corrosion process, determined only the dealloying in Al. Other elements remained in initial concentrations. Overall, the resistance of the alloy in saline environment seems to be promising, with significant improvement over the comparable compositions of 2000 and 7000 series alluminum alloys.

Experimental procedures

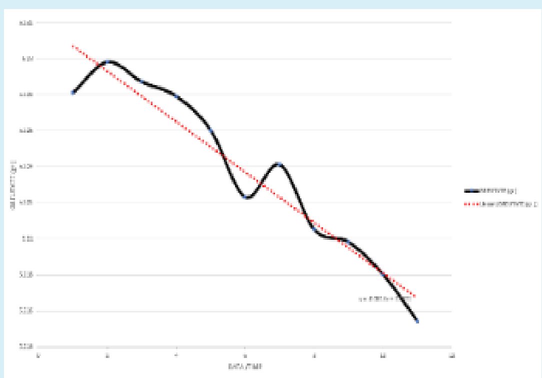
$Al_7Cu_{0.2}Si_{0.2}Zn_{0.2}Mg_{0.1}$ complex concentrated alloy was prepared in a Linn MFG-30 induction furnace, with inert atmosphere. High purity elements such as Al, Cu, Si, Zn and Mg were used as raw materials. The alloy batch, weighing 300 g, was elaborate in an alumina-based crucible. The alloy was casted into a cylindrical copper ingot mold in an argon-controlled atmosphere and than remelted in a resistance furmace to improve homogenity. The resulted as cast alloy ingots proceeded to heat treatment and rapid solidification procedures. The heat treatment was performed at 450^0C for 24 hours. Small alloy bars of 10mm in diameter were also used for the rapid solidification process. Melt - spun ribbons were obtained at high rotational speeds. Samples from the specimens in the three different states (as-cast, heat treated and melt-spun) were sent to chemical and structural analyses. Specimes were tested for corrosion resistance in 3wt% and 5wt% NaCl solution and at different contact area. The obtained corrosion film was analyzed by SEM-EDS analysis to determine the composition and structural behavior of the alloy.

Results

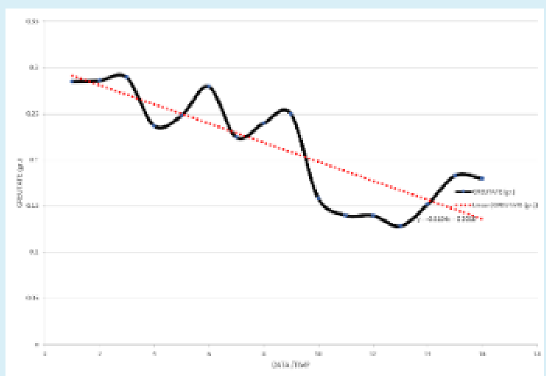
Variation of weight for various type of specimens



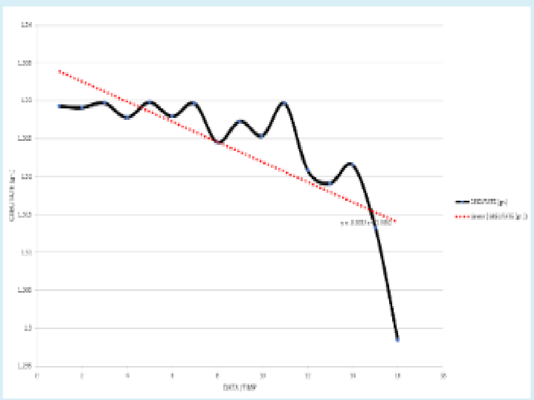
P1 as-cast



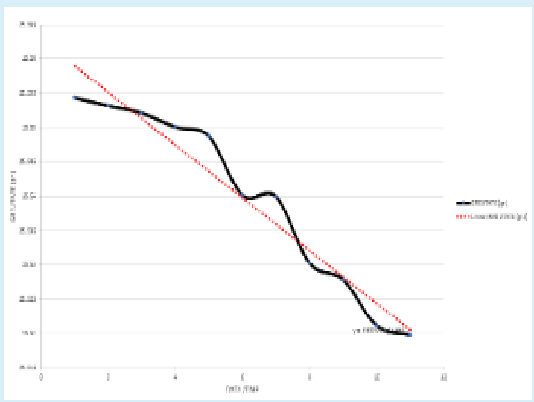
P3 heat treated



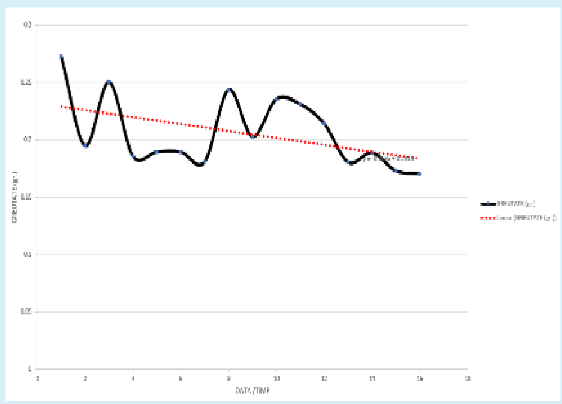
P5 melt spun



P2 as-cast



P4 heat treated



P6 melt spun

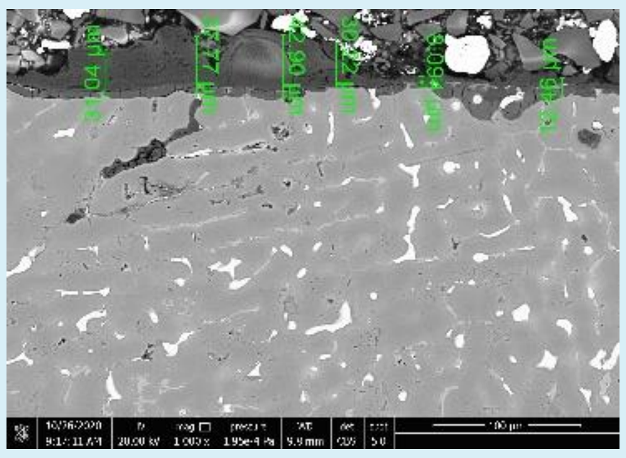
Alloy composition

Alloy	Composition (wt.%)				
	Al	Cu	Si	Zn	Mg
$Al_7Cu_{0.2}Si_{0.2}Zn_{0.2}Mg_{0.1}$	85	5.5	2.04	5.1	0.9

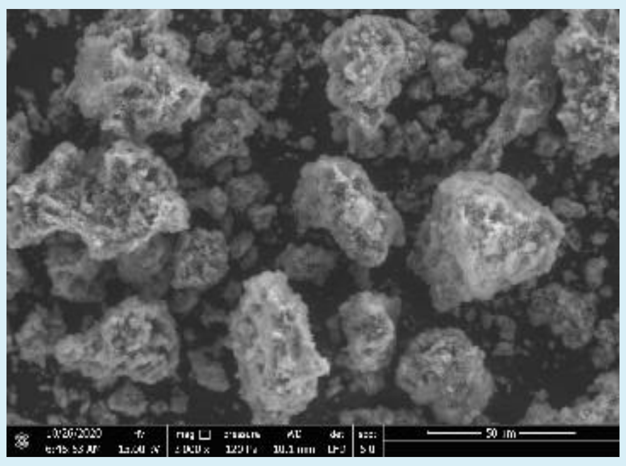
Alloy sample weighing values

	Presentation mode	Contact area [cm²]	Saline solution [%gr. NaCl]	V_{cor} [g/m²·h]
P1	As-cast	3.80	3	0.06
P2	As-cast	3.92	5	0.14
P3	Heat treated	4.96	3	0.4
P4	Heat treated	13.08	5	0.45
P5	Melt-spun ribbon	8.96	3	0.042
P6	Melt-spun ribbon	6.40	5	0.28
P8	2014 As-cast	4.53	3	0.94
P7	7075 As-cast	4.30	3	0.73

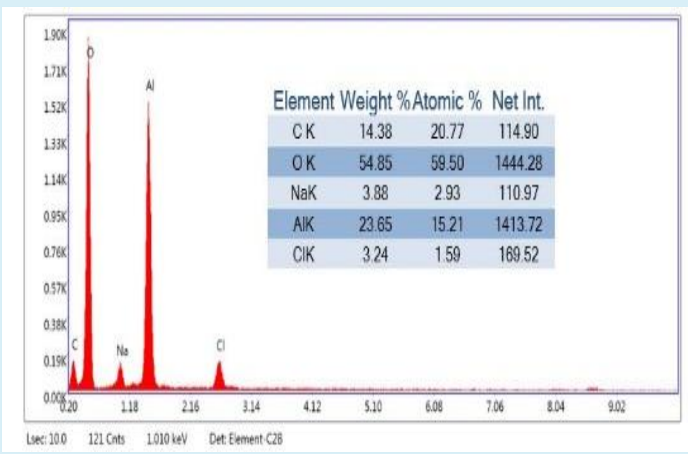
SEM-EDS analyses of the samples subjected to corrosion tests



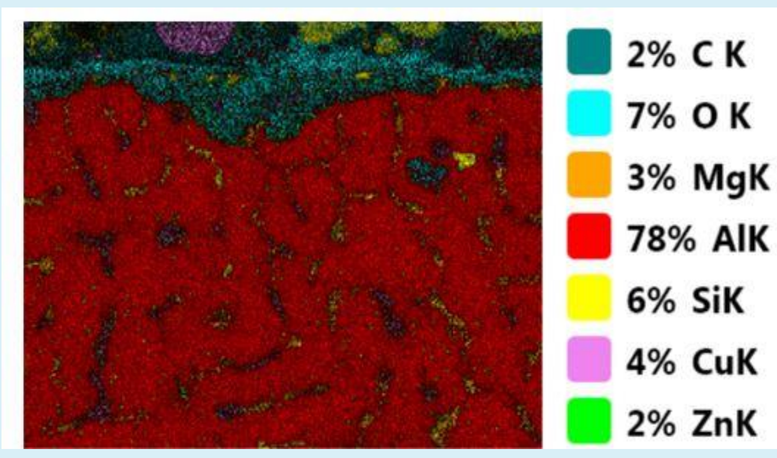
Surface structure



Corrosion film granulation



Corrosion film composition



Corrosion film mapping

Conclusions

The corrosion resistance of $Al_7Cu_{0.2}Si_{0.2}Zn_{0.2}Mg_{0.1}$ complex concentrated alloy was determined by the gravimetric method for three different structural states:as-cast, heat treated and melt-spun. According to the adhesion of the layer of corrosion products (oxides, chlorides), the weight of the samples during the corrosion test, shows weight variations, and the general tendency is to decrease the weight. The calculated corrosion rate for the analysed samples was compared with the values obtained for 2000 and 7000 aluminum alloy series. The melt-spun samples showed better results compared to the heat treated samples. The specimens were analyzed by SEM-EDS method for surface morphology in longitudinal and transversal section. The corrosion film presented good homogeneity and dense texture. The analyzes revealed different oxide layer thicknesses for each sample, which propagates interdendritically in the base metal mass. The analysis of the corrosion product showed that it consists of irregularly shaped granular aggregates. Local semi-quantitative chemical analysis by EDS revealed a rich presence of Al, O, Na, Cl and C in the corrosion layer.

Acknowledgements

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