ABSTRACT

Aluminium and aluminium alloys are widely used in various industrial applications in everyday life, especially due to their outstanding strength and mechanical properties in combination with relatively light weight and a low price. Al alloys have reduced corrosion resistance compared to bare Al due to the presence of metal inclusions such as copper, magnesium, zinc, iron, silicon, manganese and others. The metal inclusions improve the mechanical properties of the alloy, but in contact with the corrosive medium represent the sites where the local corrosion begins. The inclusions are usually less noble according to the surrounding base alloy, therefore they represent cathodic sites where oxygen reduction occurs and leads to increased rate of corrosion. Therefore, Al alloys need to be protected against corrosion for an optimal use. For that purpose, the chromate coatings have been used for decades but due to toxicity and carcinogenicity their use is prohibited and limited. As an alternative, coatings based on salts of rare earths are explored. These are widely available in nature and environmentally friendly.

Corrosion protection of aluminium alloys 7075-T6 based on rare earths was investigated using two approaches: (i) as an additive in a corrosion medium and (ii) in the form of conversion coatings. Various salts of rare earths, i.e. $CeCl_3$, $Ce(NO_3)_3$, $LaCl_3$ in $La(NO_3)_3$, and their mixtures were used in both cases. When added directly to the corrosion medium, the best protection was achieved by the addition of $CeCl_3$ and a mixture of the $CeCl_3$ and $LaCl_3$. This type of protection is suitable for the use of materials in closed systems. Conversion coatings based on rare earths were formed on the surface of AA7075-T6 with the oxidant, i.e. hydrogen peroxide. $CeCl_3$-based coatings were particularly effective, as well as coatings based on $Ce(NO_3)_3$, while $LaCl_3$ did not achieve sufficient protection. $La(NO_3)_3$ required a higher temperature and longer conversion for its activity. Conversion coatings based on the mixed chloride salts were generally more effective. Overall, protection with conversion coatings is suitable for various applications in both closed and open systems.

Further, the impact of the addition of hydrogen peroxide on the formation of the conversion coatings on aluminium and its alloys (AA2024-T3 and AA7075-T6) was studied as well. Coatings formed using H_2O_2 exhibit improved protection of all materials. The corrosion properties of unprotected and protected alloys were studied using electrochemical methods in a 0.1 M NaCl solution. The surface morphology and chemical composition were examined by scanning electron microscopy and energy dispersion X-ray spectroscopy The oxidation states of rare earth compounds were investigated by X-ray photoelectron spectroscopy. The quality of the adhesion of coatings and surface roughness were measured as well. The corrosion resistance of conversion coatings was additionally confirmed testing in a salt spray chamber.

Salts of rare earths have proved to be a promising alternative for by chromates, but additional studies would be required to completely replace them in applications where corrosion resistance is critical. The combination of surface preparation, the formation of different conversion coatings and the use of various inhibitors could offer additional possibilities for improvement of corrosion protection.

Key words: aluminium, aluminium alloys, corrosion, rare earths