Localised Electrochemical Techniques for Studying Corrosion of Mg and Mg Alloys / coating systems: Opportunities and Challenges

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The requirement to decrease the weight of vehicle components for reduction of fuel consumption and gas (CO2) emissions has led to searching for light weight alloys. Magnesium alloys are the lightest structural materials. Despite their good mechanical properties such as high strength to weight ratio, magnesium alloys have found limited application mainly due to their poor corrosion resistance.

Among the effective methods for corrosion protection, surface treatments based on the application of sol-gel thin films are one of the most versatile alternatives which provide the possibility to design and obtain tailored and eco-friendly multifunctional surfaces onto the surface of Mg and its alloys.

In close relation with the development of new and effective methods for corrosion protection of Mg and its alloys is the use of electrochemical techniques for their evaluation. The combination of global and localised electrochemical techniques is necessary to characterise the different electrochemical activity, highly reactive sites and/or passive regions which take place on corroding surface. In the case of Mg and Mg alloys, due to its high reactivity in presence of aqueous corrosive media, that readily reacts with water, producing large amounts of H2 gas, a proper electrochemical characterisation is not an easy issue. This H2 evolution leads to a change in the natural convection of the electrolyte and thus in the electrochemistry of the system under study. The exposition time to the aggressive medium is another important factor, since the increase in pH of the solutions, due to the corrosion processes, causes the precipitation of Mg(OH)2, leading to a further change in the electrochemical activity of the material.

For its evaluation, a new methodology combining accelerated test, global and localised electrochemical techniques is proposed to study different sol-gel films applied onto AZ91 Mg alloys. The sol-gel films are designed either to provide barrier protection i.e inhibitor free films or to provide active protection, that is, sol-gel films doped with organic corrosion inhibitors, benzotriazole and L-cysteine. The localised electrochemical measurements are performed by using, i) a mini-cell system (MCS) as example of microcapillary localised electrochemical technique ii) Localised Electrochemical Impedance Spectroscopy (LEIS) and Scanning Vibrating Electrode Technique (SVET) as example of scanning localised electrochemical techniques. In this study, the advantages and challenges faced by localized electrochemical techniques to characterize Mg corrosion and the evaluation of the corrosion protection afforded by tailored sol-gel films, will be highlighted, as this remains a complex task. A new methodology which combine both global and localised electrochemical techniques is proposed specially for the study of Mg alloys/coating systems.