A New Composite Coating for Corrosion Protection of AZ31 and RZ5 Magnesium Alloys

Ferreira, MC; Zomorodian, A; Montemor, MF; Fernandes, JCS
ICEMS / Instituto Superior Técnico, University of Lisbon, Lisbon, Portugal

Biocompatible metallic materials represent the state of art for medical implants and an increasing interest in degradable alloys for biomedical devices is observed. A number of recent works have emphasized the use of magnesium alloys as a new class of bio-resorbable materials for orthopaedic implants. They combine multiple useful properties such as biocompatibility and osteoactive properties, low density, elastic modulus close to natural bones and the elimination of a second surgery for implant retrieval. However, some key issues still lack of a precise study and improvement. Problems such as in vivo reabsorption being too fast, localized and unpredictable and the fact that Mg corrosion produces hydrogen gas which may accumulate adjacent to the implant in the body still need to be overcome.

One of the most common and effective ways to control corrosion is the use of coatings and intensive research has been conducted in order to find a successful, practical and cheap process for coating magnesium alloys.

For the particular use of magnesium as orthopaedic biodegradable material, it should stand the corrosive physiological environment for the entire duration of the repair or healing of the injured bone tissue. Then, the implant should be gradually dissolved or absorbed in the human body. Thus, a good coating must protect the material during the healing process, allowing it to degrade afterwards.

In this work a new composite coating, involving an oxide layer followed by a second layer of organic nature, was tested on magnesium alloys AZ31 and RZ5. The first layer is obtained by anodizing in alkaline solution of sodium hydroxide, sodium silicate, sodium fluoride and glycerol, whereas the organic layer consists of a new formulation developed by the authors, based on polycaprolactone. This polymer has shown to efficiently protect Mg against corrosion but tends to degrade by hydrolysis in physiological conditions (such as in the human body), so this protection is lost after a certain period, allowing the material to slowly start to corrode, being assimilated back into the body, as required for a resorbable implant.

Electrochemical Impedance Spectroscopy was used to assess the behaviour of the composite coating during immersion in Hank's solution, showing a remarkable increase in the corrosion resistance, compared to the bare material, with initial impedance values in the range of 10^9 ohm.cm². After several weeks of immersion, the natural degradation of the polymer coating layer is reflected on a progressive increase in the corrosion rate of the magnesium alloy substrate, as expected.