Electrochemical surface engineering of biomedical metal alloys

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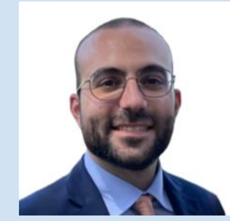

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Electrochemical surface treatments

Concept

The demand for biomedical metallic devices to support damaged biological structures is steadily increasing, and biomaterials are receiving special attention from both academia and industry. Some of the best-known applications are heart valves, stents, implants for bones and orthopaedic screws and plates. Implants can be permanent or biodegradable. Permanent components must maintain functionality and structural integrity for the entire lifetime of the host or until their scheduled removal, they are designed to resist corrosion and thus not release harmful ions. Biodegradable prostheses support biological structures for a fixed time, they are designed to be absorbed by the physiological environment, and thus they don't require a second surgery to be removed, following the principle of "Fix-Heal-Disappear". The major issue with biodegradable implants is to correctly match corrosion rate with tissue healing time; these devices should have mechanical properties comparable to those of the specific tissue, adequate corrosion resistance, as well as excellent tribological properties, biocompatibility, osseointegrability and nontoxicity. Careful design of surface treatments is necessary.

Scientific approach

Surface treatments are an efficient strategy to improve the interaction at the implant/tissue interface without altering the performances at the bulk. The most common and effective surface treatments are (electro)chemical conversion coating (such as stannate based chemical conversion coating or anodizing), electrodeposition and electrophoretic deposition. These processes are simple, scalable and easily integrated into existing production chains, enabling very precise changes in surface properties. Different simulating solutions with increasing complexity will be investigated, studying biodegradable implants even in inflammatory conditions. Corrosion resistance will be assessed with electrochemical methods such as EIS and polarization curves, or by hydrogen evolution rate (HER) measurements, and biocompatibility of coating will be verified with in vitro cellular vitality test. Biodegradation of coated implant will be modelled with FEM strategies in order to predict corrosion behaviour and mechanical stability in different operating conditions.

Research objectives

AZ31 magnesium alloy and other biodegradable materials will be investigated. A multi-step surface treatment will be optimized to obtain a biocompatible coating, able to match implant degradation with the tissues healing time, and to preserve its mechanical resistance for the whole scheduled life of the implant.