# Chapter 11
# Tribo-Corrosion Behaviour and Characterization of Biocompatible Coatings

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## ABSTRACT

*Commercially available metallic orthopaedic implant materials cause major problems like stress shielding and the release of harmful ions due to corrosion and wear. Also, the secondary operation is a must for the implant removal. Therefore, the biodegradable and biocompatible magnesium (Mg) implant materials have been investigated. Mg shows favorable biological properties and matching mechanical properties with the natural bone. Mg alloys rapidly corrode in the physiological environment, which cause failure of the implant before completing the expected function. Surface coating is the most effective method for improving the corrosion performance of Mg and its alloys. Hydroxyapatite (HA), being the most stable phase of calcium phosphates in physiological conditions, is preferred as a coating material. The chapter focuses on the tribo-corrosion and characterization of HA coatings prepared by electrodeposition process on Mg alloys. The results are useful for the designer community in the selection of biocompatible coatings and process parameters to maximize the life of bio-implants.*

DOI: 10.4018/978-1-7998-9683-8.ch011

## INTRODUCTION

Biomaterials interact and coexist with biological systems to repair or replace or augment the diseased tissue, organ or function of the body. The biomaterials must be biocompatible, i.e. they should not produce any harmful or undesirable effect. The biomaterials include metallic, ceramic, polymeric and composite materials (Ramakrishna et al., 2010; Park & Kim, 2003). Biomaterials that are used in orthopaedic applications are generally called as 'orthopedic biomaterials' or 'implants'. Orthopedic biomaterials are mainly employed in osteosynthesis, arthroscopy, joint replacement, dental implant reconstruction and spine stabilization. This chapter focuses on the implants used in osteosynthesis. Osteosynthesis is fixation and repair of fractured bone (Hallab & Jacobs, 2020; Rodríguez-González, 2009). A bone fracture is break or disruption in normal architecture of bone. Whenever bone fractures, it needs a surgery to implant extra material, which can support the fractured bone and helps to heal it. The biomaterials used as orthopaedic implants include bone plates, rods, screws, pins, wires, etc. They are used to serve the purpose of bone support, fracture fixation or total joint replacement.

The biocompatibility and mechanical properties are two most important factors for selection of a material as orthopaedic implant. The outstanding mechanical properties and acceptable biocompatibility of metallic materials make them a potential candidate for orthopaedic application (Niinomi, 2002). The traditional metallic implants used to support fractured bone during its healing process are stainless steel, titanium and cobalt-chromium alloys. Though these materials are having excellent mechanical properties, they induce some problems in bone healing process. In comparison with natural bone, they have higher elastic modulus. Due to this, the implant material carries more external load than the bone, which leads to loss of density of healing bone and bone becomes weaker. This undesirable effect is called as 'stress shielding effect' (Nagels et al., 2003). Also, the corrosion and wear of these metallic implants in physiological environment, releases harmful ions which cause inflammation and detrimental tissue reactions causing tissue damage (Jacobs et al., 1998; Lhotka et al., 2003). Besides this, these implants are biocompatible but not biodegradable. They provide only temporary support; therefore, they must be removed by secondary surgery after bone healing process is over (Park & Kim, 2003). This causes loss of financial resources and may additionally induce post operative infections. Therefore, in order to reduce such complications, the use of degradable and biocompatible metallic implants has been investigated.

Magnesium (Mg), which is biocompatible and biodegradable, has been studied extensively to replace traditional metallic implants. Magnesium is degraded gradually in the physiological environment and is replaced by the healing tissue. $Mg^{2+}$ ions, released during the degradation process, are harmless to the human body. Also, the biodegradability of Mg eliminates the need for secondary surgery. But the corrosion rate of Mg in the body is very high in the physiological environment, which may lead to loss of mechanical integrity of Mg-based implant before the completion of the bone healing process. Surface coating is a preferential method used to delay the corrosion of Mg-based implants. It is mandatory that, the coating material should also be biocompatible and biodegradable. The HA is a natural element of human bone and teeth. But HA cannot be used for load-bearing applications due to its intensive brittleness. Therefore, it is used as a coating material on Mg-based substrate. This chapter focuses on the electrodeposition of hydroxyapatite (HA) on the surface of Mg-based implants to delay its corrosion in a physiological environment.