

Corrosion behavior of polypyrrole/hydroxyapatite nanocomposite thin films electropolymerized on NiTi substrates in simulated body fluid

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Hydroxyapatite (HAp) nanoparticles synthesized via microwave irradiation. Polypyrrole (PPy)/HAp nanocomposite was obtained using electropolymerization on nitinol (Ni) titanium (Ti) substrates. Fourier transform infrared was employed to characterize the nanocomposite formation. Electrochemical properties of the nanocomposite were investigated using polarization and electrochemical impedance spectroscopy (EIS) in simulated body fluid (SBF, 37 ± 0.1 °C). It was concluded that the NiTi specimen coated with PPy/HAp nanocomposite, has higher corrosion resistance than the NiTi coated with pure PPy in the SBF; however, NiTi was better than both coated NiTi. EIS results confirmed corrosion properties. Also, EIS was used to predict the morphology of the coatings. It predicted fine and compact morphology of the nanocomposite that was confirmed using scanning electron microscopy.

1 Introduction

In the past two decades, nitinol (Ni) titanium (Ti), a near-equiatomic intermetallic compound, has been emerged as a new type of implant materials by virtue of its distinctive thermo-mechanical and mechanical properties, namely, shape memory effect, superelasticity, and high damping capacity [1]. The material of a medical implant, irrespective of its function, must be corrosion-resistant and biocompatible to ensure long service life and to minimize its adverse biologic effect on the human body. Conflicting conclusions have been reported for corrosion resistance of NiTi samples [2, 3]. Such controversies may be attributed to the surface characteristics of the samples in the experiments [3, 4], and also to the differences in its performance requirements in various conditions [3]. However, views regarding to the corrosion resistance of NiTi in medical applications are more conservative [2, 3], mainly because NiTi has a high content of Ni.

The application of polymers as coating materials enhances the developments of new biocompatible surfaces based on usage of chemically modified surfaces [5, 6]. This approach also leads to the protection of the prosthesis against corrosion and decreases the unavoidable problem of Ni ions releasing in the surrounding tissue [5]. Polypyrrole (PPy) conductive polymer can be an appropriate material for these aims since, unlike the other artificial biopolymers, conducting polymers (CPs) can be electrodeposited directly onto the metallic implants such as Ni

and other Ti alloys [5]. Meanwhile, PPy-based composites are introduced in order to achieve a new function of PPy such as PPy/MWCNTs, PPy/Fe₂O₃, PPy/Pd, and PPy/clays that were used as supercapacitor [7], photovoltaic cells [8], electrocatalysis [9], and organic semiconductors [10], respectively.

Hydroxyapatite (HAp) (Ca₁₀(PO₄)₆(OH)₂), is a primary constitute of the calcified tissues (i.e., bones and teeth) which has been extensively used as a implant material for bone and tooth substitute owing to its resemblance to mineral components of human hard tissues [11]. Also, it has a good bioactivity, biocompatibility, and osteoconductivity with human body constituents [12].

The object of this work is to electrochemically prepare PPy/HAp nanocomposites onto NiTi substrates in aqueous solutions containing HAp nanoparticles. Fourier transform infrared (FTIR) spectroscopy and X-ray diffraction (XRD) methods were used to characterize the nanocomposite and nanoparticles. Scanning electron microscopy (SEM) was used to observe the surface morphology of the nanocomposite thin films. Thermal gravimetric analysis (TGA) was used to evaluating the thermal stability of the nanocomposite and to determine the HAp content in the nanocomposite. Polarization test and EIS were employed to study the behavior of the nanocomposite in the simulated body fluid (SBF).

2 Experimental

All the chemical reagents used in this work, were of analytical grade and were purchased from MERCK, Germany.

To obtain the HAp nanoparticles 50 mL solution of Na₂HPO₄ (0.06 M) and cetyl trimethylammonium bromide (CTAB, 0.1 M) was stirred (25 °C, 30 min). Then 50 mL of Ca(NO₃)₂·4H₂O (0.1 M)

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