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Authors
Goldman, Marni
Saiz, Eduardo
Gomez-Vega, Jose M.
et al.

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In Vitro Behavior of Glass Coatings on Ti6Al4V

M. Goldman, E. Saiz, J. M. Gomez-Vega and A. P. Tomsia
Materials Sciences Division, Lawrence Berkeley National Laboratory, 1 Cyclotron Rd., Berkeley, CA 94720, USA

Introduction

A set of glasses based on Hench's Bioglass have been developed in previous work with the goal of using them as coatings on metal implants to enhance osseointegration.[1] Attempts at coating the glasses on Ti6Al4V were successful for glasses whose silica content was greater than 55%. At lower silica contents, the glasses were unable to form coatings due to high stresses resulting from large differences in thermal expansion coefficients between the glass and alloy. The purpose of the present work is to evaluate the successful coatings *in vitro.*

Materials and Methods

The glasses were prepared by mixing and firing the required reagents. Their compositions are shown in Table 1. Coatings were prepared by an enameling technique on 1cm×1cm×1mm Ti6Al4V substrates. *In vitro* tests were performed in simulated body fluid (SBF) at 37°C for periods ranging from 1 to 60 days. The coatings were evaluated by x-ray diffraction (XRD). The surfaces and polished cross sections of the coatings were examined by scanning electron microscopy with associated energy dispersive spectroscopy analysis (SEM-EDS) and micro-Fourier Transform Infrared Spectroscopy performed at the Advanced Light Source (Berkeley, CA). Inductively coupled plasma (ICP) was performed on the SBF to monitor the concentrations of Ca, P, Si, and Mg.

Results

The behavior of both 6p61 and 6p68 glasses were similar, and thus, only the results for 6p68 are presented. XRD results show the appearance of apatite peaks after 1 month in the 6p57 coating and they grow at 2 months (Fig. 1). The spectra of the 6p68 coating do not show any change through 2 months (Fig. 1). SEM results revealed the formation of a layer on the 6p57 coating after 1 month which continued to grow through the second month (Fig. 2). EDS found this layer to be rich in calcium and phosphorous. The corresponding FTIR results in Fig. 2 reveal the phosphate peaks associated with apatite have formed. A spectrum from synthetic hydroxyapatite (HA) is shown for comparison. In contrast, no layer forms on the 6p68 coating. SEM showed that after 2 months some corrosion had taken place (Fig. 2). EDS did not discover any change in composition nor did FTIR display any significant changes during the 2 months in SBF. ICP results detected an increase in concentration for Si and Mg in the SBF, which grew larger over the 2 month period (especially Si) for 6p57. For the same coatings, the concentrations of both Ca and P were seen to increase over the first month, followed by a steady decrease during the second month. No significant concentration changes were detected in the SBF from the 6p68 samples.

Discussion

Glass coatings on Ti6Al4V have been studied *in vitro*. Glass composition was found to be critical for the formation of apatite in SBF. In particular, the concentration of silica must be below 60%. This is in agreement with the results of Hench et al.[2] In this work, an apatite layer formed on 6p57 coatings after 1 month in SBF and continued to grow for another month. This apatite was observed using XRD, SEM-EDS, and FTIR. No significant changes were observed in the 6p61 and 6p68 coatings under the same conditions. The data suggest that the mechanism for apatite formation is similar to the one proposed by Hench.[2]

Table 1. Composition of the glasses (wt%).

	SiO_2	CaO	Na_2O	MgO	P_2O_5	K_2O
6P57	56.5	15.0	11.0	8.5	6.0	3.0
6P61	61.1	12.6	10.3	7.2	6.0	2.8
6P68	67.7	10.1	8.3	5.7	6.0	2.2

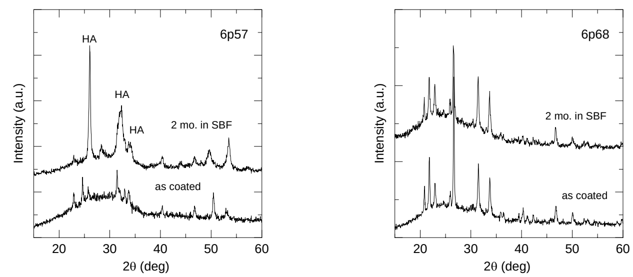

Figure 1 XRD analysis of the coatings.

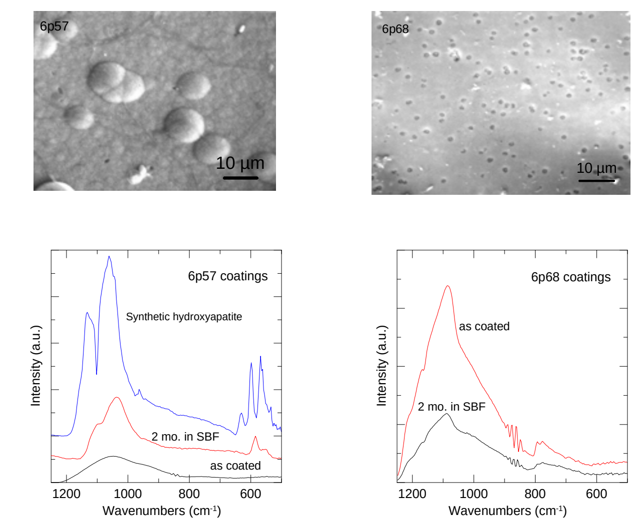

Figure 2 SEM micrographs and corresponding FTIR of the coatings. Synthetic HA is shown for a comparison.

References:

1. Gomez-Vega JM, Saiz E and Tomsia AP, *J. Biomed. Mat. Res.*, **46**(4), 549-559, 1999.
2. L.L. Hench and Ö. Andersson, "Bioactive glasses," in *An Introduction to Bioceramics*, L.L. Hench and J. Wilson (eds.), World Scientific, Singapore,1993, pp. 41-62.

Acknowledgments

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