Surface functionalization of biomaterials with plant derived biomolecules for bone contact applications

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SUMMARY

Surface functionalization allows to combine the properties of biomaterials (e.g. bioactivity) with those of plant derived molecules (e.g. antioxidant, anticancer). Surface grafting of polyphenols (gallic acid, tea and grape extracts) was performed on bioactive glasses and chemically treated Ti6Al4V (bioactive).

INTRODUCTION

Among plant derived molecules, polyphenols have documented antioxidant, anticancer and antibacterial ability [1,2]. Moreover, they can stimulate osteoblast differentiation and promote apoptosis of tumoral cells [3-4]. It is possible to combine the properties of these molecules with those of bioactive materials trough a surface functionalization.

MATERIALS AND METHODS

A silica-based bioactive glass [5] and chemically treated bioactive Ti6Al4V [6,7] were used as substrates while Gallic acid and polyphenols extracted from green tea or red grape skin were used as biomolecules for the functionalization. The surface functionalization procedure was optimized [8] in order to maximize the grafting and investigated by means of the Folin&Ciocalteu method and X-Ray Photoelectron Spectroscopy (XPS) analyses. The *in vitro* bioactivity was studied by means of Field Emission Scanning Electron Microscopy (FESEM) and Fourier Transform Infrared Spectroscopy (FTIR) after soaking in simulated body fluid (SBF).
Surface charge and isoelectric point were investigated by mean of zeta potential measurements. Free radical scavenging activity evaluation was performed in order to investigate the antioxidant ability of the glass samples. *In vitro* cellular tests were performed on glass functionalized samples.

RESULTS

The presence of polyphenols on the surfaces is confirmed by XPS analyses by the appearance of characteristic peaks (C-O and C=O bonds) in the carbon and oxygen regions. The Folin&Ciocalteu test demonstrates the presence and redox activity of polyphenols on all the substrates and evidences a clear relation between surface reactivity and grafting ability. The bioactivity tests show the deposition of hydroxyapatite on the functionalized samples and an influence of biomolecules on its amount and shape for glasses. Zeta potential measurements evidence a shift of the isoelectric point of glass samples after functionalization. A certain antioxidant activity of bare glass has been evidenced and it is improved by the grafting of tea polyphenols. *In vitro* cellular tests highlight a reduction of the vitality of tumoral cells, compared to healthy osteoblasts, on functionalized glass.

DISCUSSION AND CONCLUSIONS

XPS analyses, zeta potential measurements and Folin&Ciocalteu tests show the presence and the activity of the polyphenols on the surfaces. Bioactivity tests highlights an improvement of the deposition of hydroxyapatite on the surface of the functionalized glass samples. A certain antioxidant ability has been evidenced for glass samples and is improved by tea polyphenols.
In conclusions, polyphenols were successfully grafted to the surface of glass and Ti6Al4V samples maintaining their activity. Polyphenols improve in vitro bioactivity, antioxidant and anticancer ability of glass. The surface functionalization seems to be a good way to combine the properties of bioactive materials for bone contact applications with those of polyphenols.

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