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Engineering of the Hydroxyapatite Cell Adhesion Capacity

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I. Introduction

In spite of the high success in understanding of human cells interaction with bone replacing bioimplants in a human there are still biocompatibly problems. These often are connected with eligible human cells incapability for attachments to the implant surface that influence regeneration of bone tissue.

Following the general adhesion theory attachment of the cell to the bioimplant is controlled in particulary by an electrostatic force contributing interaction between the cell and the implant. Generally the electrical communication could be engineered owing to a surface electrical potential of the implant. The potential could be supplied by the both external sources and the surface itself.

Hydroxyapatite (HAP) is the popular material for the bioimplants. The technologies that are typically in use to engineer the electrical charge of the HAP employ its electrical polarization due to the external electrical field or because of radiation. In both cases the opposite surfaces of the HAP based implant are acquiring the unlike (in sign) charges. Therefore differently charged implant surfaces could induce cell processes in the opposite directions, that is undesirable. Therefore the considered technologies are restricted.

However to reach the uniformity of the electrical charge distribution a reconstruction of the HAP ion subsystem of the entire surface layer could provide polarization vectored from/to the bulk. By this way the uninformety of the charge distribution could be reached.

To improve biocompatibility and stability of HAP properties the doping is applied.

The article is targeted to demonstrate a possibility of technology for electrically functionalization of the surfaces of differently doped HAP (Ar, Sr, Si).

II. Methods

The first principles methods to study proton transfer peculiarities in HAP were employed in. Ab initio quantum-chemical calculations (with HyperChem and Gaussian98 code, HF, 6-31G(d)) were held to investigate the optimized HAP structure and energy barriers on possible proton transport ways.

When HAP is disposed in a high pressure hydrogen atmosphere conditions, a strong gradient of the proton concentration directed from the bulk to the surface is supplied. As the result the proton of the HAP increased a probability to transfer from the surface location to the bulk, the stable, negative charge depositing on the surface.

III. Results and discussion

The Attachment of the cells Fig. 1 demonstrates a correlation of the number of the cells attached to HAP in dependence on the hydrogenation forced increment of φ and doping of HAP.

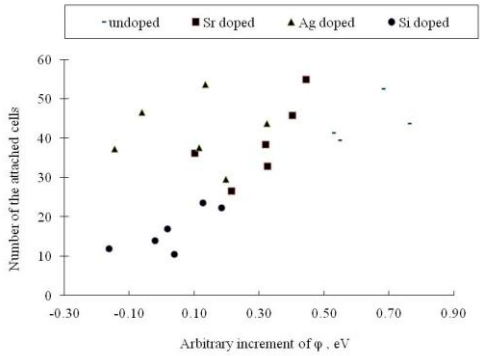

Fig. 1. Correlation of the number of the cells attached to HAP in dependence on electron work function increment and doping.

The results generally evidence that the number of the attached cells increases in dependence on φ increment. However the strongest correlation is demonstrated by Si and Sr doped HAP. Perhaps these materials are more advanced for surface charge engineering.

A. Experiment with the animals

Hydrogenation of the implant model surface layer increased its φ on ~ 0.1 eV. As the result MSCP differentiation directions was influenced. Connective tissue growth was improved. Probability of following ossification with growth of the membrane reticulated bone was 20 %. Decrease of φ on the above value led to primary formation of the bone from the marrow MSCP.

IV. Conclusions

1. The reached hydrogenation technology was able to engineer electrical charge of the HAP surface that has an influence on osteoblast attachment.
2. The Si and Sr doped HAP were more advanced materials for surface charge engineering
3. Hydrogenation of HAP based implant model influenced directions of MSCP differentiation. Connective tissue growth was improved.
4. The hydrogenation technology could be employed for the controlled engineering of the HAP surface charge to enhance osteoinduction.

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