

MODIFICATION OF HYDROXYAPATITE AS A FILLER FOR PMMA BONE CEMENTS

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Introduction

Bone cement is a popular biomaterial used in medicine for the restoration of pathological loss of bone and the fixation of prosthesis. Its properties must meet strictly defined criteria that determine the success of the therapy, health and even life. Although, there are many types of bone cement already designed and widely used. This study focuses on a particular type of bone cement – polymethylmethacrylate (PMMA) bone cement. It is extinguished by high mechanical strength, but contains a toxic, carcinogenic residual monomer (about 4-7%), has a low adhesion to bone cells and its polymerization results in both: exothermic effect and shrinkage. Publications in the recent literature indicate that additive of natural component like hydroxyapatite (HAp) may have a positive impact on these features [1,2]. Even the fillers with highly valuable properties cannot fully perform its role when there is a problem with its dispersion in polymeric matrix. Small size of filler's particles determines tendency to creation of aggregates and agglomerates. It worsens dispersion and results in lack of homogeneity in composite's properties. Problem could be solved by prevention of agglomerates' creation. It is possible due to the modification of nanofillers [3,4]

Materials and Methods

Hydroxapatite was made by a wet method and its surface was modified by using the RF PECVD (*Radio Frequency Plasma Enhanced Chemical Vapour Deposition*) technique. Modified HAp was examined regarding to the wettability of the surface (tensiometric method) and chemical structure by FTIR measurements (*Fourier Transform Infrared Spectroscopy*). Finally, it was mixed with the polymer in order to create bone composite. Surface morphology of the bone composite was evaluated using Scanning Electron Microscopy (SEM) and chemical structure with FTIR. Thermodynamic characteristic was obtained after DSC (*Differential Scanning Calorimetry*) examination. Evaluation of the mechanical properties was possible due to the hardness measurements in Shore D scale. Wettability of the composite was established on the basis of the drop shape analysis (DSA) method.

Results and Discussion

Optimization of plasma-chemical modification was made due to Fourier Transform Infrared Spectroscopy. Chemical structure of HAp was frequently measured in order to check in which conditions (glow discharge power, gas flow) the surface is modified on the biggest extend. It turned out that not always the highest values of the power and flow of the methane were required to obtain detectable changes in chemical structure. Methyl groups could be observed on HAp's surface. Measurements of the surface free energy proved that powder after modification is more hydrophobic. It allows to make the surface of HAp similar to the organic matrix (PMMA). This property is especially valued when it

comes to prevention of aggregates' creation. Obtained bone medium was measured regarding to its wettability. Its surface turned out to be hydrophobic. Plasma-chemical modification of HAp and improved technique of mixing it with bone cement results in homogenic structure of the composite. Hydrophobic surface of hydroxyapatite prevents creation of its agglomerates. The incorporation of modified hydroxyapatite slightly decreases hardness of the composite, and it is a desirable effect. With increased concentration of hydroxyapatite composites become less brittle. Differential Scanning Calorimetry helped to prove that higher concentration of HAp in PMMA bone cement shortened a little bit the polymerization process. Incorporation of hydroxyapatite minimize generation of the heat.

Conclusions

Modified HAp indicate hydrophobicity and its surface free energy decreases. The morphology of the composite is more homogenic when HAp is modified. The drop of hardness is slightly higher for modified filler in comparison to nonmodified one. Time of polymerization is shorter when the composite includes higher concentration of HAp.

References

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