99n Design of Pilot Plant for Production of Advanced Bioactive Mineral-Polymer Composites for Guided Bone Regeneration

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According to the American Orthopedic Society there are over 6 million bone fractures and nearly 3.5 million orthopedic procedures in the field of hard tissue repair and replacement in the USA only. The osteal grafts market exceeds today 5 billion US dollars annually and steadily occupies the second place after materials and systems for a hemotransfusion worldwide. It has annual growth ca. 7-12 % that is related mainly to the augmentation of the population lifetime, especially in developed countries. In Russia, according to expert assessment, only for the purposes of crania-maxillofacial surgery it is necessary to have 25,000-30,000 implants per annum with an average cost of ca. 3,000 - 4,000 roubles each. As for orthopedics, this volume could be increased at least by one order of magnitude. Polymeric scaffolds, in which biologically active guest species are dispersed throughout porous matrix to encourage dendritic attachment of new tissue forming cells, growth factors and drugs, have widespread applications in tissue engineering. Conventional methods using organic solvents or raised temperature to process the polymer often lead to undesirable thermal and/or solvent induced degradation or changes in its molecular conformations. Combination of various physical-chemical methods involving supercritical carbon dioxide (scCO2) allows avoiding these undesirable consequences in production of polymer scaffolds possessing demanding morphology and good compatibility with bioactive enzymes, growth factors and bone-forming cells. As a result of our previous research within ISTC Project framework we have developed two methods of advanced bioactive porous mineral-polymer composite fabrication: mould casting and compression moulding followed by scCO2 and thermal treatment. With the use of these developed technologies we produced a wide range of polyacrylic composite scaffolds homogeneously filled with up to 30 wt.% of hydroxyapatite (HA). All samples were mechanically tested and analyzed by Scanning Electron Microscopy, EDAX and Gel Permeation Chromatography to study surface and internal domain morphology, chemical composition, molecular weight (Mw) and polydispersity (Mn) alterations. The sets of samples were also implanted into white rat (“Wistar” line) femoral bone epiphysis for 15, 30 and 60 days to study living tissue response. The implants demonstrated well pronounced effect on acceleration of the osteointegration and new bone regeneration processes. At the final stage of our study the experimental samples of implants were clinically tested in Moscow's Center of Children's Maxillofacial Surgery and we have received an extremely positive response from the medical experts and surgeons. Main Tasks for the future R&D activity: - Scale-up design and optimization of the developed techniques for a new advanced bioactive materials fabrication. - Pilot production of small series of custom-designed scaffolds and implants for their use in surgical practice. - Full scale clinical trial of the developed products to get official approval for their use in surgical practice on a regular basis. Conclusions. Use of the developed advanced materials and implants in clinics will lead to decreasing of the inflammation rate, immune reaction and long-term implant failure probabilities; expansion of categories of patients (especially among elderly people, children and teenagers) which can de treated by these implants; acceleration of bone/implant integration; shortening of the rehabilitation period and quality of life enhancement. Key words: polyacrylics, pores structure formation, biocompatibility, hydroxiapatite, supercritical carbon dioxide.