National Institute of Technology Rourkela

Defence Seminar

Seminar Title	: Phosphate Glass with In Situ Formed Nanodiamonds for Bone Tissue Engineering
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Venue	: Seminar Room (Department of Biotechnology and Medical Engineering)
Date and Time	: 31 Jul 2025 (4.00pm)
Abstract	: Factors like sedentary lifestyle and an aging population are expected to increase the bone-related disorders among the Indian and global populations. To overcome the increasing demand for bone regeneration and repair, artificial materials will play a significant role. One such material is phosphate glasses, with compositions closely resembling bone minerals. The soluble nature of phosphate glasses accounts for their potential application as bioactive materials, inducing biological response via released ions while degrading. Incorporating nanodiamonds with excellent biocompatibility and mechanical properties in hard tissue engineering constructs shows enhanced cell adhesion, cell proliferation, and improvement in mechanical strength. Considering the significance of both phosphate glasses and nanodiamonds in bone tissue engineering, the study explored phosphate glasses with in situ formed nanodiamonds for enhanced bone tissue engineering. For the phosphate glasses with in situ formed nanodiamonds, it was hypothesized that in the presence of sodium and phosphorus at a glass-forming temperature, carbon may nucleate into nanodiamonds within the phosphate glass matrix. For hypothesis testing, the disodium salt of adenosine triphosphate was heated at 900ºCfor two hours and then quenched to form a glass. The glass was then characterized to identify the presence of nanodiamond phases and to understand the structure and in vitro biological properties. Subsequently, sodium tripolyphosphate, phosphorus pentoxide, and polyvinyl alcohol were processed with varying heating times and concentrations to obtain glasses. Strontium was further incorporated into the glasses to enhance and en route the glasses towards bone tissue engineering. The presence of nanodiamonds within the phosphate glass matrix was confirmed using HRTEM, Raman spectroscopy, and XPS, validating the study's hypothesis. Analysis using FTIR, Raman spectroscopy, and XPS demonstrated that the presence of carbon within the glass matrix promoted polymerization, or lengthening, of metaphosphate structures in the phosphate glass matrix. Furthermore, the formation of a hydroxyapatite layer on the surface of the glasses when immersed in simulated body fluid confirmed their bioactivity. The cell-based studies of the developed glasses using MG63 cell lines showed viability in the range of 81-144% and varying ALP activity in between 94-159%, with respect to the tissue culture plate, indicating their cytocompatibility and osteoinductivity. These glasses exhibited cytocompatibility with MG63 cells and also promoted osteoinductivity, as evidenced by increased alkaline phosphatase activity. Moreover, the glasses also have antimicrobial efficacy of up to 92% against Staphylococcus aureus (Gram-positive) and Escherichia coli (Gram-negative). The variation of carbon amount in glass and melting time duration affected the structure, biocompatibility, cellular response, and antimicrobial activity of the glasses. The addition of strontium resulted in the depolymerization of the phosphate glass matrix and enhanced ALP activity. Phosphate glass with in situ formed nanodiamonds was also composited with nanohydroxyapatite, enhancing its mechanical strength and cytocompatibility. Overall, this study successfully demonstrated the feasibility of producing a novel bioactive phosphate glass containing in situ formed nanodiamonds. The developed glasses hold promising potential as an alternative material for their application as a bioactive synthetic bone substitute in bone tissue engineering.

Keywords: Phosphate glass, nanodiamonds, biomolecular glass, strontium-doped phosphate glass, nanohydroxyapatite, bone tissue engineering