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Strontium and Selenium Doped Bioceramic Incorporated Hydrogel for Faster Apatite Growth and Bone Regeneration Applications

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Abstract : Polymeric 3D hydrogels have pivotal role in bone tissue regeneration applications. Hydrogels behave similar to the living tissues because they have large water imbibing capacity in swollen state and adjust their shape according to the tissues during tissue formation after implantation. On the other hand, hydrogels are very soft, fragile and lack mechanical strength. Incorporation of bioceramics can improve mechanical strength. Furthermore, bioceramics synthesized by sol gel technique may enhance the apatite formation and degradation rates which can lead to the increase in faster rates for new bone and tissue regeneration. Simulated body fluid (SBF) induces the poly-condensation of silanol groups which leads to formation of silica matrix and provide active sites for the precipitation of Ca2+ and PO43- ions to form apatite layer which is similar to mineral form of bone. Therefore, authors have synthesized bioceramic incorporated Polyacrylamide-carboxymethylcellulose hydrogels by free radical polymerization and bioceramic compositions of xSrO-(36-x)CaO-45SiO2-ySeO3-(12-y)P2O5-7MgO (where x=0,4 and y=0,2 mol%) were synthesized by sol gel technique. Bioceramics incorporated in polymer matrix induces quicker apatite formation during immersion in SBF by raising the pH with the release of alkaline ions during ion exchange process and the apatite formation takes place in alkaline medium. The behavior of samples PABC-0 (without bioceramics) and PABC-20 (with 20 wt% bioceramics) were evaluated by X-Ray Diffraction and FTIR. In term of bioactivity, it was observed that PABC-20 has shown hydroxyapatite (HA) formation on 1st day of immersion whereas, PABC-0 was shown apatite formation on 7th day of immersion in SBF. The rapid rate of HA growth on 1st day of immersion in SBF signifies easy regeneration of damaged bone tissues. Degradation studies have been undertaken in Phosphate Buffer Saline and PABC-20 exhibited slower degradation rate up to 9%as compared to PABC-0 up to 18%. Slower degradation rate is suitable for new tissue regeneration and cell attachment. Also, Zeta potential studies have been employed to check the surface charge and it has been observed that samples carry negative charge when immersed in SBF. In addition, the swelling test of the samples have been performed and relative swelling ratio % observed for PABC-0 is 607% and PABC-20 is 305%. This indicates that the incorporation of bioceramics leads to the filling up of the voids in between the polymer matrix which in result reduces porosity and increase the mechanical strength by filling the voids. The porosity of PABC-0 is 84% and PABC-20 is 72%. PABC-20 sample demonstrates that bioceramics incorporation reduce the porosity and improves mechanical strength. Also, maximum in vitro cell viability up to 98% with MG63 cell line has been observed which indicate that the bioceramic incorporated hydrogel(PABC-20) provide the alkaline medium which is suitable environment for cell growth.

Keywords : hydrogels, hydroxyapatite, MG63 cell line, zeta potential
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