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Synthesis of hydroxyapatite scaffold for biomaterials applications using a PU foam

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Introduction: Composites materials are very essential in many form for the survival of the human life, it may be structural (1) functional or biomaterial (2). The bone and flexible cartilaginous tissues constitute human skeleton, and responsible for support and flexible body movement. Key components of the bones are made up of HAP [$Ca_{10}(PO_4)_6(OH)_2$] crystallites deposited over collagen. Natural bones possessed a porosity of 50-90%. Four tissues which helps in constant state of remodeling of the bones named, osteoblasts, osteoclasts, osteocytes, and bone lining cells. Micro-crack and other defects can easily be removed by these remodeling processes induced by external factors. However, replacements of these body parts from an implant exhibited due to an accident might affect this constant modeling. A biocompatible material needed for this particular job and termed as biomaterials. Alternatively, biomaterials are the materials that serve as replacement of body part or function of a body part in a safe, economical, reliable, and physiologically accepted manner. Likewise, these bio-materials may belong to metallic, ceramics, polymers, and composites. Every biomaterial may have its advantage and disadvantage depending upon its use. However, for knee or hip implants, good mechanical properties and high fracture toughness is needed. In this direction, the synthesis of biomimetic synthetic HAP powder at 37 °C in synthetic body fluid is already reported. The current project aims to synthesize nano HAP via a hydrothermal process followed by the fabrication of the porous HAP scaffold.

Methods: Calcium nitrate tetrahydrate ($CaNO_3.H_2O.4H_2O$) and Diammonium hydrogen phosphate $(NH_4)_2HPO_4$ were used for the synthesis of HAP via hydrothermal process through co-precipitation process. Received powder of the precipitate from the reaction were homogeneous and nano-sized (~50 nm). A slurry was prepared by dissolving HAP into the polyvinyl alcohol/water (50:50 by *w*/*w*) solution. Sponges made up of PU foam with different pore sizes (30 and 90 ppi) and 1x1x1 cm dimensions were dipped in the slurry and dried in the oven at 100 °C for 24 hrs. Slurry-coated sponges were kept in the oven again at 600 ºC for removing foam and binder followed by sintering at 1050 ºC for 4 hrs.

Results & Discussions: FE-SEM images of the fabricated scaffold have been reported in Figures 3 (c) and (d). Macro pores of the HAP scaffold are easily visible. Interestingly, the evaporation of binder and PU foam did not harm the scaffold wall, and all the pore walls were well inter-connected. Scaffold developed in the current work is well suited for incorporating magnesium. It also has a porosity level of 85-90%, which is excellent for the fabrication of composites. Pore diameter can be altered by changing PU foam diameter according to requirement.

Conclusions: The HAP prepared from Ca $(NO_3)_2.4H_2O$ and $(NH_4)_2HPO_4$ by co-precipitation method was in phase. Porous HAP prepared from the polymeric sponge method were well inter-connected and had about 85-90% porosity with a pore diameter ranging from 300-900 μm. It was expected that scaffold prepared by using PU foam was the novel method with interconnected pores. None of the researchers yet tried to fabricate the sample by using PU foam. These scaffolds can be used for making composite with magnesium. The resorbable rate of the magnesium can be controlled by changing the pore diameter.

Keywords: *Biomaterials, PU Foam, Bioresorbable Composites*
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