Preparation of a biomimetic nanocomposite scaffold for bone tissue engineering

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Introduction

Three-dimensional porous scaffolds are mandatory components of bone tissue engineering systems. Biomimetic techniques have been used to reproduce natural bone structure and its chemical composition to make bone scaffolds[1-3].

Dual diffusion of calcium and phosphate ions into hydrogel especially natural polymers such as collagen, gelatin has been considered as a biomimetic method.

The objectives of this study were to use the double diffusion method in a physiologically relevant environment to prepare a biomimetic GEL-ACP nanocomposite scaffold and to investigate ACP's phase conversion to HA during incubation in a simulated body environment.

Materials and Methods

A double diffusion method was used for biomineralisation of a gelatin hydrogel leading to form a nanocomposite scaffold. Fig 1 shows the details of this setup. Following diffusion of calcium and phosphate ions into the gel, a white precipitate formed within the gel and thickened After 48 h reaching 1 cm. The resulting nanocomposite was extracted and cut into 2 mm layers and freeze-dried to create a porous and finally cross-linked a 1% glutaraldehyde solution for 24 h. To study the possible precipitate phase conversion, nanocomposites samples were soaked in a simulated body fluid (SBF) (kokubo buffer solution) (pH 7.4) and incubated at 37℃ for 5 h.

Precipitated mineral within gelatin hydrogel and prepared nanocomposite scaffold and were analyzed using scanning electron microscopy, X-ray diffraction (XRD), fourier transform infrared spectroscopy(FTIR), transmission electron microscopy(TEM) and mechanical testing.

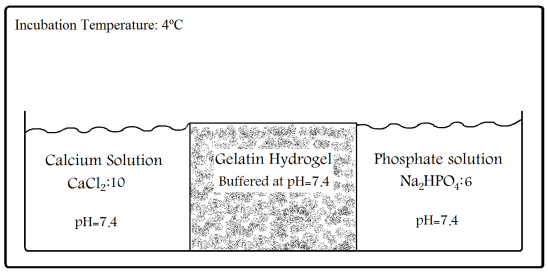

Figure1- Schematic view of reactor used for biomineralization of apatite within GEL hydrogel via double diffusion

Results and Discussion

The results showed that prepared nanocomposite scaffolds were porous with three-dimensionally interconnected microstructure, pore size ranging from 150 to 350 µm(Fig2). Porosity was about 82% and nanocrystalline precipitated minerals were dispersed evenly among gelatin fibers. A mineral containing amorphous calcium phosphate and brushite precipitate was formed within the gelatin matrix at 4°C. After incubation in SBF solution at 37℃ for 5 days, the mineral phase was transformed to nanocrystalline hydroxyapatite(Fig3).

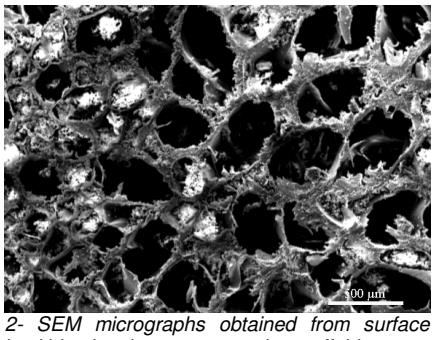

Figure 2- SEM micrographs obtained from surface of the synthesized biomimetic nanocomposite scaffold

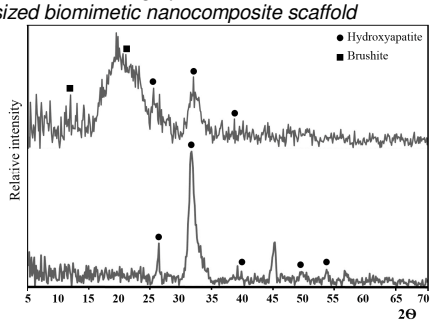

Figure3. XRD diffractogram for the precipitated minerals formed at 4℃ (up) and after incubation in SBF (down).

Conclusion

In this study, in situ formed nanocomposite scaffolds were designed and fabricated using a biomimetic approach. A mineral containing ACP and DCPD precipitate was formed within the GEL matrix at 4℃. After incubation in SBF solution at 37℃ for 5 days, the mineral phase was transformed to nanocrystalline HA. It should be noted that precursor phases inside a scaffold implanted into the body can result in biomimetic conversion of precursors to HA that is very similar to the bone mineral. This HA has a profound level of biocompatibility. Thus, our results highlight the potential use of engineered biomimetic bone tissue scaffolds in the bone tissue repair process.

References

1-Manjubala et.al, Acta Biomaterialia 2006; 2: 75–84.

2- Ehrlich et.al, Journal of Membrane Science 2006; 273: 124-128.

3-Gomes et.al, Materials Science Forum 2008; 587/588: 77-81.