Development of chitosan/hydroxyapatite composite membranes for guided bone regeneration

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Introduction

Recently, guided bone regeneration (GBR) techniques have been successfully applied to prevent epithelium and fibrous tissue infiltration into bone defects by using a barrier membrane [1][2]. Chitosan membranes are very attractive candidates for wound dressings [3] and guided tissue regeneration [4] because of their biodegradability and non-toxicity. However, as a bone substitute material, chitosan itself has some limitations in inducing rapid bone regeneration. In this study, chitosan/hydroxyapatite (HA) composites were prepared by a co-precipitation method, and then the composites were formulated into a membrane form after the dynamic filtration and freeze-dry process. These unique processing techniques would give the composite membranes a porous structure and a better match in mechanical properties with natural bone.

Materials and method

Chitosan (Sigma) with a medium molecular weight was used as a starting material. The chitosan powders were firstly dissolved in 1% (v/v) acetic acid to obtain a chitosan solution. Then chitosan/H_3PO_4 mixture and $Ca(OH)_2$ were simultaneously added into the reaction vessel at 40°C. The obtained slurry was dynamically filtered and freeze-dried to form a uniform membrane. As a control, the chitosan membrane was also prepared following the same procedure. The membranes were characterized by X-ray powder diffraction (XRD) and scanning electron microscopy (SEM).

Results and discussion

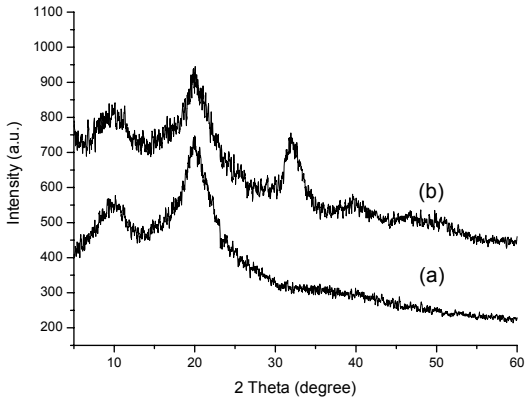

Fig. 1. XRD patterns of (a) chitosan and (b) chitosan/HA membranes

As shown in Fig. 1, chitosan displays two diffraction peaks centered at around 10° and 20.8°. The sharp pattern indicates that pure chitosan prepared by our method has a relatively high crystallinity. The XRD pattern of the mineral phase in the composites (Curve b in Fig. 1) is exactly matched with the Powder Diffraction File (PDF Card No. 9-432), confirming the formation of pure HA. However, the extensive broadening and overlap of the diffraction reflections which are similar to natural bone, indicate the poor crystallinity of HA crystals. Fig. 2 shows the SEM micrograph of chitosan/HA membranes. There are many micro-sized pores inside the membranes. Despite the porous structure, the composite membranes possess high tensile strength. A detailed investigation of the tensile property and the evaluation of the biocompatibility of the membranes are in progress.

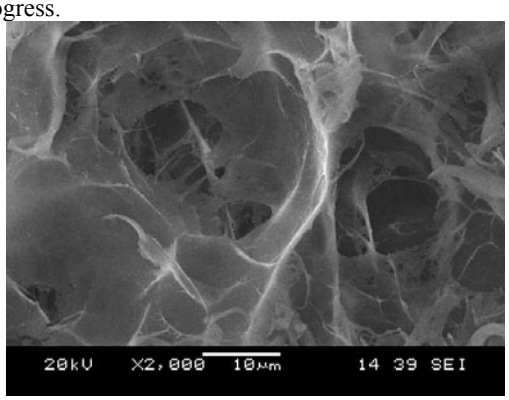

Fig. 2. SEM micrograph of the porous chitosan/HA membrane

Conclusions

Chitosan/HA composites were successfully fabricated into a thin membrane form by a co-precipitation method and the subsequent dynamic filtration process. XRD results confirmed the mineral phase to be pure hydroxyapatite with poor crystallinity. After the freeze-dry treatment, the obtained composite membranes had a porous structure, but their mechanical strength was high. Such a chitosan/HA composite membrane is very promising for the future applications in guided bone regeneration. In addition, this approach is applicable for the preparation of multi-layered membranes based on chitosan/HA or other organic/inorganic composites.

References

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