

PLA / Vaterite Composite Microfiber Membranes for GBR

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Guided bone regeneration (GBR) is one of the useful methods for bone reconstruction *in vivo*. Membranes used for GBR are required to have flexibility to adapt shape of a bone-defect area, strength to keep the area for long period and porosity to permeate nutrition. In addition, we believe that the ability to enhance bone formation in the bone-defect area is required by the GBR membranes. An electrospun-fiber mat is expected to be a useful candidate for the GBR membrane. Calcium and a trace amount of silicon ions were reported to enhance the bone formation by osteoblasts [1]. A microfiber membrane of poly(lactic acid) (PLA) and silicon-doped vaterite composite was prepared by electrospinning in the present work.

Silicon-doped vaterite (SiV) powders were prepared by a carbonation process with methanol [2]. A 150 g of Ca(OH)₂, 60 ml of aminopropyltriethoxysilane (APTES) and 2000 ml of methanol were mixed with blowing CO₂ gas for 75 min at a rate of 2000 ml/min. The resulting slurry was dried at 110 °C, resulting in the preparation of SiV powders. The amount of silicon in SiV was estimated to be approximately 3 wt% by X-ray fluorescence analysis. Vaterite powders were also prepared by the carbonation process without APTES.

SiV or vaterite powders were kneaded with PLA (PURASORB[®], Mw; 260 kDa) under 200 °C, resulting in the formation of the PLA composites containing 60 wt% of the powders. The composites were dissolved in chloroform to prepare the composite solution for electrospinning. Electrospinning was carried out with 20 kV of an impressed voltage. The prepared composite fibrous mats using SiV and vaterite powders are denoted by SiV-P and V-P, respectively.

The composite fibers with sizes of 0.5 – 20 μm in diameter were prepared by electrospinning. Their diameters were controllable by changing the conditions on the electrospinning, such as the PLA concentration in the composite solution and solvent. The prepared composite fibrous mats showed flexibility and was found to have high porosity by field emission scanning electron microscopy. SiV or vaterite powders were observed on the surfaces of the composite fibers. SiV-P showed higher flexibility in comparison with V-P. The results in ¹³C cross polarization magic angle spinning nuclear magnetic resonance and Fourier transform infrared reflection spectroscopy revealed that chemical bonds (amide I) were formed between amino groups in APTES and carboxy groups in PLA. The chemical bonds were expected to cause the higher flexibility of SiV-P.

A 0.3 – 0.7 ppm/day of silicon species were continuously released from SiV-P in the culture medium. The silicon species were suspected to be released through the degradation of the PLA matrix and vaterite. SiV-P was expected to be useful for biomedical materials, such as GBR membranes, with high bone-forming ability.

References

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