Synthesis of Bioactive Calcium-Containing Silica Xerogel/ Chitosan Hybrid Materials for Biomedical Application

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Introduction

Recently, many studies have been done to improve biological and mechanical properties of materials through the incorporation of organic and inorganic substance [1]. The sol-gel processing is well known as one of the useful method to prepare hybrid materials [2]. Room-temperature processed silica-xerogel has been investigated for their potential use for bone tissue engineering [3]. Silica-xerogel has excellent bioactivity, but it reacts with surrounding tissues too fast, which deteriorates its long-term stability. Chitosan is a natural biopolymer that has been shown to have flexibility, bioresorption and pH sensitivity. However, chitosan is mechanically weak and lack of bioactivity [4]. A silica-xerogel/chitosan hybrid composite of xerogel and chitosan is expected possible to have advantages in terms of stability, mechanical and biological properties. Therefore, this study is aimed at the fabrication of calcium-containing silica-xerogel/chitosan hybrid composites using sol-gel process, also at the characterization and evaluation of biological properties by in vitro tests.

Materials and Methods

The calcium-containing silica-xerogel (Ca-xerogel) was synthesized as described elsewhere [3]. Chitosan was dissolved in 0.2N HCl until a homogenous 6% chitosan solution was obtained. Ca-xerogel/chitosan hybrid composites were produced by mixing the Ca-xerogel with chitosan at different ratios [10%, 20%, 50%, 80% chitosan] and stirred for 4 h. Specimens were aged for 4 days in an incubator at 37℃ and then dried for 4 days, and then ultrasonically cleaned in distilled water. The phase and morphology of the samples were investigated by FT-IR and SEM, respectively. The biological performance of the hybrid composites was addressed through MC3T3 cellular responses in comparison with that of Ca-xerogel.

Results and Discussion

The formation of the hybrid composites was confirmed by the FT-IR patterns as shown in Figure 1(a). As chitosan was added to xerogel, Si-O-Si ($460cm^{-1}$) and Si-OH($960cm^{-1}$) peaks decreased, while NH_2($1173cm^{-1}$) and C-O($763cm^{-1}$) peaks were detected. Figure 1(b) shows a fracture surface morphology of the hybrid composite. The Ca-xerogel/chitosan composites have a uniform and very fine micro structure. The SEM morphologies of the MC3T3 cells on the hybrid composites after culturing for 3h are shown in Figure 2. The cells on the hybrid composite were attached well. Figure 3 shows the proliferation of cells on samples by MTS assay. The MC3T3 cells on Ca-xerogel/ chitosan hybrid composites showed a higher level of proliferation behavior compared to that on the Ca-xerogel.

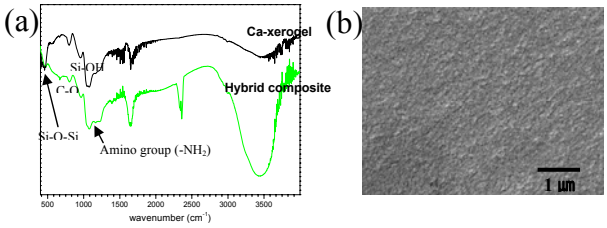

Figure 1. FT-IR patterns (a) and SEM image (b) of Ca-xerogel/ chitosan hybrid composites.

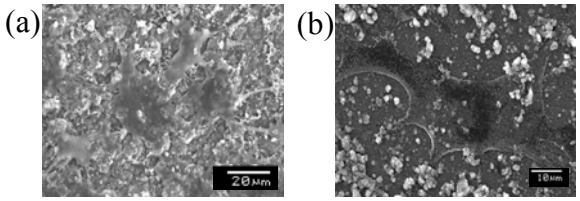

Figure 2. Morphologies of cells on hybrid composites (a) low magnification (b) high magnification.

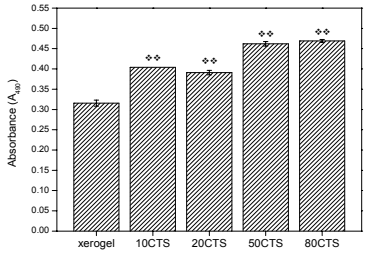

Figure 3. The proliferation behavior of cells on specimens with different composition. *Statistically significant difference compared with the xerogel cells (❖❖$p < 0.01$) ($n = 3$).

Conclusions

Calcium-containing silica-xerogel/ chitosan hybrid composites were synthesized by sol-gel process. Produced composites had homogeneous surface morphology and very fine micro-structure. Also, the hybrid composites were shown good attachment behavior and exhibited significantly higher proliferation compared with simple silica-xerogel. These findings provide their potential utilization as biomedical applications.

References

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