Degradation and Mechanical Characteristics of Photopolymerized PEGDA Hydrogels as Tissue Engineering Scaffold

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Introduction

Recently, photopolymerized poly (ethylene glycol) diacrylate (PEGDA)-based hydrogel has been extensively used in tissue engineering applications, especially as cell-based scaffold. PEGDA is soluable to both water and biological fluid, and has been shown to possess cytocompatibility and biocompatibility. Additionally, PEGDA can be readily molded into a given shape and can maintain their distinct 3-D structure following in vivo applications. PEGDA hydrogel has been shown to accommodate the growth and differentiation of mesenchymal stem cells into multiple lineages such as bone and cartilage. Despite its increasing use in cell-based tissue engineering, the degradation behavior and mechanical properties of the PEGDA as tissue engineering scaffolds are not well understood. In this study, we measured the degradation and mechanical characteristics of PEGDA hydrogel.

Materials and Methods

Poly (ethylene glycol) diacrylate (PEGDA) (MW=3,400 Da, Shearwater Polymers, Huntsville, AL) was dissolved in sterilized 0.01M PBS solution supplemented with antibiotics before adding the biocompatible photoinitiator 2-hydroxy-1-[4-(hydroxyethoxy)phenyl]-2-methyl-1-propanone (Ciba, Tarrytown, NY), then photopolymerized at λ=365nm to make hydrogel at 2, 5, 10 and 15 min using long-wave UV light (Glomark, Upper Saddle River, NJ). The surface characteristics and degradation behavior were examined by FTIR-ATR. Mechanical compressive stiffness was measured in PBS solution at 37°C up to 7 wks (N=3) using MTS (Eden Prairie, MN). Human bone-marrow-derived mesenchymal stem cells (hMSCs) (AllCells LLC, Berkeley, CA) were suspended in liquid-phase PEGDA at a density of $2x10^4$ cells/gel. Cell viability was evaluated using live/dead viability kit (Molecular Probes, Eugene, OR) under fluorescent microscope. Cell morphology was observed under SEM (HITACHI S-3000N) at accelerating voltage of 10 kV. All quantitative experimental data were analyzed by AVONA.

Results and Discussion

1. PEGDA hydrogel was effectively photopolymerized in the time range of 2 to 15 min. The FTIR spectra confirmed that the consumption of double bonds (C=C) during photopolymerization for hydrogel formation, and the crosslinking was enhanced with the UV-irradiation time.
2. The PEGDA hydrogels formed by photopolymerization at 2, 5, 10 and 15 min showed gradual decreases in compressive stiffness. The PEGDA hydrogel formed at 15min of UV-irradiation seems to be constant with the time. This proved that the enough strong crosslinking density induced.
3. Cell viability of the encapsulated hMSCs in PEGDA hydrogel fabricated with different photopolymerization times lacked notable differences, suggesting that hMSCs maintain effective viability in PEGDA. SEM demonstrated the presence of cells, either individually situated or clustered in groups, in PEGDA hydrogel. The cells had sphere-shape.

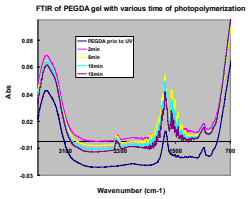

Fig.1. FTIR presented the spectra for the various photopolymerized PEGDA hydrogels and PEGDA prior to photopolymerization.

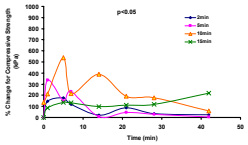

Fig. 2. The percentage changes of compressive stiffness for various PEGDA hydrogels at 2, 5, 10 and 15 min of photopolymerization.

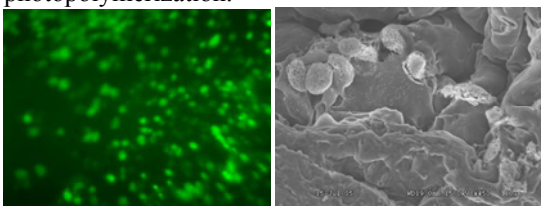

Fig.3. Image for live/dead test showed the cell viability of hMSCs in PEGDA hydrogel.
Fig.4. SEM showed the presence of hMSCs and their spherical morphology in PEGDA hydrogel

Conclusions

PEGDA hydrogel fabricated with different photopolymerization times leads to different mechanical stiffness, and nonetheless, accommodates the encapsulation of human mesenchymal stem cells. PEGDA can be tailored for the needs for various biological structures in tissue engineering.

References

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