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In vitro Degradation Behavior of Photopolymerized PEG Hydrogels as Tissue Engineering Scaffold

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Abstract-- **PEGDA was photopolymerized to form hydrogels under different UV light irradiation times. In order to investigate the degradation rate in vitro, the various PEGDA hydrogels were incubated in PBS solution at 37°C in shaking water bath system. The physical-chemical properties such as pH values, dimension, mass and volume change, compressive strength and Young's modulus were measured. MALDI-MS and SEM were employed to evaluate the PBS solutions and corroded hydrogels after a designed period of time till 8 weeks. The results indicate that the PEGDA formed hydrogels can be tailored with prompted properties specifically for various cell-based tissue engineering needs.**

I. INTRODUCTION

Poly (ethylene glycol) diacrylate (PEGDA) hydrogel is increasingly used for tissue engineering due to demonstrated biocompatibility, tissue-like water content and 3D network structure. For instance, PEGDA hydrogel has been repeated used in cartilage, bone and adipose tissue engineering (Bryant and Anseth, 2003; Wang et al, 2003; Alhadlaq et al., 2004; Stosich and Mao, 2005). An added advantage of PEGDA hydrogel network is its moldability into the shape and dimensions of the target tissue by photopolymerization. However, it is often desirable to tailor the degradation rate of PEG hydrogel so that the mechanical strength of PEG is maintained, whereas the encapsulated cells in PEG continue to differentiate (Bryant and Anseth, 2003; Wang et al, 2003; Bryant et al, 2004). The degree of photocrosslinking of the PEG hydrogel is an important factor in its degradation rate, but has not been systematically investigated. Thus, this study was designed to investigate the in vitro degradation rates of PEG hydrogel as a function of photopolymerization time.

II. MATERIALS AND METHODS

Hydrogel preparation.
Poly(ethylene glycol) diacrylate (MW 3400; Shearwater Polymers, Huntsville, AL) (PEGDA) hydrogels was prepared by photopolymerization under UV-365 nm lamp at 2, 5, 10, and 15 min. Cylinderical disks (3 x 5 mm) were fabricated and placed in PBS buffer solution.

Degradation.
The PEG hydrogel disks in PBS solution, changed weekly, were placed in a thermostatic water bath at 37 ± 0.2°C. PEG degradation rates were measured at 0, 1, and 5 days, and then 1, 2, 3, 4, 6, 8 wks. At each time point, PEG hydrogel samples were removed from PBS solution and blotted to remove excess surface water. The dimensions, weight, and compressive properties were measured with scale and calipers, and mechanical testing. After freeze-drying, PEG hydrogel samples were coated with platinum and observed under SEM (Hitachi S-3000N) at 15 kV for morphological structures on both the external surface and cross-section. The pH values for the PBS solutions were determined. Matrix-Assisted Laser Desorption Ionization-Time of Flight Mass spectrometer (MALDI-TOF MS, Voyager-DE PRO, Applied Biosystems) was employed to investigate the fragments in the PBS solutions, using a-Cyano-4-hydroxycinnamic acid as matrix (N=3 per group).

Statistical Analysis
Statistical analysis was performed using ANOVA and Bonfferroni tests with an alpha level of 0.05.

III. RESULTS

A. The pH value and Young's modulus decreased slightly with time. The dimension, volume and mass increased slightly over 8 wks in vitro (Figure 1). All of these results were statistically analyzed $p<0.05$.

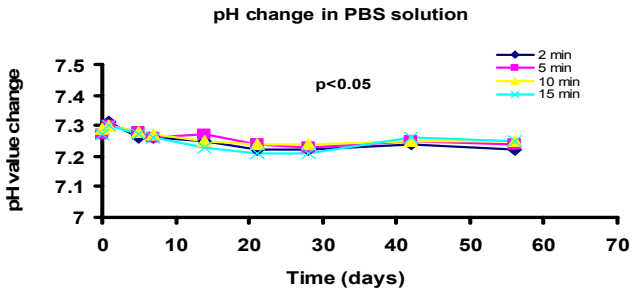

Figure 1: A

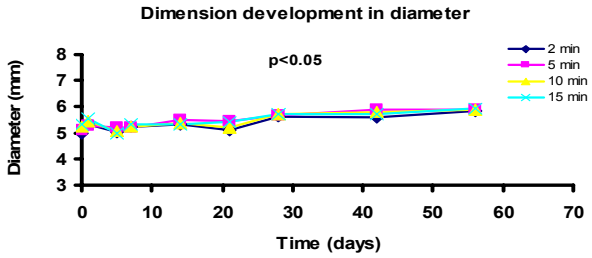

Figure 1: B

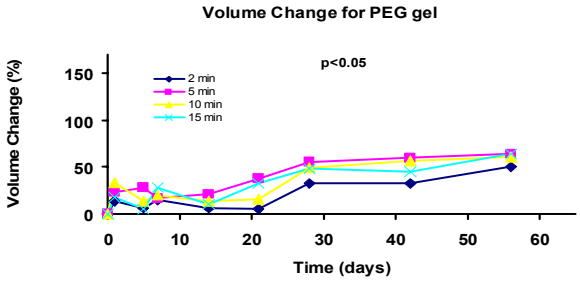

Figure 1: C

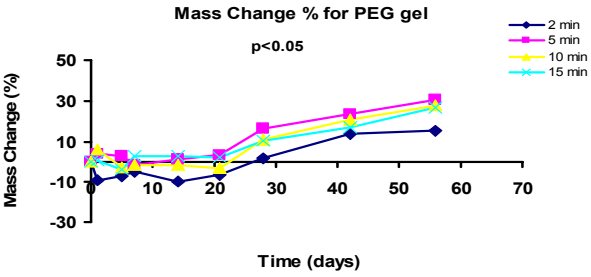

Figure 1: D

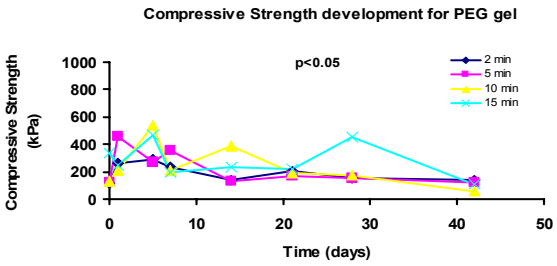

Figure 1: E

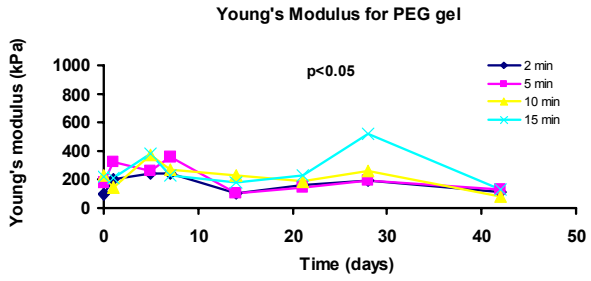

Figure 1: F

Figure 1. PEG gel degradation in PBS buffer solution in vitro. (A) pH values; (B) volume; (C) Dimension; (D) Mass; (E) Compressive strength; (F) Young's modulus.

B. MALDI-TOF MS indicated various size particles in the PBS buffer solution in the degradation processing of different PEGDA gels with 2, 5, 10 and 15 min of photocrosslinking time (Figure 2).

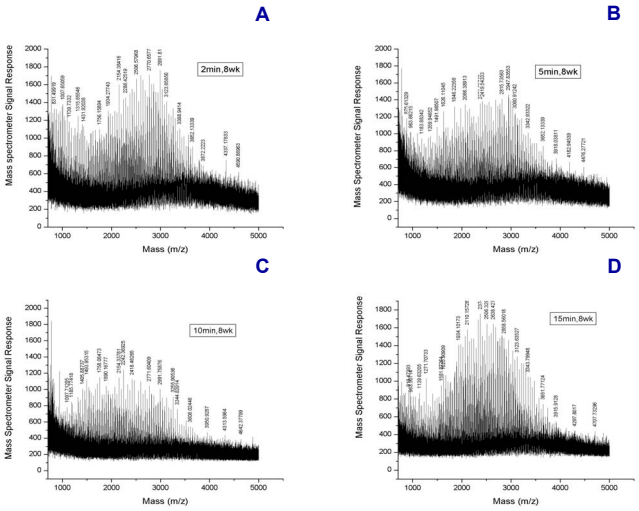

Figure 2. Representative MALDI MS for degradation of PEGDA hydrogel. A, B, C, and D showed the spectrum for 8 weeks with 2, 5, 10 and 15 min exposing photocrossking time separately.

C. SEM showed changes in the pore structures and surface during the 8-wk degradation time.

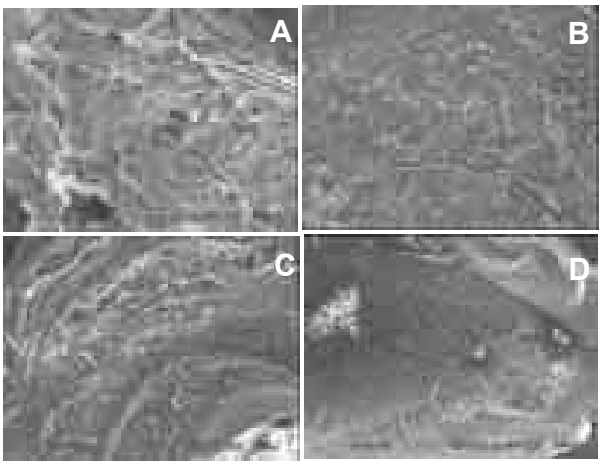

Figure 3. SEM structures for the PEGDA hydrogel for 8 weeks in PBS solution with 2 (A), 5(B), 10(C) and 15(D) min of photocrosslinking time.

IV. DISCUSSION

Our findings indicate that PEG hydrogel undergoes small but significant degradation in vitro in PBS buffer solution. The weight, volume and dimensions of PEGDA hydrogel were gradually increased over 8 wks, indicating its ability to retain water molecules. This is likely due to the high hydrophilic properties of PEGDA hydrogel and swollen behaviors, and likely an important property for cartilage tissue engineering (Wang et al., 2003; Alhadlaq et al., 2004; Alhadlaq and Mao, 2005). The small and yet significant decrease in Young's modulus along with an increase in water content needs to be addressed in tissue engineering approaches such as those proposed in Fig. 4. MALDI MS indicates a few small particles released from PEGDA gel over the 8 wks of time, further confirmed by the pH in PBS solution. The PEGDA gel with 2 min of photocrosslinking seems to have more multiple fragments produced in degradation process. This effect demonstrates the weaker degree of photocrosslinking in this sample as compared with others and can be confirmed by the SEM images. The external surface for the PEG gel with 2 min of photopolymerization showed marked number of cracks and pores in comparison with others. These results of in vitro degradation of PEGDA indicate that its degradation rate can be altered by various degree of photocrosslinking. For a long time of degradation behavior and in vivo animal tests are extensively under investigations.

V. CONCLUSION

The photopolymerized PEGDA hydrogel has different degradation rates in PBS solution as a function of the amount of cross-linking, and photopolymerization time. Manipulation of PEDGA crosslinking may be tailored for various needs as scaffolds for tissue engineering.

ACKNOWLEDGEMENTS

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