Influence of UV Crosslinking Time on the Mechanical Properties and Degradation of GelMA Hydrogels

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Gelatin methacryloyl (GelMA) is widely used in biomedical engineering due to its biocompatibility and tunable mechanical properties. Precise control of both mechanical behavior and degradation is crucial for tissue engineering applications. However, the effect of photo-crosslinking parameters is still not fully understood. In this study, synthesized GelMA hydrogels were UV-crosslinked for 60, 90, and 120 s. Mechanical properties were evaluated using biaxial tensile testing, enabling the determination of Young's modulus and stress–strain behavior in two directions. Degradation was assessed under physiological conditions based on mass loss and changes in material stability [1], [2].

The results showed that increasing crosslinking time significantly improved mechanical properties. When comparing samples crosslinked for 60 s and 120 s, the median Young's modulus increased by over 600% in the X-direction and over 720% in the Y-direction. This was accompanied by higher maximum stress and an approximately 35% decrease in maximum strain. Degradation exhibited a two-stage behavior, with a rapid initial mass loss (~30% after 1 h), followed by a slower increase to ~45% after 24 h, ~55% after 72 h, and ~75% after 168 h, at which point the sample lost its structural integrity.(Fig. 1, example for the 90 s group). Hydrogels crosslinked for 60 s lost structural integrity after prolonged incubation, whereas samples crosslinked for 120 s remained stable and more resistant to degradation due to higher crosslinking density.

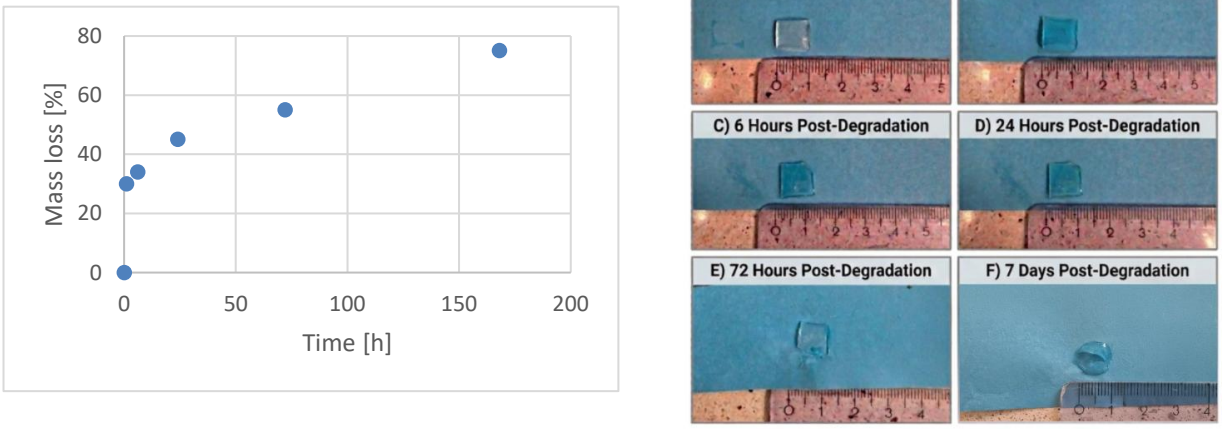

Figure 1 Degradation of GelMA hydrogels crosslinked for 90 s: mass loss over time (left) and representative images of samples after 0, 1, 6, 24, and 72 h of degradation (right).

These findings demonstrate that photocrosslinking time plays a key role in controlling both the mechanical properties and degradation behavior of GelMA hydrogels, which is important for the design of materials for biomedical applications.

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