Photo-crosslinked water-soluble PEA-based hydrogels for cell encapsulation: A rheological study

Introduction

Scaffolds for tissue regeneration can be made from bio-based polymers, which offer inherent biological compatibility. However, batch-to-batch variability and limited tunability restrict their broader application. In contrast, biodegradable synthetic polymers allow precise control over chemical and mechanical properties but lack biological signalling [1]. Amino acid-containing polyester amides (PEAs) address this gap by combining biocompatibility with tunability. The polyester segment ensures biodegradability, while the polyamide segment enhances mechanical and thermal stability [2]. Hydrogels based on amino acid-derived PEAs offer a favorable environment for cell proliferation, with reproducible physical and chemical properties [3–5]. Photopolymerization enables simple, non-toxic in situ gelation at physiological pH and temperature [6]. However, excessive UV exposure can damage cells [7], making it essential to minimize exposure while ensuring proper gelation.

Methods

PEAs were synthesized in two steps. First, Monomer 1 was prepared by esterifying an amino acid (L-alanine, L-valine, or L-leucine) with a diol (1,6-hexanediol, 1,10-decanediol, or 1,12-dodecanediol). Second, Monomer 1 was polymerized with di-ρ-nitrophenyl fumarate (to introduce crosslinkable sites) and PEG-diamine (for water solubility) in dimethylacetamide at 70 °C for six hours. The resulting PEAs were photo crosslinked using Irgacure 2959 or LAP. Gelation time and plateau modulus were determined by rheological analysis of storage (G') and loss (G") moduli.

Results

For PEA10A5K (alanine, 1,10-decanediol), gelation times with 0.4% Irgacure, 0.5% LAP, and 0.05% LAP were 1.5 h, 3 min, and 12 min, respectively (Figure 1a). A 0.05% LAP concentration was selected for all further experiments, balancing low cytotoxicity and short gelation time. G' correlated with polymer molecular weight rather than amino acid type (Figure 1b).

Conclusions

Gelation times were determined while keeping the minimal photoinitiator concentration, which is ideal for cell survival in the final application. Next, cell viability and encapsulation studies will be performed.

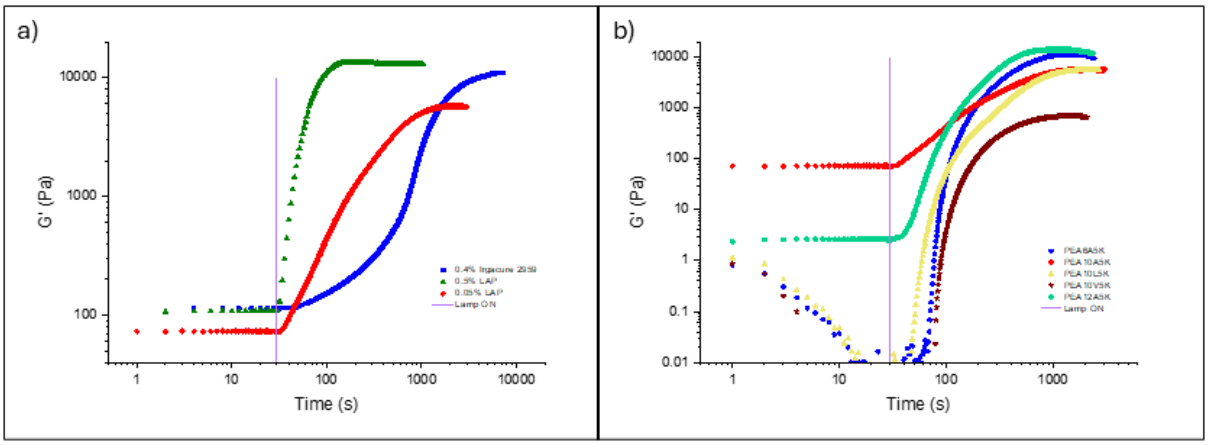

Figure 1 Storage modulus (G') of hydrogel produced from a) PEA10A5k (alanine and 1,10 decanediol, Mw=54000 g/mol) using photoinitiators Irgacure 2959 and LAP b) PEA6A5K (alanine and 1,6 hexanediol, Mw=43400 g/mol), PEA10A5K, PEA10L5K (leucine and 1,10 decanediol, Mw=35000 g/mol), PEA10V5K (valine and 1,10 decanediol, Mw=31300 g/mol) and PEA12A5K (alanine and 1,12 dodecanediol, Mw=63500 g/mol) and 0.05% LAP, using 5 % concentration of polymer in the hydrogel precursor solution during the in-situ gelation process

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