

# Tailoring the Mechanical Characteristics of PEG-based Hydrogels for the Production of High-performance Soft Tissue Expander

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**Statement of Purpose:** Shortage of available soft tissue is a common challenge facing the reconstructive surgeons. A possible solution could be soft-tissue expansion. Keeping tissue under constant tension leads to stretching of the existing skin, which stimulates cell divisions, and results in formation of the new cells, followed by growth of new tissue. A material or device designed to induce skin or tissue expansion for the purpose of reconstructive and plastic surgeries has been called a tissue expander. Recently, hydrogels are investigated for tissue expansion applications, primarily due to their ability to retain large volumes produced by swelling. However, the poor mechanical strength and toughness after swelling are major disadvantages of using hydrogels. PEG diacrylate (PEGDA) hydrogels are highly tunable in terms of the mechanical properties. In fact, mechanical properties of the hydrogels can be controlled by varying the molecular weight or concentration of the polymer. The purpose of this study is to develop a new self-inflating (PEG-based) tissue expander with tunable mechanical properties.

**Methods:** PEG with a molecular weight of 2000, 6000, and 10000 g/mol was purchased from Merck. Acryloyl chloride (Ac) and triethylamine (TEA) and 2, 2-Azobisisobutyronitrile (AIBN) as radical initiator were purchased from Sigma-Aldrich. PEGDA with molecular weights of 2, 6 and 10 K were prepared by esterification reaction of acryloyl chloride with PEG diols using the reported method with slight modifications [1]. The prepared diacrylates, and the blend of them, underwent radical cross-linking reaction to form hydrogels. Compared to the hydrogels prepared from one molecular weight, the use of multiple molecular weights of PEG may provide a more versatile and useful design for various hydrogels with different properties. In order to evaluate the acylation reaction and presence of vinyl double bonds in macromeres fourier transform infrared spectroscopy (FTIR) and nuclear magnetic resonance (<sup>1</sup>H NMR) was used. In addition, morphology and compressive properties are tested by SEM and compression test. The quantification of the pore size based on the SEM pictures was analyzed by Image J software.

**Results:** The PEGDA macromere shows peaks at 1635 cm<sup>-1</sup> and 1725 cm<sup>-1</sup>, which correspond to the double-bands of acrylates and C=O stretching vibration. SEM images show interconnected pores with size variations between 2 and 35 μm (Fig.1). As anticipated, pore sizes strongly depend on the hydrogel composition and correlate with the precursor molecular weight. Overall, we observed an increase in the size of the pores with an increase in PEGDA-10k macromere concentration. As

shown in fig. 2, P2 hydrogel (PEG6K) shows compression strength and modulus of 217.6±51.4 Pa and 110±20.5 kPa, respectively, at 60.5± 0.7% strain, while for the corresponding P8 hydrogel (blend of PEG6K and PEG10K) compression modulus of 73.4±13.1 kPa and lower elastic modulus of 28.3±1.5 kPa were registered at 62±5% strain.

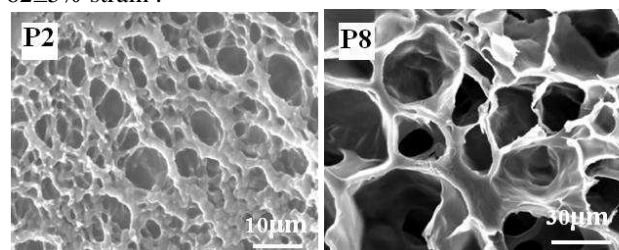


Figure 1: Cross section morphology of samples

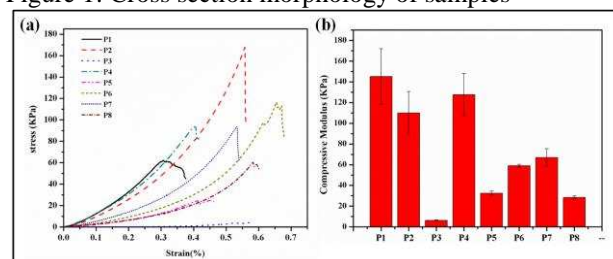


Figure 1: (a) stress-strain curve, (b) compressive modulus. The results show that P8 hydrogel is capable of withstanding at least 25 cyclic mechanical loading and unloading without crack formation undergoing significant permanent deformation. The flexible and elastomeric nature of the P8 network can be partially attributed to the sufficiently long and flexible PEG chains between cross-links.

**Conclusions:** In this study, self-inflating expanding hydrogels synthesized based on PEGDAs of different molecular weights have been developed and characterized. The goal of this project was to show that mixed molecular weight PEGDA blends could produce a hydrogel system with tunable mechanical properties. The conclusion can be drawn that, of the eight studied compositions, P8 hydrogel with the described mechanical properties is promising expander candidates. In future studies in vivo tests will be done to histologically investigate the clinical applicability of these hydrogels for tissue expansion. The ability to control the pore size and mechanical properties by controlling the proportion of molecular weights within the polymer blend makes this approach a unique platform with marked potential for clinical use.

**References:** Akhilash K.G. Biomacromolecules. 2011; 12:1641-1650