Dual-Responsive Poly(Ionic Liquid) Hydrogels

Alexandru Tudor, Larisa Florea*, Simon Gallagher, Dermot Diamond

Insight Centre for Data Analytics, National Centre for Sensor Research,
Dublin City University, Dublin, Ireland

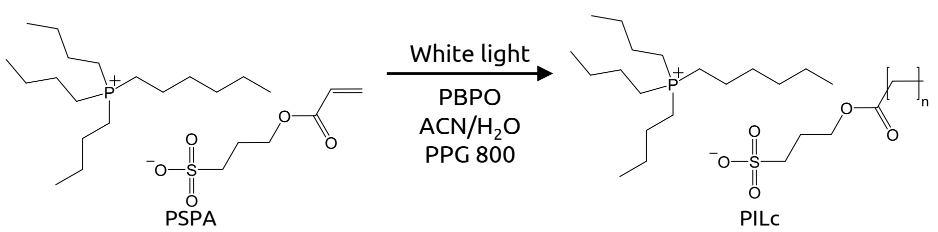
Centre for Data Analytics

Insight

Introduction

Poly(ionic liquid)s are defined as ionic liquids which feature polymerizable groups in either the cation, the anion, or both. The aim of this study was to synthesise a tributylhexyl phosphonium sulfopropyl acrylate (PSPA) poly(ionic liquid) (PIL) hydrogel and characterise its temperature and salt concentration induced shrinking. The gels were photo-polymerised in circular moulds and were hydrated in deionized water (DI water). The area shrinking upon exposure to a stimulus was calculated using the following formula: %s = $(A_i - A_f)/A_i \cdot 100$, where A_i is the initial area of the swollen hydrogel and A_f is the final area of the hydrogel, after the application of the stimulus.

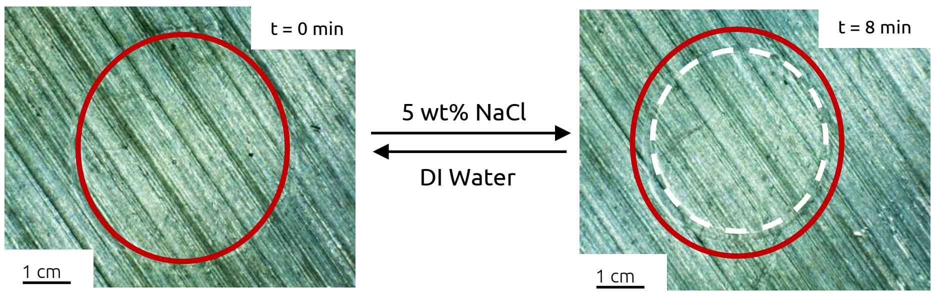
PIL Synthesis



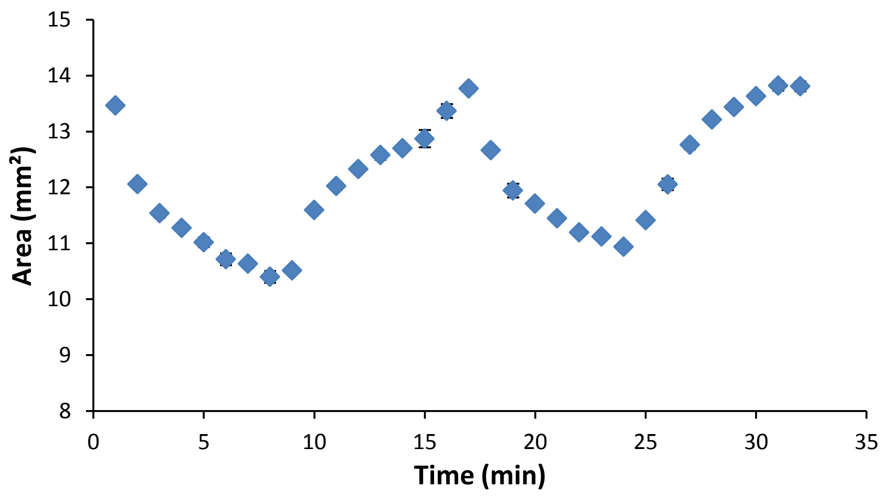
Salt Concentration Induced Shrinking

The mechanism behind the salt response can be explained by the polyelectrolyte effect. The presence of a competing salt in the hydration medium causes the hydrogel to shrink, because the hydration equilibrium between the polymer chains and the hydrating water is disrupted.

The crosslinked PIL hydrogel shrank by ~23% in area when its hydration medium was changed from DI water to 5 wt% NaCl solution.

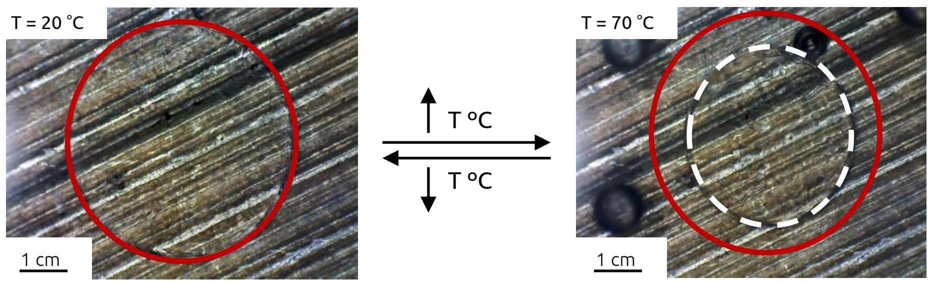


The salt concentration induced shrinking is a reversible process. Changing the hydration medium back to DI water causes the hydrogel to return to its initial size.

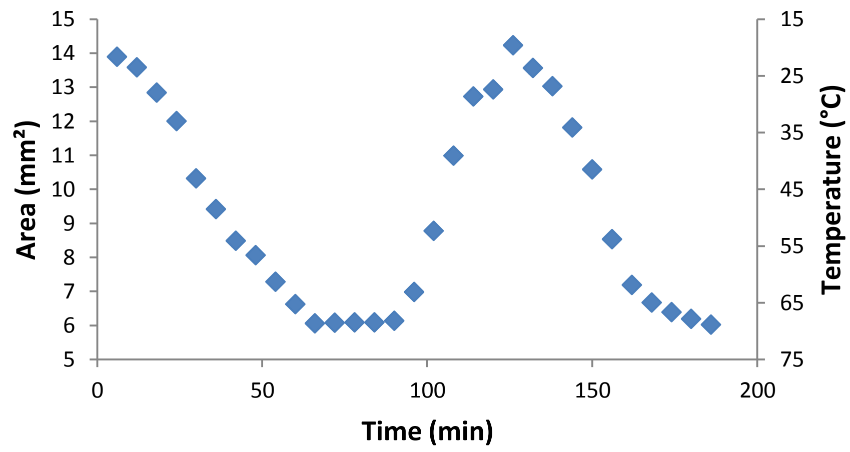


Temperature Induced Shrinking

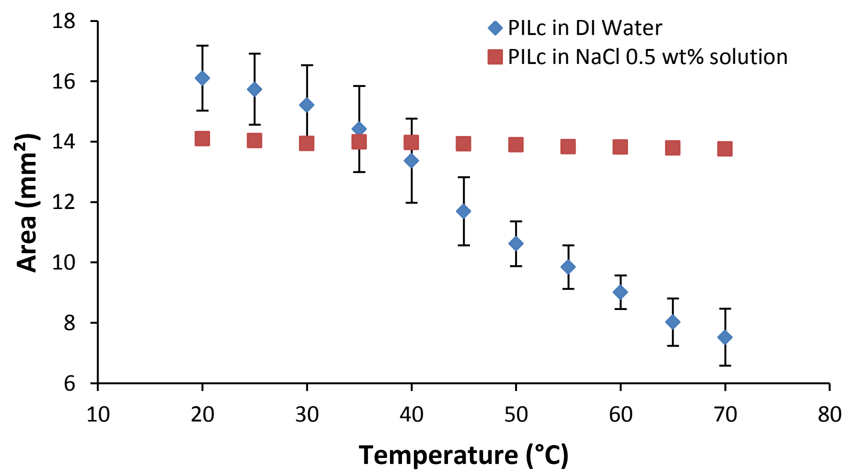
The temperature-induced shrinking stems from the fact that the PIL possesses a lower critical solution temperature. This property causes the linear PIL to precipitate from its aqueous solutions, while in the case of the crosslinked polymer, it causes the hydrogel to shrink.



The increase in temperature from 20 °C to 70 °C causes the hydrogels to shrink by ~53% in area.



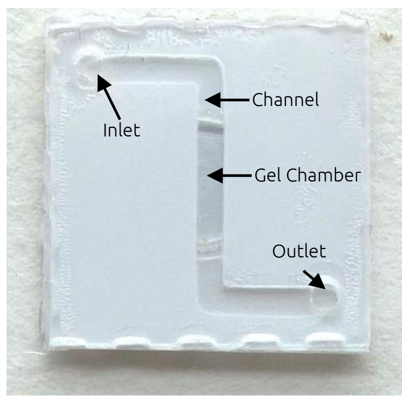
As in the case of salt concentration, the temperature induced shrinking is a reversible, repeatable process.



The presence of a chaotropic salt in the hydration solution of the hydrogel inhibits the shrinking caused by the increase in temperature.

Conclusions

A crosslinked dual-responsive phosphonium PIL hydrogel was synthesised. It was found that the size of the hydrogel can be modulated by both temperature changes and salt concentration. Both shrinking processes are reversible and repeatable, which makes the hydrogels suitable for integration in microfluidic platforms as thermo- and salt actuated micro-valves.



Acknowledgements

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