Poly(Ionic Liquid) Based Dual Responsive Smart Hydrogels

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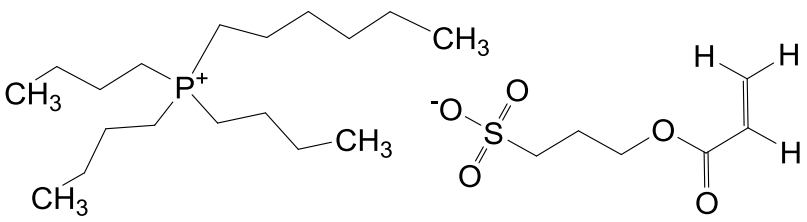
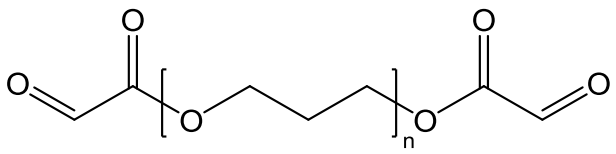
Introduction

Poly(ionic liquid)s (PILs) are a subclass of ionic liquid that feature polymerizable groups either in the cation, the anion or both. Applications of these materials include solid ion conductors, CO_2 absorption and energy storage. Furthermore, a branch of PILs feature lower critical solution temperature (LCST) behaviour, making them suitable for the synthesis of temperature responsive materials. The aim of this study was to synthesize thermo-responsive crosslinked PIL hydrogels based on phosphonium PILs. Moreover, taking into account that these PIL hydrogels consist of polyelectrolyte chains, the effect of added salt was also investigated.

Experimental Methods

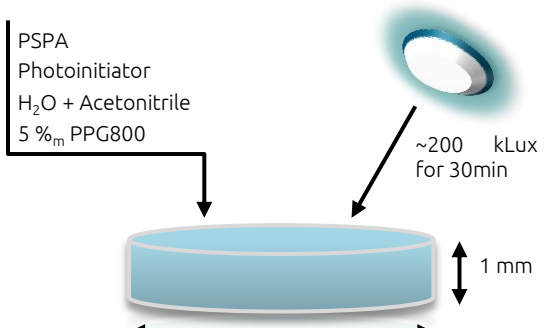


Tributylhexyl phosphonium 3-sulfopropyl acrylate (PSPA)

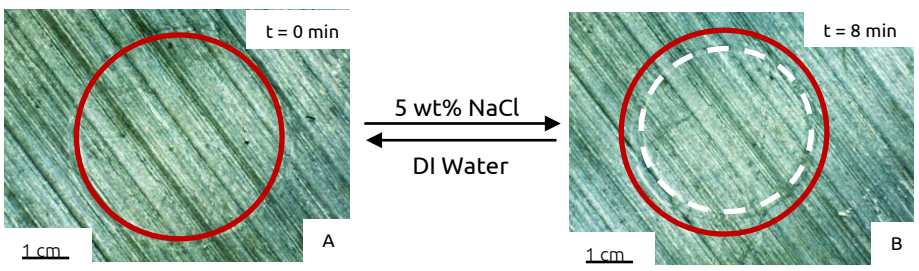


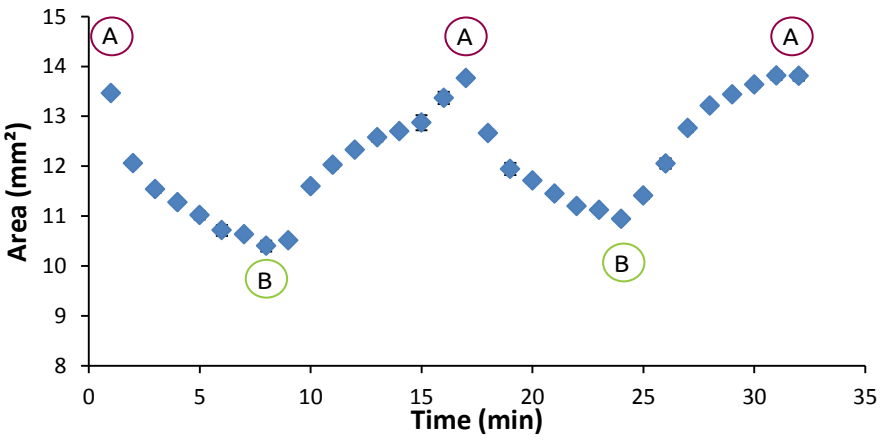
Poly(propylene glycol) diacrylate (PPG800) M_n = 800

The thermal response was measured by taking digital microscope images of the hydrogels swollen in deionized water between 20 and 70 °C, in 5 °C steps. The salt response was measured by placing the hydrogels in a 5% w/w NaCl solution and taking images every 1 min for a total duration of 10 min.

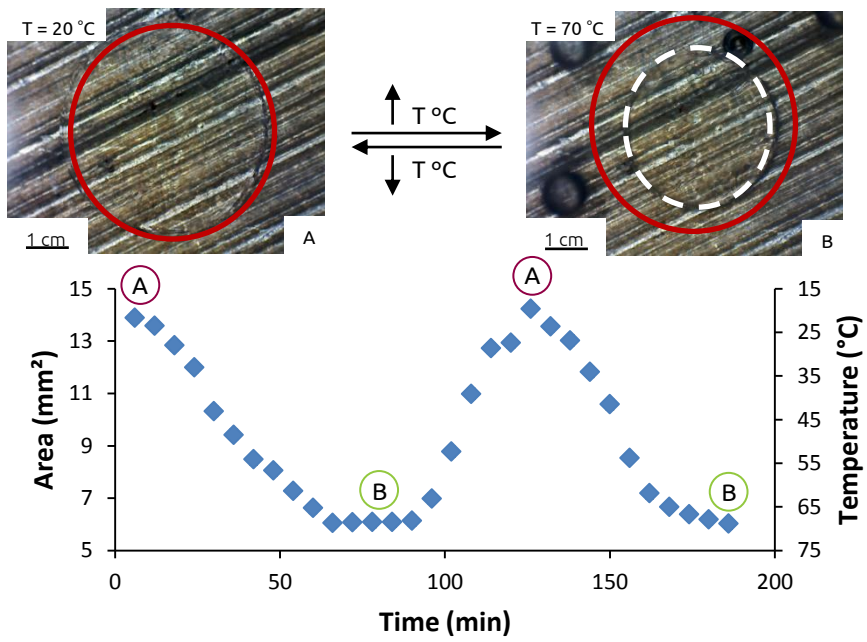


Stimuli – Induced Shrinking

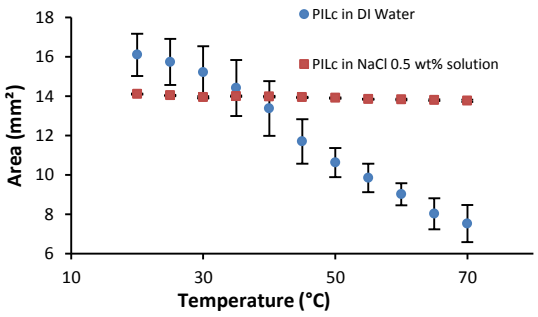




The crosslinked PIL hydrogel shrank by ~23% in area when its hydration medium was changed from DI water to 5 % w/w NaCl solution.



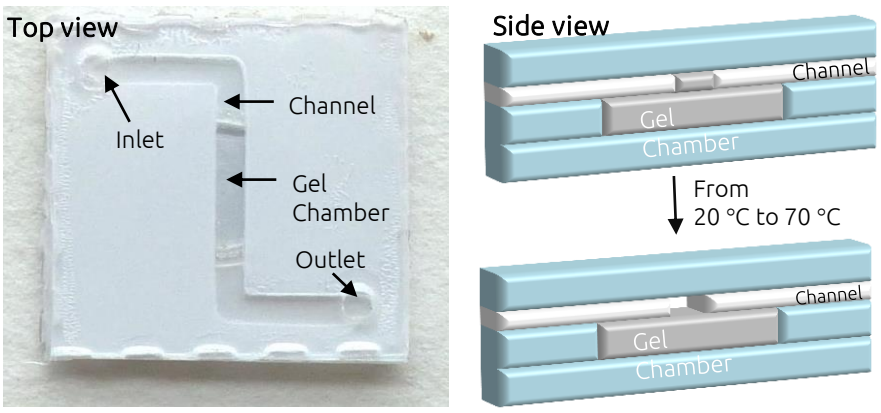
The increase in temperature from 20 °C to 70 °C causes the hydrogels to shrink by ~53% in area.



The presence of a salt in the hydration medium also inhibits the appearance of the LCST. Also, using different Na^+ salts as foreign salts in the hydration solution causes the hydrogels to shrink to different sizes. This effect comes from the different electrostatic screening caused by each different anion.

Microfluidic Device Integration

The PILc hydrogels were incorporated into microfluidic chips to assess the possibility of using them as stimuli-responsive valves. The microfluidic device consists of three layers of poly(methyl methacrylate) bound with two layers of pressure sensitive adhesive (PSA). The channel is made in the PSA layer (~80 µm). The device has a total thickness of 1 mm.



Conclusion

Crosslinked phosphonium PILs were synthesised and had their stimuli-responsive properties characterised. It was found that both the temperature and the presence of a foreign salt in the hydrating medium can cause the hydrogels to shrink and both processes are reversible. Following this, the hydrogels were incorporated into microfluidic devices as stimuli-responsive valves and will be further characterised regarding their ability to control the flow of liquid inside the device.

Acknowledgements

The authors are grateful for financial support from the Marie Curie Initial Training Network funded by the EC FP7 People Programme OrgBIO (Marie Curie ITN, GA607896) and Science Foundation Ireland (SFI) under the Insight Centre for Data Analytics initiative, Grant Number SFI/12/RC/2289.