



Thermo-responsive Poly(Ionic Liquid) Valves for Microfluidic Devices

Alexandru Tudor, Janire Saez, Larisa Florea, Fernando Benito-Lopez and Dermot Diamond

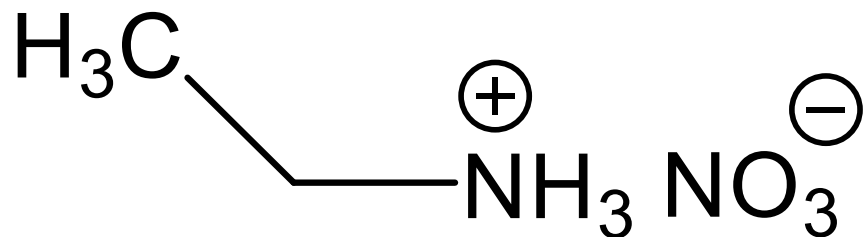




The Origin of Ionic Liquids



1914



Ethylammonium Nitrate



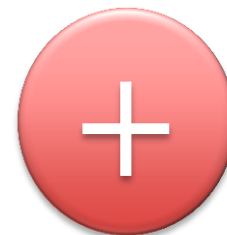
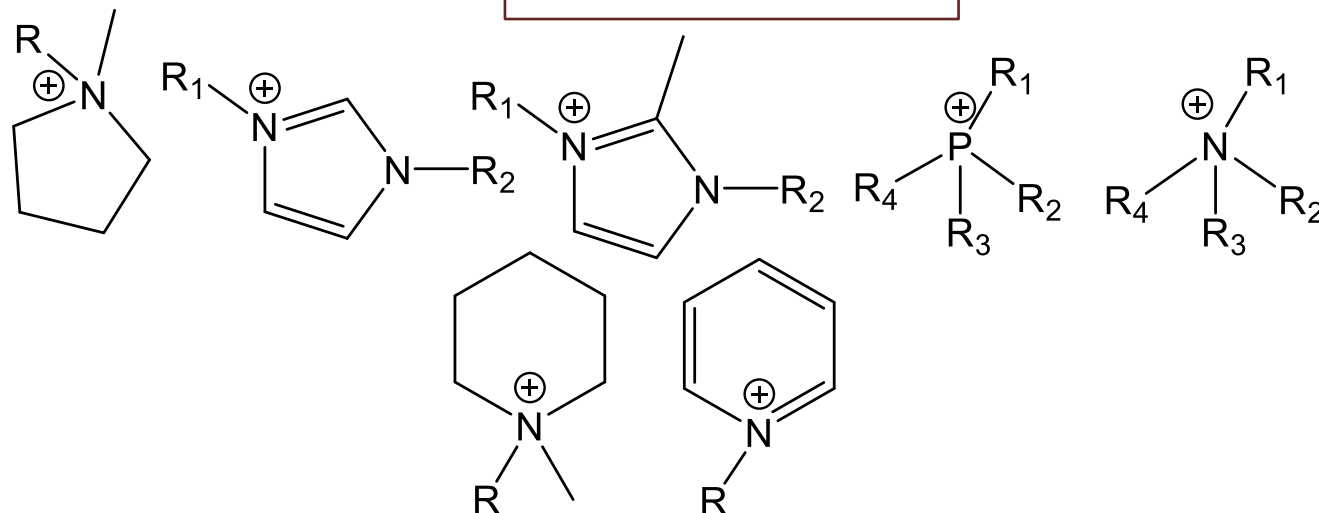
Paul Walden (1863-1957)



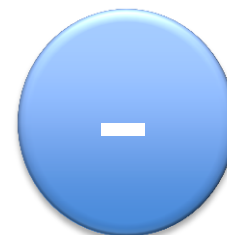
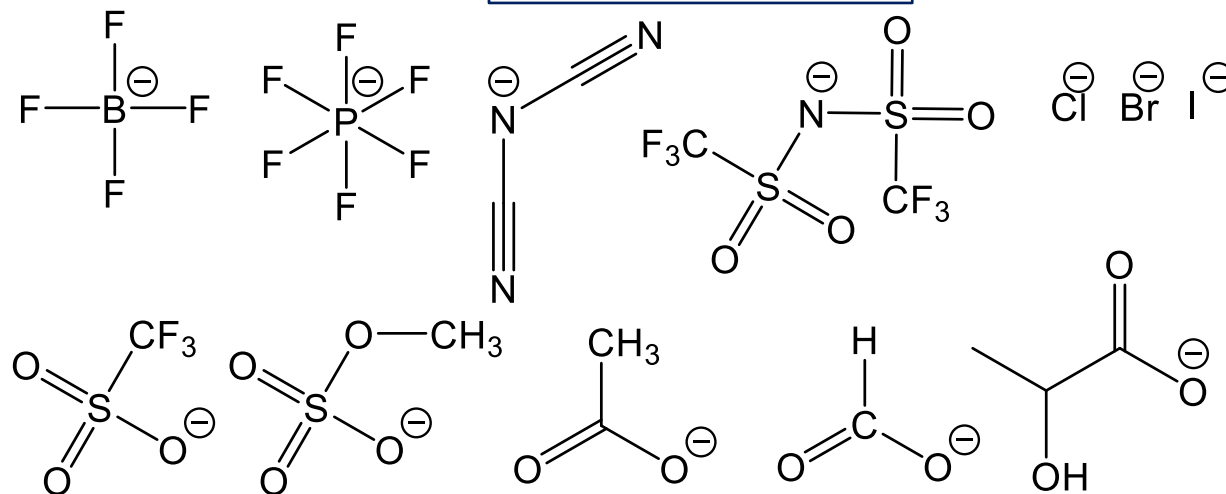
Ionic Liquids



Common cations



Common anions

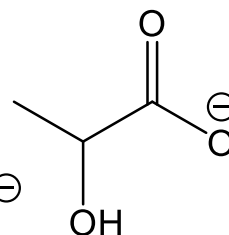
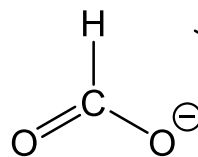
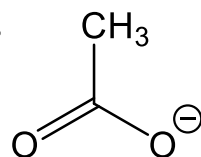
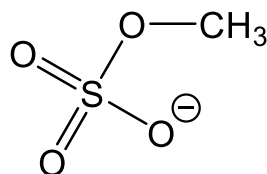
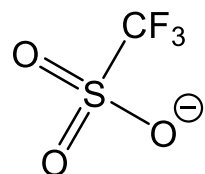
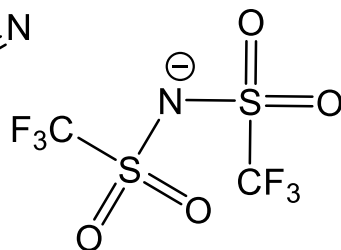
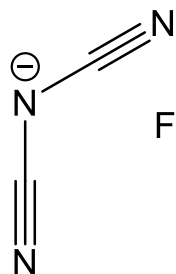
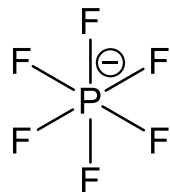
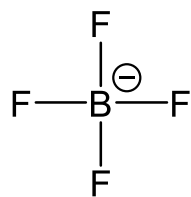
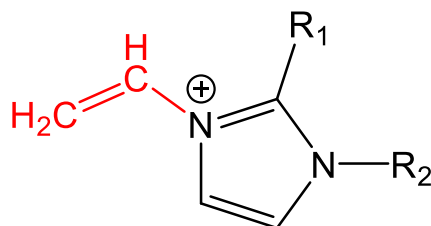
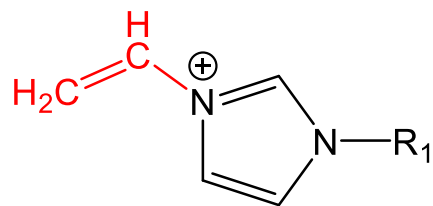
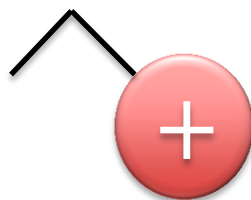




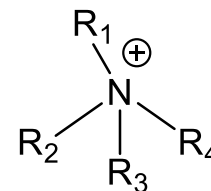
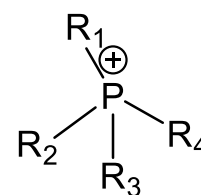
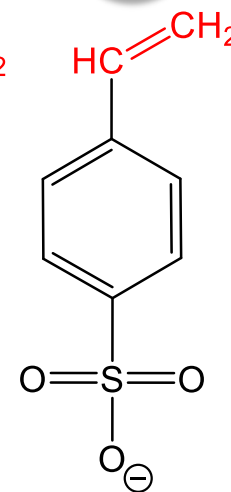
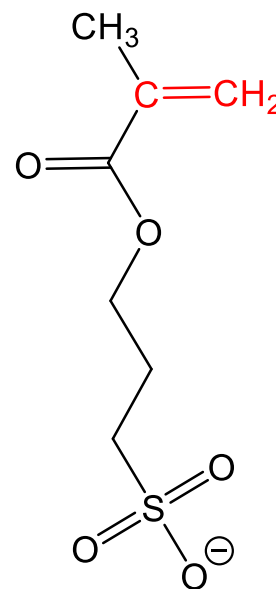
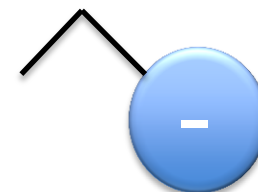
Ionic Liquid Monomers



Cationic

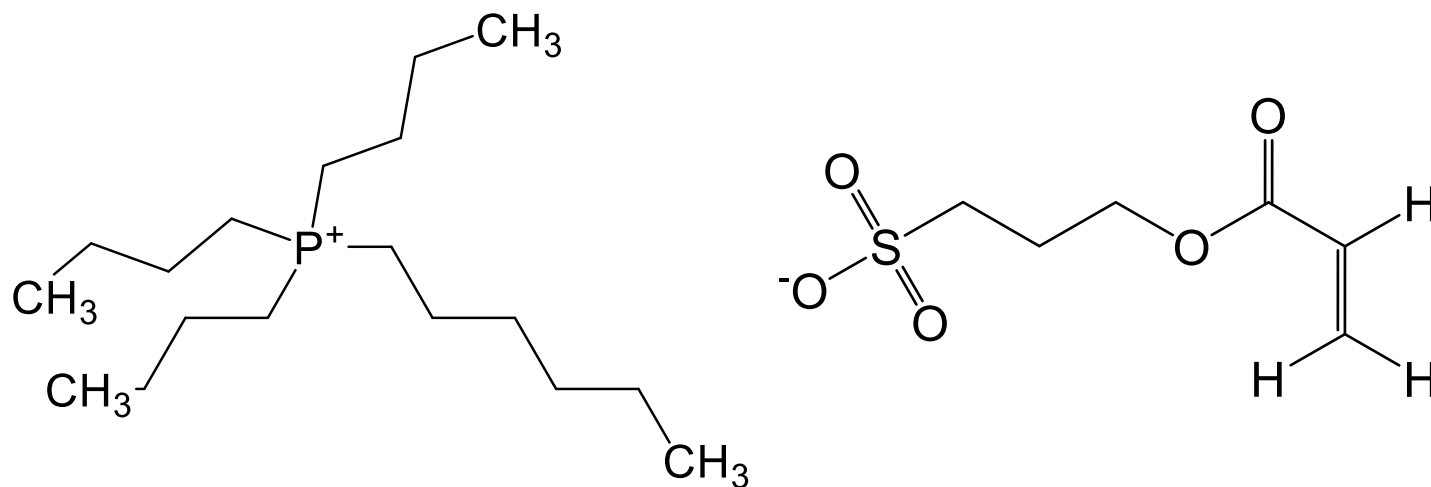


Anionic



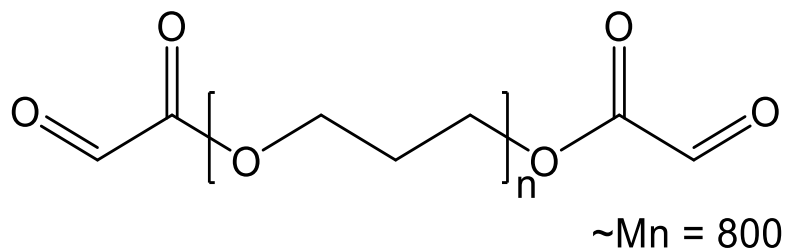
Crosslinked Poly(Ionic liquid)s

Monomer



Tributylhexyl Phosphonium Sulfopropyl Acrylate (P₄₄₄₆-SPA)

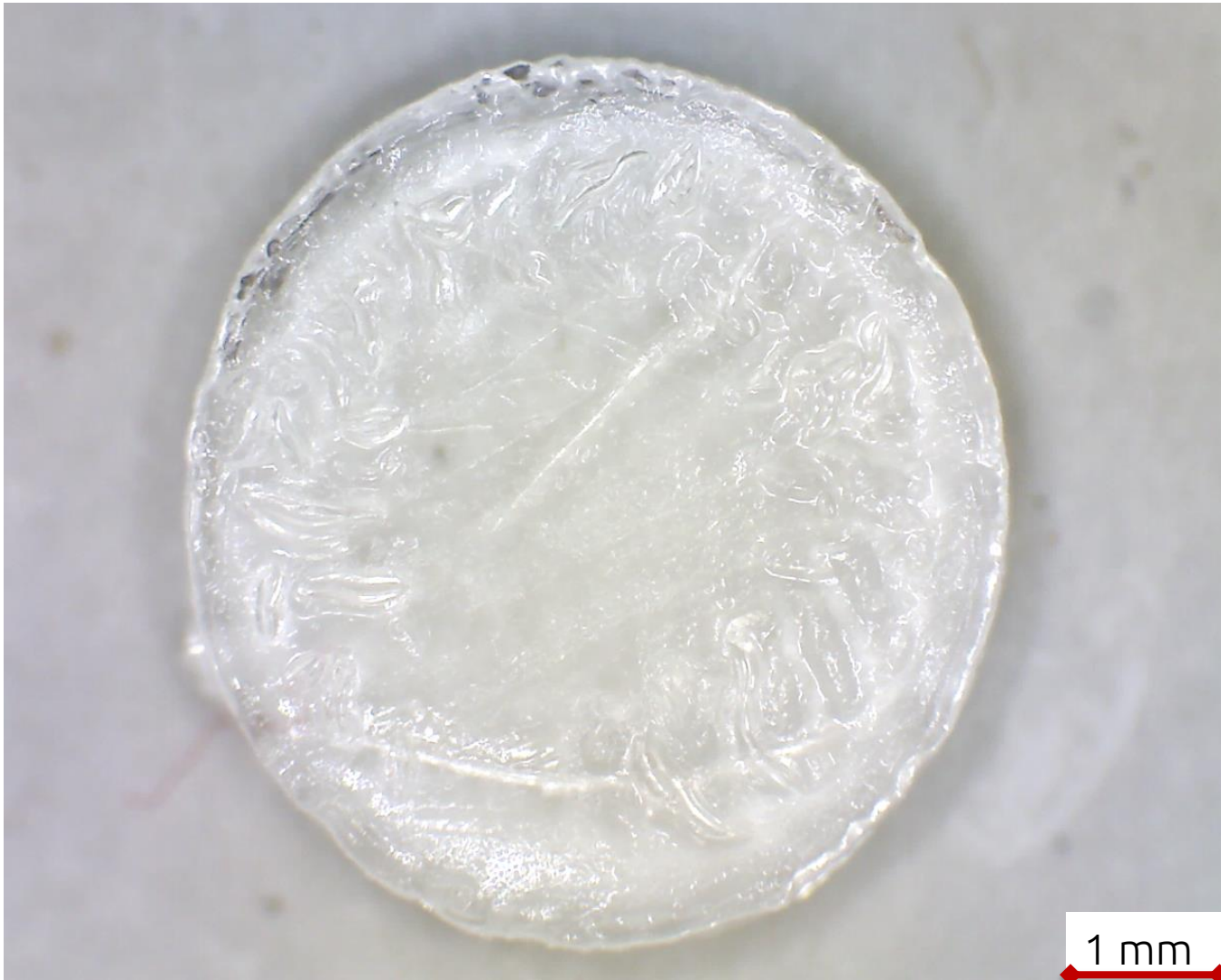
Crosslinker



Polypropylene Glycol Diacrylate



Poly (Ionic Liquid) Hydrogels

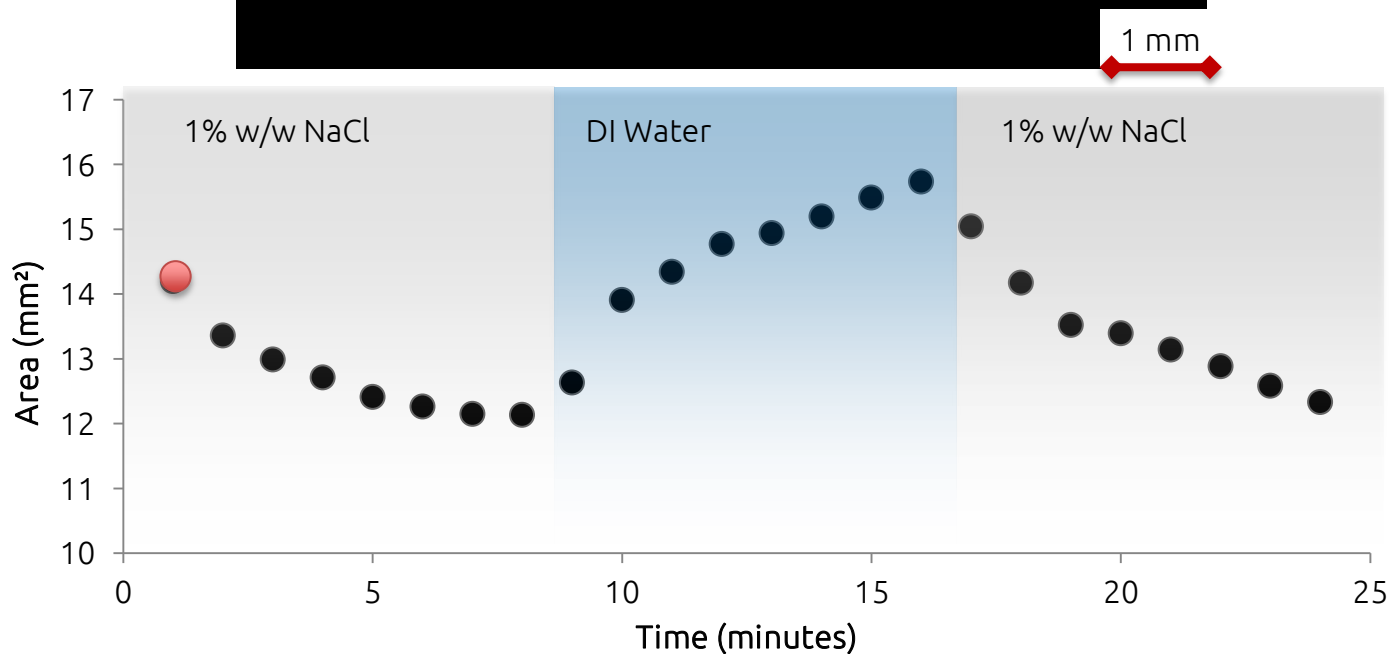




The Salt-induced Response of P_{4446} -SPA Hydrogels

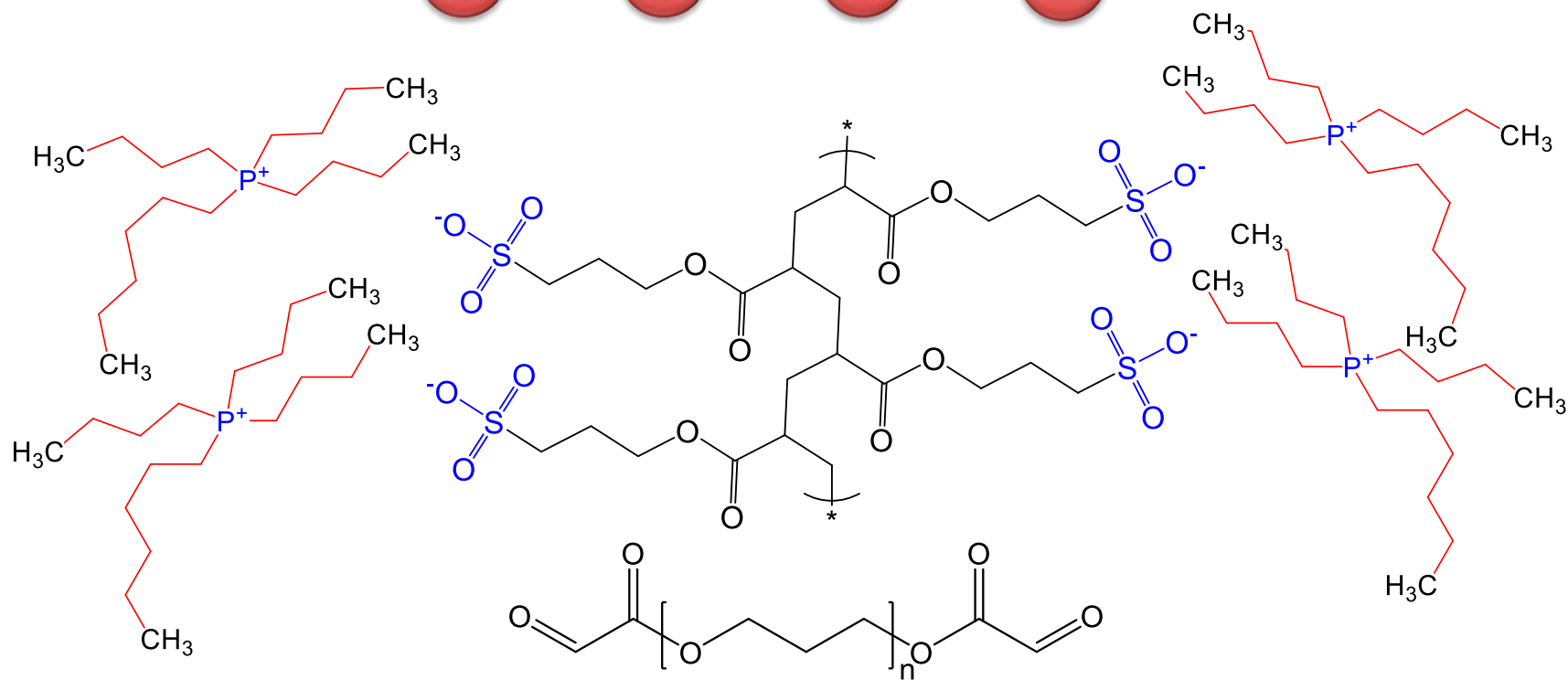
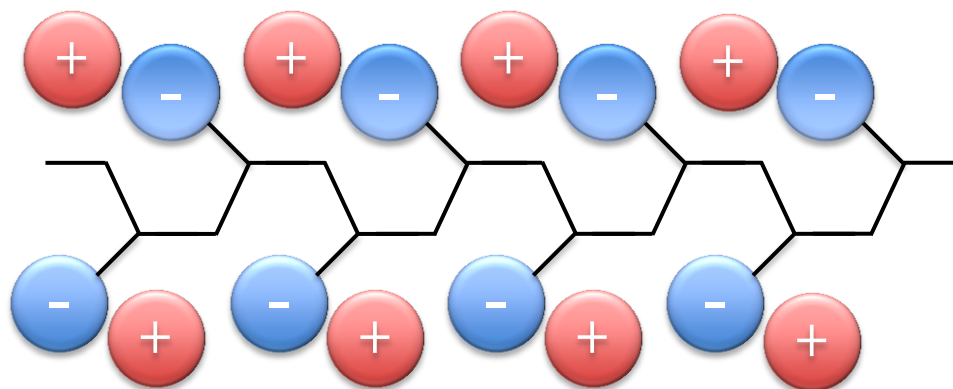
Work method:

- The gels were swollen in deionized water
- The response was recorded by changing the hydration medium to 1% w/w NaCl solution, deionized water and back to 1% w/w NaCl solution.
- For each step, pictures were taken at a 20 second interval.
- The temperature was set at 20 °C.





Temperature Responsive Poly(Ionic Liquid)s

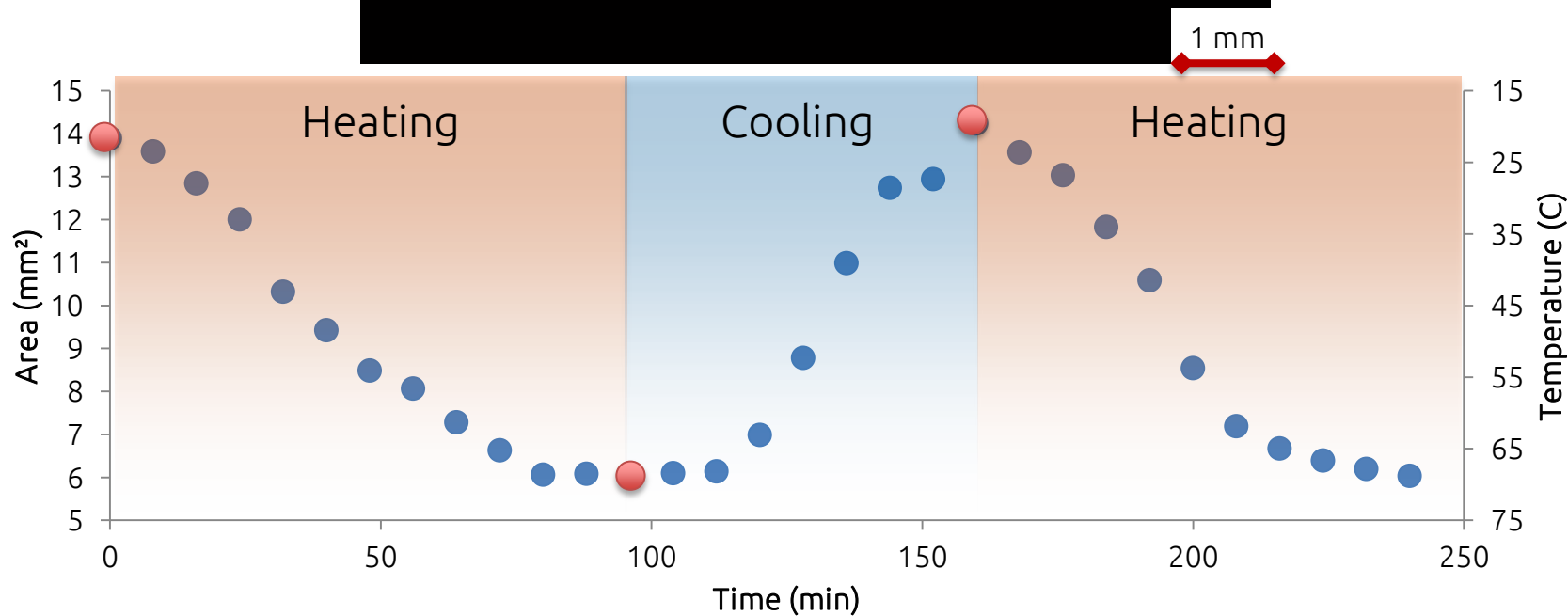


$\sim M_n = 800$



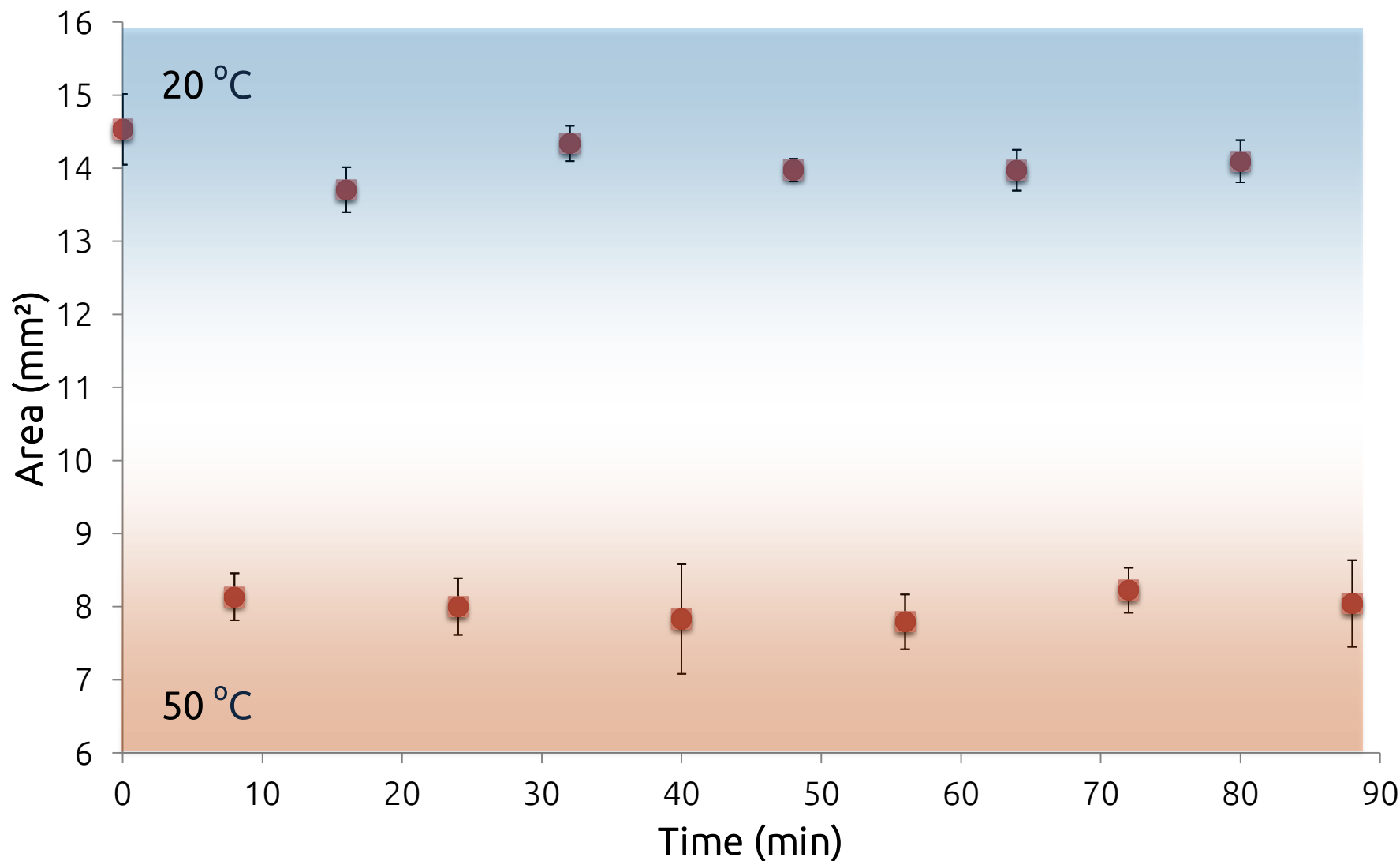
The Thermal Response of P_{446} -SPA Hydrogels

- Temperature Programme:
 - From 20 °C to 70 °C in 10 °C/min
 - 10 minute isothermal step at 70 °C
 - From 70 °C to 20 °C in 13.33 °C/min
 - 11 minute isothermal step at 20 °C
 - This was repeated 2 times.

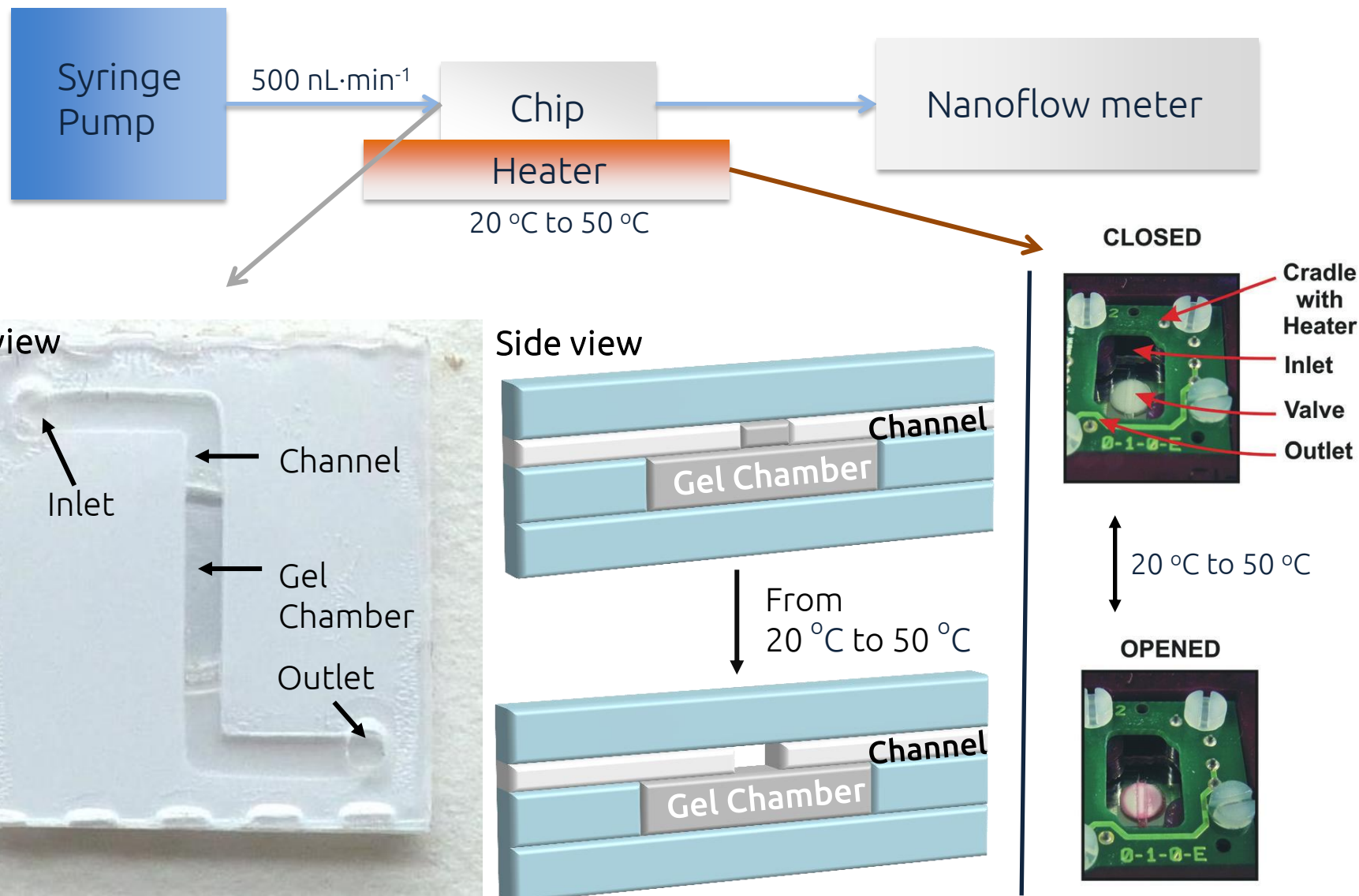




Swelling-Reswelling Cycle

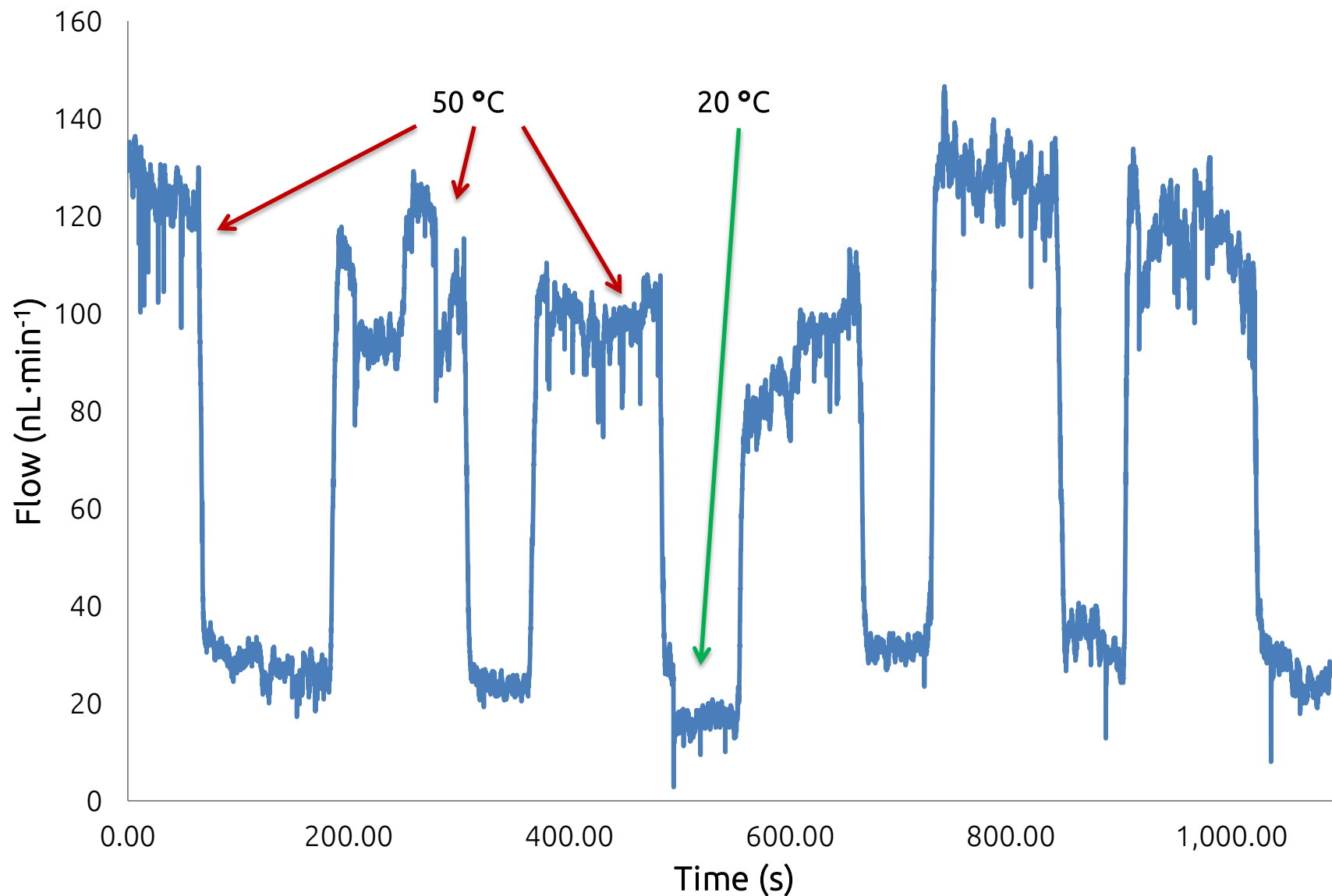


Microfluidic Chip Fabrication



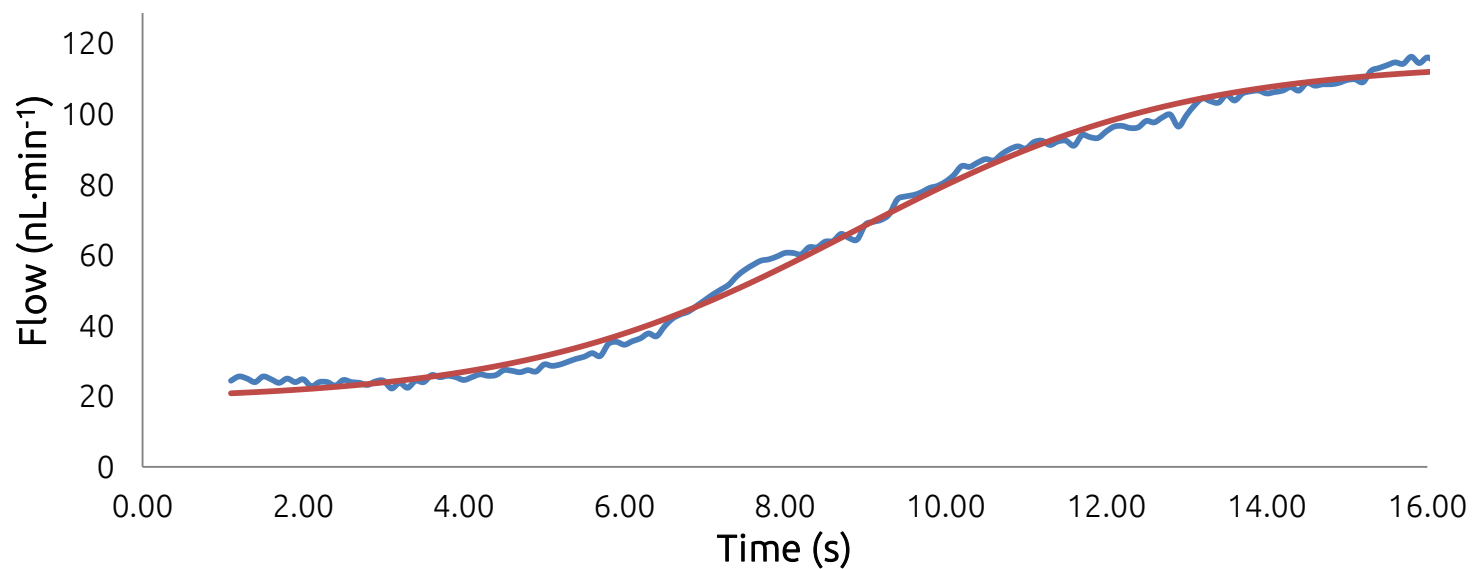
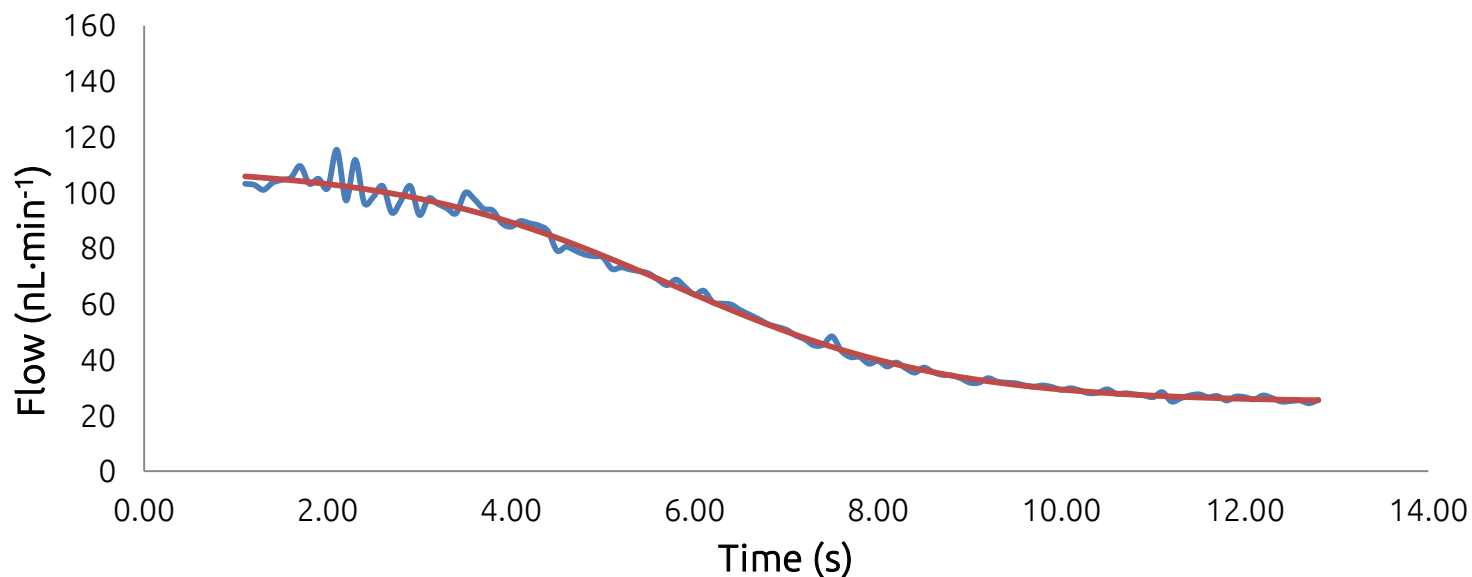


Temperature-regulated Flow





Shrinking and Swelling Kinetics





Acknowledgements

- Dr. Larisa Florea, Dr. Simon Gallagher, Dr. Simon Coleman.
- Dr. Fernando Benito-Lopez, Janire Saez.
- Conor O'Quigley, Tom Glennon.
- Wayne Francis, Aishling Dunne, Danielle Bruen, Jennifer Deignan.
- John Burns, Joseph Hennesy.
- Prof. Dermot Diamond.
- Marie Curie ITN FP7 OrgBIO project.



MARIE CURIE ACTIONS



SEVENTH FRAMEWORK PROGRAMME



MASC
Project no: 269302
Materials and Advanced Sensor
Knowledge Exchange



NAPES
NEXT GENERATION ANALYTICAL PLATFORMS
FOR ENVIRONMENTAL SENSING



COMMON SENSE
MARINE SENSORS - MARINE MONITORING



aquawarn



Insight



Conclusions

- Thermo-responsive P_{4446} -SPA hydrogels can be used as temperature-operated valves in microfluidic devices.
- Further investigate the possibilities of using the P_{4446} -SPA hydrogels as flow regulators in microfluidic chips.



Valve shrinking kinetics

$$y = \frac{a}{1 + e^{b+cx}} + d$$

Where:

- a. the maximum value of the curve
- b. the intercept
- c. the slope
- d. the offset



Rate constant calculation results

Shrinking			Swelling	
Repetition	C		Repetition	C
1	0,89		1	0,91
2	0,36		2	0,94
3	0,52		3	0,83
4	0,80		4	0,38
5	0,67		5	0,49
6	0,62		6	
MEAN	0,64		MEAN	0,71
DESVEST	0,19		DESVEST	0,26
RSD (%)	29,80		RSD (%)	36,41



The Salt-induced Response of P_{4446} -SPA Hydrogels

Work method:

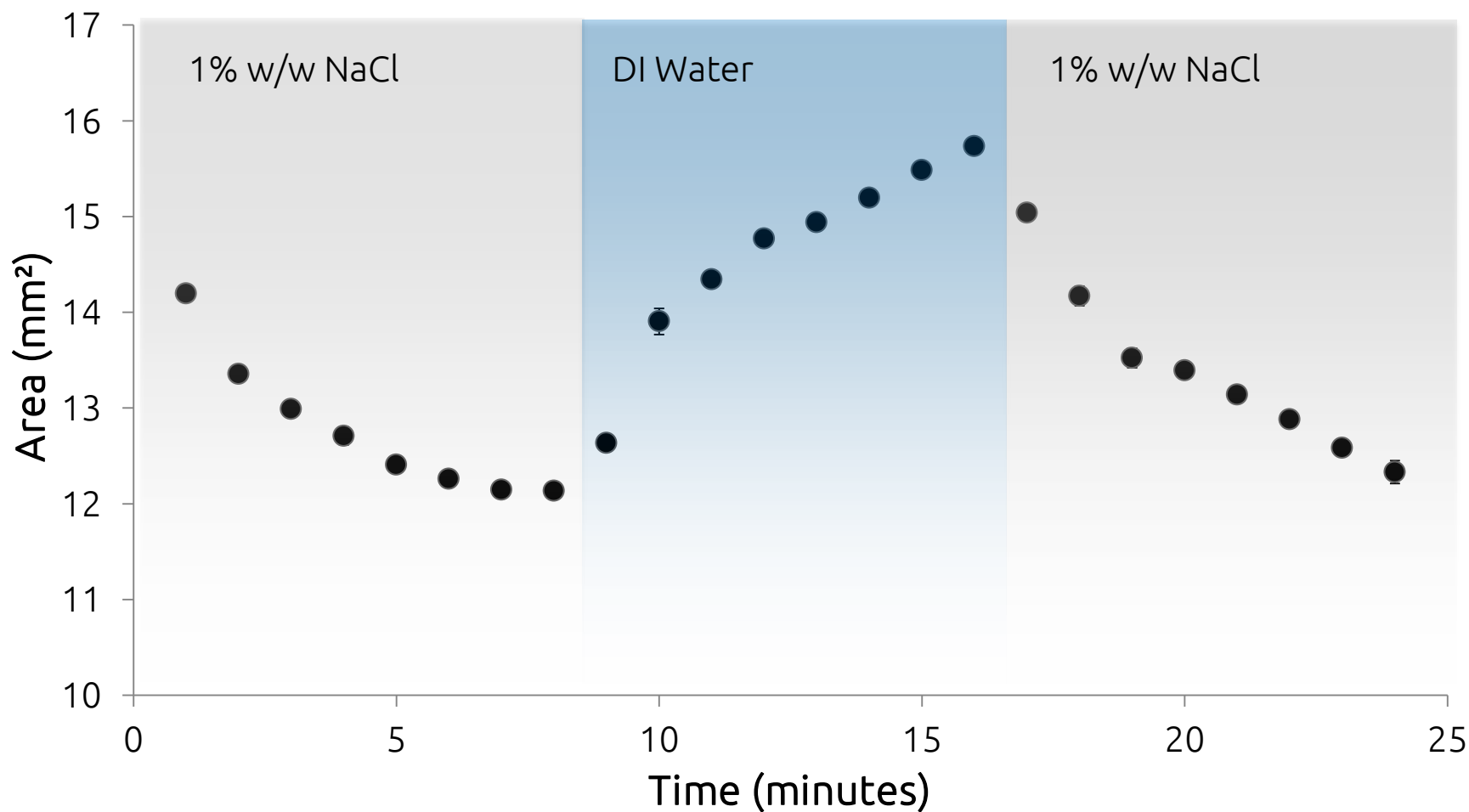
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- The temperature was set at 20 °C.

1 mm





Salt Concentration Induced Shrinking





The Thermal Response of P_{4446} -SPA Hydrogels

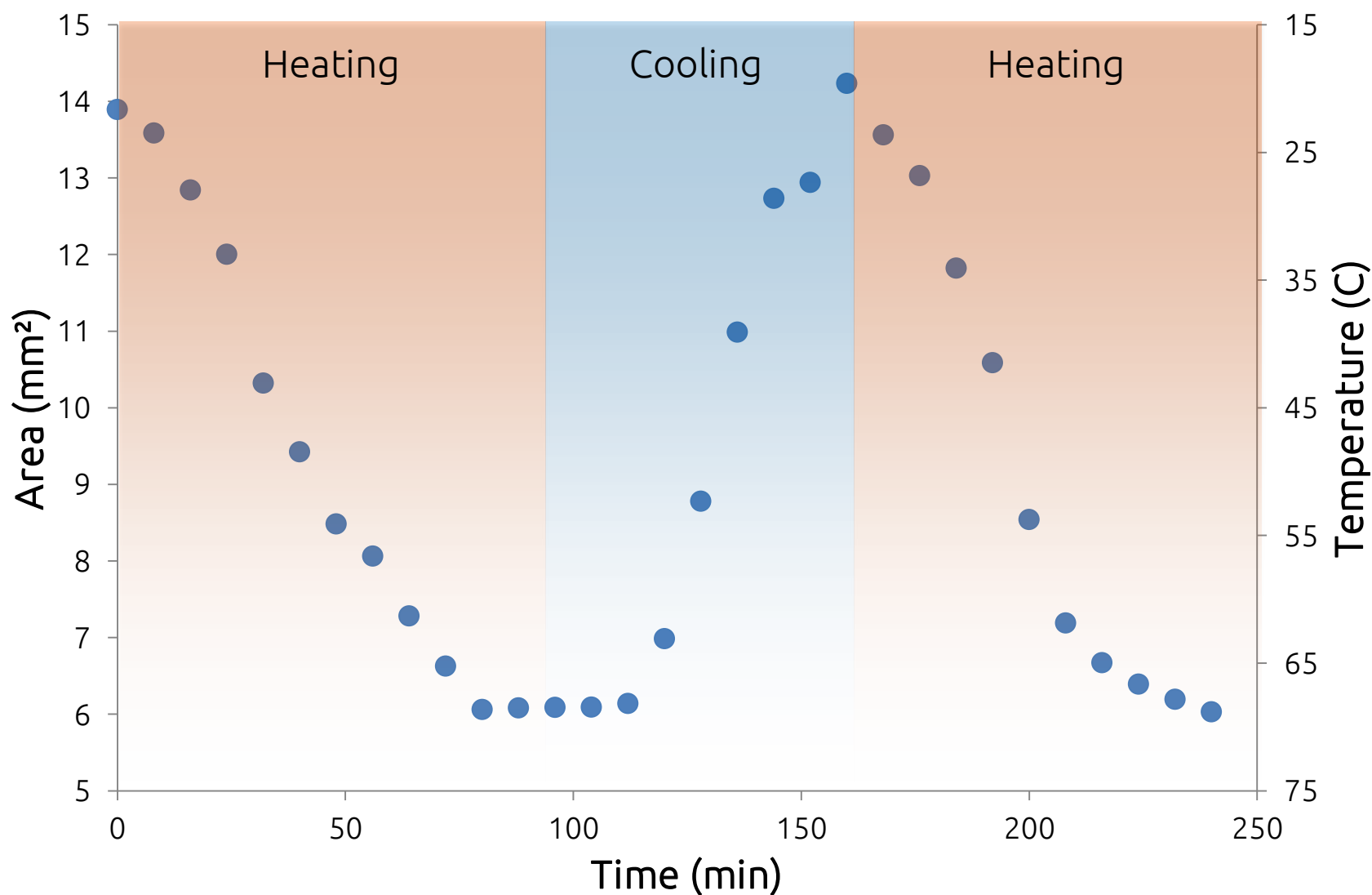
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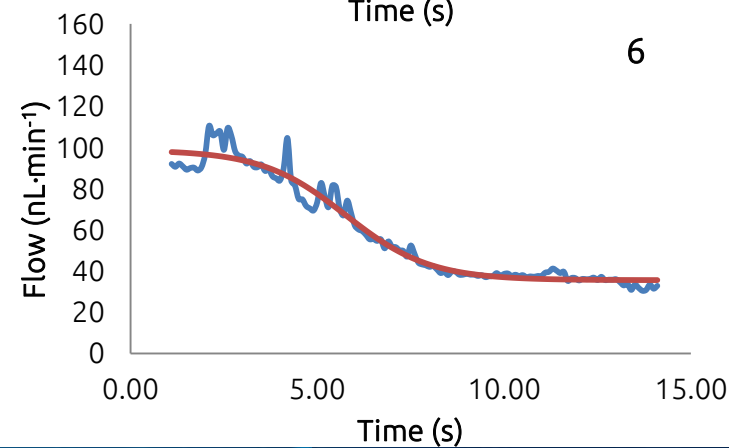
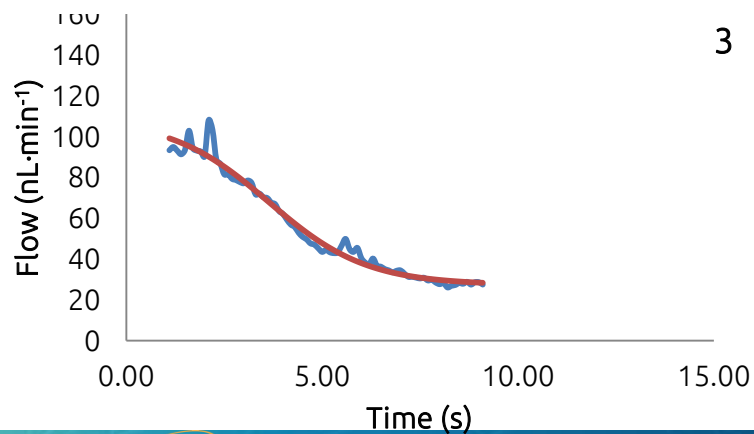
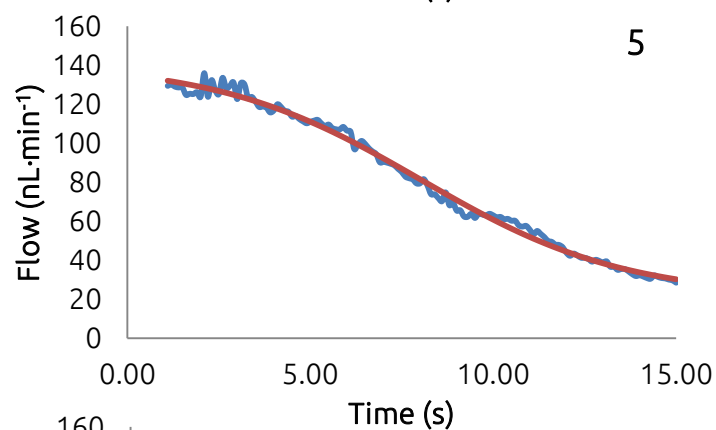
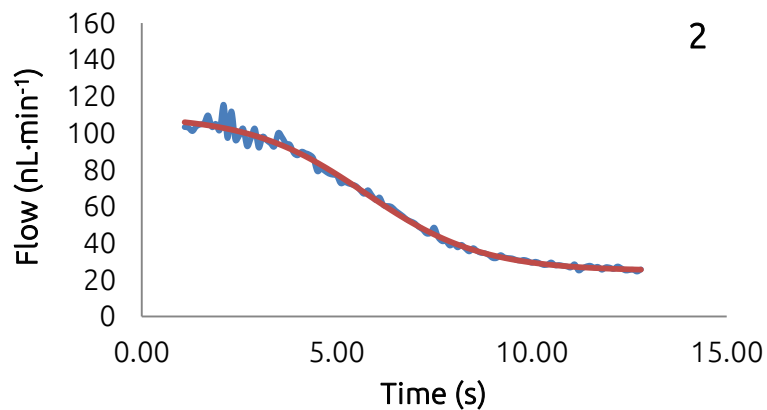
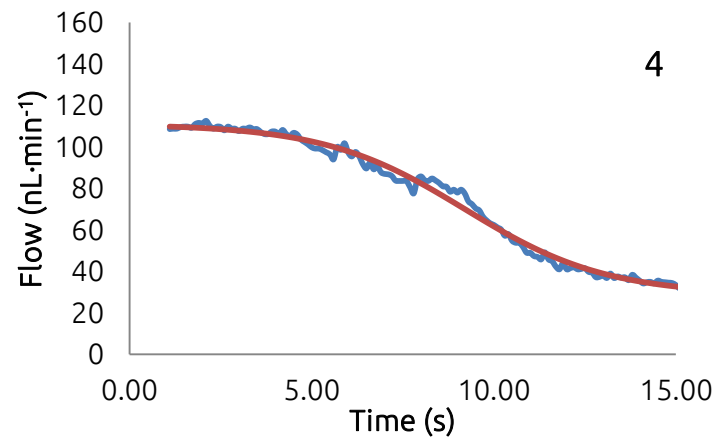
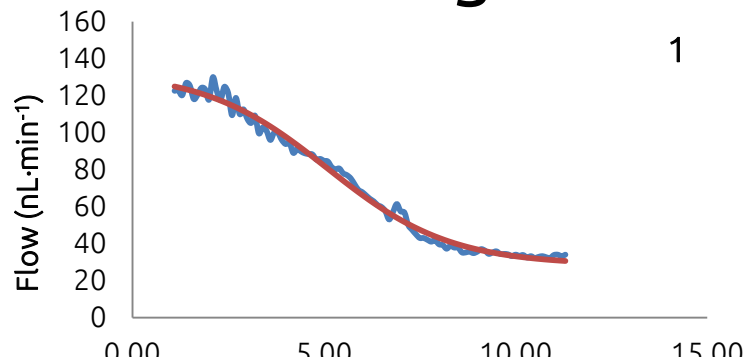


Temperature-induced Shrinking Kinetics





Valve Shrinking Kinetics





Valve Swelling Kinetics

