DCU Water: the greatest global challenge

ATWARM International Conference

CLARITY clarity-centre.org

Novel, stimuli-responsive materials for fluid handling in microfluidic sensor platforms

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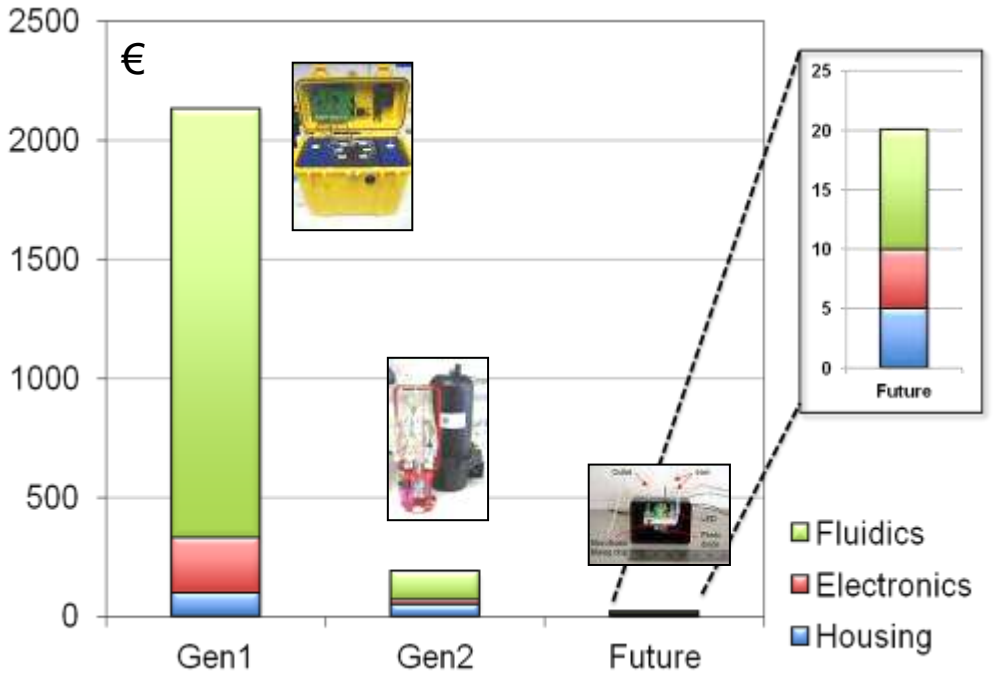
ATWARM project 3.7

Presentaton outline

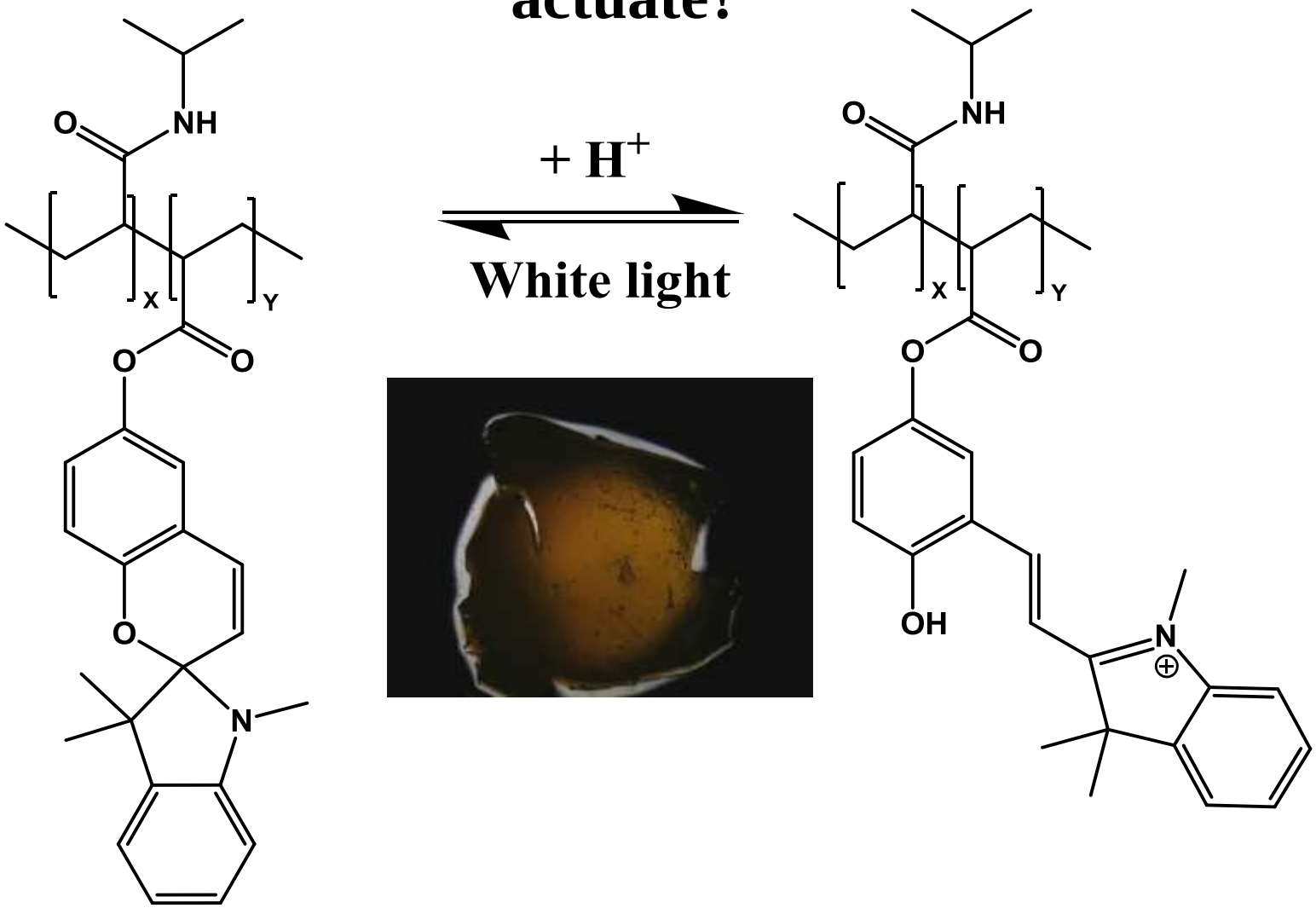
1. Water quality and stimuli-responsive materials
2. Current photoresponsive actuator gel systems
3. New stimulus-responsive materials
4. Results
5. Conclusions
6. Future work and impact

Water quality and stimuli-responsive materials?

- Autonomous sensor platforms for water quality are available
- High cost, high maintenance, high power usage
- Evolutionary engineering approach
- **Revolutionary materials research**



How does the photo-switchable gel actuate?



Hydrophobic
Collapsed

Hydrophilic
Swollen

What are the drawbacks?

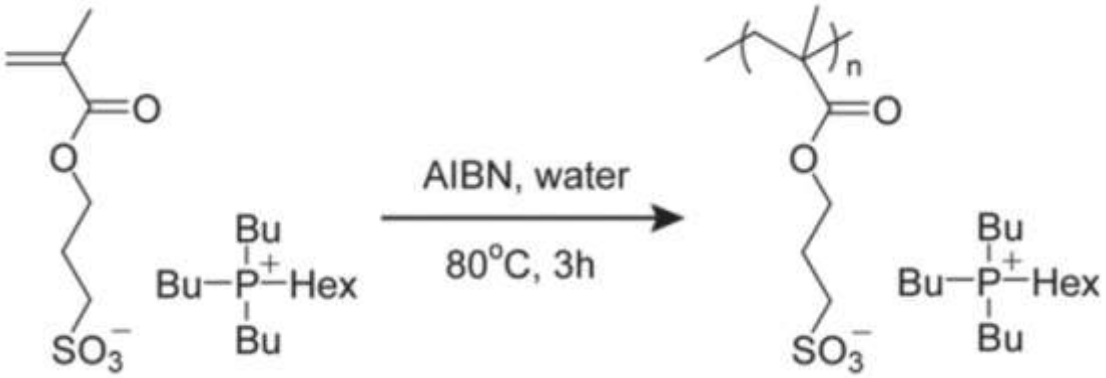
Every photo-responsive poly(NIPAM) gel published so far requires being soaked in HCl to operate

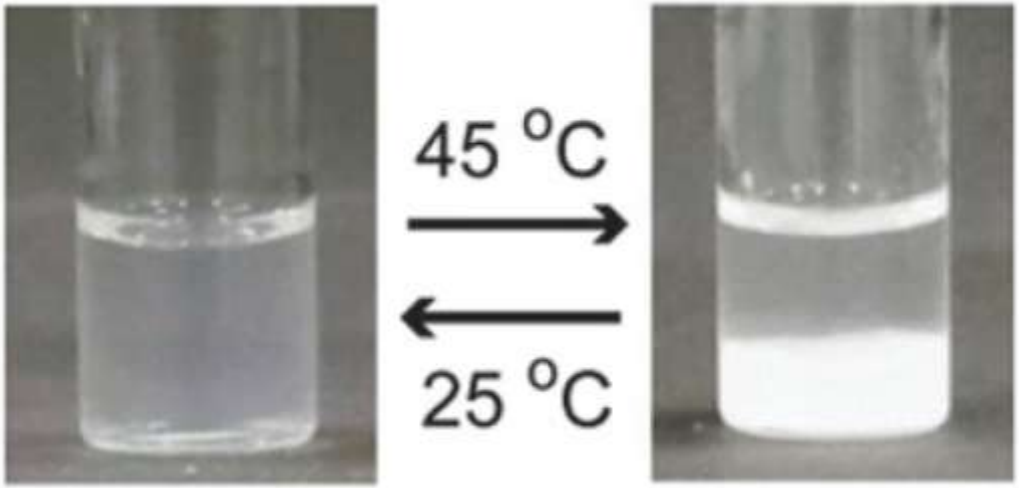
This limits:

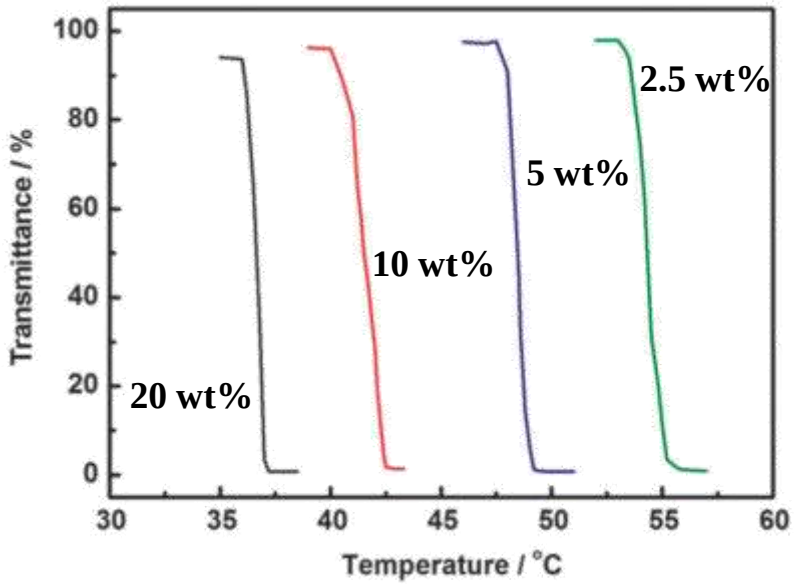
- **The design and operation**
- **Operational pH range**
- **Areas of application**
- **Reversibility (only one-shot devices available)**
- **Slow speed of reswelling (takes ~60 min)**

New thermo-responsive materials

polymeric LCST ionic liquids

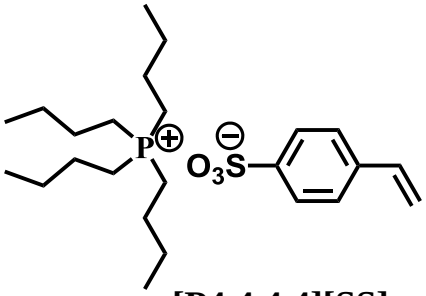




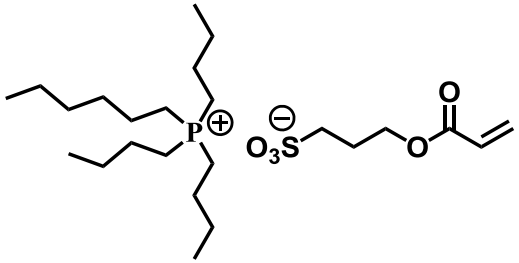


Y. Kohno, Y. Deguchi and H. Ohno, *Chem. Commun.*, 2012, **48**, 11883-11885.

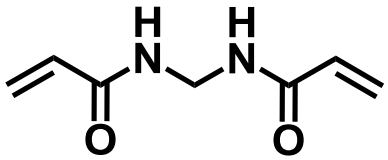
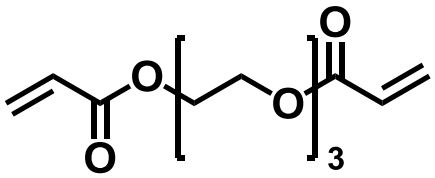
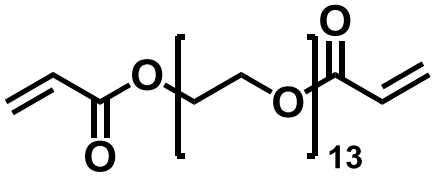
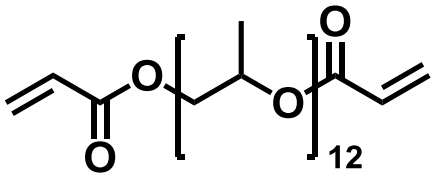
Preparation of thermo-responsive poly(IL) gels



[P4,4,4,4][SS]



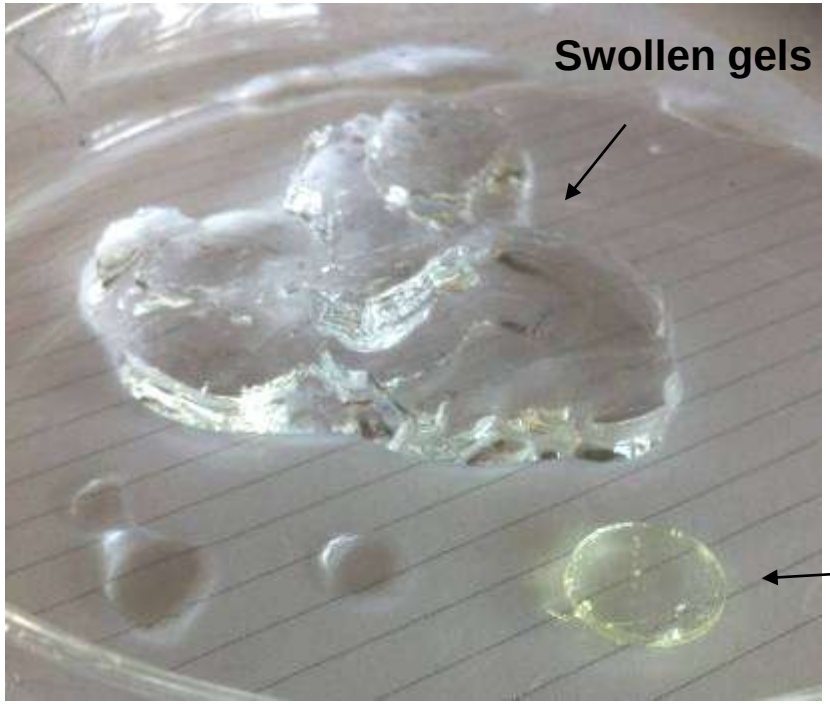
[P4,4,4,6][SPA]

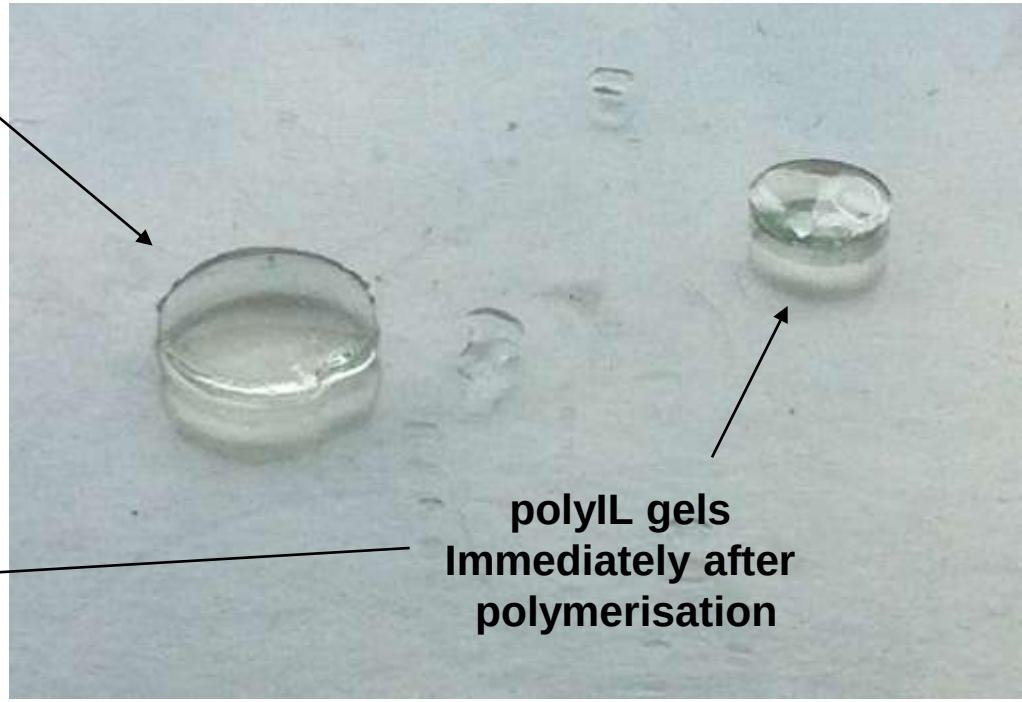
 MBIS	Cracks, no stable shape, excessive swelling	Cracks, no stable shape, excessive swelling
 PEG 256 diacrylate	Cracks, no stable shape	Cracks, no stable shape
 PEG 700 diacrylate	Stable, transparent gel	Stable, transparent gel
 PPO 800 diacrylate	Stable, transparent gel (up to 9 %mol)	Stable, transparent gel (up to 9 %mol)

Preparation of thermo-responsive poly(IL) gels

$[P_{4,4,4,4}][SS]$ + 10 % MBIS

$[P_{4,4,4,6}][SPA]$ + 5 % PPO800 diacrylate

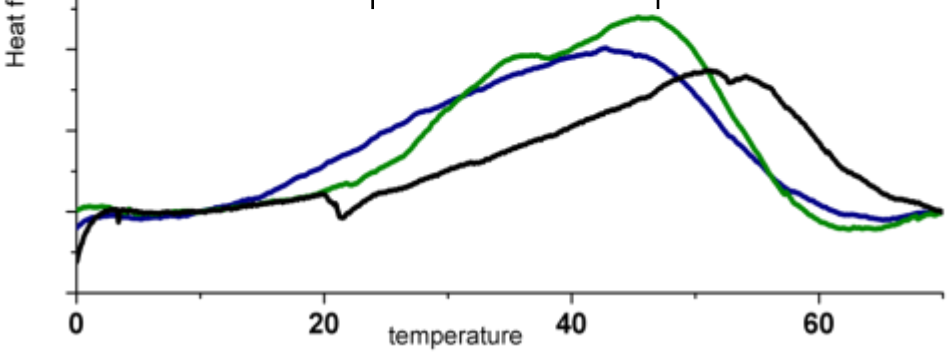


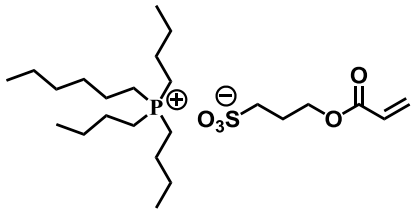


Only longer chain crosslinkers allow mechanically stable hydrogels

Thermal analysis of poly(IL) gels (DSC)

	Crosslinker content [%]	LCST Max [˚C]
▬	5	52.6
▬	7	46.1
▬	8	42.9

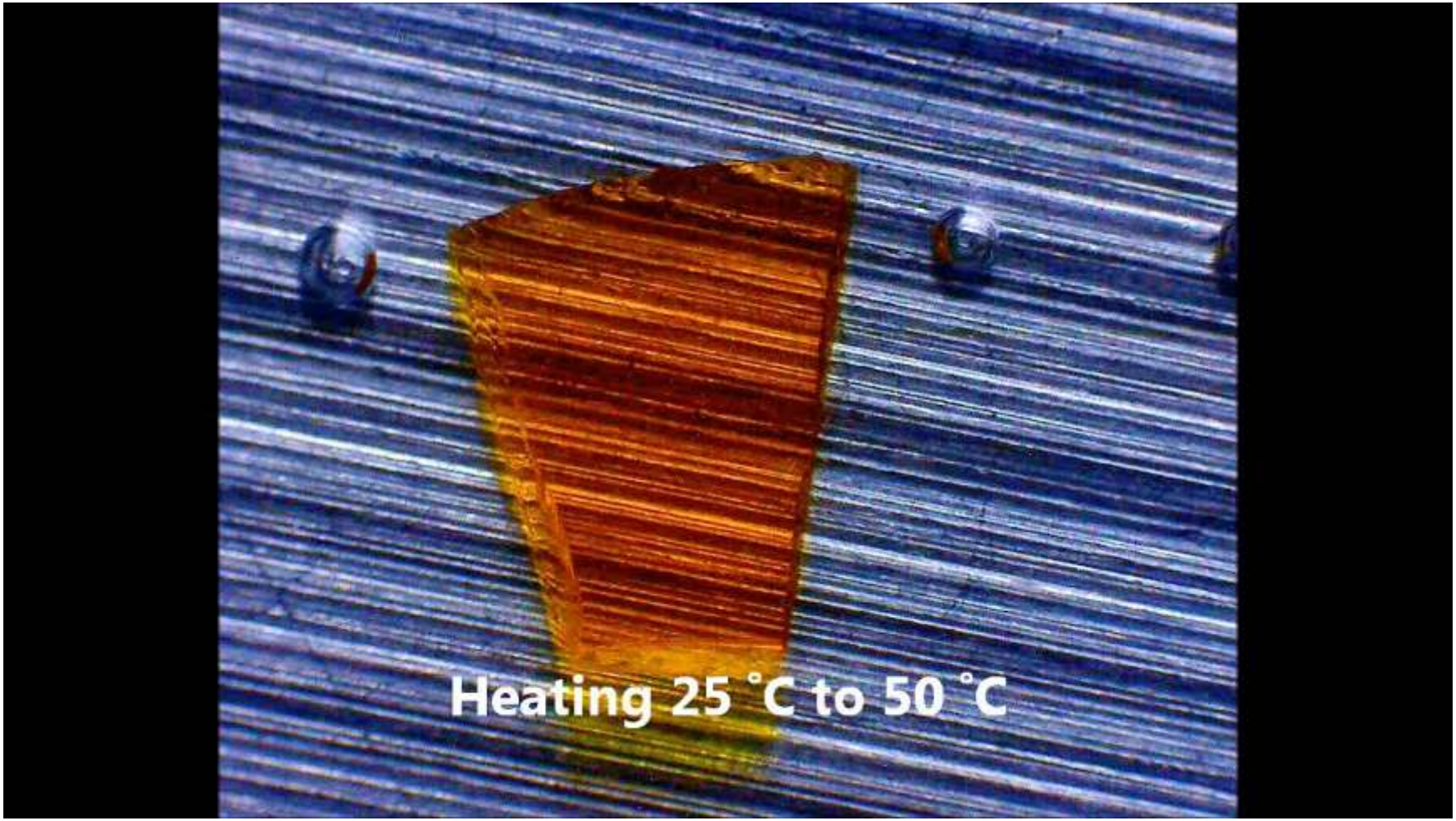




Crosslinker amount allows LCST tuning

Crosslinking significantly broadens the LCST peak

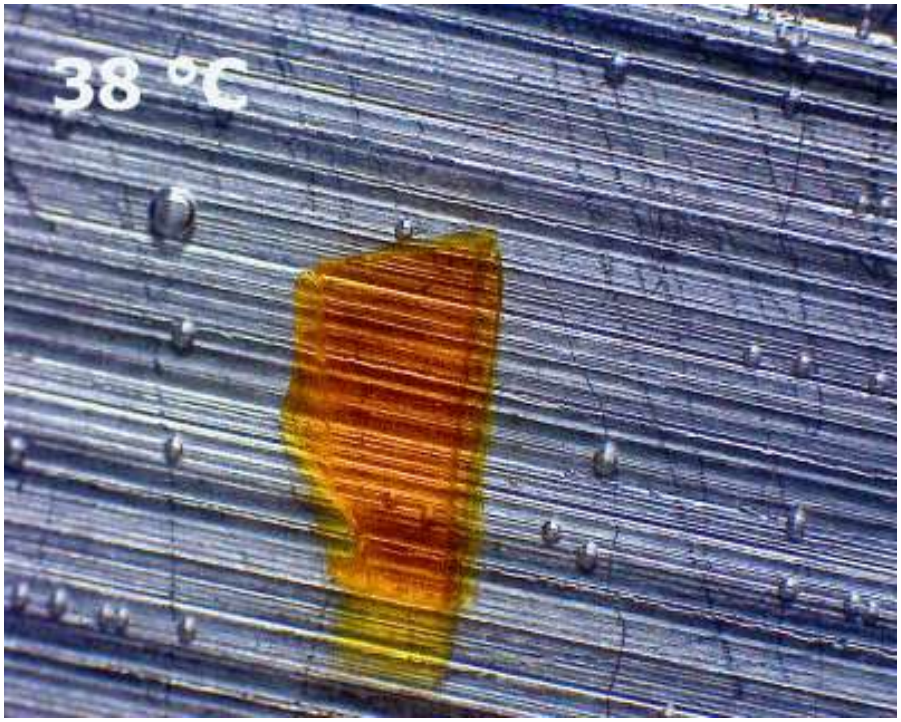
Thermal behaviour of poly(IL) gel



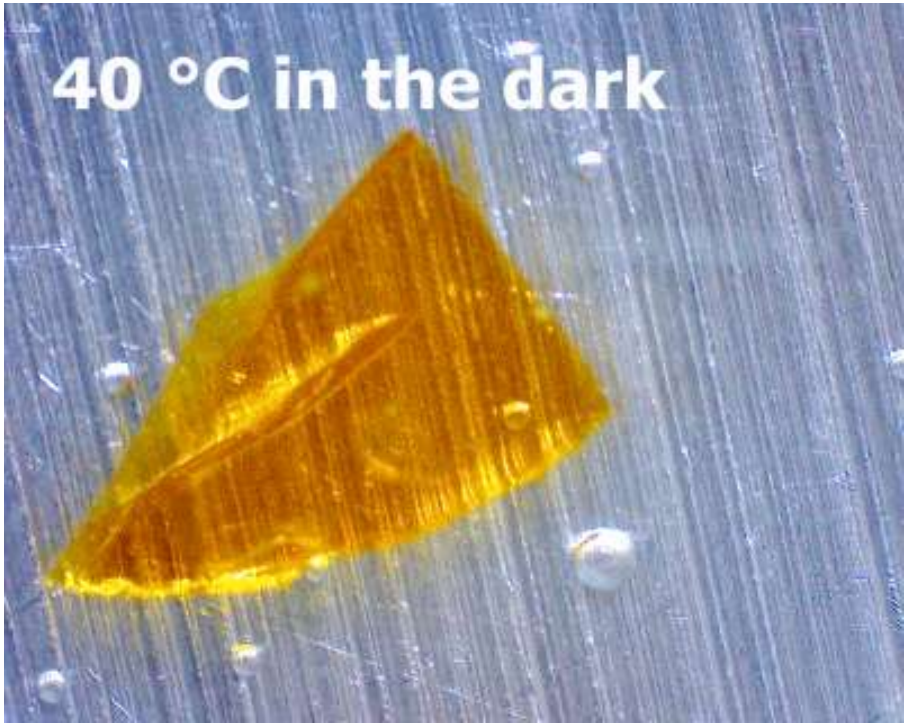
1 mm

Speed 64x

Thermal and photo-resposnive behaviour of poly(IL) gel



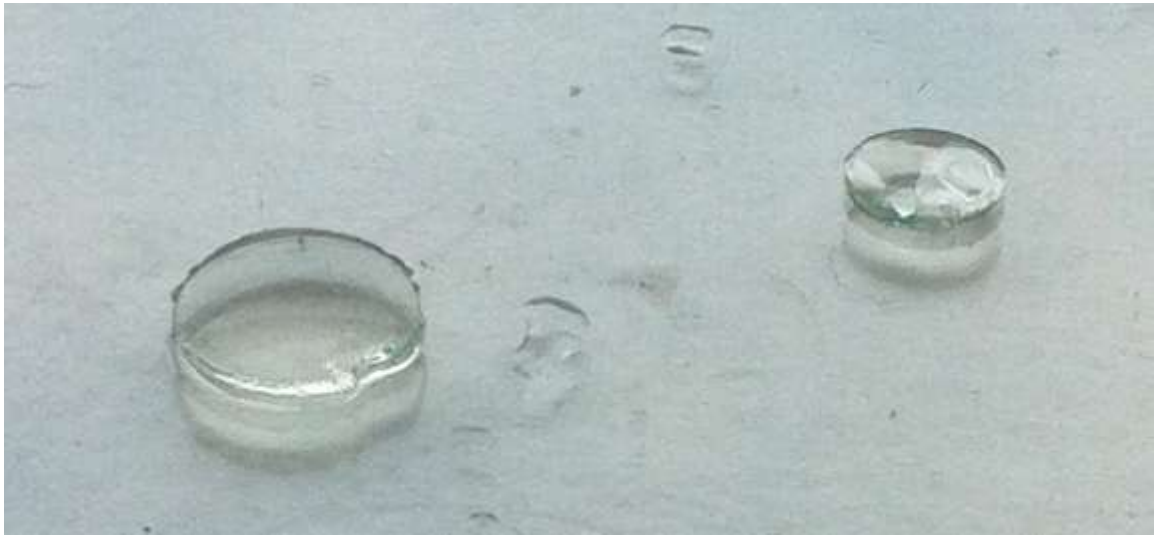
1 mm



1 mm

Conclusions

- Hydrogels from monomeric temperature-responsive ILs can be produced
- Gels shrink gradually as temperature increases
- Photo-responsive property can be added
- Potential application as valves in autonomous microfluidic sampling systems/sensors



Future work and impact

Improve speed of actuation

Improve the LCST peak distribution

Incorporation into microfluidic manifolds

Demonstration of a fully functional microfluidic valve

Acknowledgements

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Thank you for attention!