Project 3.7: Microfluidic platforms incorporating stimulus-responsive materials for Water Quality

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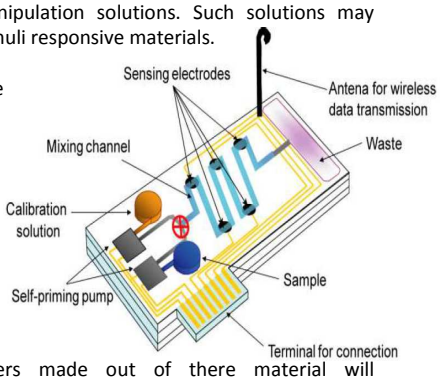
Background:

Current flow control solutions in analytical platforms have high power consumption and are prone to mechanical failure.

To scale down such analytical platforms and enable them to be incorporated into wireless sensor networks one needs revolutionary flow manipulation solutions. Such solutions may come in the form of stimuli responsive materials.

Novel stimuli-responsive materials can:
- Shrink
- Bend
- Move

After appliying:
- Light
- Magnetic field
- Heat



• Using flow controllers made out of there material will dramatically reduce power consumption and size of the full device. (Fig. 1)

•Research in this field will allow better water quality and environment monitoring.

Areas investigated:

•Thermoresponsive poly(NIPAAm) ionogels based on phosphonium ionic liquids

• Magneto-responsive composite poly(NIPAAm) ionogels incorporating functionalised magnetic nanoparticles

• Development and characterisation of photo responsive poly(NIPAAM) hydrogels

• Investigation of themoresponsive polyionic liquid hydrogels

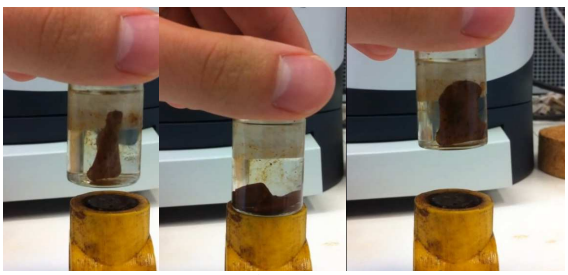


Fig. 1. Magnetic gel contracts rapidly after placing above a permanent magnet but after removing the magnetic field the gel returns to its original shape quickly and reversibly

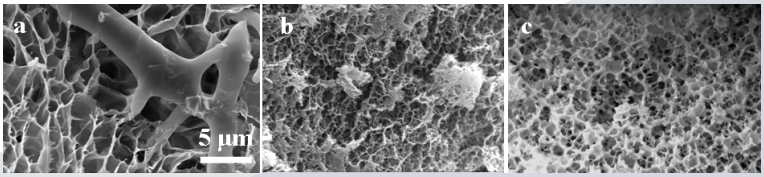


Fig. 2. SEM pictures showing the morphology of the thermoresponsive poly(NIPAAm) gels. a) no porogen used, b) PEG 2000 porogen used, c) PEG 20 000 porogen used.

Key results:

• By changing the anion-cation combinations in the phosphonium ionic liquid used to make thermoresponsive poly(NIPAAm) ionogels one can tune the polymerisation speed, viscoelastic properties of the ionogels and their thermoresponsive behaviour

•Functionalising magnetic particles with polymerisation-active groups allows covalent incorporation of said particles into poly(NIPAAm) ionogels forming composite magnetically actuated ionogels

•Incorporation of acrylic acid into spiropyran functionalised poly(NIPAAm) gels improves their actuation degree allowing then to actuate without immersion in HCl. Inducing porosity in these gels increases the speed of actuation.

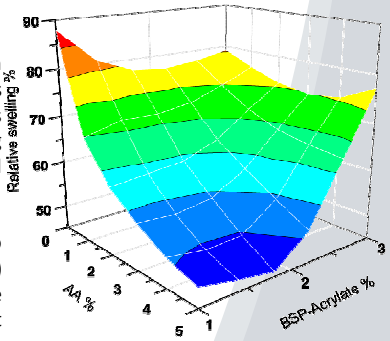


Fig. 3. Effects of acrylic acid (AA) and spiropyran (BSP-Acrylate) content on the light induced shrinking of the gels after 20 min of irradiaiton

•Thermal and actuation behaviour of thermoresponsive polyionic liquid hydrogels with crosslinkers of varying length have been investigated

Main outputs:

•Bartosz Ziółkowski, Monika Czugała, Dermot Diamond, "Integrating stimulus responsive materials and microfluidics: The key to next-generation chemical sensors", **Journal of Intelligent Material Systems and Structures**, Published online 27 September 2012. DOI: 10.1177/1045389X12459591.

•Bartosz Ziółkowski, Zeliha Ates, Simon Gallagher, Robert Byrne, Andreas Heise, Kevin J Fraser and Dermot Diamond, "Mechanical properties and U.V. curing behaviour of Poly(N-isopropylacrylamide) in phosphonium based ionic liquids", **Macromolecular Chemistry and Physics, Macromolecular Chemistry and Physics, 2013**. 214(7): p. 787-796. DOI: 10.1002/macp.201200616

•Bartosz Ziółkowski, Katrin Bleek, Brendan Twamley, Kevin J. Fraser, Robert Byrne, Dermot Diamond, Andreas Taubert, "Magnetic Ionogels (MagIGs) Based on Iron Oxide Nanoparticles, Poly(N-isopropylacrylamide), and the Ionic Liquid Trihexyl(tetradecyl)phosphonium Dicyanamide", **European Journal of Inorganic Chemistry, 2012.** 2012(32): p. 5245-5251. DOI: 10.1002/ejic.201200597

•Bartosz. Ziółkowski, Larisa Florea, Janick Theobald, Fernando Benito-Lopez and Dermot Diamond, "Self-protonating spiropyran-co-NIPAM-co-acrylic acid hydrogel photoactuators", **Soft Matter, 2013**, 9, 8754-8760 DOI: 10.1039/c3sm51386f.

•Bartosz. Ziółkowski, Larisa Florea, Janick Theobald, Fernando Benito-Lopez and Dermot Diamond, "Porous and self-protonating spiropyran-based NIPAM gels with fast reswelling kinetics", in preparation

•Bartosz Ziółkowski and Dermot Diamond, "Thermoresponsive poly ionic liquid gels", **Chemical Communications, 2013**, 49, 10308-10310, DOI: 10.1039/C3CC45862H

•Bartosz. Ziółkowski, Larisa Florea and Dermot Diamond, "Photo-responsive spiropyran-based N-isopropylacrylamide (NIPAM) gels", **United Kingdom patent no: 1313220.4 filed July 24, 2013**

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