**Solvato-morphologically controlled photo-responsive hydrogels for micro-valve applications**

Aishling Dunne, Larisa Florea* and Dermot Diamond

---

**Introduction**

Integrating stimuli-responsive materials into microfluidic systems could provide external control over fluid flow and reduce the over-all complexity of the device. In this study photo-actuator hydrogels were generated using a N-isopropylacrylamide-co-acrylated spiropyran-co-acrylic acid (p(NIPAAm-co-SP-co-AA) copolymer. These hydrogels have the ability to contract upon exposure to white light and reswell in the dark. It was shown that the photo-actuation is successfully reversible in a relatively short time period (seconds to minutes). The hydrogels were then incorporated in microfluidic devices as micro-valves for photo-control of flow.

**Photo-actuated hydrogels**

Actuation mechanism

Actuator p(NIPAAm-co-SP-co-AA) micro-structured hydrogels were photo-polymerised through micro-patterned masks. Their photo-induced shrinking and reswelling mechanism was studied under white light irradiation and in the dark, respectively. In water, the acrylic acid comonomer dissociates, resulting in the protonation of the photochromic spiropyran (SP) to protonated merocyanine (MC-H+). This form is hydrophilic allowing the hydrogel to swell. Exposure to white light promotes isomerisation of MC-H+ form to the less hydrophilic SP form, triggering the hydrogel to contract.

**Micro-patterned hydrogels**

Hydrogel microstructures covalently attached to glass substrates were photo-polymerised through micro-patterned masks using white light.

- Circular masks of 1mm diameter.
- Hydrogel height: 60μm.
- Polymerisation time: 10-20 seconds.

**Results**

The polymerisation solvent has been shown to directly influence the morphology of the hydrogel, by producing highly porous hydrogels of different pore sizes. This has an impact on the diffusion path length for water molecules moving in/out of the hydrogel, thus enabling the swelling and shrinking kinetics of the hydrogel to be tuned.

**Hydrogel valve application**

Hydrogel microstructures were photo-polymerised in-situ inside PDMS/glass microfluidic channels. Exposure to white light causes the valves to contract thus opening the channel, allowing fluid to flow. The opposite was seen when the valve was kept in the dark. These hydrogels can be successfully used as photo-controlled valves in microfluidic systems for repeatable ON/OFF flow modulation in neutral environments.

**Conclusions**

Integration of photo-responsive hydrogels in microfluidic systems could provide new routes towards the fabrication of smart, externally controlled systems.

---

*This project has been funded by Science Foundation Ireland under the Insight initiative, grant SFI/12/RC/2289.*