pH-induced shrinking and swelling of hydrogels based on copolymers of acrylic acid and acrylamide

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Hydrogels are three-dimensional polymeric networks that can absorb and retain large quantities of water in relation to their physical size. By incorporating stimuli-responsive units into the gel structure, hydrogel materials can be actuated by external stimuli such as photo, thermal, electro and chemical (e.g. pH).

In this paper, we demonstrate that the size and volume of a pH sensitive hydrogel based on acrylic acid (AA) and acrylamide (Am) can change when exposed to different pH environments. The pH responsive hydrogels that were developed used copolymers of AA and Am in different molar ratios 30:70, 50:50 and 70:30, respectively.

At a pH value above the pK_a of AA (pH > 4.5) the AA dissociates to the more hydrophilic acrylate anion (A^-) triggering swelling of the hydrogel. In contrast, at pH < 4.5, the hydrogel contracts due to the formation of the less hydrophilic AA form in the polymer backbone, which triggers the release of water from the gel causing it to physically contract.

The hydrogel samples were photo-polymerised using a photo-mask with 1mm diameter circles exposed. Each of the hydrogel samples was placed in pH solutions varying from pH 1-14. The hydrogels with 50:50 molar ratio of Am:AA in the polymer backbone produced hydrogels with the highest relative pH response when compared with the other molar ratios, having a large diameter increase from pH 2 (~0.57mm) to pH 10 (~3.27mm). Successive changes of the solution pH showed that the pH-induced actuation is a reversible process with no detectable hysteresis.