Bipedal Hydrogels Walking in the Light

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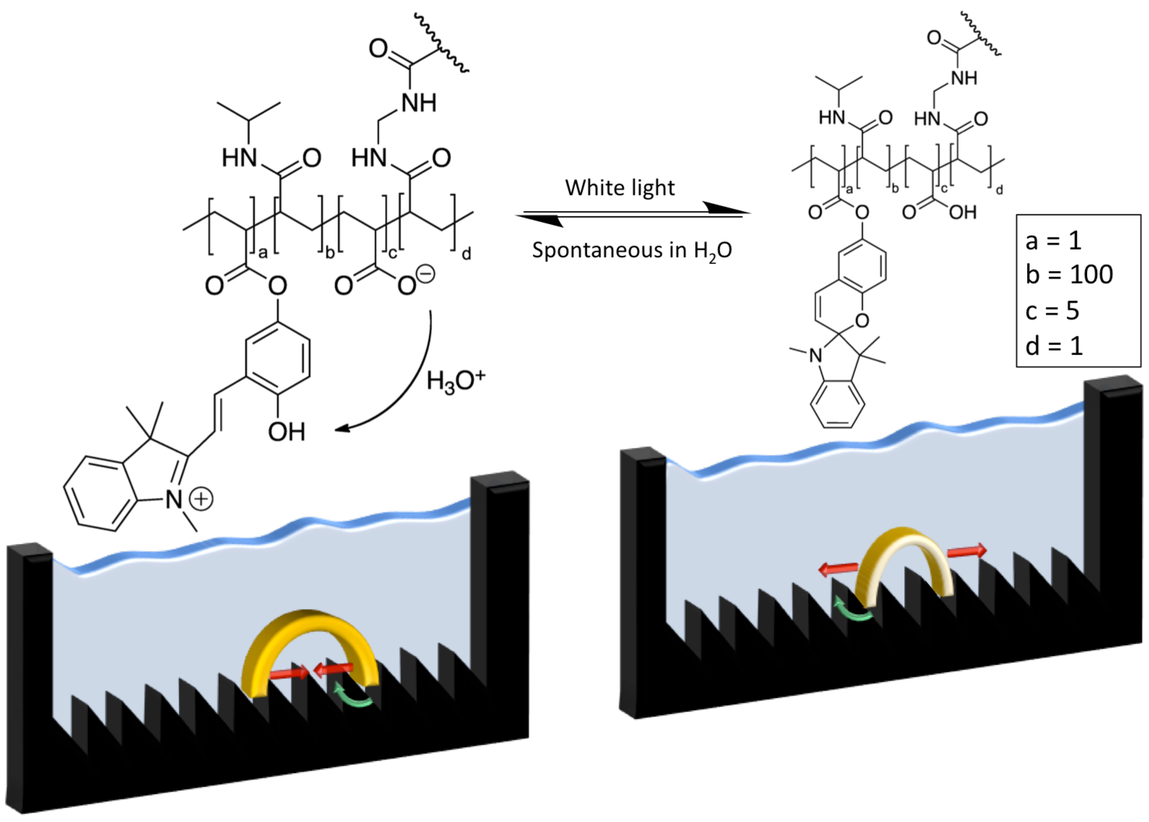
Introduction

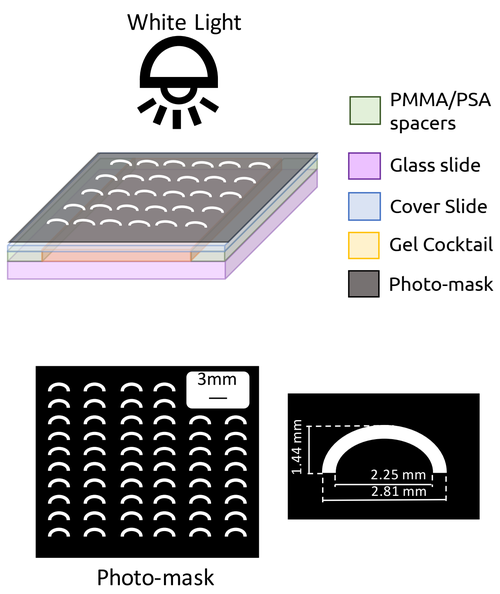
Here we report on the synthesis of a bipedal hydrogel walker, based on *N*-isopropylacrylamide-*co*-acrylated spiropyran-*co*-acrylic acid p(NIPAAm-*co*-SP-*co*-AA). When placed onto a ratcheted surface, the actuation of the bipedal gel produces a walking motion by taking a series of steps in a given direction, determined by the design of the ratchet scaffold.

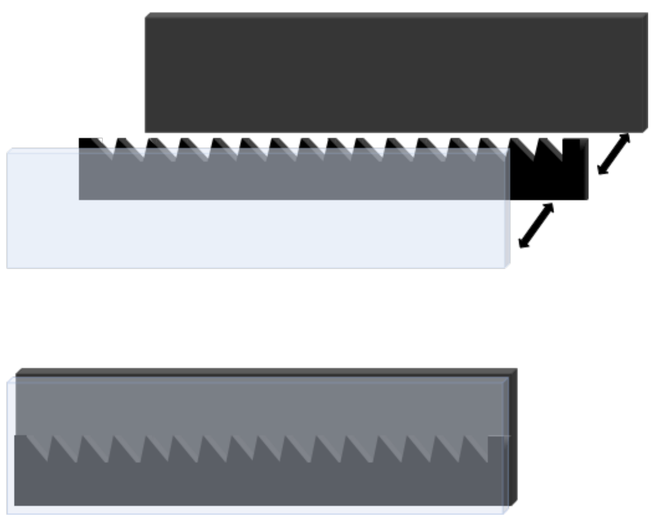


In the dark, SP is protonated to the hydrophilic MC-H$^+$ form by the AA comonomer. Under these conditions, the gel expands and shows a yellow colour, specific to the MC-H$^+$ form. When the hydrogels are exposed to white light, the MC-H$^+$ is switched back to the SP form. The SP form is less hydrophilic, causing the polymer chains to collapse and expel water from the gel to the external environment

Walker Fabrication

The arc-shaped hydrogel walkers were prepared using a home-made cell. The cell was filled with monomer solution and exposed to white light through the mask. The polymerisation time was varied from 40 to 50second, in order to compare polymerisation times with walker functionality.





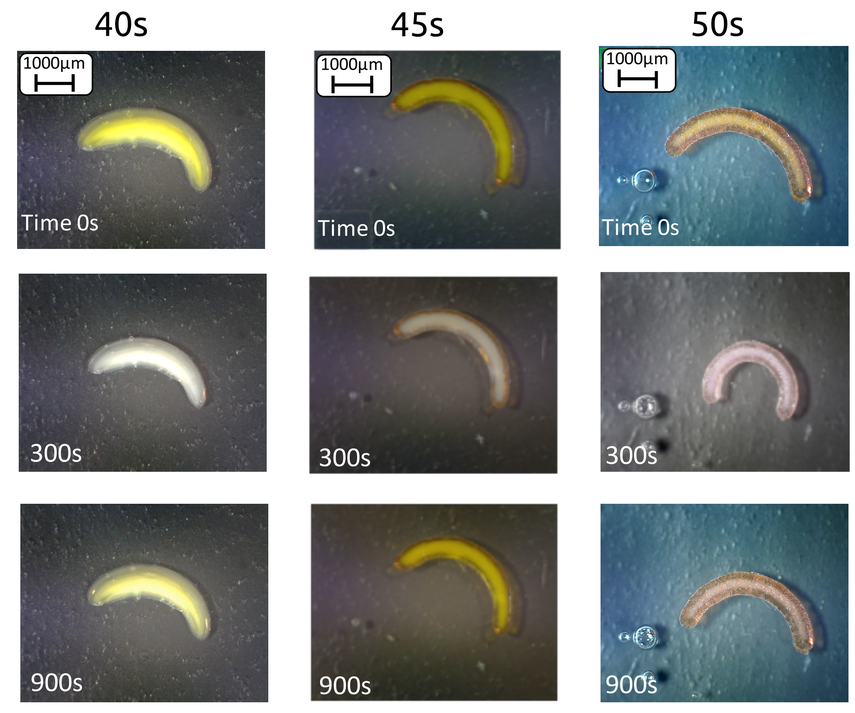
Ratchet Fabrication

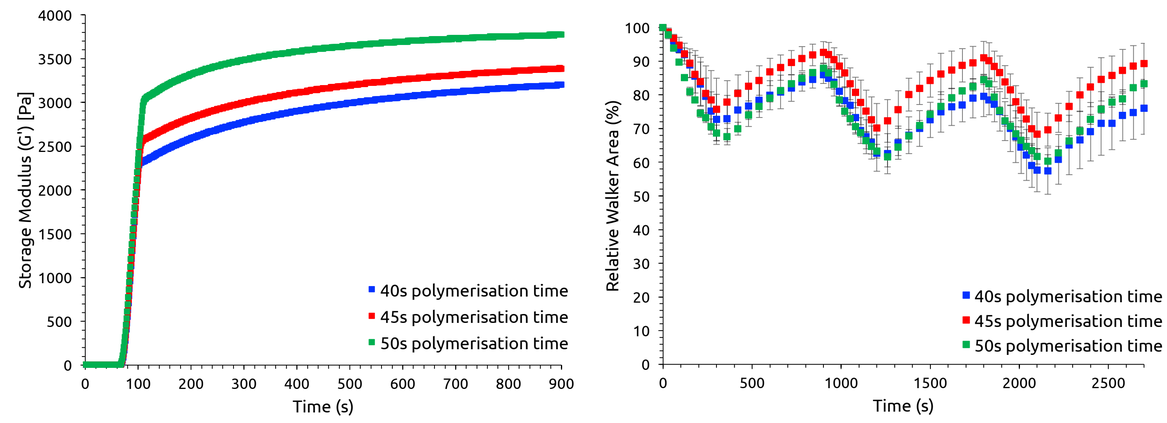
The ratcheted layers were designed using AutoCAD and cut out of black PMMA sheets using a CO_2 laser ablation system. For the assembly of the ratcheted channel, a back PMMA layer, the ratchet layer and a glass slide were attached.

Results

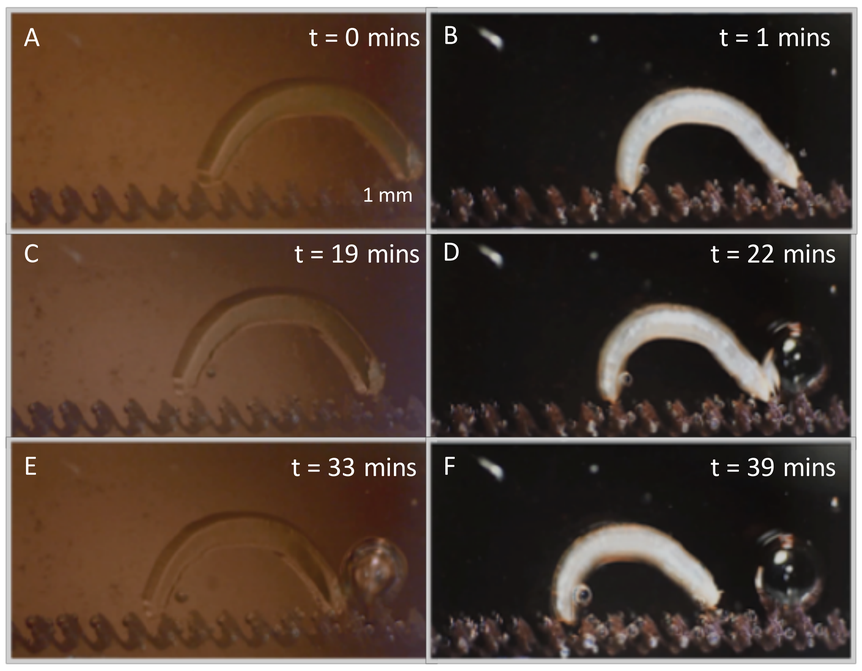
The hydrogel walkers were polymerised under different polymerisation times, to examine the effect on the relative area changes during white light/dark cycles. The 50 second polymerised gels showed the greatest degree of swelling/contraction, improved actuation repeatability and dramatic change over the leg distance during actuation cycles.

Polymerisation Times





The 50 second polymerised bipedal gels were investigated for their ability to walk on a ratcheted surface when submerged in water.



Conclusion

In conclusion, we have synthesised a hydrogel walker based on p(NIPAAm-co-SP-co-AA), which is able to achieve unidirectional walking when submerged in water and placed onto a ratcheted surface. These results show that photo-responsive hydrogels make promising candidates for the development of biomimetic soft robots, which could exploit their reversible and repeatable actuation.

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