Additive Manufacturing of Ionically Conductive Polymer Membrane Artificial Muscles

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Abstract:

While Electroactive Polymers or EAPs are a rapidly growing field of research interest, there are difficulties in the integration of additive manufacturing techniques to produce ionic EAP complex objects. Other research groups, such as Carrico et al (2015), make use of extrusion based additive manufacturing techniques. However, light based additive manufacturing of ionic EAPs remains a novel and exciting approach. Our research has shown promising results in the vat-based additive manufacturing of these ionic EAP membrane actuators. By combining vat-based photopolymerization techniques and synthetic polymer chemistry a novel ionomeric polymer network was synthesized from a liquid resin. Under photo-polymerisation this novel resin forms and ionomeric polymer membrane material that undergoes cation exchange from a cation-chloride salt solution.

The coating of precious metal electrodes via surficial adsorption of the metal salt and corresponding reduction to nanoparticles can be utilised to fabricate ionic EAP actuators. After which these ionomeric polymer networks facilitate cation motion through the polymer network under an electric field

This novel photo-resin has shown printability in a commercially available Digital Light Processing (DLP) 3D printer. These 3D printed Ionic EAP actuators were also controllably actuated via a sinusoidal waveform from a signal generator. 3D printed Ionic EAP actuators displayed a displacement range of up to 3mm using a frequency of 0.01 Hz and an amplitude of 3 V. This research has shown that by merging the fields of polymer chemistry and materials engineering, newfound understanding in the additive manufacturing of ionomeric membrane materials can be attained. Therefore, further advancing the fields of soft robotics, soft sensors and membranology.

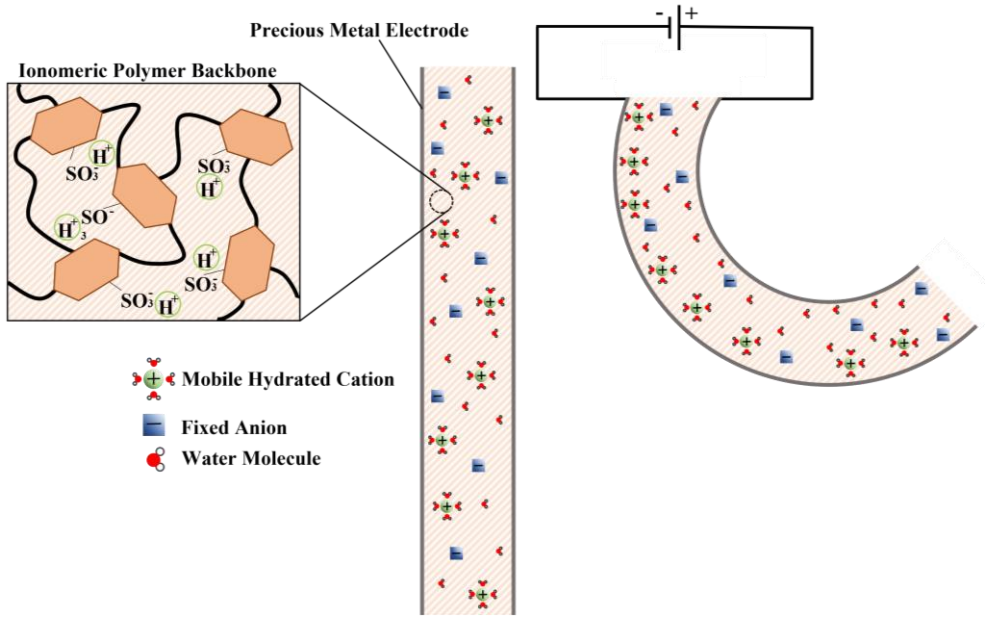

Figure 1: Schematic of the actuation mechanism of the IPMC membrane materials. Reproduced from K. E. Engel, P. A. Kilmartin, O. Diegel, *Polymer Chemistry* **2022**.

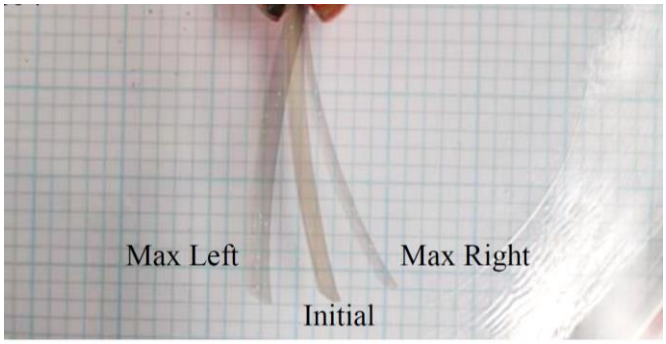

Figure 2. Reversable actuation of a DLP fabricated cation conductor polymer membrane

Keywords: Additive Manufacturing, Ionic Electro-active Polymers, Actuators, Artificial Muscles, Ionic Conductors