Field Concentration in Hydrogel-Elastomer Devices

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Dielectric elastomer actuators (DEAs) are promising for many applications owning to their remarkable merits such as large deformation, fast response, high efficiency, low cost, and light weight. Recently, hydrogels have been used to activate DEAs. In these devices, hydrogels serve as the stretchable transparent electrodes and elastomers serve as the stretchable transparent dielectrics. However, the emerging of such hydrogel-elastomer devices has posed many challenges due to the distinct nature of hydrogel and elastomer. Intensive researches are taking place to learn more about hydrogel-elastomer systems in order to meet the challenges.

In this work, we study field concentration and its influences on hydrogel-elastomer devices. We fabricate a DEA by using polyacrylamide (PAAm) hydrogels containing lithium chloride (LiCl) as the electrodes and polydimethylsiloxane elastomer (PDMS) as the dielectrics. We find that most devices fail on the side of electrodes where field concentration is the strongest. We observe salting out phenomenon and local temperature increase (**Fig. 1**), as well as plasma during the experiments. We hypothesize that electric field concentrates at the edges of hydrogels, causing the surrounding air to break down. Breakdown of air produces plasma that heats up hydrogels thus leading to the salting out. We note that the breakdown of air helps dissipate energy into the air and protects the DEAs. In the end, to show that the field concentration can be useful, we demonstrate two proof-of-concept devices by taking the advantages of field concentration.

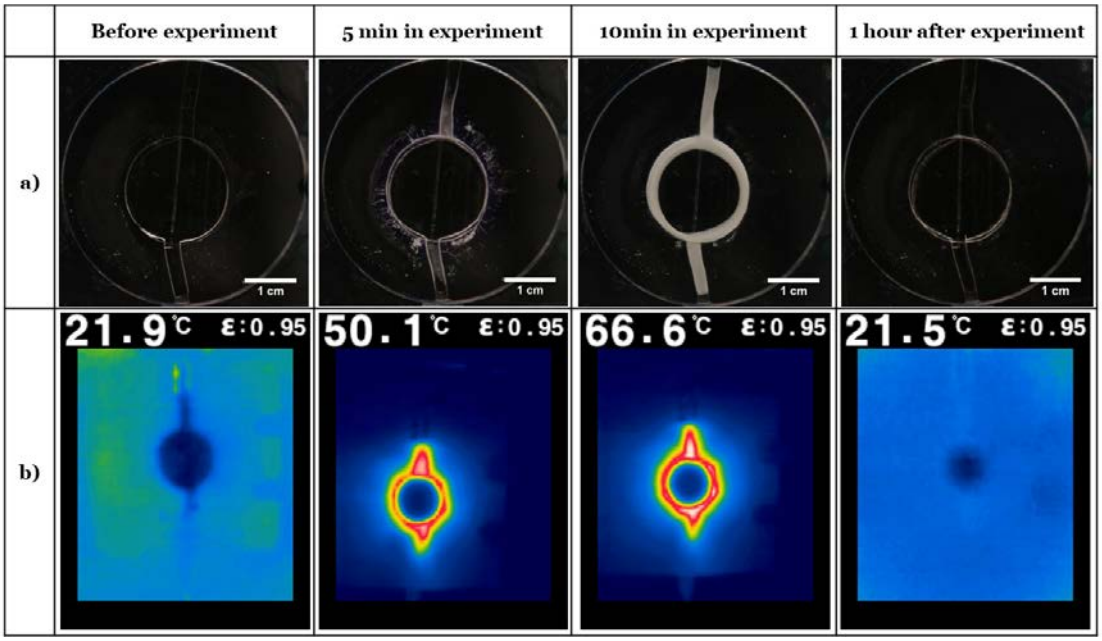

Figure 1. Salting out and localized temperature increase. a) Digital images showing the salting out evolving process of a DEA driven by PAAm hydrogels containing 8 mol/L LiCl under applied voltage that is 80% of the break down voltage with frequency fixed at 1 kHz. b) Corresponding thermal images of the DEA before experiment, 5 minutes in experiment, 10 minutes in experiment and 1 hour after experiment. Local temperature increase is observed. The highest local temperature reaches 66.6 ℃ after 10 minutes of experiment.