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Field Concentration in Hydrogel-Elastomer Devices

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Dielectric elastomer actuators (DEAs) are promising for many applications owing 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 this work, we study field concentration and its influences on hydrogel-elastomer devices. We fabricate a DEA by using polyacrylamide hydrogels containing lithium chloride as the electrodes and polydimethylsiloxane elastomer as the dielectrics. We find that most devices fail on the side of electrode, where field concentration is the strongest. We observe salting out phenomenon and local temperature increase, 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. Which 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.