ELECTRO-RESPONSIVE HYDROGEL FILMS AND BEADS: USING ELECTRIC FIELDS TO BREAK OR STICK GELS

Srinivasa R. Raghavan, Department of Chemical & Biomolecular Engineering, University of Maryland, USA
sraghava@umd.edu

Hydrogels based on water-soluble synthetic or biopolymers are a common class of soft materials. They can be easily prepared either by covalent crosslinking (free-radical polymerization) or by physical crosslinking, e.g., via ionic or hydrogen-bonds. Numerous studies have been published on hydrogels with responsive properties, such as the ability to swell, shrink, or change shape in response to external stimuli such as temperature, pH, light or magnetic fields. Electric fields are another type of stimulus, but hydrogels are not commonly thought to be electrically responsive, unless they can conduct electricity (e.g., if the polymer backbone is a conductive polymer or if the material is a nanocomposite with conductive particles).

This talk will present studies from our lab showing a rich variety of behavior induced by electric fields on polyelectrolyte hydrogels, all of which are nonconductive. First, we study 'electro-adhesion'. When a film or bead of a cationic gel is contacted for just a few seconds with a film or bead of an anionic gel under a DC voltage of about 10 V, the two form a strong adhesive bond. When the polarity is reversed, the phenomenon is reversed, i.e., the gels can be easily detached. Most interestingly, the same phenomenon also works with certain animal tissues. That is, many tissues are anionic, and we show that cationic gels can be electro-adhered to them. We thereby demonstrate that cuts or tears in tissues can be electro-sealed using gels. As an extreme case, two severed pieces of a tube can be stuck back together using a gel strip that spans both cut segments; this is thereby an example of a needleless suture using only hydrogels and an electric field.

Next, we study hydrogel beads and capsules made from common biopolymers like alginate and chitosan using ionic complexation. When these beads are placed in aqueous solution and subjected to an electric field of about 10 V/cm, the particles deform within a minute and then burst within about 5 min. Such deformation and rupture can be used to release solutes loaded inside these structures. Alternately, the deformation of the beads can be used to create electrically actuatable valves, where the flow of a liquid occurs only when the bead blocking the flow is deformed, and thereby dislodged. These kinds of electro-responsive phenomena could find application in wearable device technologies. Electric fields are attractive because they can be easily applied even from remote locations, and possibly using wireless signals.