From electroactive and electroresponsive hydrogel materials to soft electrochemical actuators

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Polymeric hydrogels are a class of soft materials that consist of a hydrophilic polymer network filled with an aqueous solution. The presence of a polymer network immobilizes the solvent, causing it to lose its fluidity. On the macroscale, the three-dimensional gel network is responsible for preserving the hydrogel's shape, storing mechanical energy, and participating in deformation processes, while on the microscale, diffusional processes of small molecules occur similarly to those in liquids.

One particularly interesting property of hydrogels is their ability to undergo the volume phase transition (VPT). This process involves the reversible swelling or shrinking of the gel, with volume changes reaching up to 1000 times, resulting in significant alterations in its properties. VPT can be triggered by minor changes in environmental conditions, such as temperature, pH, ionic strength, the presence of specific ions or molecules, and electric or magnetic fields. [1,2]

Recently, a new class of smart hydrogels has emerged, exhibiting shape and swelling transitions driven by redox processes.[3] The integration of electrosensitive hydrogels with conductive surfaces offers promising opportunities for developing electrochemical actuators, including artificial muscles, valves, and drug delivery systems (Fig. 1). However, these materials face challenges such as slow reaction kinetics, limited mechanical stability, and incomplete reversibility, which hinder their practical use in soft electrochemical devices. Strategies to overcome these limitations, along with examples of synthesis and applications of electrosensitive thin layers and microgels attached to conductive surfaces, will be discussed. [4-7]

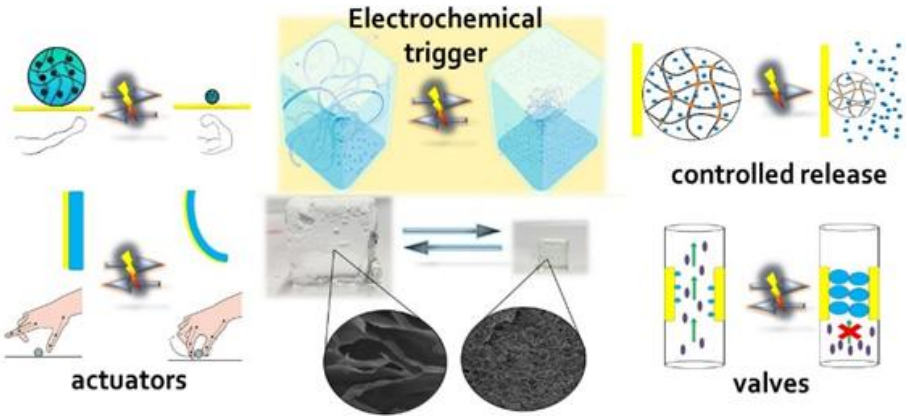

Fig. 1 Volume phase transition schematic and examples of applications of electrosensitive gels.

Literature:
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