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Experimental and Finite Element Analysis of Large Deformation Characteristics of Magnetic Responsive Hydrogel Nanocomposites Membranes

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Abstract : Stimuli-responsive hydrogel nanocomposite membranes are gaining significant attention these days due to their potential applications in various engineering fields. For example, sensors, soft actuators, drug delivery, remote controlled therapy, water treatment, shape morphing, and magnetic refrigeration are few advanced applications of hydrogel nanocomposite membranes. In this work, hydrogel nanocomposite membranes are synthesized by embedding nanometer-sized (diameter - 300 nm) Fe_3O_4 magnetic particles into the polyvinyl alcohol (PVA) polymer. To understand the large deformation characteristics of these membranes, a well-known experimental method ball indentation technique is used. Different designing parameters such as membrane thickness, the concentration of magnetic particles and ball diameter on the viscoelastic properties are studied. All the experiments are carried out without and with a static magnetic field. Finite element simulations are carried out to validate the experimental results. It is observed, the creep response decreases and Young’s modulus increases as the thickness and concentration of magnetic particles increases. Image analysis revealed the hydrogel membranes are undergone global deformation for ball diameter 18 mm and local deformation when the diameter decreases from 18 mm to 0.5 mm.

Keywords : ball indentation, hydrogel membranes, nanocomposites, Young's modulus
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