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Tuning Nanomechanical Properties of Stimuli-Responsive Hydrogel Nanocomposite Thin Films for Biomedical Applications

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Abstract : The design of stimuli-responsive hydrogel nanocomposite thin films is gaining significant attention in these days due to its wide variety of applications. Soft microrobots, drug delivery, biosensors, regenerative medicine, bacterial adhesion, energy storage and wound dressing are few advanced applications in different fields. In this research work, the nanomechanical properties of composite thin films of 20 microns were tuned by applying homogeneous external DC, and AC magnetic fields of magnitudes 0.05 T and 0.1 T. Polyvinyl alcohol (PVA) used as a matrix material and elliptical hematite nanoparticles (ratio of the length of the major axis to the length of the minor axis is 140.59 ± 1.072 nm/52.84 ± 1.072 nm) used as filler materials to prepare the nanocomposite thin films. Both quasi-static nanoindentation, Nano Dynamic Mechanical Analysis (Nano-DMA) tests were performed to characterize the viscoelastic properties of PVA, PVA+Hematite (0.1% wt, 2% wt and 4% wt) nanocomposites. Different properties such as storage modulus, loss modulus, hardness, and Er/H were carefully analyzed. The increase in storage modulus, hardness, Er/H and a decrease in loss modulus were observed with increasing concentration and DC magnetic field followed by AC magnetic field. Contact angle and ATR-FTIR experiments were conducted to understand the molecular mechanisms such as hydrogen bond formation, crosslinking density, and particle-particle interactions. This systematic study is helpful in design and modeling of magnetic responsive hydrogel nanocomposite thin films for biomedical applications.

Keywords : hematite, hydrogel, nanoindentation, nano-DMA
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