Crosslinked Zwitterionic Hydrogel with Integrated Functionality for Health Management and Monitoring

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Abstract: Conductive hydrogels have emerged as a promising material for health treatment and monitoring applications, however, the integration of cryoprotective properties with persistent antimicrobial functionality in hydrogel systems poses a formidable scientific challenge. We synthesized composite hydrogels by copolymerizing [2-(methacryloxy)ethyl]-dimethyl-(3-sulfopropyl) ammonium hydroxide (SBMA), N-[tris(hydroxymethyl)methyl]acrylamide (THMA), and acrylamide (AM) using one-pot method. The hydrogen bonding and dipole–dipole interactions in the network synergize to endow the composite hydrogels with good mechanical, ionic conductivity, and adhesion properties. The composite hydrogels showed robust mechanical properties (9.7±0.3 MPa), impressive adhesion (14.3±2.5 kPa), outstanding ionic conductivity (1.58 ± 0.1 S/m) and a gauge factor (GF = 1.85), which could be ascribe to effective ion transport within the polymer skeleton. Furthermore, the hydrogel demonstrates excellent biocompatibility and notable hemostatic properties, achieving rapid hemostasis in mouse liver models within 34 ± 4.36 s. Interestingly, the hydrogel proficiently monitors wound temperature, allowing for precise tracking of the healing process. In addition, another zwitterionic (STAPG) hydrogel with excellent frost resistance, conductivity, adhesion, and antibacterial properties was successfully prepared by incorporating phytic acid (PA) into a polymer reaction based on SBMA/THMA/AM using glycerol (GL)-water as a binary solvent. By leveraging PA molecules to inhibit ice crystal growth without compromising flexibility (700%), conductivity (3.60 S/m), and adhesion (23.11 kPa), the health monitoring characteristics of the STAPG wearable sensor at low temperatures were effectively achieved. Significantly, even after being frozen at -55 ºC for 24 h, STAPG still exhibited a conductivity of 0.51 S/m. As a wearable sensor, the STAPG hydrogel can still provide stable and accurate monitoring of human limb behavior and electrocardiogram (ECG) changes after being stored at -45 ºC for 14 days. This may offer a promising application prospect for designing sensors suitable for health treatment and monitoring under harsh temperature conditions.