Interface Modification of TPU-Reinforced Polymer-Based Silica Aerogels with Hierarchal Multimodal Porosity and Extremely High Surface Area

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ABSTRACT

A nanocomposite strategy for the selective inclusion of viscoelastic polymerized silica precursor such as polyvinyltrimethoxysilane (PVTMS) into electrospun thermoplastic polyurethane (TPU) fiber is demonstrated to create effective stress-transfer pathways within three-dimensional (3-D) aerogel composites with thermal insulation characteristics. Inspired by the bone architecture in the human body, with large amounts of hard segments and small amounts of soft segments, the 3-D interconnected TPU-embedded PVTMS-based composite (PVTMS/TPU) aerogel achieves synergistic strengthening in fibers'

orientation direction. The sol-gel approach has been taken in this study to initiate network formation throughout the PVTMS chains to form a 3-D network. The resulting PVTMS/TPU composite aerogel exhibited complete structural deformations and high compressive mechanical strength (17.68 MPa) while showing exceptional thermal stability. The obtained structure offers a full hierarchal multimodal porosity and extremely high surface area due to a special approach taken in this study in designing the interface between electrospun TPU fibers and PVTM chains. Owing to the combination of excellent mechanical and thermal stability properties, the PVTMS/TPU composite aerogel can be used as a thermal insulation material for strain sensors, showing very short response and load bearing with extreme durability. Such bio-inspired architecture opens the door to fabricating new 3-D-multifunctional and mechanically durable nanocomposite aerogels for flexible devices.