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Multiscale Manufacturing Strategy for Tough and Strong Hierarchical Organ-hydrogels

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Abstract

Conductive hydrogels have emerged as versatile materials for flexible electronics and soft robotics, owning to their great stretchability and sensing capability. However, most hydrogels still encounter difficulties in meeting the demanding requirements of real-life applications due to the long-standing challenge of reproducing the excellent mechanical properties and multifunctionalities observed in natural soft tissues. For example, mammalian skin exhibits excellent tearing resistance and flexibility due to an intricate hierarchical structure of collagen fibers and fibrils. Similarly, the hierarchical organization of tendons endows them with high strength and flexibility, allowing them to endure mechanical stress and execute contractions and relaxations. Inspired by the remarkable properties of bio-soft tissues, we have developed various multiscale manufacturing strategies to produce strong and tough conductive organo-hydrogels with hierarchical structures. This involves a freeze-casting solution substitution strategy, a facile combining strategy of self-assembly and stretch training, and a self-assembly-induced bridge cross-linking strategy. The strength of our materials has increased from 6.5 MPa, 20.78 MPa, and 54.8 MPa, while the toughness has also increased from 58.9 MJ/m3, 153.97 MJ/m3, to 260 MJ/m3, owning to multiple strengthening and toughening mechanisms at different scales. We have demonstrated the potential applications of our materials for monitoring sport behaviours in soccer training, non-contact speaking detection, and controlling artificial arms for grabbing objects, etc.

Biography

Dr. Wei Zhai is an Assistant Professor in the Department of Mechanical Engineering at the National University of Singapore (NUS). She received her Ph.D. from the University of Cambridge in 2015 and worked as a Research Scientist at the Singapore Institute of Manufacturing Technology, A*STAR, until 2019. Her research group is currently working on 4Ms – Multiscale Manufacturing of Multifunctional Materials, including lattice structures, hydrogels, and composites. Since joining NUS in 2019, her team has published articles in journals including Science Advances, Advanced Materials, Materials Today, Advanced Functional Materials, Acta Materialia, ACS Nano, etc. She also serves as the Editor for Materials & Design and Section Editor for Materials Today Communications.