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Design tough and resilient hydrogels for artificial cartilage and heart valve

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ABSTRACT

As swollen polymer networks in water, hydrogels are usually brittle. However, hydrogels with high toughness play critical roles in many plant and animal tissues as well as in diverse applications such as tissue regeneration. Here, we demonstrate that the general principle for the design of tough hydrogels is to implement mechanisms to dissipate substantial mechanical energy but still maintain high elasticity of hydrogels. A matrix that combines various mechanisms is constructed for the first time to guide the design of next-generation tough hydrogels. We highlight that a particularly promising strategy for the design is to implement multiple mechanisms across multiple length scales into nano-, micro-, meso-, and macrostructures of hydrogels. Thereafter, we use the multiscale multimechanism approach to design a tough and resilient hydrogel capable of 3D printing and cell encapsulation. A multiscale model is further developed to quantitatively explain the experimental results and guide the design of future hydrogels.