Mechanically Robust Hydrogels Emulating Mechanical Properties of Stiff Load-Bearing Tissues

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To replace a damaged hydrogel or support/monitor its normal operation in the body, developing artificial hydrogels with similar mechanical properties to those found in nature is required. While natural hydrogels have a stiffness ranging from a few Pa to GPa, the existing artificial hydrogel is too soft to be applicable for stiff load-bearing tissues. Herein, we design hydrogels based on two approaches to achieve a combination of strength and stiffness of MPa-to-GPa and toughness, along with a simple reconstructing method. The first approach is to apply a design principle and fracture mechanism of natural composite material into a hydrogel. Through the reconstructing, tough polymeric matrices and horizontally aligned stiff ceramic microplatelets compose a mechanically robust hydrogel, where an effective load transfer from the matrix to the platelet and fracture resistance through platelet pull-out are observed. The second approach is to apply a generic principle of polymer chemistry to a hydrogel. Significant densification of polymer chains within polymer networks, implemented through the suggested method, produces a hydrogel with remarkably high strength and stiffness.