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Rationally designing the mechanical properties of protein hydrogels

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Naturally occurring biomaterials possess diverse mechanical properties, which are critical to their unique biological functions. However, it remains challenging to rationally control the mechanical properties of synthetic biomaterials. Here we provide a bottom-up approach to rationally design the mechanical properties of protein-based hydrogels. We first use atomic fore microscope (AFM) based single-molecule force spectroscopy to characterize the mechanical stability of individual protein building blocks. We then rationally design the mechanical properties of hydrogels by selecting different combination of protein building blocks of known mechanical properties. As a proof-of-principle, we demonstrate the engineering of hydrogels of distinct extensibility and toughness. This simple combinatorial approach allows direct translation of the mechanical properties of proteins from the single molecule level to the macroscopic level and represents an important step towards rationally designing the mechanical properties of biomaterials.