Bioinspired Nanocomposites of Resilin and Cellulose Whiskers
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Introduction
Resilin is a polymeric rubber-like protein secreted by insects to specialized cuticle regions, in areas where high resilience and low stiffness are required. Resilin binds to the cuticle polysaccharide chitin via a chitin binding domain and is further polymerized through oxidation of the tyrosine residues resulting in the formation of dityrosine bridges and assembly of a high-performance protein-carbohydrate composite material [1]. Plant cell walls are protein-polysaccharide composites exhibit extraordinary strength exemplified by their ability to carry the huge mass of some forest trees. Inspired by the remarkable mechanical properties of insect cuticles and plant cell walls we hypothesized that novel composites of resilin and cellulose will display useful mechanical properties combining strength and elasticity.

Materials and Methods
Recombinant resilin fused to cellulose binding domain (CBD) was expressed and purified from E. coli. Cellulose Whisks (CW) were prepared by H₂SO₄ hydrolysis of micro crystalline cellulose followed by repeated washing cycles with H₂O and sonication resulting in honey like liquid crystal suspensions. CW suspensions were subsequently cast into aluminium molds and lyophilized resulting in stiff and plastic highly porous sponges (Fig. 1A). Resilin-CBD solutions were embedded into the sponges and polymerized either by [Ru(bpy)₃]²⁺/ammonium per-sulfate system or by Fe/H₂O₂ photo-Fenton system that we have recently adopted for this protein.

Results
Composite sponges of resilin and CW resulted in dramatic alteration in mechanical behaviour including high elasticity, resilience and resistance to repeated cycles of mechanical stress (Fig. 1B). In addition we report the successful polymerization of resilin by photo-Fenton reaction resulting in elastic, rubber-like, hydrogels (Fig. 1C)

Discussion and Conclusions
Tendons, ligaments and spine related diseases are among the most common health problems in adult populations. In spite of impressive advances in regeneration, these tissues require biomaterial scaffolds that can handle high mechanical strength with durability. Resilin-CBD and cellulose nano-composite systems display high strength and elasticity and therefore offer potential utility for studies of regeneration of these challenging tissues.

References

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