**Title:** Modeling and Experiment to Predict Protein Biomaterial Performance

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Tailored materials with tunable properties are crucial for applications as biomaterials, for drug delivery and as functional coatings. An emerging paradigm in designing such materials is the construction of hierarchical assemblies of simple building blocks into complex architectures with superior properties. Here we review results in designing genetically programmable and processable biomaterials based on silk. In its natural role it serves as a versatile protein fiber with hierarchical organization to provide structural support, prey procurement or protection of eggs. Through an abstraction of knowledge from the physical system, silk, to a mathematical model using category theory, we describe how the mechanism of spinning fibers from proteins can be translated into engineered biomaterials. We report modeling and experiment of the assembly process in a microfluidic channel, which serves to elucidate the rules that govern the construction of the system by closely integrating modeling and experiment at different length- and time-scales. Our study provides a strategy to design synthetic silk-like protein sequences for optimal shear-flow induced fiber assembly, as well as insights into the natural spider silk spinning mechanism that can also be applied to other biomaterials.

FUNDING: NIH U01EB014976