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Portale, Giuseppe

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VIEWS & COMMENTS

Novel engineered proteins for mechanomaterials

Giuseppe Portale (✉)

Zernike Institute for Advanced Materials, University of Groningen, 9747 AG, Groningen, the Netherlands

In stark contrast to traditional polymer fibers such as nylon and Kevlar, biomaterials [1], e.g., spider silks and silkworms, exhibit extraordinary mechanical behaviors due to the combination of high strength and high toughness. Fan et al. for the first time fabricated one type of mechanically strong and fluorescent biological fibers by feeding silkworm with carbon nanodots. There is ~50% improvement in the fibers' strength when compared to regular silks [2]. Moreover, biomimetic protein fibers from the recombination of spider silk proteins have been studied extensively. However, in those works [3], the hierarchical structure of recombinant spidroins cannot be preserved well or some functional domains are absent. Those shortcomings led to the recombinant protein fibers with weak mechanical properties when compared to natural spider silks, which thus limit their technical applications. At present, the development of new types of alternative structural proteins for the fabrication of high-performance biological fibers is a hot issue.

Recently, Prof. Kai Liu and his colleagues from Tsinghua University and Chinese Academy of Sciences reported a series of new structural proteins and their fascinating mechanical performance (Fig. 1). Learning from nature, they genetically engineered a novel chimeric protein containing the sequences of a cationic ELP and a SRT protein [4]. High-strength and high-toughness in the fibers were realized by the introduction of a wet spinning technology. Remarkably, the chimeric protein fibers exhibit a breaking strength up to ~630 MPa and the corresponding toughness as high as ~130 MJ/m^3, making them superior to many recombinant spider silks and even comparable to some native spider types. Therefore, this work provides a novel concept for the fabrication of robust biological fibers through the development of new types of structural chimeric proteins.

Moreover, inspired by the widely available structural proteins in nature, this group demonstrated an efficient microfluidic spinning technique to fabricate globular bovine serum albumin (BSA) protein-based fibers [5]. In this work, the BSA fibers exhibit a high toughness of ~143 MJ/m^3, which is comparable to the dragline spider silks (≈150 MJ/m^3). This is the first example for robust

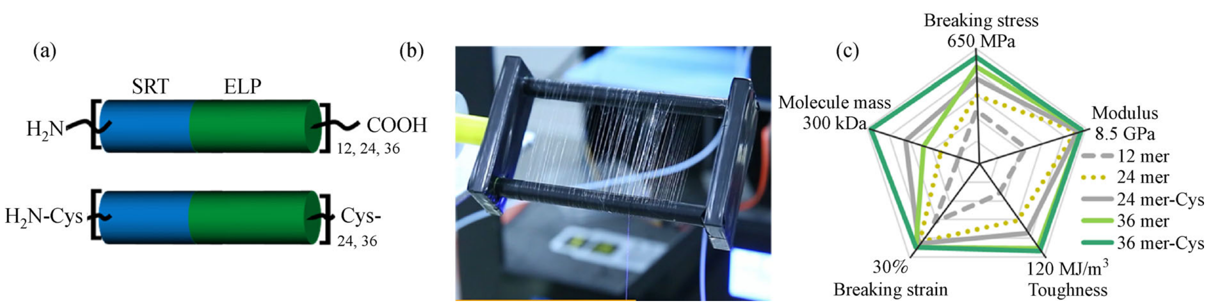

Fig. 1 (a and b) Design and fiber production based on the engineered chimeric proteins, which consist of a squid ring teeth (SRT) segment and a cationic elastin-like polypeptide (ELP) sequence [4]; (c) spider chart representing the mechanical performance evolution of the chimeric protein fibers.

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E-mail: g.portale@rug.nl

biological fiber production on the basis of non-fibrous proteins. Besides the pristine proteins, they realized another fiber which is assembled with engineered negatively-charged proteins and cationic surfactants through supramolecular interactions [6]. Particularly, by genetically tuning charge density of the protein components, the mechanical performance of the materials can be actively programmed in the range of one order of magnitude.

Those works will provide a new avenue for the design and construction of novel proteins and mechanomaterials. The developed genetically engineering technique also facilitates the mass production.

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Giuseppe Portale is a professor at the Zernike Institute for Advanced Materials, University of Groningen, the Netherlands. He received Ph.D. in chemistry from the University La Sapienza, Rome, Italy in 2006. Then he carried out postdoc research in Grenoble ESRF and then became a beamline scientist in 2009. In 2015 he joined the University of Groningen as assistant professor. His research group is focusing on the study of structure-property relationship in polymer-based materials and on the influence of processing conditions on the final structure of polymer specimens and devices.