A Synthetic Biology Approach for Making Spider Silk: From Gene Design to Fabrication

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Abstract

Nature has evolved a variety of complex yet elegant and functional biomaterials, providing a formidable source of inspiration for scientists. For example, spider dragline silk, used by spiders as the safety line and the web frame, is a fantastic protein fiber which is five times stronger by weight than steel, and three times tougher than the top quality man-made fiber Kevlar. However, natural spider silk cannot be conveniently obtained by farming spiders due to their highly territorial and aggressive behavior. Fortunately, microbial synthetic biology offers an alternative approach to biosynthesize recombinant spider silk proteins, which is rather challenging because they are very large, highly repetitive, and abundant in specific amino acids such as glycine and alanine.

In this talk, I will introduce biomimetic design and assembly of long, highly repetitive genes encoding the recombinant spider silk proteins. Used as production chassis are microbes that have been engineered with enhanced pools of precursors for silk protein production. The soluble silk proteins are then spun into insoluble, strong fibers with native-like mechanical properties in an all-aqueous process. Alternatively, the soluble silk proteins are used as substrates for fabrication into precise nanostructures by applying ion or electron beam. The diverse forms and tunable properties of spider silk-based materials and devices reflect the power of synthetic biology in modular design of protein-based polymers at the DNA, protein, and material levels.

Brief Biography

Xiaoxia Xia is currently a professor in Department of Bioengineering at Shanghai Jiao Tong University. She earned her PhD in Chemical and Biomolecular Engineering at KAIST in 2009. After three and a half years' postdoctoral training at KAIST and Tufts University, she joined Shanghai Jiao Tong University in 2012. Her current research focuses on developing synthetic biology tools and creating microbial hosts for the design and sustainable production of advanced protein-based functional materials. She has authored more than 40 papers in the prestigious journals including PNAS, Advanced Materials etc. She was awarded Eastern Scholar Professorship in 2012 and 2017, and Pujiang Talent Award in 2013. She also serves as editorial board members of ACS Biomaterials Science & Engineering, Biotechnology Journal and Metabolic Engineering Communications.

Brief CV

Xiaoxia Xia, Ph.D.

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Education:

B.S. Fermentation Engineering, Nanchang University, China, 2001

M.S. Fermentation Engineering, ECUST, China, 2004

Ph.D. Chemical & Biomolecular Engineering, KAIST, Korea, 2009

Professional Career:

2009-2010: KAIST, Korea, Postdoctoral Fellow

2010-2012: Tufts University, USA, Postdoctoral Fellow

2012-2018: Shanghai Jiao Tong University, China, Tenure-track Assistant Professor

2018-Present: Shanghai Jiao Tong University, China, Professor & Tenured Associate Professor

Research Interests:

1. Protein-based Functional Materials
2. Synthetic Biology
3. Protein Engineering

Selected publications

1. Xia XX* et al. ***Adv Mater,*** 2018, 30(30):1706983 (selected as back cover).
2. Xia XX* et al. ***Adv Mater*****,** 2018, 30(20):1705919 (selected as inside back cover).
3. Xia XX* et al. ***ACS Biomater Sci Eng,*** 2017, 3(8): 1576−1585.
4. Xia XX* et al. ***ACS Biomater Sci Eng,*** 2017, 3(3): 335−341.
5. Xia XX* et al. ***Biomacromolecules,*** 2016, 17(11): 3508−3515.
6. Xia XX* et al. ***Biomacromolecules,*** 2015, 16(11): 3704−3711.