Engineering intracellular and extracellular electron pathways for cellular energy metabolism

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Abstract

Extracellular electron transfer (EET) of exoelectrogens and electrophilic cells plays fundamental rules in cellular energy metabolism, which enabled many energy and environments applications, such as microbial electrochemical systems (MES) including microbial fuel cells, microbial electrolysis cells, microbial reverse-electrodialysis cells, and microbial electrosynthesis. MES technologies are appealing in capturing energy from organic wastes and biomass and converting these organics into value-added chemicals via inward transferred electrons as reducing equivalent. Bacterial EET that dictates the exchange of electrons between bacteria and conductive surfaces of electrodes is a major bottleneck in determining the efficiency of MES. In this talk, I will present our recent researches in engineering microbes and the interactions between microbes and electrodes to facilitate EET. Based on the molecular mechanisms of EET, i.e., direct-contact via *c*-type cytochromes, and shuttle-mediated EET, we engineered the well-established exoelectrogenic bacterium, *Shewanella oneidensis*, by synthetic biology approaches: (1) exogenous synthesis of flavins (e.g., vitamin B2) as electron shuttles in *S. oneidensis*; (2) engineering de novo NADH biosynthesis and cofactor engineering in regulation of $NADH/NAD^+$ ratio, thus increasing intracellular releasable electron pool to enhance EET; (3) To overcome the thin and poor morphology of naturally occurred biofilm, we engineered three-dimensional self-assembled electrochemically active biofilms, as highly structured microbial communities attached on electrodes, to facilitate EET efficiency; and (4) to increase the spectrum of carbon sources that can be used by exoelectrogens, we rationally engineered microbial consortia that included fermenter and exoelectrogens for simultaneously enhanced metabolism and EET. Such synthetic biology efforts in engineering EET efficiency of exoelectrogens could facilitate the applications of EET in many energy and environmental applications.

Speaker's biography

Hao Song is a professor in biochemical engineering at the Key Laboratory of Systems Bioengineering (MOE), School of Chemical Engineering and Technology, Tianjin University, China. He received Ph.D. in Chemical Engineering in 2004 from the University of Houston. After working as a postdoctoral research fellow at the University of Texas Health Science Center, and a research associate at Duke

University, he joined Nanyang Technological University at Singapore as an assistant professor in 1999. In 2013, he joined Tianjin University as a professor. His research interests include synthetic biology and metabolic engineering, in particular, microbial electrocatalysis (microbial fuel cells and microbial electrosynthesis), and microbial ecosystems, with applications in energy and drug biosynthesis. He has published over 80 papers and reviews, including *Nature Chemical Biology, Nature Communications, Angew Chemie, Energy & Environmental Science, and ACS Synthetic Biology*, etc.

Brief CV

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Education:

BS Chemistry, Nankai University, China, 1994

Ph.D. Chemical Engineering, University of Houston, USA, 2004

Professional Career:

2004-2006: University of Texas Medical School, Postdoc.

2006-2009: Duke University, Research Associate.

2009-2013: Nanyang Technological University (NTU), Singapore, Assistant Professor.

2013- date: School of Chemical Engineering and Technology, Tianjin University, Professor.

Research Interests:

1. Microbial electrocatalysis & photosynthesis of chemicals from CO_2
2. Biosynthesis of drugs

Selected publications

1. Yang S, et al. ***ACS Synthetic Biology**,* 2019, 8, 70.
2. Li, F. et al. ***Nature Communications***, 2018, 9: 3637.
3. Li, F. et al. ***ACS Synthetic Biology***, 2018, 7: 885.
4. Chen, X. et al. ***ACS Catalysis***, 2018, 8: 4429.
5. Lin, T. et al. ***Nano Energy*** 2018, 50: 639.
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7. Cao, Y et al. ***ACS Synthetic Biology***, 2017, 6: 1679.
8. Yang, Y. et al. ***ACS Catalysis***, 2015, 2: 1749.
9. Yong, Y. et al. ***Angewandte Chemie Int Ed.***, 2014, 53: 4480.
10. Song, H. et al. ***Nature Chemical Biology***, 2009, 5: 929.