

Insights: Publications

Engineering cyanobacterium with transmembrane electron transfer ability for bioelectrochemical nitrogen fixation

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Increasing attention has been paid to bioelectrochemical nitrogen fixation (e-BNF) as a promising approach to achieve the NH_3 synthesis under mild conditions. However, currently developed microbial e-BNF systems all rely on diffusible mediators to deliver redox equivalents inside the bacteria. Challenges of using diffusible mediators include toxicity, inefficient transmembrane diffusion, mediator inactivation, mediator contamination, and low energy efficiency. To date, e-BNF through transmembrane electron uptake without using diffusible electron mediators has not yet been reported. Herein, we describe a genetic strategy to engineer cyanobacterium *Synechococcus elongatus* PCC 7942 with transmembrane electron transfer (TET) ability to realize e-BNF without the addition of soluble mediators. The engineered *S. elongatus* PCC 7942 strain Se-nif with N_2 fixation activity was further transformed with an outer membrane protein cytochrome S OmcS, which contributes for the extracellular electron transfer (EET) ability of *Geobacter* sp. The engineered Senifom strain exhibited enhanced TET ability resulting in an approximately 13-fold higher NH_3 production rate than the corresponding Se-nif strain. The Faradaic efficiency of the Senifom e-BNF system was calculated to be approximately 23.3%, which is higher than the previously reported e-BNF systems. The electron pathway of the obtained extracellular electron was briefly analyzed and an extracellular electron uptake mechanism in the Senifom strain was proposed. This work demonstrates that a genetically engineered conduit can facilitate transmembrane electronic communication from the electrode to living cells, thereby providing insights into bioelectrosynthesis technology, especially the e-BNF systems and ammonium production.