Creation of High Light Stress Tolerant Green Cell Factory of Cyanobacteria

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Abstract

Cyanobacteria are promising host microorganisms for the production of industrial bio-molecules because these cells can directly fix carbon dioxide through the Calvin Benson cycle and convert it into target compounds using light energy. However, excess light, such as in summer, damages their photosystem and inhibits photosynthetic activity. Because high light (HL) stress is one of the major obstacles in the bio-production of cyanobacteria, it is highly desired to develop an HL tolerant strain for enhancing their rates of growth and production of various bio-molecules for industrial applications. Here, we obtained a HL tolerant (Tol) strain of *Synechocystis* sp. PCC6803 through an adaptive laboratory evolution (ALE). Although the growth of the parental strain almost stopped when exposed to 9,000 μmol m^{-2} s^{-1} light, no growth inhibition was observed in the Tol strain. We identified two mutations in the genome involved in HL stress tolerance in the Tol strain.

Background & Results

ALE experiment is a method used to induce tolerance against stress conditions. A serially passaged culture is performed under a stress environment with decreasing the growth rate, which allows the selection of mutants with improved growth phenotypes. In the present study, an evolved strain of *Synechocystis* sp. PCC6803 was obtained through an ALE experiment under HL stress conditions. We identified key mutations involved in the HL tolerance using whole genome sequencing and reverse engineering. Although the growth of the parental strain almost stopped when exposed to 9,000 μmol m^{-2} s^{-1} light, no growth inhibition was observed in the Tol strain. Excitation-energy flow was affected because of photosystem II damage in the parental strain under HL conditions, whereas the damage was alleviated and normal energy flow was maintained in the Tol strain. Whole genome sequence analysis and reverse engineering revealed two mutations in the genome involved in HL stress tolerance in the Tol strain.

Significance of the research and Future perspective

To create green cell factories by cyanobacteria, HL stress tolerance is a critical issue to realize a development of industrially useful bioprocesses. ALE and systems biology including omics analysis, *in silico* cell modelling and experimental analysis would provide better understanding and superior designability of photosynthetic organisms.

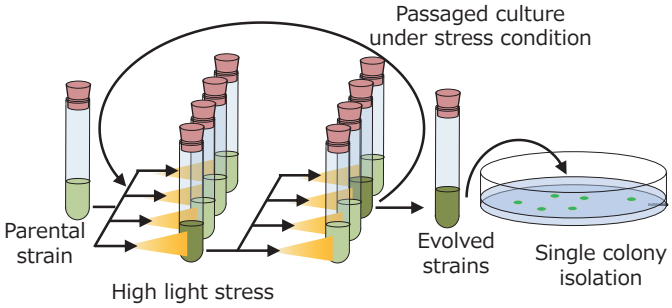

Fig. 1 Adaptive laboratory evolution under high light stress condition

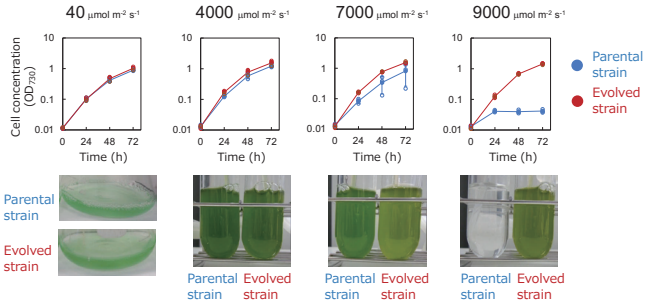

Fig. 2 Cell growth of the high light stress tolerant strain

Patent

Treatise Yoshikawa, Katsunori; Ogawa, Ken-ichi; Toya, Yoshihiro et al. Mutations in *hik26* and *slr1916* lead to high-light stress tolerance in *Synechocystis* sp. PCC6803. Communications Biology. 2021; 4(1): 343. doi: 10.1038/s42003-021-01875-y

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