Skysong Innovations
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Photosystem I-Hydrogenase Chimeras for Making H2 In Vivo

With increased demand for energy, particularly from inexpensive, renewable, and environmentally friendly sources, Hydrogen (H2) is an attractive target product, with over 60 million tons produced globally. Unfortunately, around 95% of hydrogen is produced from steam reformation of fossil fuels, contributing to rising atmospheric CO2. Reengineering fundamental processes in photosynthetic organisms can provide a platform for solar powered bio-factories that can generate high-energy product molecules, such as hydrogen. One such photosynthetic organism that shows promise in this space is algae, because of their photosynthetic capabilities and unique hydrogenase enzymes. However, despite various attempts to improve hydrogen production in algae, inactivation of hydrogenase by oxygen and competition for reductant with other processes have hindered efforts.

Researchers at Arizona State University have developed a novel process for creating engineered photosynthetic cells having altered electron flow for greater biohydrogen production. Using Chlamydomonas reinhardtii, a green algae, as an experimental system, an in vivo fusion of photosystem I (PSI) and the FeFe hydrogenase was created. Cells expressing the new PSI-hydrogenase chimera direct electron flow away from CO2 fixation towards proton reduction and biohydrogen production. This production of biohydrogen can be sustained over many days while maintaining cell viability.

These chimeras, using only the sun and water, provide the foundation for a cheap and renewable platform for creating bio-factories capable of driving difficult redox transformations.

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Potential Applications

- Production of biohydrogen (H2)

Benefits and Advantages

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- Environmentally friendly and renewable
- Efficient – 2.7 mmol H_2 h^{-1} per g dry weight of cells (could perform well even on a cloudy day)
- Long-term H_2 production – H_2 was produced continuously for 5 days at an average rate of 14.0 ±1.7 μmol H_2 h^{-1}
- Scalable and economically feasible
- O_2 evolution is constrained from PSII, preserving hydrogenase activity for sustained H_2 production over many days
- Eliminates the need to use nutrient deprivation, PSII inhibitors or mutations
- Preserves the proton pumping and ATP production carried out by the PETC, maintaining cell viability

For more information about this opportunity, please see

Kanygin et al - Energy Environ Sci - 2020

For more information about the inventor(s) and their research, please see

Dr. Redding's departmental webpage