Overcoming Nation's Roadblocks to Photosynthetic H_2 Production

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Abstract

Algal photosynthetic hydrogen (H_2) production is a potentially clean energy resource. However, there are a number of technical issues that must be addressed before algal H_2 production can become practical. In this paper, we will discuss the following six physiological problems that currently challenge researchers and investors in the field of photosynthetic H_2 production. These problems are: (1) restriction of photosynthetic H_2 production by accumulation of a proton gradient, (2) competitive inhibition of photosynthetic H_2 production by CO_2, (3) requirement for bicarbonate binding at photosystem II (PSII) for efficient photosynthetic activity, (4) competitive inhibition by O_2, (5) classic O_2 sensitivity of the hydrogenase enzyme, and (6) light-saturation phenomenon due to large antenna size. Potential solutions to overcome these roadblocks to photosynthetic H_2 production will also be presented. The solutions are based on a novel approach that has recently been developed at Oak Ridge National Laboratory (2001 ORNL Invention Disclosure). In this approach, a "designer alga" for efficient and robust H_2 production will be created by genetic insertion of hydrogenase promoter–programmed polypeptide proton channels in photosynthetic thylakoid membranes. This designer alga will be integrated also with the benefits of an O_2-tolerant hydrogenase that will be created by NREL and a smaller chlorophyll antenna size that will be created by UC Berkeley. Therefore, this ORNL effort is complementary with those of NREL and UC Berkeley, and will contribute jointly with the sister NREL and UC projects to achieving a common goal of effective photobiological H_2 production. By use of this approach, we will be able to simultaneously solve the six physiological problems for efficient and robust production of H_2 through photosynthetic water splitting.

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