Improving Photosynthesis for Hydrogen and Fuels Production
January 24, 2011
Webinar Q&A

Q: How do you induce hypoxic photosynthesis? I imagine you N-stress, to accumulate starch first?
A: Initially, sulfur deprivation was used as the tool by which to accumulate starch in the cells, and also to bring photosynthesis to a level lower than that of respiration. Since then, a number of labs in different countries have worked to devise genetic methods for achieving the same result without the attendant nutrient deprivation.

Q: What is the "mechanism" for antenna # reduction via the tla's? How do the tla's work? Do they limit chloroplast membrane biosynthesis, etc?
A: Different genes (e.g. Tla1, Tla2, Tla3) work in different ways to bring about a reduction in the chlorophyll antenna size of photosynthesis. For example, the Tla1 gene works at the nuclear DNA level, regulating aspects of the relationship of the cell (the nucleus) with the chloroplast (chlorophyll accumulation and antenna size).

Q: When studying loss of starch while making H2, how is Hydrogen production for fuel affected because of loss of starch from the cells?
A: Hydrogen production with this method will last so long as the cellular reserves of starch permit it (3-5 days). At the end of this period, cells need to go back to normal photosynthesis to replenish the starch reserves (another 3-5 days). Thus, the method permits an alternation of normal photosynthesis and hydrogen production.

Q: Will this work with artificial light, LEDS etc.?
A: It does work with artificial light, LEDs included. Most of the work in lab was done with artificial light, and I know of a couple of other labs that have used LEDs.

Q: On slide 9, what was the scheme name for photosynthesis?
A: It is called the "Z-scheme of photosynthetic electron transport". It is a potential energy diagram, showing how energy-poor electrons from water (H_2O) are elevated by the energy of sunlight to become energy-rich electrons, until they can be deposited on the electron carrier molecule known as "ferredoxin" (FD).

Q: What is the relative difference in dry weight produced per day between the wild-type and tla mutant(s)?
A: We have done this systematically only with the tla1 mutant. In our experiment, the difference in dry weight was about 160% for the tla1 strain (100% for the wild type).

Q: What determines the minimum size of antenna?
A: This is the minimum number of chlorophyll molecules that are needed for the assembly of the "core" of the photosystems. Less chlorophyll results in no photosystem assembly, which would be counterproductive.

Q: The wild and tla1, do they have different growing conditions?
A: They are subjected to exactly the same growth conditions, both in the lab and in the greenhouse.

Q: How stable is the genes of tla1?
A: Very stable. We have not lost the tla1 property in 6-years of continuous cultivation of this strain.

Q: Are there any bio hazards associated with this?
A: Green microalgae do not entail any kind of biohazard. To begin with, they are encountered everywhere in the natural environment, and they are in fact beneficial as they can absorb and breakdown contaminants from the environment, and even clean wastewater.

Q: What % of solar energy is converted to useful form using this approach?
A: Wild type green microalgae can normally convert 2-3% of solar energy (solar-to-biomass conversion). The tla1 strain converts about 4-5%.

Q: Will this new strain survive in the wild if it were to escape?
A: The modified strains are severely compromised in their ability to compete and survive in the wild. Firstly, their chlorophyll antenna size has been substantially reduced, so that they cannot compete for sunlight absorption with any other wild type photosynthetic organism. Secondly, their metabolism has been altered to favor hydrogen production, which might benefit our economy, but it further compromises the ability of these cells to generate their own biomass and to grow.

Q: Could you elaborate on Slide 32-negative O2 evolution on the graph?
A: At zero light intensity (in the dark) cells do only respiration, which entails uptake of oxygen (hence the negative value).

Q: Will this create competition between algae for biofuels and algae for fuel cells?
A: Depending on the prevailing need, the photosynthetic microorganisms can be tailored to perform one application at a time, e.g. can be geared to generate hydrogen for fuel cells or biofuels for other applications.

Q: How can algae culture be maintained from wild bacteria infestation?
A: This would be one of the engineering and scale-up challenges, probably specific for the various operators and geographical regions. Examples of approaches to avoid this problem: Fully enclosed bioreactors afford protection from invading microorganisms and (most importantly) microalga grazing critters (microalgae are rich in protein, sugars and vitamins). A commonly used "head start" approach (when a substantial inoculum is used to overwhelm any completion) is another example.

Q Are there any tla mutants that have not been altered to favor hydrogen production?
A: All tla mutants, as originally developed, were not at the same time altered to favor hydrogen production. The tla property confers 3x-higher sunlight utilization efficiency to a mass culture of microalgae, irrespective of the product to be generated. Thus, tla strains could be applied for enhanced hydrogen production in a high density culture, and this is one important product application. tla strains could also be used for enhanced rates of microalgal biomass accumulation, or for enhanced generation of other useful bio-products (e.g. fuels). The key here is that a tla property substantially improves the solar-to-product energy conversion efficiency of photosynthesis in a mass culture, irrespective of what the ultimate product of the process might be.