Novel approach for photosynthetic production of carbon neutral biofuel from green algae

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Credit: University of Turku

Reducing carbon emissions in order to prevent climate change requires developing new technologies for sustainable and renewable biofuel production. Molecular hydrogen is regarded as one of the most promising energy carriers due to its high energy density and clean, carbon-free use. A research group from the University of Turku, Finland, has discovered an efficient way for transforming solar energy into the chemical energy of biohydrogen through the photosynthesis of

green algae that function as cell factories.

During photosynthesis, green algae utilise harvested solar energy to split water, release oxygen into the atmosphere and produce biomass that functions as an excellent feed-stock in the blue biorefinery.

Green algae are also efficient biocatalysts and can transform solar energy and carbon dioxide directly into different valuable compounds, such as vitamins, antioxidants, polymers, and carbohydrates.

"When algal cells are first incubated under anaerobic conditions in the dark and then exposed to light, they start producing hydrogen efficiently, but unfortunately only for a few seconds," says the leader of the research group, Yagut Allahverdiyeva-Rinne, Associate Professor of Molecular Plant Biology at the University of Turku.

Researchers have already for decades believed that the main obstacle to the longer-term hydrogen production in algae in light is the destruction of the hydrogenase enzyme, a key element in this process, which is caused by oxygen.

"Since algae constantly release oxygen during their photosynthesis that occurs simultaneously with the production of hydrogen, maintenance of anaerobic conditions in illuminated cultures has been particularly troublesome," says Senior Researcher Sergey Kosourov, a member of the research group.

New and Ecologically Sustainable Method to Produce Biohydrogen

The researchers at the University of Turku decided to apply the knowledge retrieved from the basic research on the photosynthesis of

algae and established a new method for producing hydrogen that does not expose green algae to additional nutritional starvation and, thus, without applying any significant stress to the cells.

The researchers showed that the production of hydrogen could be significantly extended by simply exposing the anaerobic algal cultures to a train of strong yet short light pulses, which are interrupted by longer dark periods.

"Under these conditions, algal cultures exposed to sunlight do not accumulate oxygen in the medium. In addition, algae steer the electrons resulting from the decomposition of water and charged by sunlight into hydrogen production instead of biomass accumulation. The process lasts for, at least, several days and the maximum rate of the production of hydrogen occurs during the first eight hours," Kosourov says.

The research indicated clearly that a major obstacle to efficient hydrogen production is not oxygen but a strong competition between two metabolic pathways: carbon dioxide fixation leading to the biomass accumulation and the hydrogenase enzyme catalysing photoproduction of hydrogen.

"The study opens up new possibilities for the construction of efficient living cell factories for the production of biofuels and different chemicals directly from sunlight, carbon dioxide and water. The research provides important information on how to avoid 'wasting' solar-driven energy in biomass production and how to apply this energy directly for the production of useful bio-products," Allahverdiyeva-Rinne says.

The new method developed by the researchers is valuable both for the basic research of the photosynthesis of algae and for the research and development work of the industrial sector when producing new technologies for the large-scale production of carbon neutral biofuels.

More information: Sergey Kosourov et al, A new approach for sustained and efficient H2 photoproduction by Chlamydomonas reinhardtii, *Energy & Environmental Science* (2018). DOI: 10.1039/c8ee00054a

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