



Comprehensive Series in Photochemical
and Photobiological Sciences

Microalgal Hydrogen Production

Achievements and Perspectives

Edited by Michael Seibert and Giuseppe Torzillo



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Microalgal Hydrogen Production Michael Seibert, Giuseppe Torzillo, 2018-03-19 Hydrogen could be the fuel of the future Some microorganisms can produce hydrogen upon illumination Biological methods of production could be greener than chemical or physical production methods but the potential of biological methods is still being harnessed This comprehensive book highlights the key steps necessary for future exploitation of solar light driven hydrogen production by microalgae The highly regarded editors bring together 46 contributors from key institutions in order to suggest and examine the most significant issues that must be resolved to achieve the goal of practical implementation while proposing reliable methodologies and approaches to solve such issues This 19 chapter book will be an indispensable resource for academics undergraduate and graduate students postgraduates and postdoctoral scholars energy scientists bio chemical engineers and policy makers working across the field of biohydrogen and bioenergy *Algal Biorefinery: An Integrated Approach* Debabrata Das, 2015-11-30 This book critically discusses different aspects of algal production systems and several of the drawbacks related to microalgal biomass production namely low biomass yield and energy consuming harvesting dewatering drying and extraction processes These provide a background to the state of the art technologies for algal cultivation CO₂ sequestration and large scale application of these systems In order to tap the commercial potential of algae a biorefinery concept has been proposed that could help to extract maximum benefits from algal biomass This refinery concept promotes the harvesting of multiple products from the feedstock so as to make the process economically attractive For the last few decades algal biomass has been explored for use in various products such as fuel agricultural crops pigments and pharmaceuticals as well as in bioremediation To meet the huge demand there has been a focus on large scale production of algal biomass in closed or open photobioreactors Different nutritional conditions for algal growth have been explored such as photoautotrophic heterotrophic mixotrophic and oleaginous This book is aimed at a wide audience including undergraduates postgraduates academics energy researchers scientists in industry energy specialists policy makers and others who wish to understand algal biorefineries and also keep abreast of the latest developments *Microalgal Hydrogen Production* Michael Seibert, Giuseppe Torzillo, 2018 This title documents the increased interest in achievements in the field of light driven microalgal hydrogen production and the bottlenecks currently preventing exploitation of the technology in the practical arena **Microalgal Hydrogen Production: Achievements and Perspectives**, 2018 Hydrogen could be the fuel of the future Some microorganisms can produce hydrogen upon illumination Biological methods of production could be greener than chemical or physical production methods but the potential of biological methods is still being harnessed This comprehensive book highlights the key steps necessary for future exploitation of solar light driven hydrogen production by microalgae The highly regarded editors bring together 46 contributors from key institutions in order to suggest and examine the most significant issues that must be resolved to achieve the goal of practical implementation while proposing reliable

methodologies and approaches to solve such issues This 19 chapter book will be an indispensable resource for academics undergraduate and graduate students postgraduates and postdoctoral scholars energy scientists bio chemical engineers and policy makers working across the field of biohydrogen and bioenergy Maximizing Light Utilization Efficiency and Hydrogen Production in Microalgal Cultures, 2014 The project addressed the following technical barrier from the Biological Hydrogen Production section of the Fuel Cell Technologies Program Multi Year Research Development and Demonstration Plan Low Sunlight Utilization Efficiency in Photobiological Hydrogen Production is due to a Large Photosystem Chlorophyll Antenna Size in Photosynthetic Microorganisms Barrier AN Light Utilization Efficiency *Photobiological Hydrogen Production from Native Green Algal Strains and Cyanobacterial Strains of Thailand* Somrak Rodjaroen, Niran Juntawong, Nopadol Riablershirun, Aparat Mahakhant, Nattanan Panjaworayan, Mahāwitthayālai Kasēsāt. Interdisciplinary Graduate Program, 2010 Photobiological Hydrogen Production Michael Seibert, Stephen Lien, P. F. Weaver, Solar Energy Research Institute, 1979* **Maximising the Photobiological Production of Hydrogen Using Leachate, While Monitoring Algal Photosynthesis Using Pam Fluorometry** Sarah Anne White, 2014 **Updated Cost Analysis of Photobiological Hydrogen Production from Chlamydomonas Reinhardtii Green Algae** Wade A. Amos, 2004

Photobiological Production of Hydrogen, 1979 This literature survey of photobiological hydrogen production covers the period from its discovery in relatively pure cultures during the early 1930s to the present The focus is hydrogen production by phototrophic organisms and their components which occurs at the expense of light energy and electron donating substrates The survey covers the major contributions in the area however in many cases space has limited the degree of detail provided Among the topics included is a brief historical overview of hydrogen metabolism in photosynthetic bacteria eucaryotic algae and cyanobacteria blue green algae The primary enzyme systems including hydrogenase and nitrogenase are discussed along with the manner in which they are coupled to electron transport and the primary photochemistry of photosynthesis A number of in vivo and in vitro photobiological hydrogen evolving schemes including photosynthetic bacterial green algal cyanobacterial two stage and cell free systems are examined in some detail The remainder of the review discusses specific technical problem areas that currently limit the yield and duration of many of the systems and research that might lead to progress in these specific areas The final section outlines in broadest terms future research directions necessary to develop practical photobiological hydrogen producing systems Both whole cell near to mid term and cell free long term systems should be emphasized Photosynthetic bacteria currently show the most promise for near term applied systems *Photobiological Hydrogen Production*, 1979 Hydrogen production by phototrophic organisms which has been known since the 1930 s occurs at the expense of light energy and electron donating substrates Three classes of organisms namely photosynthetic bacteria cyanobacteria and algae carry out this function The primary hydrogen producing enzyme systems hydrogenase and nitrogenase will be discussed along with the manner in which they couple to light driven electron

transport In addition the feasibility of using in vivo and in vitro photobiological hydrogen producing systems in future solar energy conversion applications will be examined Photobiological Hydrogen Production by Facultative Photosynthetic Bacteria ,1985 Photobiological Hydrogen Production with Switchable Photosystem-II Designer Algae ,2014 A process for enhanced photobiological H₂ production using transgenic alga The process includes inducing exogenous genes in a transgenic alga by manipulating selected environmental factors In one embodiment inducing production of an exogenous gene uncouples H₂ production from existing mechanisms that would downregulate H₂ production in the absence of the exogenous gene In other embodiments inducing an exogenous gene triggers a cascade of metabolic changes that increase H₂ production In some embodiments the transgenic alga are rendered non regenerative by inducing exogenous transgenes for proton channel polypeptides that are targeted to specific algal membranes **Photobiological Hydrogen Production by Facultative Photosynthetic Bacteria** ,1985 **Photobiological Production of Hydrogen and Electricity** Michael Seibert,Solar Energy Research Institute,1980 This paper will examine how phototrophic microorganisms use the photosynthetic apparatus to generate hydrogen and how these processes might be harnessed for energy production The emphasis is on photosynthetic bacteria and green algae The bacteria cannot split water but they can use a number of waste products as substrates for hydrogen production Algae can split water but their potential for energy production is long range due to technical problems which must be surmounted by continued basic research Another approach which may lead to a new solar technology involves the isolation of the primary photosynthetic apparatus the reaction center complex This complex can be immobilized on an electrode and used in a photoelectrochemical cell Recent studies have demonstrated that this system can directly convert light energy into electric energy *Photobiological Hydrogen Production and Carbon Dioxide Sequestration* Halil Berberoglu,2008 **Photogeneration of Hydrogen** Anthony Harriman,Michael A. West,1982 **Engineering Photosynthetic Organisms for the Production of Biohydrogen** ,2014 Oxygenic photosynthetic organisms such as green algae are capable of absorbing sunlight and converting the chemical energy into hydrogen gas This process takes advantage of the photosynthetic apparatus of these organisms which links water oxidation to H₂ production Biological H₂ has therefore the potential to be an alternative fuel of the future and shows great promise for generating large scale sustainable energy Microalgae are able to produce H₂ under light anoxic or dark anoxic condition by activating 3 different pathways that utilize the hydrogenases as catalysts In this review we highlight the principal barriers that prevent hydrogen production in green algae and how those limitations are being addressed through metabolic and genetic engineering We also discuss the major challenges and bottlenecks facing the development of future commercial algal photobiological systems for H₂ production Lastly we provide suggestions for future strategies and potential new techniques to be developed towards an integrated system with optimized hydrogen production **Photobiological Production of Hydrogen, a Solar Energy Conversion Option** Paul Weaver,Stephen Lien,Michael Seibert,1979 Engineering in Vitro

Photobiological Hydrogen Production Stacey Akie Shiigi, 2015 Hydrogen is an important industrial chemical and attractive next generation fuel Current methods for its production rely on steam reformation of fossil fuels which liberates greater than 1% of the annual global carbon dioxide emissions therefore there is a need for sustainable hydrogen production processes Nature has provided a biological catalyst for hydrogen production in FeFe hydrogenases These complex enzymes catalyze the reaction which combines electrons and protons to generate hydrogen Our long term goal is to integrate a non native FeFe hydrogenase into the photosynthetic electron transport chain of a cyanobacterium to couple photosynthetic water splitting with hydrogen production One challenge to implementing this pathway is that heterologous hydrogenases interact inefficiently with the photosynthetic machinery and electrons will be lost to native competing pathways in the cyanobacteria Engineering the hydrogenase and other pathway components in vivo is challenging due to the limited tools available for genetic engineering these photosynthetic organisms We developed an improved in vitro pathway using Photosystem I complexes isolated from a cyanobacterium to mimic in vivo electron flow to the hydrogenase or the main competing pathway the production of NADPH This system provides fine tuned control over the reaction components and environment including concentrations of proteins in the pathways to study and control electron flux We demonstrate the use of a non native ferredoxin to facilitate electron transfer between the photosystem and hydrogenase Finally we will describe coupling our photosystem pathway with a high throughput hydrogen sensor to assess hydrogen production rates in microtiter plates This approach can be extended to the high throughput screening of in vitro synthesized enzyme or electron carrier libraries to develop components that support high photobiological hydrogen production rates

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