cells

MDPI

Review

Algae-Bacteria Consortia as a Strategy to Enhance H_2 Production

Neda Fakhimi, David Gonzalez-Ballester, Emilio Fernández, Aurora Galván and Alexandra Dubini *

Departamento de Bioquímica y Biología Molecular, Facultad de Ciencias, Universidad de Córdoba, Campus de Rabanales, Edif. Severo Ochoa, 14071 Córdoba, Spain; z72fafan@uco.es (N.F.); dgballester@uco.es (D.G.-B.); bb1feree@uco.es (E.F.); bb1gacea@uco.es (A.G.)

* Correspondence: alexandra.dubini@uco.es; Tel.: +34-957-218-352

Received: 16 April 2020; Accepted: 26 May 2020; Published: 29 May 2020

check for updates

Abstract: Biological hydrogen production by microalgae is a potential sustainable, renewable and clean source of energy. However, many barriers limiting photohydrogen production in these microorganisms remain unsolved. In order to explore this potential and make biohydrogen industrially affordable, the unicellular microalga *Chlamydomonas reinhardtii* is used as a model system to solve barriers and identify new approaches that can improve hydrogen production. Recently, Chlamydomonas–bacteria consortia have opened a new window to improve biohydrogen production. In this study, we review the different consortia that have been successfully employed and analyze the factors that could be behind the improved H_2 production.

Keywords: algae; bacteria; biohydrogen; *Chlamydomonas reinhardtii*; co-cultures; consortia; hydrogen

1. Introduction

Finding renewable, sustainable and clean energy sources has become one of the main priorities of our society. Hydrogen (H_2) is a promising clean and carbon-free energy source with a high energy value (142 kJ/g) that can be easily interconverted with electricity and used for domestic and industrial applications. Currently, H_2 production techniques include steam reforming natural gas/oil, coal gasification, biomass gasification/pyrolysis, and electrolysis and thermolysis of water. All these techniques are either polluting and/or demand a large amount of energy [1,2]. Under this scenario, the biological production of H_2 (bioH_2) has garnered considerable attention in recent decades, as it could be a cheap and renewable source of fuel. Different microorganisms such as microalgae, cyanobacteria, photosynthetic bacteria and some heterotrophic bacteria can produce H_2 [3,4]. Algae and cyanobacteria are well-known photoautotrophic organisms able to convert CO_2 into organic matter and release O_2 during this process. Under specific conditions, H_2 production is linked to photosynthetic activity. Non-oxygenic photosynthetic bacteria can also use light and organic acids (and other chemical forms) to obtain energy and produce H_2, without releasing O_2. Heterotrophic bacteria, on the other hand, can degrade organic matter and release CO_2, with some of them also producing H_2. Among them, photobiological H_2 evolution by green algae and cyanobacteria has attracted considerable attention since, potentially, they do not require organic carbon sources to produce H_2, only water and sunlight [4–6]. Moreover, microalgae and cyanobacteria are the most dominant photosynthetic organisms on Earth, which increases their biotechnological interest. However, photosynthetic H_2 production is still inefficient for industrial implementation due to its low yield and rate of H_2 generation. One of the most important bottlenecks of biological H_2 production is its sensitivity to oxygen (O_2). In all the H_2-producing microorganisms, O_2 is a strong repressor of H_2 production.