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Review

Photosynthetic hydrogen production

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ABSTRACT

Among various technologies for hydrogen production, the use of oxygenic natural photosynthesis has a great potential as can use clean and cheap sources—water and solar energy. In oxygenic photosynthetic microorganisms electrons and protons produced from water and redirected by the photosynthetic electron-transport chain via ferredoxin to the hydrogen-producing enzymes hydrogenase or nitrogenase. By these enzymes, e^- and H^+ recombine and form molecular hydrogen. Hydrogenase activity can be very high but is extremely sensitive to the photosynthetically evolved O_2 that leads to reduced and unstable H_2 production. However, presently, several approaches are developed to improve the energetic efficiency to generate H_2. This review examines the main available pathways to improve the photosynthetic H_2 production.

Contents

Abbreviations: Chl, chlorophyll; Fd, ferredoxin; PQ, plastoquinone; PS, photosystem; RC, reaction center.

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1. Introduction

Solar energy stored by photosynthesis over billions of years constitutes the main source of energy available on Earth. It can therefore be argued that one of the most important events in the Earth's history is the evolution of photosynthetic organisms capable of water oxidation. In these organisms, photosystem II (PS II) uses sunlight to split water, an energetically unfavorable reaction, where electrons and protons are extracted from water, and oxygen is released as a by-product. In turn, accumulation of the oxygen evolved resulted in an aerobic atmosphere. Formation of an ozone layer allowed organisms to move from the ocean to the land.

Thanks to photosynthesis, captured solar energy is accumulated in the form of coal, oil and gas. These fuels have been intensively used and are becoming limited. Out of the global energy consumption in 2005, 86% was obtained from fossil fuels (oil, 37%; coal, 23%; natural gas, 26%) [http://www.eia.doe.gov/oiaf/ieo/index.html]. Moreover, global energy consumption will increase from the current level of 12.8 TW to 27 TW by 2050, which will lead to a global warming of the Earth [1]. During the last 50 years, the concentration of atmospheric CO_2 increased by 18% [http://www.esrl.noaa.gov/gmd/ccgg/trends/] and the surface temperature of the Earth increased by 0.64 °C [2]. It is still debatable how much the activity of human industry is responsible for this global change of climate because there are so many variables. Nevertheless, there is one thing for which human activity is definitely responsible for: the invention of many ways to liberate CO_2, and hardly anyway to assimilate it. This is problematic because we are distorting the balance of the carbon cycle by consumption of our inherited carbon resource, without much hope for its renewal. Therefore, renewable and clean energy sources must be developed