SEMI-ARTIFICIAL PHOTOSYNTHESIS FOR GREEN HYDROGEN PRODUCTION – OVERVIEW, CHALLENGES AND POSSIBILITIES

Sabine KUBICEK[1,*], Oliver SPADIUT[2]

Sustainable energy production and storage technologies are needed to decouple industrial growth from carbon dioxide production. A promising candidate for energy storage is hydrogen [1]. This molecule has a high energy density and produces only water upon combustion [2]. Hydrogen is successfully used for mobility, as seen by the growing number of hydrogen fuel stations in Europe [3] and plays an important role as reducing agent in industry. The direct reduction of steel is one example where hydrogen can be used to decarbonize an industry which now relies on a carbon dioxide producing process [4], [5].

But up to date, more than 90 % of the worldwide available hydrogen is produced by using fossil fuels as educts and is therefore not a sustainable alternative to conventional energy production and storage [6]. An alternative is so-called green hydrogen, which is generated from water splitting by using renewable energy sources. Electrolysis of water in PEM (polymer electrolyte membrane) cells powered by water, sun or wind energy is already commercially available and an important step towards green hydrogen production [7]. This process includes the conversion of energy from renewable sources into current and a second conversion of current into hydrogen. Since the efficiency is not 100 %, every conversion step loses energy. Therefore, hydrogen production directly from sunlight is desired. This can be realized with photocatalytic processes.

Photoenzymes of plants, cyanobacteria or algae can split water into oxygen gas, hydrogen ions and electrons [8]. These enzymes have a high theoretical efficiency and work at room temperature and pressure. In combination with hydrogenases [9] or gold nanoparticles [10], these hydrogen ions and electrons can be used to form green hydrogen. This photocatalytic hydrogen production through isolated enzymes obtained from organisms is called semi-artificial photosynthesis [10]. The involved enzymes are found in readily available organisms and their production is a carbon negative process due to autotroph biomass formation of plants, cyanobacteria, or algae.

In this contribution, we want to give an overview about research done on semi-artificial photosynthesis, present current challenges and possibilities and give some ideas for advancement of this field towards industrial application.

Referenzen

[1] K. T. Møller, T. R. Jensen, E. Akiba, und H. Li, „Hydrogen - A sustainable energy carrier“, *Prog. Nat. Sci. Mater. Int.*, Bd. 27, Nr. 1, S. 34–40, Feb. 2017, doi: 10.1016/j.pnsc.2016.12.014.

[2] C. Hebling *u. a.*, „Eine Wasserstoff-Roadmap für Deutschland“, S. 51.

[3] „H2.LIVE: Wasserstofftankstellen in Deutschland & Europa“, *H2.LIVE*. https://h2.live/ (zugegriffen Sep. 03, 2021).

[4] A. Bhaskar, M. Assadi, und H. Nikpey Somehsaraei, „Decarbonization of the Iron and Steel Industry with Direct Reduction of Iron Ore with Green Hydrogen“, *Energies*, Bd. 13, Nr. 3, S. 758, Feb. 2020, doi: 10.3390/en13030758.

[5] D. Kushnir, T. Hansen, V. Vogl, und M. Åhman, „Adopting hydrogen direct reduction for the Swedish steel industry: A technological innovation system (TIS) study“, *J. Clean. Prod.*, Bd. 242, S. 118185, Jan. 2020, doi: 10.1016/j.jclepro.2019.118185.

[6] C. Acar und I. Dincer, „3.1 Hydrogen Production“, in *Comprehensive Energy Systems*, Elsevier, 2018, S. 1–40. doi: 10.1016/B978-0-12-809597-3.00304-7.

[7] M. Carmo, D. L. Fritz, J. Mergel, und D. Stolten, „A comprehensive review on PEM water electrolysis“, *Int. J. Hydrog. Energy*, Bd. 38, Nr. 12, S. 4901–4934, Apr. 2013, doi: 10.1016/j.ijhydene.2013.01.151.

[8] A. Badura *u. a.*, „Light-Driven Water Splitting for (Bio-)Hydrogen Production: Photosystem 2 as the Central Part of a Bioelectrochemical Device“, *Photochem. Photobiol.*, Bd. 82, Nr. 5, S. 1385, 2006, doi: 10.1562/2006-07-14-RC-969.

[1] TU Wien, Institute of Chemical, Environmental and Bioscience Engineering, Research Area Biochemical Engineering, Gumpendorfer Straße 1a, 1060 Vienna, Austria , +43 1 58801 166487, sabine.kubicek@tuwien.ac.at, https://www.vt.tuwien.ac.at/bioprocess_engineering/integrated_bioprocess_development/EN/

[2] TU Wien, Institute of Chemical, Environmental and Bioscience Engineering, Research Area Biochemical Engineering, Gumpendorfer Straße 1a, 1060 Vienna, Austria , +43 1 58801 166473, oliver.spadiut@tuwien.ac.at, https://www.vt.tuwien.ac.at/bioprocess_engineering/integrated_bioprocess_development/EN/

[9] D. Mersch *u. a.*, „Wiring of Photosystem II to Hydrogenase for Photoelectrochemical Water Splitting“, *J. Am. Chem. Soc.*, Bd. 137, Nr. 26, S. 8541–8549, Juli 2015, doi: 10.1021/jacs.5b03737.

[10] T. Kothe, W. Schuhmann, M. Rögner, und N. Plumeré, *9 Semi-artificial photosynthetic Z-scheme for hydrogen production from water*. De Gruyter, 2015, S. 189–210. Zugegriffen: Aug. 27, 2021. [Online]. Verfügbar unter: https://www.degruyter.com/document/doi/10.1515/9783110336733.189/html