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Review

A review on dark fermentative biohydrogen production from organic biomass: Process parameters and use of by-products

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HIGHLIGHTS

- H_2 production via dark fermentation of waste biomass is promising.
- Parameters influencing dark fermentation can be optimized for higher H_2 yields.
- Effluents can be utilized further for energy recovery and for other valued uses.
- Net energy gain and pH control are important issues.

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ABSTRACT

Dark fermentation of organic biomass, i.e. agricultural residues, agro-industrial wastes and organic municipal waste is a promising technology for producing renewable biohydrogen. In spite of its potential, this technology needs further research and development to improve the biohydrogen yield by optimizing substrate utilization, microbial community enrichment and bioreactor operational parameters such as pH, temperature and H_2 partial pressure. On the other hand, the technical and economic viability of the processes need to be enhanced by the use of valuable by-products from dark fermentation, which mostly includes volatile fatty acids. This paper reviews a range of different organic biomasses and their biohydrogen potential from laboratory to pilot-scale systems. A review of the advances in H_2 yield and production rates through different seed inocula enrichment methods, bioreactor design modifications and operational conditions optimization inside the dark fermentation bioreactor is presented. The prospects of valorizing the co-produced volatile fatty acids in photofermentation and bioelectrochemical systems for further H_2 production, methane generation and other useful applications have been highlighted. A brief review on the simulation and modeling of the dark fermentation processes and their energy balance has been provided. Future prospects of solid state dark fermentation are discussed.

Contents

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1. Introduction

Environmental friendly energy carriers and sources are the most highlighted topic in the energy and environmental sector. The current global energy demand is mostly dependent on reserves of fossil fuels, which are depleting, and the world is facing severe pollution problems from the by-products of fossil fuels uses [1]. The scientific community has widely accepted the fact that the increasing CO_2 level due to the use of fossil resources is impacting the greenhouse gas effect and global warming. Therefore, different ways to harness the energy from clean renewable sources are being developed, but the search for reliable energy sources is still on.

In the past years, the research and development interests have been directed towards renewable energy technologies like the anaerobic digestion (AD) of organic biomass and waste. For alternative energy carriers, hydrogen could be the fuel of the future because of its high energy content, environmental friendliness of production, and also because it can give substantial social, economic and environmental credentials [2]. Hydrogen is a carbon-free clean fuel, as the only final by-product of its combustion is water [2]. Hydrogen can also be helpful in addressing global warming and increasing pollution problems. Furthermore, it is preferred over methane owing to its wider industrial applications, i.e. H_2 is used in the synthesis of ammonia and hydrogenation of edible oil, petroleum, coal and shale oil [3]. Hydrogen can be directly used either in combustion engines because of its highest energy per unit weight, i.e. 143 GJ per ton [2] among known gaseous biofuels or to produce electricity via fuel cell technologies [4]. Thus, the creation of a hydrogen economy which incorporates the production and use of hydrogen as an energy carrier could in the future lead to sustainable energy systems [1,5].

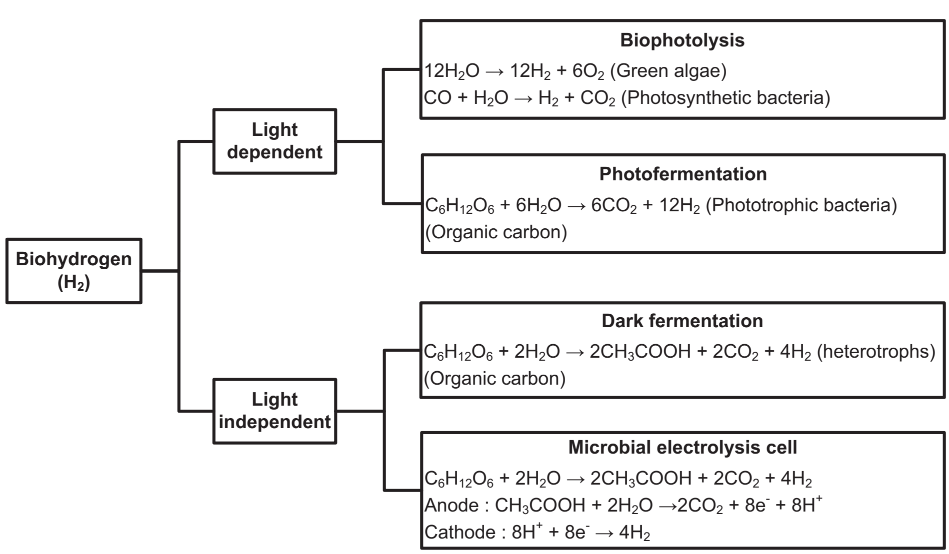

Fig. 1. Biological pathways to produce hydrogen.