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Fermentative hydrogen production from microalgal biomass by a single strain of bacterium *Enterobacter aerogenes* — Effect of operational conditions and fermentation kinetics

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ABSTRACT

Biohydrogen production through dark fermentation is a promising technology for generating renewable energy, while using microalgal biomass as a third generation feedstock can further increase the sustainability of the process. In the present study, *Scenedesmus obliquus* was used as model microalga substrate for studying the impact of operational parameters in batch dark fermentation trials using a strain of *Enterobacter aerogenes* bacteria.

(i) The initial gas-liquid ratio in the bioreactor (from 1.3 to 8.2) was tested, resulting in higher bioH_2 yields for ratios above 5.

(ii) Different bacterial growth, inoculation procedures and fermentation media were tested in combined experiments. The best conditions were chosen by maximising bioH_2 yield and minimising production time and costs.

(iii) The autoclave sterilization effect on sugar extraction and bioH_2 yield was tested for different microalga concentrations (2.5–50 g/L) with best results attained for 2.5 g/L (81.2% extraction yield, 40.9 mL H_2/g alga).

For the best operational conditions, fermentation kinetics were monitored and adjusted to the Modified Gompertz model, with t_{95} (time required for bioH_2 production to attain 95% of the maximum yield) below 4.5 h. The maximum hydrogen production was higher when using wet algal biomass enabling the energy consuming biomass drying step to be skipped.

1. Introduction

The production of hydrogen from renewable sources is a promising alternative for the future, considering the need for cleaner energy carriers and a reduction in carbon dioxide emissions. Hydrogen is a carbon-free fuel (upon oxidation produces only water) and the most energy-dense fuel per unit mass (142 kJ/g).

The European Strategic Energy Technology Plan [1] has identified hydrogen-based technologies among the technologies needed in Europe to achieve its target for 2020: a 20% reduction in greenhouse gas emissions; a 20% share of renewable energy sources in the energy mix and a 20% reduction in primary energy use. Hydrogen can play an important role in the reduction of local air pollutants, as well as in the decarbonisation of Europe's Transport system.

At present, however, hydrogen is mainly produced from fossil fuels (e.g. natural gas steam reforming, coal gasification) or water (e.g. electrolysis, photolysis) through energy intensive processes. It is therefore essential to develop and optimize more environmentally-friendly, energy-efficient and sustainable hydrogen production processes, namely through biological biomass fermentation.

The production of hydrogen through anaerobic fermentation is a relatively simple process and can use a wide spectrum of substrates, including waste products [2] and microalgae, such as *Scenedesmus obliquus* [3], *Nannochloropsis* sp. [4], *Chlorella vulgaris* [5], *Dunaliella tertiolecta* [5], *Spirogyra* sp [6]. *Enterobacter aerogenes* is known as an efficient biohydrogen producing bacterium, as it is one

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