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Energy requirement and CO_2 emissions of bioH_2 production from microalgal biomass

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ABSTRACT

This paper presents the life cycle inventory (LCI) of hydrogen production by *Clostridium butyricum* fermentation of *Scenedesmus obliquus* hydrolysate. The main purpose of this work was to evaluate the potential of H_2 production from microalgal biomass and the respective energy consumption and CO_2 emissions in the bioconversion process considering the microalga production, acid hydrolysis of *S. obliquus* biomass, preparation of the inoculum and culture media, and fermentation. The scale-up to industrial production was not envisaged.

The hydrogen yield obtained in this work was 2.9 ± 0.3 mol H_2/mol sugars in *S. obliquus* hydrolysate. Results show that this process of biological production of hydrogen can achieve 7270 MJ/MJ_{H_2} of energy consumption and 670 kg CO_2/MJ_{H_2}. The microalgal culture is the stage responsible for 98% of these total final values due to the use of artificial lighting. All stages and processes with the highest values of energy consumption and CO_2 emissions were identified for future energetic and environmental optimisation.

1. Introduction

The growing consumption of fossil fuels that consequently causes serious negative environmental impacts worldwide is at the center of global climate change policies discussion, aiming to implement new and alternative solutions to respond to these concerns. New energy sources like biofuels have been regarded as a potential commodity to reduce fossil fuel dependence [1]. The other potential solution is hydrogen that appears as an alternative fuel and "energy carrier". About 450 billion m^3 of hydrogen [2] are currently produced and consumed worldwide but mostly as raw material for the production of various chemicals rather than as a fuel itself. Hydrogen is mainly produced from natural gas (central steam reforming), oil, coal and water [2,3], although it can also be produced by biological processes such as dark and photo fermentation [4–8].

Microalgal biomass constitutes a potential source of renewable feedstock, as it can be used as substrate for the biological conversion into biofuels and biogas [9–11]. *Scenedesmus obliquus*, a robust microalga with good productivity rates, has been proved to be very versatile as a raw material for biofuels production (biodiesel, bioethanol and biohydrogen). This green microalga contains approximately 12–14% of oil and 10–17% of sugar [12] and is therefore a good source for biodiesel [11,13–15], bioethanol [16,17] and hydrogen production [18,19]. Starch is one of the major intracellular storage carbohydrate in microalgae and constitutes an important substrate for fermentation processes, e.g. bioethanol and biohydrogen production [15]. Zachleder et al. (1988) [20] found that starch

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