Measuring the environmental footprint of bio-hythane (hydrogen-methane) production from renewable resources

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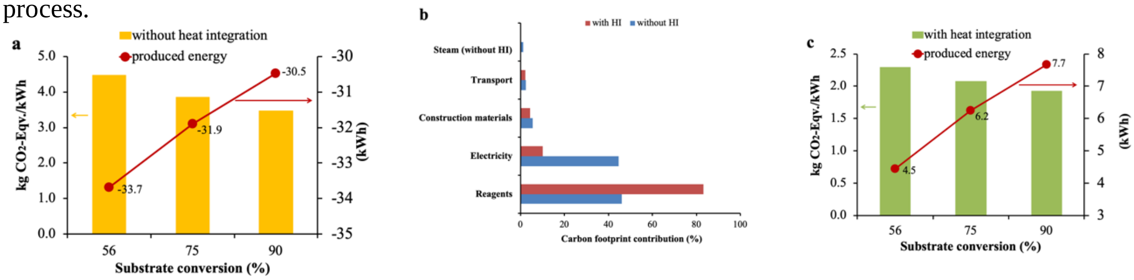
1. Introduction – The synthesis of hydrogen (H_2) and methane (CH_4) from non-renewable raw materials has been related to the consumption of large amounts of energy [1,2]. Hythane, a mixture of H_2 (5-20%) and CH_4 (80-95%), can be synthesized by dark fermentation from renewable substrates and wastes; their combustion is efficient and is not associated with the emission of nitrogen oxides and sulfur. In addition, the low carbon content of the mixture allows decreasing CO_2 emissions as evidenced in internal-combustion engines [1,2]. Although anaerobic digestion in two-steps can improve the robustness and efficiency of the process, there is not enough information available regarding the impact of the operational conditions on both the energy performance and the environmental footprint of the process. This study addresses this problem through the use of life cycle assessment (LCA).

2. Experimental – The study considered the four main stages indicated in the ISO standard 14040 (goal and scope definition, inventory analysis, impact assessment, and interpretation). LCA modelling was undertaken using openLCA software (GreenDelta©). This study evaluated the environmental and energetic performance of hythane produced from a model substrate (glucose) by means of a sequential acidogenic (pH=5.5, T=35 °C) and methanogenic (pH=7.5, T=35 °C) process. Best operating conditions were selected through a central composite design; in each case, the variables considered were substrate (C_S) and microorganisms (C_X) concentration.

3. Results and Discussion – Figure 1 shows the results generated using IPCC-2013 (The Intergovernmental Panel on Climate Change) method. The H_2 produced did not compensate the energy consumed in the acidogenic step; moreover, in the absence of heat integration (HI), the two-steps process was not self-sufficient energetically (Fig. 1a). Reagents and chemical auxiliaries (NaOH-H_2SO_4) and steam generation were considered the environmental hotspots of the process because they comprise 90% of the carbon footprint (Fig. 1b). On the other hand, HI and substrate conversion in the methanogenic step increased the amount of produced energy and reduced the carbon footprint of the process (Fig. 1c). Heat integration allows reducing the carbon footprint and increasing the power generation capacity of the process.



4. Conclusions – This work evaluated the energetic and environmental performance of a technology that does not operate yet at an industrial scale; however, LCA results are key inputs to determine in advance the contribution of this alternative in reducing greenhouse gas emissions.

5. References [1] P. Fokaides, E. Christoforou, Handbook of Biofuels Production, 2016. [2] Demirbas, A., Biohydrogen For Future Engine Fuel Demands, Springer, 2009. [3] Horan, N., Yaser, A., Wid, N, Springer, 2018.

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