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Eric Trably, Eric Latrille, Claire Bougrier, Guillaume Guizard, Pascal Gras, Benoit Vassal, Thierry Conte, Jean-Philippe Steyer

OPERATION OF AN INNOVATIVE PILOT PLANT FOR THE BIOHYTHANE PRODUCTION FROM THE ORGANIC FRACTION OF MUNICIPAL SOLID WASTE (OFMSW)

E. Trably[1,], E. Latrille[1,*], C. Bougrier[2], G. Guizard[1], P. Gras[1], B. Vassal[1], T. Conte[1] & JP Steyer[1]*

[1] INRA, UR050, Laboratoire de Biotechnologie de l'Environnement, avenue des Etangs, Narbonne F-11100, France
[2] VEOLIA Environnement Recherche & Innovation, Zone portuaire de Limay 291, avenue Dreyfous Ducas, LIMAY F-78 520,France
*corresponding authors: eric.trably@supagro.inra.fr ; eric.latrillle@supagro.inra.fr

Introduction

Two phase anaerobic processes have been largely studied over the past ten years for their high conversion performances [1]. They consist of a first stage reactor operated under acidogenic conditions and producing biohydrogen by dark fermentation, coupled to a second stage methanogenic digester. Concomitant production of biohydrogen and methane is of particular interest since they both represent valuable energy sources utilizable for producing heat, electricity or as biofuel. Moreover, the addition of biohydrogen to methane, so-called biohythane, contributes substantially to increase the burning velocity and the stability of the combustion, as well as to lower the emission level of CO and NOx [2-3]. Among the potential organic substrates, the organic fraction of municipal solid waste (OFMSW) represents an abundant, cheap and rapidly functional source of substrates since OFMSW are nowadays widely treated by anaerobic digestion [4]. In addition, Liu *et al.* [5] showed that a two stage process enhanced the conversion of the OFMSW to biogas by 21%, likely because the first acidogenic stage acted as an additional acidic hydrolytic pretreatment step. The aim of the present work was to evaluate the performances of an innovative two stage pilot plant for producing biohydrogen and methane from OFMSW.

Material & Methods

The pilot plant was composed of two anaerobic reactors placed in series with a specially design feeding track (**Figure 1**). The first acidogenic reactor, dedicated to biohydrogen production, was operated with a working volume of 22L, hydraulic/solid retention time of 11 h, and a regulated pH at 5.5. The reactor was agitated with a magnetic stirring and was not inoculated at start of the experiment. The second reactor consisted of two compartments: one, at the top, for treating wastewaters with microbial fixed beds, and the second, at the bottom, for degrading remaining solid residues by settling. This reactor was operated with a working volume of 358L, a hydraulic retention time of 7 days and a solid retention time higher than 60 days. Both reactors were operated under mesophilic conditions (35°C). Biogas composition, as well as pH, temperature, electrical conductivity, Volatile Fatty Acids (VFAs) concentration (by titrimetry), and redox potential were on line monitored. Biogas and VFAs compositions were also measured periodically by GC-TCD and GC-FID, respectively.

Results & Discussion

The acidogenic reactor (R1) was continuously fed to reach a steady state after at least three hydraulic retention time. The electrical conductivity, the redox potential and the biogas production of R1 are shown in Figure 2A. Redox potential decreased gradually to reach the optimal value for biohydrogen production by dark fermentation, as previously observed in laboratory reactor (*). The low periodic pulses (20mV) of redox potential indicated the semi-continuous feeding of the OFMSW. The pH regulation was fixed at 5.5 and was effective since less than 0.2 pH unity could affect significantly the efficiency of the process, as reported by Liu *et al.* [5]. The increase of the electrical conductivity (Figure 2B) indicated an accumulation of VFAs in the reactor, mainly acetate and butyrate (50:50) (*). At this stage, the VFAs accumulated up to 2 $g.L^{-1}$, and were then fully degraded in the methanogenic reactor. Online and offline VFA measurements were both consistent with lab-scale observations in 2L reactor (*). Furthermore, after few months of operation, almost all organic solids were degraded in both reactors, indicating the high conversion efficiency of the system.

In addition, biohythane gas was produced in the first R1 reactor, with a biogas composition of 12% H_2, 35% CO_2 and 53% de CH_4. According to lab-scale experiment (*), it was concluded that the methane originated mainly from reactor R2 through the connecting valves. At this stage, the biogas flow rate was 101 $mL.L^{-1}.h^{-1}$, with a hydrogen productivity of around 12 $mL.L^{-1}.h^{-1}$. The average hydrogen yield was 3.8 $mLH_2.g_{VS}^{-1}$ which was consistent with lab-scale results (*), but corresponded to a lower level of hydrogen- producing potentiality when considering all organic

substrates [6]. Since the OFMSW was principally composed of hemicellulosic compounds, it was concluded that the microbial hydrolysis was unfavourable for biohydrogen production since hydrogen seems to be rapidly consumed by homoacetogenic bacteria in laboratory experiments (*). In the methanogenic reactor (R2), the biogas was composed of 60% CH_4 and 40% CO_2, under a biogas flow rate of 60 $mL.L^{-1}.h^{-1}$. The methane yield reached around 109 $mLCH_4.gVS^{-1}$.
Further experiments are currently in progress in order to increase the hydrolysis of OFMSW and, thenceforth, the amount of biohydrogen, through the addition of more biodegradable substrate, *e.g.* biowaste, and increasing the organic loading rate.

(*) additional data to be presented

Acknowledgments
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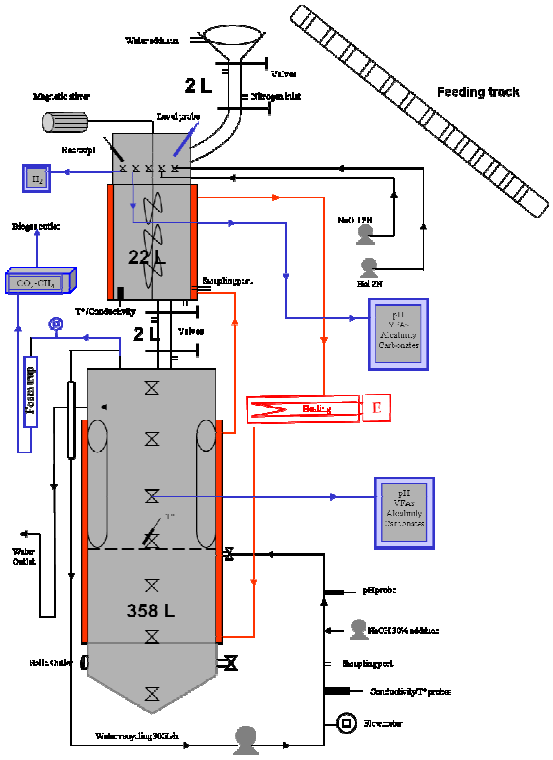
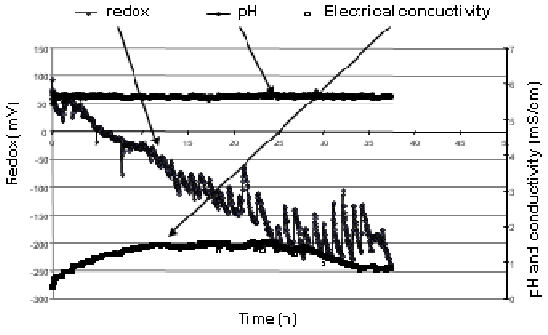


Fig. 1: Fully automated two-stage process for biohydrogen and methane (biohythane) production with a feeding track specially designed for solid substrates.

2A.



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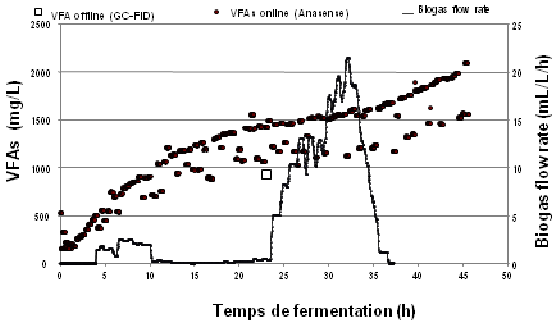

Fig. 2: Acidogenic bioH_2-producing reactor: monitoring of the redox potential, conductivity and pH (online) (2A), and the Volatile Fatty Acids and biogas (online) and VFAs (offline) (2B)