Research Summary Sheet

Summary of Deliverable 3.2

Biogas upgrade into biomethane and biohythane at pilot scale

Context and Challenges

Agricultural wastes represent nowadays a consistent amount of the waste generated in the EU, achieving at least the 50% of the fresh harvested crops and then a huge amount of biomass resources. These streams are often treated via anaerobic digestion to produce biogas. One of the main aims of the NoAW project is the implementation of modified AD processes to produce high added values like hydrogen, biomethane and poly-hydroxy-alkanoates.

WP3 aims at providing in-depth knowledge on both "conventional AD process" and "advanced AD technologies" improving the agro-waste management. The objective is the valorization of agricultural waste through their conversion into high value bioproducts, like Hydrogen (H2), Volatile Fatty Acids (VFAs), polyhydroxyalkanoates (PHAs), Biogas and Digestate.

The experimental activities were performed in two pilot scale biorefineries, one located in Isola della Scala (Northern Italy, Veneto Region) treating agro-waste like cow manure, grass silage, winery waste and the second located at INRA Narbonne (Narbonne, France) treating local waste and effluents generated by a wine-vinasses –based distillery. These wastes and effluents were selected as typical of the local area and were provided by INOSUD SAS (former GRAPSUD) partner. In Italy, the agro-waste was grinded through a pump and fed to a fermentation unit of 4 m^3 which operated in mesophilic and anaerobic conditions in order to produce volatile fatty acids (VFAs). Then, the same volume was discharged and processed by the screw-press separator (HRT=4days). The solid fraction fed the anaerobic digester (1 m^3 of working volume), which operates at mesophilic conditions (37°C) and HRT of 14-20 days. Around 800 L of liquid fraction rich in VFAs is processed through a screening unit with the objective to remove the course solids not removed by the screw-press. The carbon source obtained was used to feed the two Sequencing Batch Reactors for the successive polyhydroxyalkanoates production. In France, during the first year (Nov.2016-2017), waste and effluents from the distillery were periodically sent all along the operational year, for characterisation and batch assays at lab scale. Over the second year (Nov.2017-2018), the pilot plant was set-up and experiments at pilot-scale (22L fermenter + 358L anaerobic digester) were performed with discontinuous feeding of the fermenter. Optimisation of the operational parameters of the fermenter was performed, from mesophilic (35°C) to thermophilic conditions (55°C), variable pH and with inoculation or not of heat-treated/untreated mixed microbial cultures.

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The tubular MEC has been set-up using a plexiglass cylindric reactor of 12 L, the inner anodic chamber (3.14 L) was separated from the external cathodic chamber (8.86 L) by a tubular anion exchange membrane (Fumasep FAD-PEEK, FumatechGmbH). Both anodic and cathodic concentric chambers were filled with graphite granules giving by a bed porosity of 0.57. The inner anodic chamber was continuously fed with a synthetic mixture of organic substrates simulating a municipal wastewater and an acidogenic fermentate. The cathodic chamber was fed continuously with a gas mixture composed of CO2 at 30% and N2 at 70% to simulate a biogas. A three electrodes configuration was adopted by using a AMEL model 549 potentiostat and a reference Ag/AgCl electrode (+ 0.2 V vs. SHE) placed in the anodic chamber, i.e. the anode resulted the working electrode while the cathode acted as counter electrode. During the two-electrode operation, the reference electrode was shorted with the counter electrode, with this configuration the potentiostat acted like a simple voltage power supplier. All data were formatted and provided to WP1, to be available as stated in the Data Management Plan (WP1). Inlet biomass and digestate were sent for characterization at APESA prior to their use on field (tests performed in task 3.2).

Results and Applications

In Italy, after more than one year of operation the single units of the biorefinery platform were optimised and revamped to solve some technical problems. The pilot plant is ready for the scaled up production of PHA foreseen in WP6.

At the French pilot-plant, operated at smaller scale, first year of characterisation showed a high variability of the waste and effluents generated by the distillery GRAPSUD all over the operational year. A mixture of concentrated vinasses and diluted tartrate-poor or tartrate-rich waste vinasses was used for operating the pilot plant and ensure a proper functioning of the plant during the period of intense industrial activity. After one year of operation of the pilot plant in France, stable and robust production of biohythane at pilot scale was shown at mesophilic temperature (35°C), pH5.5 and when inoculated with mixed microbial cultures. Biohythane composition, ie ratio of H_2/CH_4 was always kept in an optimal range of 23.3±4.7% of H_2. Increasing the temperature to thermophilic conditions (55°C) and pH7 led to system instability by selecting methanogens in the fermenter.

Breakthroughs, benefits and added value

Overall, microbial adaptation was the key parameter for reaching a robust and stable process although working under intermittent conditions. The pilot plant operated in Italy was finally selected for scaling up the production of PHA in WP6.

Further information on NoAW project: http://noaw2020.eu

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