**Startup of a tubular Microbial Electrolysis Cell for biogas upgrading**

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**Highlights**

* Biogas Upgrading through bioelectromethanogenesis
* Fluidynamic and polarization curve characterization
* Conversion of electrical current into methane

**1. Introduction**

Biogas, the main product of the anaerobic digestion (AD) process, is a gas mixture mainly composed by carbon dioxide and methane. To obtain biomethane, with a high percentage of methane (>95%), is necessary a purification to remove the impurities such as NH3, H2S, and an upgrade step to remove the CO2. These last steps are economically expensive and usually the biogas is utilized for the cogeneration of electricity and heat, however, an innovative strategy for biogas upgrading consist in the utilization of a microbial electrolysis cell (MEC) in which the reduction of carbon dioxide to methane is performed by a biocathode. The bioelectromethanogenesis reaction is made by electroactive microorganisms who convert CO2 into CH4 (Villano et al., 2010). Here, a fully biological tubular Microbial Electrolysis Cell (MEC) has been developed for the upgrading of biogas produced by a pilot scale two stage AD reactor operated with real agricultural waste from a cattle farm, mainly composed by manure and straw and crops residues. Inside the MEC, the bioreduction reaction occurred in a cathodic chamber converting the CO2 into CH4 while the oxidation of the organic matter by an anodic biofilm partially sustained the energy demand of the process. Before the inoculation of the tubular MEC, the fluidynamic of the anodic chamber has been characterized by a tracer test while a polarization curve permitted the description of the potential distribution in the reactor. After the inoculation of the anodic and cathodic chamber the batch startup phase has been conducted by controlling the anodic potential at 0.2V vs. SHE.

**2. Methods**

The empty volume of the MEC was 12 L; The anodic and cathodic chambers were filled with graphite granules with a concentric configuration, the chambers were separated by a tubular anion exchange membrane (AEM). The synthetic biogas (70-30 % v/v N2-CO2) has been fed from the bottom of the biocathode, the graphite granules bed allowed the growing electroactive biofilm on the surface area, available for the mass transfer from gaseous to liquid phase and vice versa. The bioanode was fed with a synthetic mix of organic substrates (glucose, peptone, yeast extract and acetic acid). The MEC polarization was controlled by a three-electrode configuration, in which the anode chamber resulted the working electrode. NH4+ was used as tracer for the tracer test analyzed with the Nessler method.

**3. Results and discussion**

The tracer test permitted to calculate the hydraulic residence time (58 minutes) and the porosity of the graphite granules (0.57), moreover the test showed the complete hydraulic separation of the two chambers. In figure 1 shows the concentration of NH4+ during the tracer test.



**Figure 1.** Nitrogen concentration during the tracer test.

The polarization curve of the tubular MEC showed the dependence of the anodic and cathodic electrodic potentials as well as the current flowing in the circuit as a function of the applied potential difference. After the preliminary characterization of the fluidynamic and of the electrodic potentials, the anodic and cathodic chamber have been inoculated with an activated sludge and an anaerobic sludge, respectively. The anodic potential was set at +0.2 V vs SHE and it was fed with the synthetic mix solution with a batch configuration. After nine days from the inoculation of the MEC, the electric current profile showed the production of a current around 100 mA, indicating the capability of the anodic biofilm to consume the organic matter by suing the anode as electron acceptor. The startup process went on for 35 days reaching a maximum of 120 mA, while in the cathodic chamber, the methanogenic biofilm produced 45 mmol/d of methane with an average cathode capture efficiency (i.e. the conversion of the current into methane) around 100 %.

**4. Conclusions**

The new tubular configuration MEC startup was successfully performed by using synthetic mixture of organic substrates, that permitted the development of electroactive biofilms in the anodic and cathodic chambers to perform the bioelectromethanogenesis reaction, sustained by the COD anaerobic oxidation

**References**

1. Villano, M., et al., Bioelectrochemical reduction of CO2 to CH4 via direct and indirect extracellular electron transfer by a hydrogenophilic methanogenic culture. Bioresource Technology, 2010. 101: 3085-3090.