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SERIES HYDROGENESIS-METHANOGENESIS OF OFMSW: OPERATION AND ENERGETIC FEASIBILITY OF THE PROCESS

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Abstract

Over the last 15 years there has been an intensive research to improve the bioenergy that can be extracted from organic wastes through biotechnology. A recent option is through the series hydrogenesis-methanogenesis (H-M) process, and information on process energetic feasibility is still scarce. The aim of this work was to evaluate the effects of organic load, operation temperature on process performance and energetic feasibility of a series H-M semi-continuous process using organic fraction of municipal solid waste (OFMSW) as substrate.

Four experimental cases were set-up using OFMSW 20.9% total solids intermittently fed, as reported previously. Operational variables were two thermal regimes (35 and 55°C) and hydrogenogenic bioreactors (H-stage) running at 21 and 14 d mass retention time (MRT). Fermented solids from these biohydrogenogenic units were fed to methanogenic bioreactors (M-stage) at 28 d MRT. A steady state model of the process was developed in order to estimate the energy balance for 50 000 kg/d of wet OFMSW. On the one hand, the invested energy considered pre-heating of the feed to the H-stage, heat losses to ambient air of the bioreactors, energy for mixing the contents of bioreactors, and energy for pumping. On the other hand the generated energy was based on the heats of combustion of H_2 and CH_4 produced.

The best hydrogenic productivity was 202 mL H_2/(kg d) at 21 d TRM and 55 ºC, whereas the highest methanogenic productivity was 2023 NmL CH_4/(kg_r d) at 55 ºC fed with fermented solids from 14 d MRT. Energy balance proved that the net power was positive in all cases; the net energy was double (or higher) the energy invested in the H-M process. The highest contribution to generated energy corresponded to the methanogenic stage, which accounted for 95-98% of the total power potential.

Thermophilic was the best operating regime in terms of net power generation, despite the higher power consumption. Results confirmed earlier comparison of continuous meso and themophilic dark fermentation of OFMSW. Yet, the energetic performance was also dependent of mass retention time of the H-stage. For instance, cases #2 and #4, which operated at different thermal regime but same 14 d H-stage, had the highest P_{net} and correspondingly the highest ratio P_{net}/P_{invest} ratio. Despite the higher combustion enthalpy of hydrogen, the main contribution of the H-stage seemed to be related to providing readily digestible organic matter to the M-stage (through hydrolysis and fermentation), rather than contributing directly the power output. This work proved that H-M process is energetically feasible, yet ways of increasing hydrogen productivities should be further studied for higher power gains.

Key words: biohydrogen, energy balance, energy feasibility, methanogenesis, municipal organic solid wastes, series process