Investigation of the effect of different packing materials on biogas upgrading

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The ever-growing demand for alternative and renewable fuels instead of conventional ones holds a key role due to environmental and economic reasons. The world is facing a global energy crisis that is escalating rapidly. Thus, the management of energy resources is fundamental to the global economy and the well-being of the world population as well as the planet itself. The development of innovative, safer, and more independent sources of energy has been rendered imperative, and biogas-based technology has received tremendous attention. Biogas is considered among the most promising alternative renewable sources of energy. It is produced through anaerobic digestion and is a high-energy renewable fuel that can substitute fossil fuels. Biogas consists primarily of methane (50-70%), carbon dioxide (30-50%), and a mix of trace gases, including nitrogen, hydrogen sulfide, hydrogen and others (Angelidaki et al., 2018). Except from methane, the remaining gases contained in biogas are not desired. Thus, new technologies have been established in an effort to remove these unwanted gases from biogas. A process described as "biogas upgrade" has been widely utilized for the removal of CO_2. Biogas upgrading leads to an output gas with a higher concentration of methane than raw biogas due to the reduction or transformation of CO_2. The final gas product is called biomethane only when the biogas purification process meets as high standards as the ones applied in natural gas purification (Kougias et al., 2017). The produced biomethane can be used as a fuel for vehicles or directly injected into the gas grid and generally contributes to the production of heat and electricity (Tsapekos et al., 2021). There are several technologies for the production of biomethane; among them, a significantly promising one is the biological method, which is carried out by hydrogenotrophic methanogens. In this process, H_2 is injected into the anaerobic digester in order to reduce the CO_2 from biogas.

Different parameters are examined to maximize CH_4 production and purification during the biological biogas upgrading. Among them, the packing material (used in many different reactor setups) strongly affects the process. The packing materials support biofilm growth, immobilising the hydrogenotrophic methanogens on their surface (Kusnere et al., 2021). For this reason, the chosen material should have particular characteristics, such as optimal specific surface area and porosity necessary to sustain the growth and activity of microorganisms, to be non-toxic and cheap. The purpose of this research focuses on identifying a suitable packing material that can contribute to the improvement of the process performance and biomethanation efficiency.

Batch experiments were conducted to determine the optimum packing material for biofilm formation and thus enhancement of CO_2 conversion. For this reason, five different packing materials namely carbon pellets, raschig micro-rings, carbon foam, glass rings, and biochar, were utilized. The experiments were performed in 323 ml serum bottles with 100 ml working volume. The fraction of these materials was measured by packing a 100 Ml graduated cylinder. Enriched hydrogenotrophic culture obtained from a laboratory-scale biogas upgrading reactor was used to inoculate the batch reactors at 20% (v/v) of the working volume. Additionally, fresh biomass was used as a growth medium, ensuring that the microorganisms would be provided with all necessary nutrients and elements. The bottles were flushed with nitrogen gas and sealed with butyl rubber stoppers and aluminium crimps to maintain anaerobic conditions. When the bottles were sealed, a synthetic gas mixture of H_2:CO_2 (ratio of 4:1) was injected. All bottles were incubated at thermophilic conditions (i.e. temperature equal to 55^oC) in a continuously stirred, shaking incubator to maximise gas-liquid transfer. During the whole experimental period, all relevant biochemical parameters were monitored (i.e. gas composition, CH_4 production rate, H_2 and CO_2 conversion rate, concentration of volatile fatty acids etc).

As part of the analysis, aside from the packing materials, the following operating parameters will also be assessed for their effect on biomethane production:

- Temperature
- Pressure
- pH

The experiments are currently in progress. The results of the batch tests will be available during the conference time.

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