Effect of trickling filters in biological methanation

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Preliminary Abstract

Biogas is the product of a process, known as Anaerobic Digestion (AD). Biogas is usually composed from methane (CH_4, 50-70%), CO_2 (30-50%), as well as other from impurities, such as H_2S, NH_3, moisture etc. (although existing at significantly lower concentrations). These impurities, e.g. H_2S, are considered as highly corrosive to the equipment, and must be effectively removed. Additionally, the relatively high CO_2 fraction/content in the biogas reduces significantly its calorific value. For this reason a specific process, denoted as "biogas upgrade", is commonly applied in order to remove or transform most of CO_2 content and consequently, to increase the concentration of CH_4 in the final biogas output, hence increasing its calorific value and expanding the options for further potential applications towards e.g. the production of (bio)fuels (e.g. hydrocarbons) or of other important chemicals. An attractive method for increasing the CH_4 content in biogas is based on the biological methanization and the respective reaction between H_2 and CO_2, according to the following simple chemical equation:

$$4H_2 + CO_2 \rightarrow CH_4 + 2H_2O, \qquad \Delta Go = -130.7 \text{ KJ/mol}$$

The production of CH_4 from CO_2 by using (green) H_2 (such as that produced from electrolyzers by using renewable energy resources) provides and combines solutions to the two important environmental/energy problems and contributes to the reduction of greenhouse gas emissions. This preliminary study focuses on the production of CH_4 from CO_2 with all the benefits of potential subsequent use of it. In particular, two trickling filter-beds (reactors) have been used, with the following dimensions, containing (for comparison reasons) either activated carbon or Raschig rings, aiming to understand better the role of fillers (substrate materials) for the methanation process.

Table 1. Dimensions of trickle bed reactors.

Functional Volume	~1 L
Inner Diameter	54.80 mm
Height	50 cm

During the preliminary experiments in each reactor a culture of hydrogenotrophic microorganisms have be recirculated, in order to contact with the filter (filler) media. The CO_2/H_2 (artificial) gas mixture (at 20:80 ratio) was then injected from a special feed inlet located at the bottom of the reactors. The gas mixture as it ascends in the reactor will encounter completely digested waste from working anaerobic digestion units, which acts as nutrient solution for the growth of specific microorganisms, and which will be fed to the reactors with proper drippers from their upper surfaces. The reactors will be operated in the thermophilic area (55 ± 1^{o} C), by using heated mantles.

The experiments will investigate the major operating parameter, i.e. GRT (Gas Retention Time), in the reactors, in order to optimize the conditions of the system, leading to the maximum conversion of CO_2 to CH_4. The change of residence time of the gas for each treatment will be performed after the achievement of stable reactor operating conditions (i.e. following the stable production of CH_4 for at least 5 days).

Table 2. Gas retention times for each treatment.

Treatment	**Gas Retention Time (min)**
A	360
B	240
C	120
D	60

During the experiments, there will be also examined:
• The composition of exhaust gases from the reactors
• The pH values and effects in the process
• The metabolic intermediates (VFA)
• The presence of nutrients (Ca, K, etc.)