METHANOL PRODUCTION FROM BIOGAS

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One of the major environmental problems nowadays is the presence of carbon dioxide in the atmosphere, which causes the well known greenhouse effect. For this reason, the capture and recovery of the CO_2 is being widely investigated. Some of the employed techniques allow for the reutilization of this compound in other processes, for example in the production of methanol, with high importance in chemical industries. Besides, methanol can be used as fuel, replacing petrol in some applications.

Figure 1. Methanol production plant

Methanol production by selective hydrogenation of carbon dioxide is a new technological alternative for the capture and reutilization of CO_2. When CO_2 is mixed with methane, such as in the case of biogas, it can be used as a a carbon source in the synthesis of methanol, according to the Steam Methane Reforming reaction (SMR), where the gases formed in methane reforming act as precursors for the alcohol.

The main reactions occurring during methanol synthesis process are:

$$CH_4 + H_2O \rightarrow CO + 3H_2 \quad (1)$$ Steam methane reforming

$$CO_2 + H_2 \leftrightarrow CO + H_2O \quad (2)$$ Inverse water-gas shift reaction

$$CO + 2H_2 \leftrightarrow CH_3OH \quad (3)$$

$$CO_2 + 3H_2 \leftrightarrow CH_3OH + H_2O \quad (4)$$

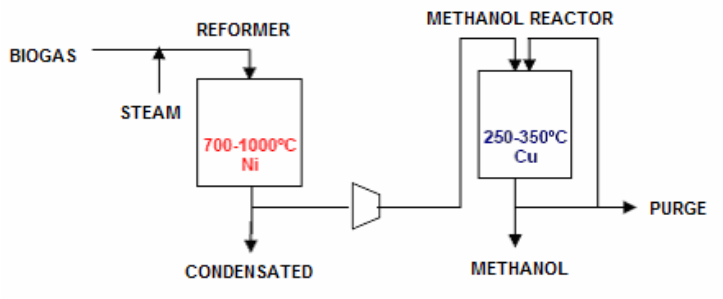

Figure 2. Process scheme

There are two basic stages in the process: biogas reforming and methanol synthesis.

Due to the heterogeneity of the kinetics of both stages the catalyst selection and the operational conditions are critical. High temperatures are necessary to obtain high conversions due to the strongly endothermic nature of the reforming reaction of methane with CO_2. Best results are usually reported when Ni/Zn/Al catalysts are employed. Reactions (1) and (2) correspond to the reforming stage, while methanol synthesis includes reactions (3) and (4). The second stage requires lower temperatures than the first one, however higher pressures are needed. Conventional catalysts for this second stage are Cu-based, although good results are also achieved in the presence of noble metals.

Biogas reforming is based on a thermodynamic equilibrium that can be simulated by different programs. The simulation provides the theoretical compositions that will be achieved. Best results are obtained if steam is employed at this reforming stage.

On the other hand, methanol synthesis is not thermodynamically but kinetically controlled. The kinetics of methanol reaction has an important effect in this second stage. Therefore, to determine the best conditions of the process, it is necessary to test different types of catalysts as well as different conditions of temperature and pressures.

Methanol can be produced either by reactions (3) or reaction (4). Since methanol is always produced regardless of the composition of the feed stream, it is not clear what the preferential way is (when CO, CO_2 or both compounds are present).

OBJECTIVES

This project intends to study the technical feasibility of biogas conversion into methanol, by performing experiments in a laboratory scale plant. The yield and the selectivity of the process will be studied together with the kinetics of the methanol synthesis using commercial catalysts. Different temperatures and pressures will be selected for this study.