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## **BIOGAS UPGRADING AND CO<sub>2</sub> CAPTURE BY ADSORPTION TECHNOLOGIES**

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## **BIOGAS UPGRADING AND CO<sub>2</sub> CAPTURE BY ADSORPTION TECHNOLOGIES**

### **1. Purpose**

The reduction of CO<sub>2</sub> and CH<sub>4</sub> emissions to atmosphere is a matter of great concern nowadays since both gases can contribute significantly to the so-called greenhouse effect that describes the trapping of heat near earth's surface by gases in the atmosphere. At the same time CO<sub>2</sub>/CH<sub>4</sub> separations are of interest in treating gas streams like landfill gas, biogas and coal-bed methane. Accordingly, there is a need to investigate on this topic and that can be done with improved efficient technologies to separate or remove CO<sub>2</sub> and CH<sub>4</sub> from exhaust gases.

### **2. Design, Methodology or Approach**

Biogas is mainly composed by CH<sub>4</sub> (60 to 70%) and CO<sub>2</sub> (30 to 40%) and to obtain a high energy content CO<sub>2</sub> needs to be separated from CH<sub>4</sub>. For this purpose a variety of solid physical adsorbents have been considered including molecular sieve zeolites and a new class of adsorbents named Metal-Organic Frameworks (MOFs). The technology for biogas upgrading using adsorbents is called Pressure Swing Adsorption (PSA). With this technique, carbon dioxide is separated from the biogas by adsorption in a porous solid under elevated pressure. The adsorbing material, is regenerated by a sequential decrease in pressure before the column is reloaded again, hence the name of the technique. In this work, we will present breakthrough experiments and selectivity data of CO<sub>2</sub> and CH<sub>4</sub> in MOF-508b and zeolite 13X at 303, 313, 323, 343, 373 and 423 K and partial pressures up to 4.5 bar. These data was used to develop a mathematical model useful to design (simulation) a cyclic adsorption processes (PSA) for the purification of biogas and CO<sub>2</sub> sequestration using porous solid adsorbents.

### **3. Results/Findings**

The design of a Pressure Swing Adsorption process for biogas upgrading using porous solids requires the measurement of thermodynamic data such as the adsorption equilibrium data and selectivities between CO<sub>2</sub> and CH<sub>4</sub> based in the ratio of the amount adsorbed of the compounds at a certain temperature and pressure. Such data can be obtained from breakthrough experiments. At LSRE it has been performed a detailed experimental study with zeolite 13X and MOF-508b.

Figure 1 shows an experimental breakthrough curve performed in a fixed bed containing zeolite 13X feed with a 50/50-CH<sub>4</sub>/CO<sub>2</sub> mixture at 313 K and 5 atm. The breakthrough curve clearly shows the potential of zeolite 13X to separate a CH<sub>4</sub>/CO<sub>2</sub> mixture since a clear separation of CH<sub>4</sub> from CO<sub>2</sub> is observed at the outlet of the bed with a long plateau of pure CH<sub>4</sub> for a period around 4 minutes.

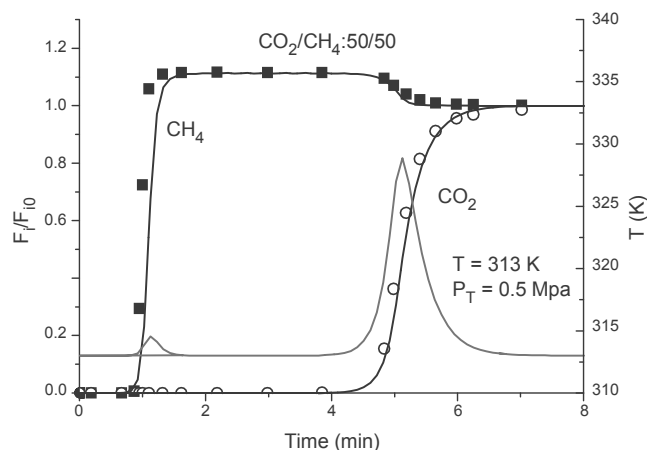


Figure 1 Binary 50/50 breakthrough curve of CO<sub>2</sub>/CH<sub>4</sub> in 13X zeolite at the temperature of 313 K and total pressure in the column of 0.5 MPa. Points are experimental data and lines represent model (simulated) predictions (black for fluxes and red for temperature).

Figure 2 shows the temperature dependent sorption selectivity obtained for several 50/50 and 25/75 CO<sub>2</sub>/CH<sub>4</sub> mixture experiments as a function of total pressure of the sorbate species. The  $S_{CO_2/CH_4}$  is very high at the low temperature of 313 K and total pressure of sorbates of 0.0666 MPa being 36.3 and 21.1 for the 25/75 and 50/50 mixtures, respectively.

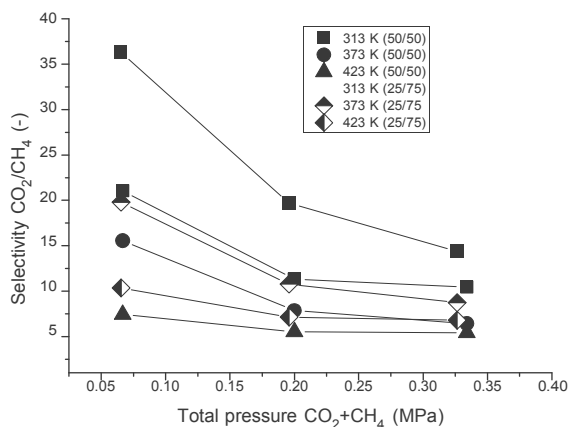


Figure 2. Selectivities as function of temperature and total mixture pressure of adsorbable species for several binary 50/50 and 25/75 mixture ratio experiments.

#### 4. Conclusions

Among the several technologies available for CO<sub>2</sub> removal Pressure Swing Adsorption (PSA) using a porous solid has been proved to be an efficient one. The discovery of new porous solids can increase the competitiveness of PSA technology. In this work it is shown through experimental data that the new 13X zeolite binderless beads zeolite can improve significantly the PSA technologies for BIOGAS upgrading with selectivities CO<sub>2</sub>/CH<sub>4</sub> that can reach the value 34 and amounts adsorbed of CO<sub>2</sub> around 5.2 mmol/g. A mathematical model was also developed and validated through experimental data to design PSA adsorption processes for biogas upgrading.