Application 2024

Performance and characterization of two activated carbons fo biogas treatment applications

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One of the solutions that could contribute to decrease dependence from fossil fuels is represented by the exploitation of fuels from biomass through anaerobic digestion. The use of this renewable source determines a very low environmental impact but the resulting biogas is generally poor in energy content. For this reason, biogas can be exploited using a high efficiency conversion system, such as high temperature fuel cells, enhanced in a micro-cogeneration plant.

Unfortunately, sulphur compounds, halogenated hydrocarbons and siloxanes can often be found in biogas. The main sulphur compounds present in biogas are hydrogen sulphide H2S (100-1000 ppm), mercaptanes (0-100 ppm) and traces of COS, CS2 and SO2. H2S represents one of the most harmful compounds for environment and working equipment. In fuel cells applications, H2S poisons both the reformer and the electrodes catalysts of the fuel cell, reacting with nickel; consequently, the biogas should be purified and H2S fraction reduced down to the tolerance limit (< 1 ppm) to allow its safe use. There are many clean up technologies to reduce sulphur levels, but not all can reach ultra-low sulphur for fuel cell applications.

In this project, sulphur removal through adsorption systems is studied: the behaviour and adsorption capacity of selected adsorbent materials are investigated. So far, two impregnated activated carbons (AC AIRPEL ULTRA DS from Desotec and AC RGM1 from Norit) have been tested in N2 and biogas matrices, and in dry and wet conditions. It was seen that in dry biogas, AC Norit RGM performs much better than AC Desotec AIRPEL ULTRA DS. However, in wet biogas (45-50% R.H.) Norit RGM slightly enhances its performance, while Desotec AIRPEL ULTRA DS shows a significant increase of its adsorption capacity, reaching a value similar to the RGM one.

Therefore, further tests are needed to study the behaviour of these two impregnated activated carbons and determine their adsorption capacity in the real operating conditions. Furthermore, characterization of the materials is needed both before and after their use.

The project can be divided in three different tasks:

1) Performance of AIRPEL ULTRA DS and RGM in:

- Biogas matrix
- H2S inlet = 600-800 ppmv
- Temperature = 30 - 40 ºC
- Pressure = 1 bar
- Relative Humidity = 70-100 %
- O2 inlet = 4 times stoichiometric (related to H2S)

2) Characterization of the raw materials

- N2 isotherms: determination of BET surface, pore distribution and pores volume)
- Thermogravimetry
- Scanning Electron Microscopy
- Energy-Dispersive X-ray spectroscopy

3) Characterization of the used materials

- N2 isotherms: determination of BET surface, pore distribution and pores volume)
- Thermogravimetry
- Scanning Electron Microscopy
- Energy-Dispersive X-ray spectroscopy

Activity scheduling:

- Week I & II: test bench setup adjustment and test campaign study and definition
- Week III, IV & V: Test campaign execution
- Week VI & VII: Samples post-analysis
- Week VIII: Results analysis and report production.