Impact of Energy-Promoters/Additives on CO2 capture, for biogas upgrading

Randi Neerup¹, Susana Almeida¹, Dennis Skov Kloth¹, Arne Gladis¹, Nicolas von Solms¹, Philip L. Fosbøl¹

¹Center for Energy Resource Engineering (CERE), Department of Chemical Engineering, Technical University of Denmark (DTU), Søltofts Plads, Building 229, Kongens Lyngby, Denmark

Abstract
Climate change and its unexpected environmental risks drives the urge for effective greenhouse gas reduction technologies, leading to a growing interest in Biogas technologies, as an alternative to generate energy without Carbon Dioxide (CO₂) emissions.

Currently in Denmark, Biogas represents 1.5% of the total energy consumption; however, it has the potential to increase to 15% [1].

Biogas can be produced from biological resources as manure and waste water treatment; whereas untreated it contains typically 40% CO₂, Methane (CH₄) and some impurities. This leaves the gas with a low burning value (8 kWh/m³) [2]. One way to increase the burning value (to 15 kWh/m³) is to upgrade the biogas to biomethane and inject it in the natural gas grid; unavoidably the CO₂ is released to the atmosphere during the process.

Alternatively the biogas can be upgraded to, not only produce biomethane, but also pure CO₂, bioCO₂, as well. This can be used downstream for products like food, welding and biofuel applications.

The aim of this project is to perform a basic absorption test of 30 wt% MEA using additives which have a potential to reduce energy consumption in coolers, reboilers, and wash sections of the CO₂ capture plant.

The objective is to prove that the additives will have similar or better performance on mass transfer compared to 30 wt% MEA. This conclusion allows us to use the additives in existing columns, designed for MEA CO2 capture. For this, we will apply the DTU packed column, which is 10 meters high and 10 cm in diameter. A second objective is to study which height of absorption column allows us, not to have 90% capture, but to have 2% CO₂ in the outlet. This condition is very relevant to biogas upgrading. In order to distribute methane into the Danish natural gas grid system it must contain no more than 2% CO₂.

The results of the study will be applicable to future front end engineering designs (FEEDs) of biogas upgrading plants.

Pilot
The used pilot is 10 m high, with 10 cm diameter packed column of 250 Y structured Mellapak (see Figure 1). The absorption experiments were performed at atmospheric pressure and the solvent was...
at room temperature before it entered the column. The gas flow was set to 15 kg/hr and the CO₂ concentration to 33.9 vol%, the liquid flow was varied during the campaign as well as the liquid inlet height. During the experiments, liquid samples were taken at each meter of column height and the solvent loading was measured both by density measurements and BaCl₂ titration so that the full column profile could be studied.

![Absorption Column](image)

**Figure 1** – Absorption Column where the experiments were conducted.

![Graph](image)

**Figure 2** – CO₂ concentration at the outlet of the column as function of the L/G ratio with 6 m column.

**Experimental design**

Two additives were studied (DTUad1 and DTUad2) at 15 wt%. These were compared to 30 wt% MEA. The performance was analyze in order to see the influence of CO₂ absorption efficiency. The
inlet CO₂ loading is industrially relevant, 0.25 mol CO₂/mol amine. The experimental results were compared, under equivalent experimental conditions.

The DTUad1 and DTUad2 names are currently patented pending; however, they may be released during GHGT 14 conference.

**Results and Conclusions**

Figure 2 shows the result of 9 pilot runs with fixed inlet conditions. The liquid flow was change from one run to the next at fixed gas flow. Increasing the L/G resulted in higher CO₂ absorption, expectedly. The results show that a goal of 2% CO₂ in the natural gas can be obtained with 6 m column height and a minimum L/G ratio of 9.3 kg of liquid/kg of gas. We observed that at L/G ratio of 11.5 almost all the CO₂ was absorbed. This conclusion is the same for 30 wt% MEA with and without additives. However, this solution represents a higher operational cost compared to the L/G ratio of 9.3 that also reaches the 2% CO₂ goal. A full table with the experimental results will be available for the final work report.

It was observed, on both additives that they behaved similarly to the solution containing only 30 wt% MEA. It can be concluded that the presence of additives do not influence CO₂ absorption efficiency to a large extend. This is a positive conclusion since we only want these additives to influence the performance of the energy consuming units of the capture process. The absorption column is not one of them.

The experiments were carried out with the propose of determine the dimensions and design of a mobile test unit (MTU) with a capacity up to 40 Nm³/h of biogas. The MTU design and built will be transported around Denmark in order to test the efficiency of the DTU additives.

**References**