16th International Conference on Greenhouse Gas Control Technologies **GHGT-16**

23-27th October 2022, Lyon, France

An Experimental Assessment on the Impact of Amine Concentration in the Oxidative Degradation of Amines

Karen K. Høisæter[a], Andrea E. Nordberg[a], Vanja Buvik[a], Solrun J. Vevelstad[b], Andreas Grimstvedt[b], Hanna K. Knuutila[a]*

[a]*Department of Chemical Engineering, NTNU, Trondheim 7491, Norway*
[b]*SINTEF Industry, P.O.Box 4760 Torgarden, NO-7465, Norway*

Abstract

For post-combustion CO_2-capture, chemical absorption utilizing aqueous amine solutions is a commonly used method (Kohl and Nielsen, 1997). A drawback of this system, however, is that the amines will degrade over time due to exposure to heat, reactive compounds in the flue gas and contact with metals. The degradation of the amines leads to solvent losses, corrosion of the process equipment, as well as a potential strain on the environment caused by the large amounts of amine-waste (Chakma and Meisen, 1997).

In recent years, utilizing water-lean solvents, or hybrid solvents, has been proposed in literature as an option to reduce the energy consumption for solvent regeneration (Heldebrant et al., 2017). The common denominator for water-lean solvents is a reduction in the water content. This can either be done by replacing the water with an organic diluent or with by increasing the amine concentration. These water-lean solvent systems have not yet been thoroughly studied, and so, there is still very little data related to how the low water concentrations influence the degradation of the amines. (Wanderley et al., 2021) Understanding how the change in solvent composition influence the degradation is an important step in improving the viability of these systems.

In this work, experimental data from the oxidative degradation of amines with increasing amine concentration will be studied. By varying the concentration of the CO_2, amines and water we will look into the impact of the solvent composition on the oxidative degradation. To this end, two series of experiments will be conducted. In the first series, the amine concentrations are varied while the loading is kept constant, i.e. the concentration of CO_2 increases with the increasing amine concentration. In the second series, the absolute amount of CO_2 is kept constant while the amine/water ratio is varied. In this way, we hope to discern the effect of the change in amine concentration separately from the effect of the CO_2 concentration.

The degradation experiments are carried out in an open setup. The solvent will be heated up and a continuous flow of O_2, CO_2 and N_2 is sparged into the constantly stirred solution. Often, experiments like this has been done at 60 °C and with an oxygen percentage of 98%. In the current work, however, the temperature will set to 75 °C and oxygen percentage will be at 6%. These

* Corresponding author. Tel.: +47 735 94 119, *E-mail address:* hanna.knuutila@ntnu.no

parameters are chosen as it has been shown to give degradation results resembling results seen from cycled degradation rigs and pilot plants (Vevelstad et al., 2021). Especially the formation of the major degradation compounds was closely mimicked. Each experiment run for 3 weeks and samples will be taken twice a week. The samples will be analysed using LC-MS and NMR. This will allow for identification and quantification the main degradation products in the different solutions. Experiments will be run with MEA as a reference system before testing other promising amines.

In the conference, we will present the results from the degradation studies and discuss how the amine concentration and CO_2 content influence the oxidative degradation. These results will give a better understanding of the effect of the solvent concentration on the amine degradation rates.

References:

Chakma, A., Meisen, A., 1997. Methyl-diethanolamine degradation — Mechanism and kinetics. Can. J. Chem. Eng. 75, 861–871. https://doi.org/10.1002/cjce.5450750506

Heldebrant, D.J., Koech, P.K., Glezakou, V.-A., Rousseau, R., Malhotra, D., Cantu, D.C., 2017. Water-Lean Solvents for Post-Combustion CO Capture: Fundamentals, Uncertainties, Opportunities, and Outlook. Chem. Rev. 117, 9594. https://doi.org/10.1021/acs.chemrev.6b00768

Kohl, A.L., Nielsen, R.B., 1997. Alkanolamines for Hydrogen Sulfide and Carbon Dioxide Removal, in: Gas Purification. pp. 40–186. https://doi.org/10.1016/b978-088415220-0/50002-1

Vevelstad, S.J., Grimstvedt, A., Haugen, G., Wiig, M., Vernstad, K., 2021. Evaluation of Results from SDR Campaigns and Pilot Data, in: Røkke, N.A., Knuutila, H.K. (Eds.), TCCS-11 - Trondheim Conference on CO2 Capture, Transport and Storage. Trondheim, pp. 35–39.

Wanderley, R.R., Pinto, D.D.D., Knuutila, H.K., 2021. From hybrid solvents to water-lean solvents – A critical and historical review. Sep. Purif. Technol. https://doi.org/10.1016/j.seppur.2020.118193

Acknowledgment

The LAUNCH project is funded through the ACT programme (Accelerating CCS Technologies, Horizon2020 Project No 299662). Financial contributions have been made by Ministry of Economic Affairs and Climate Policy, the Netherlands; The Federal Ministry for Economic Affairs and Energy, Germany; Gassnova of Norway through the CLIMIT program; and the Department for Business, Energy & Industrial Strategy, UK, with extra funding from the US Department of Energy. All funders are gratefully acknowledged.

Keywords: CCS; absorption; oxidative degradation; water-lean; hybrid solvents; amines; MEA; NMR; LC-MS;