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

23-27th October 2022, Lyon, France

Identification of degradation compounds in a blend of 1-(2hydroxyethyl)pyrrolidine and 3-amino-1-propanol

Solrun Johanne Vevelstad*, Andreas Grimstvedt, Kai Vernstad and Merete Wiig

SINTEF Industry, P.O.Box 4760 Torgarden, NO-7465 Trondheim, Norway

Abstract

Chemical absorption of CO_2 using aqueous amine solvent is a mature technology. As other processes based on chemical reaction unwanted reactions are also observed, these reactions are in this case called degradation reactions and are occurring in the presence of CO_2, O_2, NOx, other impurities, temperature, and dissolved metals. Additional simplification is also done separating this into thermal or oxidative degradation reactions. In the capture process the solvent is cycled between low and high temperature and all aspect around the chemical reactions occurring could not be represented by batch experiments for thermal or oxidative degradation studies. The thermal and oxidative degradation experiments are useful for characterization and identification of degradation compounds as well as in solvent screening phase. For a more realistic overview of the profile of degradation products a cycled set-ups that mimic the overall process is required. The degradation products formed contain various functional groups and usually advanced analytical instrumentation is required to analyze for the full specter of components. This work focuses on identification of degradation compounds in the blend of 1-(2-hydroxyethyl)pyrrolidine (1-(2HE)PRLD) and 3-amino-1-propanol (3A1P). This is a solvent previous developed in an EU project called HiPerCap [1, 2] which has been further optimized in the ongoing EU project REALISE [3]. The REALISE project aim to demonstrate CO_2 capture technology based on advanced low-energy solvent at pilot scale, additionally emissions and solvent degradation will be quantified, additionally also the quality of the liquified CO_2 will be demonstrated when impurities from flue gases from an operating refinery are introduced to the pilot.

The samples used for identification of degradation compounds originates from a cycled degradation set-up called the solvent degradation rig (SDR) that has been presented elsewhere [4, 5]. This rig is often used to investigate the robustness of the solvent at stressed conditions at higher desorber temperature or higher NOx concentration. Despite of varying experimental conditions throughout the campaign the rig gives similar profile of degradation compounds for 2-ethanolamine (MEA) that has been observed for larger pilots, e.g. MEA campaigns at the Technology Centre at Mongstad [6].

The degradation compounds identified in this work is based on standards of the degradation compounds provided by commercial suppliers. Overall, the analytical program for this blend included 42 compounds with various functional groups, where 30 of them where either observed in the solvent or in the condensate sample or in both. These 30 compounds could be divided in general and solvent specific components. For the solvents specific components, the following Liquid Chromatography – Mass Spectrometry (LC-MS) instrumentation was used for the analyses; Agilent Technologies 1290 Infinity LC coupled with Agilent Technologies 6495 Triple Quad MS detector.

For the samples from the solvent degradation rig the major degradation compounds with nitrogen is believed to be identified as the nitrogen balance over the solvent samples are closed (i.e. recovery of 100%) when also analytical uncertainties are taken into

* Solrun Johanne Vevelstad. Tel.: +47 40642608, *E-mail address:* solrun.j.vevelstad@sintef.no

consideration (see Figure 1).

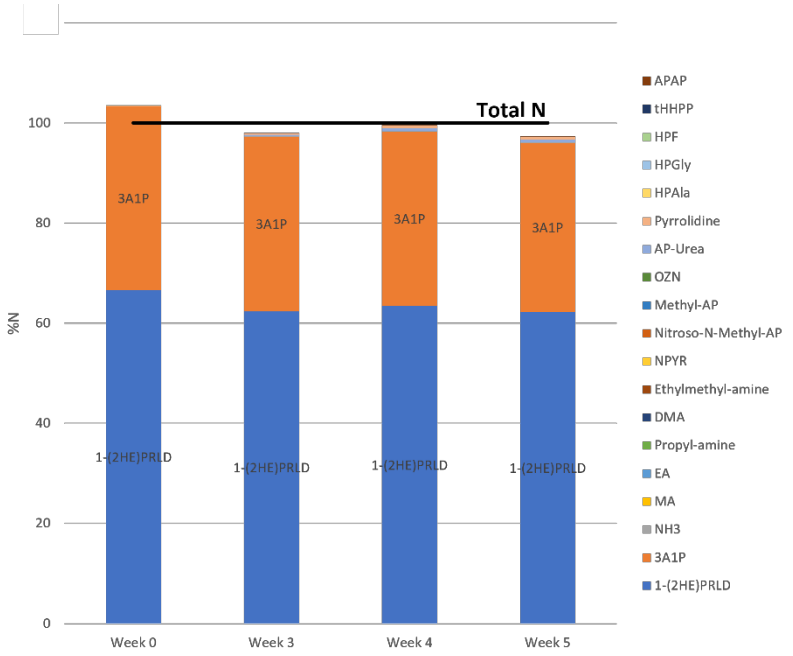

Figure 1: Total nitrogen balance for solvent samples.

Degradation pathways for many of the degradation compounds have also been suggested, an example is given for Methyl-AP in Figure 2.

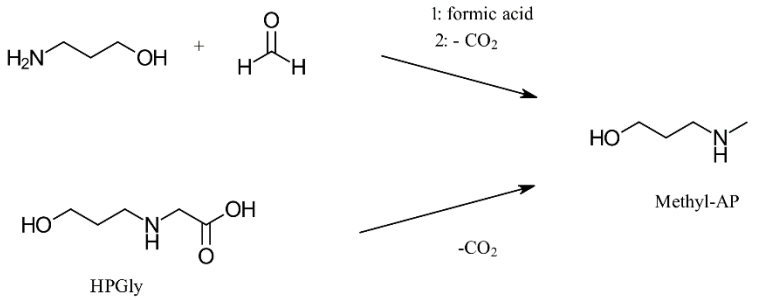

Figure 2: Suggested pathways for formation of Methyl-AP adapted from [7, 8].

The other 29 components will be presented at the conference and pathways for formation will be shown for major components.

Keywords: CO2 capture; amine blend; degradation; identification; LC-MS

Acknowledgements
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 884266

References

1. Hartono, A., et al., *Characterization of 2-piperidineethanol and 1-(2-hydroxyethyl)pyrrolidine as strong bicarbonate forming solvents for CO2 capture.* Int. J. Greenhouse Gas Control, 2017. **63**: p. 260-271.
2. Hartono, A., et al., *Promoted Strong Bicarbonate Forming Solvents for CO2 Capture.* Energy Procedia, 2017. **114**: p. 1794-1802.
3. Kim, I., et al. *Demonstrating a Refinery-Adapted Cluster-Integrated Strategy to Enable Full-Chain CCUS Implementation - REALISE*. in *Proceedings of the 15th Internaitonal Conference on Greenhouse Gas Control Technologies (GHGT-15)*. 2021. Abu Dhabi, UAE.
4. Einbu, A., et al., *A new test rig for studies of degradation of CO_2 absorption solvents at process conditions; comparison of test rig results and pilot data of degradation of MEA.* Energy Procedia, 2013. **37**(0): p. 717-726.
5. Vevelstad, S.J., et al., *Comparison of different Solvents from the Solvent Degradation Rig with Real Samples.* Energy Procedia, 2017. **114**: p. 2061-2077.
6. Morken, A.K., et al., *Degradation and Emission Results of Amine Plant Operations from MEA Testing at the CO2 Technology Centre Mongstad.* Energy Procedia, 2017. **114**: p. 1245-1262.
7. Lepaumier, H., *Étude des mecanismes de dégradation des amines utilisees pour le captage du CO_2 dans les fumées*, in *Sciences Pour l'Ingénieur*. 2008, Savoie.
8. Vevelstad, S.J., et al., *Influence of experimental setup on amine degradation.* Int. J. Greenhouse Gas Control, 2014. **28**: p. 156-167.