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Personnel exposure and sampling methods related to amine-based CO_2 capture technology

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Abstract
Decarbonizing heavy industries is key for achieving the carbon mitigation goals outlined in the IPCC-6 report [1]. Amine-based carbon capture is the among the most mature technologies available for decarbonizing existing industrial point sources for CO_2 emissions today. Technology Centre Mongstad (TCM) have since 2012 operated and demonstrated generic and proprietary amine solvents for post combustion carbon capture (PCCC) [2]. TCM is located at the west coast of Norway in the vicinity of Equinor's oil refinery at Mongstad. With access to two distinctly different industrial flue gases: MHP (Mongstad Heat Plant) and RFCC (Residual fluid catalytic cracker) and the ability to manipulate these flue gases (through dilution and CO_2 recycle), TCM can assess solvent technologies under conditions that are applicable for multiple industries [3]. A key purpose for TCM is to accelerate the adoption of carbon capture technologies, by reducing technical, economic, and environmental risks [4].

The company is a joint venture between Gassnova (the Norwegian state), Equinor, Shell and Total Energies with a common vision for testing, research and development of carbon capture and storage (CCS) for the deployment of large-scale carbon capture. The large number of public, industrial, research and academic participants involved in test campaigns performed at TCM have enriched the projects and ensured that the results will serve a broad range of audience. Both proprietary and non-proprietary campaigns have been performed since startup. Two non-proprietary solvent solutions have been tested, MEA (Monoethanolamine or 2-aminoethanol) and CESAR 1 (27 wt% 2-Amino-2-methylpropanol (AMP) and 13 wt% piperazine (PZ)). The process of removing CO_2 from a flue gas with amine-based absorption technologies introduces new components related to degradation of the main solvent. Among known components are nitrosamines which are in general classified as carcinogenic components.

The Norwegian Institute of Public Health (NIPH) was commissioned to assess the potential adverse effects of Amines based carbon capture as part of the start-up of TCM. NIPH published a report regarding health effects of amines and

derivates. The report recommends ensuring minimal or negligible risk of cancer for the population from exposure to these substances. NIPH concludes that the total amount of nitrosamines and nitramines should not exceed 0.3 ng/m^3 in air and 4 ng/L in water for the population [5].

Chemical exposure is considered as one of the major work environmental risks for personnel at TCM. Therefore, risk assessments, classification and monitoring of chemicals is an important topic for TCM. During more than ten years of operation TCM have performed several samplings related to work environment, both stationery and personnel monitoring. Stationary sampling can be used to measure average background concentrations, while personnel monitoring often is used to indicate task or shift average exposure concentrations to personnel.

Main findings at TCM shows that nitrosamines can be present when tests are performed, however median and average background levels were generally present at low concentrations (mean 5.8 ng/m^3). These results demonstrate that background levels at TCM are in compliance with today's OELV of 200 ng/m^3 for the work environment. In fact, most of the measurements were below or in the same magnitude as the level of quantification [6]. The main objective with this paper is to focus on potential personal exposure for TCM personnel. Previous study shows that in general the personal exposure is low, but personal exposure needs to be studied in more detail [6]. To achieve a more detailed description collected data will be elaborated statistically for both full shift- and task-based data. Handling of data will be in handled accordance with standard EN-689 [7].

In addition, Reyes-Lingjerde et al. have showed that there is some uncertainty regarding sampling methods [6]. There have been performed laboratory studies to identify some uncertainty. The ambition is to go deeper into this uncertainty and try to close this knowledge gap by performing new laboratory experiments.

1. *Keywords:* Nitrosamines; Amines; sampling methods; Technology Centre Mongstad (TCM); Piperazine (PZ); 2-Amino-2-methylpropanol (AMP); Monoethanolamine or 2-aminoethanol (MEA), CESAR 1; CO_2-Capture, work environment; HSE

References:

[1] IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [MassonDelmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

[2] a) E. Gjernes, S. Pedersen, D. Jain, K. I. Åsen, O. A. Hvidsten, G. de Koeijer, L. Faramarzi, T. de Cazenove, Documenting modes of operation with cost saving potential at the Technology Centre Mongstad, 14th Greenhouse Gas Control Technologies Conference Melbourne 21-26 October 2018 (GHGT-14), b) L. Faramarzi, D. Thimsen, S. Hume. A. Maxon, G. Watson, S. Pedersen, E. Gjernes, B. F. Fostås, G. Lombardo, T. Cents, A. K. Morken, M. I. Shah, T. de Cazenove, E. S. Hamborg, Energy Procedia, 114, 2017, 1128-1145, c) A. Morken, S. Pedersen, E. R. Kleppe, A. Wisthaler, K. Vernstad, Ø. Ullestad, N. E. Flø, L. Faramarzi, E. S. Hamborg, Energy Procedia, 114, 2017, 1245-1262, d) C. Benquet, A. Knarvik, E. Gjernes, O. A. Hvidsten, E. R. Kleppe, S. Akhter, First Process Results and Operational Experience with CESAR1 Solvent at TCM with High Capture Rates (ALIGN-CCUS Project), Proceedings of the 15th Greenhouse Gas Control Technologies Conference 15-18 March 2021.

[3] a) K. Johnsen, E. R. Kleppe, L. Faramarzi, C. Benquet, E. Gjernes, T. de Cazenove, A. K. Morken, N. Flø, M. I. Shah, M. Aronsson, Ø. Ullestad, CO2 product quality: assessment of the range and level of impurities in the CO2 product stream from MEA testing at the Technology Centre Mongstad (TCM), Proceedings of the 14th Greenhouse Gas Control Technologies Conference Melbourne 21-26 October 2018 (GHGT-14), b) G. Lombardo, M. I. Shah, B. Fostås, O. A. Hvidsten, L. Faramarzi, T. de Cazenove, H. Lepaumier, P. Rogiers, Results from testing of a Brownian diffusion filter for reducing the aerosol concentration in a residual fluidized catalytic cracker flue gas at the Technology Centre Mongstad, 14th Greenhouse Gas Control Technologies Conference Melbourne 21-26 October 2018 (GHGT-14).

[4] TCM webpage: https://tcmda.com/about-tcm/#Our_purpose , accessed 04.11.2021

[5] M. Låg, B. Lindeman, C. Instanes, G. Brunborg, P. Schwarze. (2011). Health effects of amines and derivatives associated with CO2 capture. Folkehelseinstituttet (Norwegian Institute of Public Health), April 2011, p.30.
[6] A. Reyes-Lingjerde, H.T. Smedbold, A. Drageset, A. Håland, A.K Morken, E.R. Kleppe, Ø. Ullestad, O.A. Hvidsten. (2021). CO2 Capture and work environmental sampling at TCM - lessons learned. Technology Centre Mongstad.
[7] Comite Europeen de Normalisation (CEN) (2019). Workplace exposure – Measurement of exposure by inhalation to chemical agents – Strategy for testing compliance with occupational exposure limit values, EN 689.