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Regulatory framework for sustainable and cost-efficient amine emission control

Hanne M. Kvamsdal*, Eirik F. da Silva, and Karl Anders Hoff

SINTEF Industry, Sem Saelands vei 2A, 7465 Trondheim, Norway

Abstract

Reactive absorption technology with amines is a mature technology, and recent improvements in thermal energy requirements and solvent management have moved amine-based CCUS further down the road towards commercialisation. Several studies and ongoing industrial CCUS projects conclude that the technology will be a major tool for reducing the carbon footprint of many hard-to-abate industries like the cement, metallurgical and steel industries, (biomass) waste incineration and the power industry.

However, emission of amines and amine degradation compounds is still a challenge due to a lack of data, quantitative documentation, and predictive models for the emissions. Such information and knowledge gaps therefore limit the pace of regulatory developments and also limits the drive towards development of process design for efficient amine emission control. It is the aim of the SCOPE (Sustainable OPEration of post-combustion Capture plants, https://www.scope-act.org/) project[1] to accelerate large scale CO_2 capture projects by providing critical data, methodologies and tools that are essential for plant owners and regulators engaged in managing emissions and permitting processes, This is ensured through the study of all the aspects required to establish a regulatory framework using a holistic approach by following the continuous path of the treated gas from source to recipient.

SCOPE is integrating multiple information sources to devise target emission values and thresholds for the design of emission control. However, it is known that the actual emitted compounds are highly dependent on the flue gas being treated, the choice of solvent and plant operating conditions. Both scientifically derived and region-specific emission thresholds and plant-specific design requirements are likely to be needed and must be based on valid models of the dispersion and fate of emissions, current understanding of the potential impacts to ecosystems and human health, the techno-economic limits to emissions monitoring and control, and legal and public expectations for the protection of the human health and the environment. We are confident that it is technically possible to bring capture plant emissions down to meet regulatory requirements, but there are often costs associated with improved emission-control. So, the question is, how shall we determine what is the acceptable capture plant emission?

In the presentation we will address on an overall level the various aspects needed to establish a regulatory framework and in particular focus on how to establish reasonable emission targets for the most important compounds from a regulatory perspective: nitrosamines, nitramines, amines, ammonia and aldehydes.

In order to determine acceptable capture plant emissions one approach is to first determine acceptable levels of

* Corresponding author. Tel.: +47 93059222, *E-mail address:* Hanne.Kvamsdal@sintef.no

emitted compounds in the environment and from that determine acceptable plant emissions. Such an approach does require insight into a number of topics:

1) Detailed insight into stack emissions
2) Atmospheric dispersion and atmospheric chemistry
3) Fate of chemicals in the environment
4) Determination of acceptable concentrations in the environment

A lot of the knowledge required to carry out such an exercise is available today (e.g., reported by[2,3] and references therein). This is further systemised and studied within the SCOPE project for each of the four topics:

1) In SCOPE, we are conducting test campaigns with focus on emission in 6 different pilots. This will help assessing various emission mitigation options at different flue-gas- and operating conditions, *e.g.*, to check out options particularly efficient for mitigating aerosol-based emission. A techno-economic analysis will be performed for the various options and such info is also important for the choice of a regularity framework for a specific plant/region. Another important topic addressed in SCOPE is emission monitoring tools for proper detection of the emitted compounds of concerns. There are challenges both related to sampling (especially for aerosol-based emission) and the accuracy of the analyses. Within SCOPE we are developing SINTEF's emission monitoring technology "ACEMS", (Absorber Continuous Emission Monitoring System), still a protype which has successfully demonstrated monitoring of trace components at ppb level in the effluent gas.

2) In SCOPE we are improving dispersion models to better predict the atmospheric chemistry for the emitted compounds and how these are spread out in the vicinity of a plant/region.

3) In SCOPE we have reviewed status related to fate of emission. E.g., it is known that there are seasonal variations (due to exposure to sunlight and the temperature changes) in how the nitrosamines and nitramines are further degraded in the environment and that they tend to end up in water rather than being adsorbed to soils and sediments. We will further explore how seasonal variations impact the fate of emission.

4) In SCOPE we have so far made a review of the knowledge related to determining realistic levels not influencing the human health and based on this a human health hazard assessment strategy will be determined for development of risk assessment practices.

References:

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