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# Aerosol and volatile amine emissions in $CO_2$ Amine-based Absorption: A comparison of MEA and CESAR1

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**Abstract**

Chemical absorption using aqueous amine solutions is a well-established method to capture $CO_2$ from industrial gases. The technology has a high level of maturity and is industrially deployed. However, for $CO_2$ capture from exhaust gases, solvent emissions may pose a significant challenge to its widespread adoption. Large-scale implementation requires strict emissions control, ensuring that the release of amines remains below national and international limits. Amine emissions can be gas-phase emissions, resulting from the inherent volatility of the solvents, and aerosol-based emissions, resulting mainly from heterogeneous nucleation and particle growth in the absorber and wash-columns [1]. Such particles grow along the absorber and water wash columns because water, amine, and $CO_2$ are transferred from the liquid and gas phases to the aerosol phase.

Aerosol emissions can be effectively mitigated using demisters in combination with water wash and dry bed sections [2]. However, the efficiency of these mitigation technologies depends on the aerosol inlet size distribution and their growth along the absorber and wash sections. The absorption plant operation and the solvent properties will also impact the absorbent emissions into the atmosphere.

While volatile emissions can be easily correlated to the solvent vapor pressure and its liquid activity, aerosol emissions exhibit a more complex and less direct dependence. $CO_2$ absorption kinetics, transport properties, and the equilibrium properties will all impact the final emissions via the aerosol phase.

This work aims to quantify and compare how solvent-specific thermodynamic, kinetic, and transport properties influence volatile and aerosol-based emissions under varying inlet aerosol size and number distributions. The work examines the significance of solvent properties in a broader context, including aerosol emissions, rather than focusing solely on the volatility of the solvent as is usually performed.

Two solvents are used for the study: an aqueous solution of 30 wt.% ethanolamine (MEA) and a blend of 27 wt.% 2-amino-2-methyl-1-propanol (AMP) and 13 wt.% piperazine (PZ), also known as CESAR1. The two systems differ in terms of solvent properties, with one important distinction being that CESAR1 is a blend of two amines [3-6].

The research methodology used is described in the following paragraph.

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**Methodology**

A realistic industrial flue gas has been chosen to simulate and optimize the $CO_2$ capture plant using MEA and CESAR1. The Aspen model developed by Morlando et al. [7] is used to simulate the CESAR1 solvent, while the default RK-eNRTL model developed by AspenTech is used to simulate the MEA solvent. The MEA and CESAR1 $CO_2$ capture plants are designed to capture 95% of the $CO_2$ entering the absorber column. The liquid mass flow rate was optimized to minimize the reboiler duty, and the optimized cases are used for the aerosol simulations.

Models describing aerosol growth and emissions using the CESAR1 and the MEA solvent have been developed by Svendsen et al. [8, 9] and validated using experimental pilot plant data. In this work, these models are used in combination with Aspen Plus to simulate the aerosol growth and their composition build-up along the absorber and water wash sections. Simulations are carried out by varying the inlet aerosol number and size distributions to investigate the difference in emissions performance between the two solvent systems as the aerosol content in the flue gas changes. The impact of the absorber and water wash section design on the aerosol and volatile emissions will also be assessed for both solvents.

To summarize, at GHGT-18, we will present results highlighting the impact of the solvent properties on the amine emission from the absorber section in the $CO_2$ capture absorption plant using MEA or CESAR1. Various inlet aerosol size and number distributions will be simulated to investigate how the amine emissions change as a function of the aerosol content and solvent properties. The results will provide insight into how to optimally operate the absorption plant to minimize the aerosol emissions and whether such strategies are dependent on the solvent chosen for the operation.

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