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Emissions with ASCC using various flue gases and wash configurations at Technology Centre Mongstad (TCM)

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Abstract

A second-generation amine solvent, AM91, was tested in the existing simple absorber/stripper at Technology Centre Mongstad (TCM) for 2650 hours in 2024-25. Flue gas from a catalytic cracker (RFCC) with high concentration of H_2SO_4 aerosol or from a gas-fired boiler (MHP) with 10-15 ppm of NO_2 was used as is or diluted with air and supplemented with recycled CO_2 to simulate gas sources with 4 to 20% CO_2. The system included two stages of water wash with pump-around and cooling and the ability to use the top stage of packing in the absorber as a trickle bed wash with bleed from the lower water wash stage. The top water wash could be isolated and operated with addition of sulfuric acid to get pH 1 to 4. This presentation addresses the results from emissions measurements. Two other presentations will address amine oxidation [1] and the general operating results [2] of this campaign.

Emissions of amines and degradation products from the top stage of water wash were continuously monitored by a proton-transfer-reaction time-of-flight mass spectrometer (PTR-ToF-MS; model PTR-ToF 8000; Ionicon Analytik, Innsbruck, Austria). This system was like that previously reported in testing at the National Carbon Capture Center [3].
Additional continuous monitoring of some species was performed with FTIR and other TCM online instruments.

Figure 1 shows the time trend in calendar hours of ammonia, AM103, and acetaldehyde concentration in the clean gas leaving the top wash. Ammonia emissions are strongly correlated with the flue gas source because the MHP gas starts with 10-15 ppm NO_2 and the RFCC gas starts with 0.5-2 ppm NO_2. Even with air dilution to get lower inlet CO_2 the ammonia emissions are much greater with the MHP. Longer periods of MHP operation resulted in 80 to 100 ppm NH_3. With RFCC operation the ammonia is typically 2 -10 ppm NH_3.

NH_3 emissions were unaffected by the bottom wash and the trickle bed but were substantially reduced by the acid wash in the top bed. In the first period (2050-2400 hrs) with intermittent acid wash operation when using MHP gas with high NO_2, NH_3 was reduced from 10-90 ppm to 100-300 ppb. In the second period (2550-2800 hrs) with RFCC gas, the acid wash reduced NH_3 from 3-20 ppm to 100-400 ppb. Ammonia emission appears to be unaffected by the other water wash options, consistent with observations from NCCC that water wash does not remove NH_3.

Figure 2 shows the emission of the principal amine in the solvent (AM91) an important degradation product (AM93) resulting from oxidation by NO_2. With the MHP flue gas, various water configurations reduced the AM91 emission to 0.1-10 ppb with multistage wash configurations. The single stage water wash reduced AM91 to 60 ppb with MHP gas. The emissions of these components were greatly increased when using the RFCC flue gas because it contained sulfuric acid aerosol that resulted in amine aerosol leaving at the top of the absorber. The RFCC flue gas was analyzed for three days by an ELPI+. The Brownian Diffusion Filter Unit l(BDU) reduced inlet particulate from 1-2 E07 particles/cm^3 to 8.5 e04 particles/cm^3, but 99% of remaining particles are in the range of 0.06 to 0.3 µm, which is the size most likely to produce amine aerosols that are not removed by packing or the mist eliminator. With RFCC gas the AM91 emission was managed at 0.2-5 ppm by increasing the temperatures of the lean solvent feed and intercooler and by operating the top bed of the absorber as a trickle bed water wash.

The emission of AM93 generally tracked the AM91 emission. AM93 varied from 0.3 to 40 ppb. It was removed by the water wash in the same way as AM91 and appeared in the amine aerosol emissions like AM91. AM93 was greatest (15-40 ppb) after sustained operation with the MHP gas containing 10-15 ppm NO_2 that also produced the greatest accumulation of AM93 in the solvent.

The emissions of the hazardous air pollutants (HAPs) acetaldehyde and AM103 mostly track with the production of NH_3 (Figure 1). These HAPs do not appear to be removed by water wash or acid wash, as also observed at NCCC. AM103 varies from 8 to 800 ppb. It seems to be directly associated with NO_2 as it step changes up when switching from RFCC to MHP and then decreases after switching from RFCC to MHP. Acetaldehyde generally varies from 7 ppb to 250 ppb, but it was as high as 1000 ppb after a few days of initial operation with MHP. Acetaldehyde is somewhat associated with ammonia.

After complete analysis of the PTR-ToF-MS results to enhance accuracy, additional results will be presented on other degradation products.

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One author of this paper consults for a process supplier on the development of amine scrubbing technology. The terms of this arrangement have been reviewed and approved by the University of Texas at Austin in accordance with its policy on objectivity in research. The authors have financial interests in intellectual property owned by the University of Texas that includes ideas reported in this paper.

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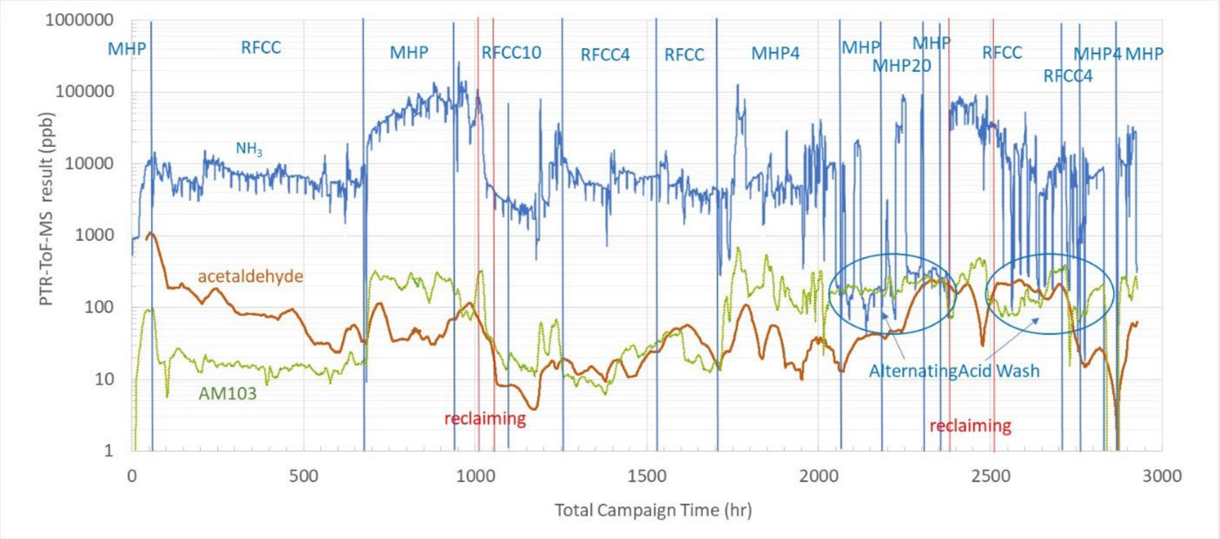

Figure 1. Emissions expected from amine oxidation. "RFCC" and "MHP" denotes periods using the catalytic cracker and gas boiler gas, respectively. MHP4, RFCC4, and RFCC10 denote periods when air was added to dilute to the flue gas to get the respective CO_2 concentration. These PTR-ToF-MS data are preliminary and may be subject to recalibration.

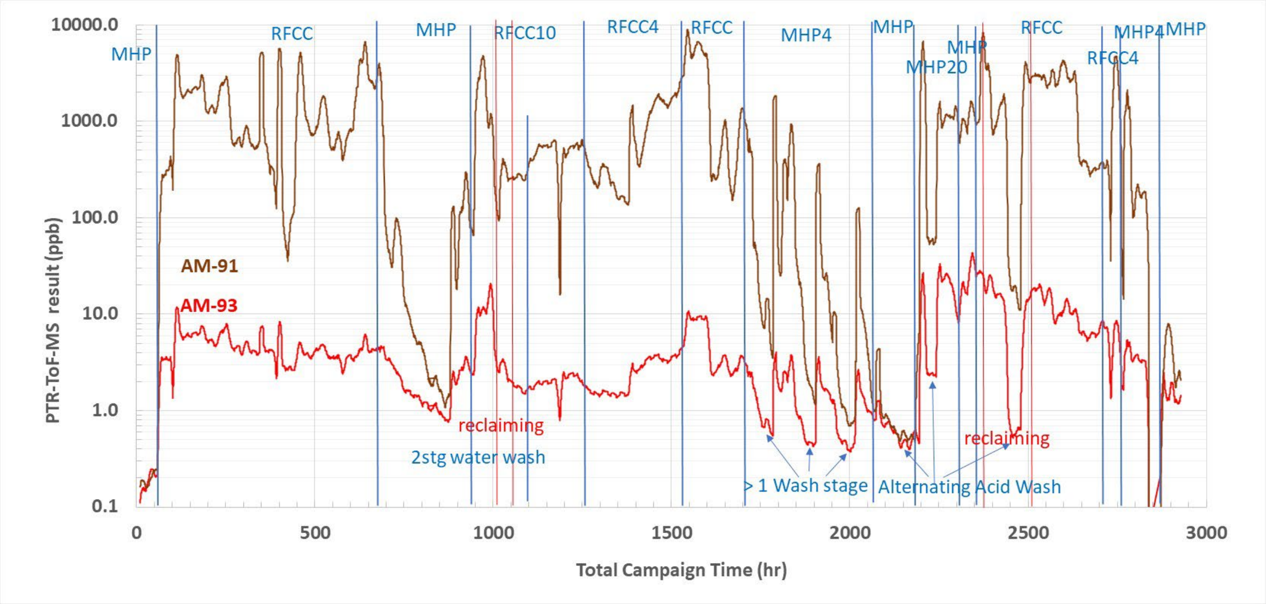

Figure 2. Emissions of AM-91 (principal amine) and AM-93. These PTR-ToF-MS data are preliminary and may be subject to recalibration.

Keywords: amine, emissions, ammonia