Amine Emission Monitoring in CCS

Monitoring Amine Emissions using the IONICON PTR-TOF analyzer

The IONICON PTR-TOF analyzer measures emissions of amines and amine degradation products in real-time down to ppt levels.

Introduction and Background

Carbon capture and storage (CCS) is a crucial technology for reducing carbon dioxide (CO_2) emissions to mitigate global warming. Among the various CCS techniques that are currently being tested, amine-based post-combustion CO_2 capture is the most mature solution. However, the use of amine solvents for scrubbing CO_2 from flue gases results in the emission of amines and their degradation products into the atmosphere. This poses environmental and health risks. Accurate monitoring of these emissions is vital to ensure compliance with environmental regulations and to optimize CCS processes.

Proton-Transfer-Reaction Time-of-Flight Mass Spectrometry (PTR-TOFMS) is a powerful tool for monitoring amine emissions in real-time down to ppt levels. This application note describes the use of IONICON PTR-TOF analyzers in monitoring trace levels of amines and their degradation products in flue gas.

Amine-based CO_2 capture

In amine-based CCS, CO_2 is chemically absorbed by aqueous amine solutions, such as monoethanolamine (MEA), 2-amino-2-methyl-1-propanol (AMP) or piperazine (PZ). The capture of CO_2 results in emissions of amines and degradation products such as ammonia, aldehydes, and nitrosamines. Such emissions must be carefully monitored to mitigate environmental and health risks.

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The IONICON PTR-TOF – an ideal amine emission monitoring tool

PTR-TOFMS is a highly sensitive analytical technique that measures volatile organic compounds (including amines) in real time down to ppt levels. Since its introduction in the mid-1990s, PTR-TOFMS has been extensively applied across a wide range of scientific research fields. Over the past decade, PTR-TOFMS has gained increasing acceptance in industrial process monitoring, particularly in the semiconductor industry, and is now an established technology with all leading manufacturers. IONICON's PTR-TOF instruments have been successfully deployed for amine emission monitoring since 2011.

Key features of the IONICON PTR-TOF analyzer for CCS applications

- **High sensitivity:** The IONICON PTR-TOF analyzer detects amines and amine degradation products at concentrations down to parts per trillion (ppt) levels, which is essential for monitoring emissions from large-scale CCS facilities.
- **Real-time monitoring:** Unlike manual impinger sampling methods, PTR-TOFMS provides continuous data in real-time with high temporal resolution, allowing operators to rapidly respond to fluctuations in emissions.
- **Versatility:** The IONICON PTR-TOF analyzer detects a wide range of organic compounds including amines, ammonia, aldehydes, nitrosamines and other Hazardous Air Pollutants (HAPs, e.g. acetaldehyde, acetonitrile or acetamide), making it an ideal tool for monitoring emissions from amine-treated flue gas.
- **Market-leading performance:** The IONICON PTR-TOF analyzer combines three features (high mass resolution, pure H_3O^+ ion chemistry, low field-induced fragmentation) that no other similar or related mass spectrometer can currently provide. This makes the IONICON PTR-TOF analyzer a unique tool for analyzing a highly complex sample such as amine-treated flue gas.
- **Compact and ruggedness:** Industrial versions of PTR-TOF analyzers are compact and designed for integration into industrial analyzer cabinets or standard racks. Their robustness and reliability make them suitable for long-term deployment in industrial environments. These instruments have mastered the challenges in several demanding industrial applications, where real-time emission monitoring is critical.

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Case Study: Emission Monitoring at Technology Centre Mongstad (TCM)

PTR-TOFMS has been successfully used for amine emission monitoring at the Technology Centre Mongstad (TCM) in Norway for more than a decade. It has been demonstrated in various measurements campaigns with a variety of different amine-based solvents that PTR-TOF analyzers

Technology Centre Mongstad (TCM) is the world's largest plant for testing and improving technologies for CO_2 capture. Image by TCM

are able to continuously track emissions of amines and amine degradation products at sub-ppb levels. In a recent study, the instrument monitored MEA and degradation products such as ammonia and nitrosamines, which were detected at levels well below regulatory limits. The advanced sampling setup, including a heated extraction probe and heated sampling lines, enabled accurate real-time measurements.

Conclusion

The IONICON PTR-TOF analyzer is a uniquely versatile and reliable tool for monitoring amine emissions in CCS applications. Its ability to provide real-time, highly sensitive detection of a wide range of compounds makes it invaluable for ensuring environmental compliance and optimizing process efficiency. As PTR-TOF technology continues to evolve, it will play an important role in making amine-based CCS environmentally safe.

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