Ambient Air Quality Monitoring of Ethylene Oxide at Chemical Manufacturing Facilities

Background

Ethylene oxide (EO) is a carcinogenic and mutagenic compound commonly used in the chemical industry, particularly as a reaction intermediate in the production of ethylene glycol. In a 2018 update to the National Air Toxics Assessment (NATA), the US EPA significantly increased its risk value for ethylene oxide. In response, industry and state regulatory agencies have expressed an interest in monitoring for very low levels of EO in and around these chemical manufacturing facilities.

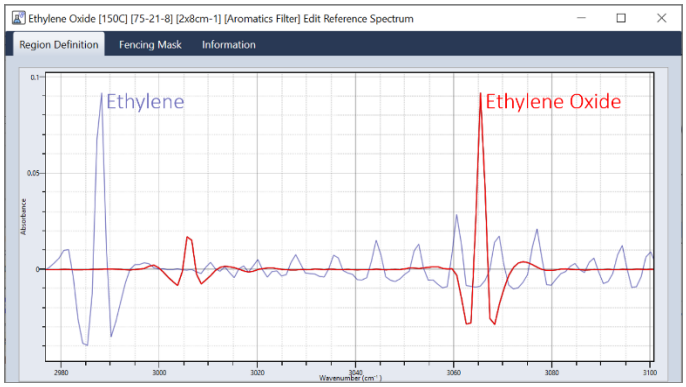
Problem

Low level detection of ethylene oxide in complex sample matrices has proved problematic for photoionization detectors (PID), since these sensors are broad band and nonselective to ethylene oxide. PID can be coupled to gas chromatography (GC) to physically separate the sample matrix, but coeluting species often interfere with the measurement of EO. GC systems may also experience significant downtime due to maintenance and calibration. Samples could be collected in sample bags or canisters and sent to a laboratory for analysis, but results may not be received for several weeks.

Due to these problems with accurate identification and analysis time, a technology optimized for **real-time direct measurement of ethylene oxide** is necessary.

Solution

The MAX-iAQ is an ambient air monitoring system capable of sequentially analyzing up to 20 sample lines for ethylene oxide. The comprehensive design provides complete control of sample streams via an integrated multiplexer that maintains continuous sample gas flow on each channel. The core of this system is Max Analytical's novel FTIR enhancement technology, called StarBoost™, that dramatically increases the sensitivity, linearity and dynamic range of the FTIR over narrow spectral bands of interest. The SNR improvements provide a **limit of detection (LOD) as low as 5ppb for ethylene oxide**. In addition, the analyzer never requires calibration and utilizes a Peltier-cooled MCT detector that allows for continuous operation.



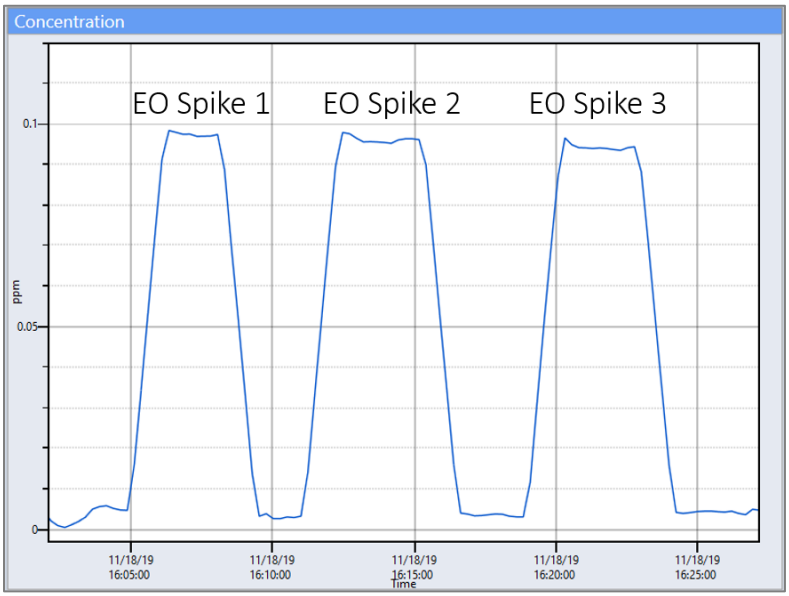
The StarBoost™ FTIR is an ideal technology for this application due to its insensitivity to cross-interferences, such as ethylene. Ethylene is the chemical precursor to EO and may be present at higher levels in and around EO manufacturing facilities. The figure at left shows the IR reference spectrum of EO (red) overlaid with the ethylene reference spectrum (blue). Since the two compounds are easily differentiated by their unique absorbance features, ethylene will not interfere with the EO measurement, therefore eliminating false alarms.

Results

To demonstrate the accurate identification and quantification of ethylene oxide in the presence of interferences, 100ppb ethylene oxide was spiked into a sample stream containing ethylene. In this experiment, the sample stream contained 97.49ppm ethylene in a balance of nitrogen. A certified calibration cylinder containing 2ppm EO and 500ppm ethane (tracer gas) was injected in triplicate into the sample stream, not exceeding 10% of the total sample flow. Prior to spiking, the EO cylinder was measured directly to demonstrate the instrument was in calibration, and the EO response was within 1.5% of the certified cylinder value. Results from the spike recovery testing are shown in the table below.

Ethylene Oxide Spike Recovery in 100ppm Ethylene			
Dilution Factor	Spike 1	Spike 2	Spike 3
Ethane without Spike (ppm)	0.402	0.304	0.234
Ethane during Spike (ppm)	22.401	22.358	21.975
Dilution Factor	0.043	0.043	0.042
Ethylene Oxide Spike Recovery			
EO Sample Average (ppm)	0.005	0.003	0.003
EO Spike Average (ppm)	0.098	0.097	0.096
Predicted EO Spike Conc (ppm)	0.102	0.101	0.099
Percent Recovery (%)	95.6%	95.9%	96.3%

For all three 100ppb EO spikes, the percent recovery was greater than 95%. These results demonstrate the accuracy and specificity of the StarBoost™ EO measurement, even in the presence of a potential interferent at 1000 times the EO concentration. A concentration plot of EO during spike recovery testing is shown below to illustrate the precision of the measurement at low ppb levels.



Technical Specifications

Time Resolution	1 min
Limit of Detection	5 ppb
Limit of Quantification	17 ppb
Accuracy at Full Scale	± 2%
Zero Drift	< 5ppb
System Bias	< 5ppb
Sample Flow	7L/min
Gas Cell Temperature	150°C

The technical specifications listed above are specific to this application and do not reflect all options and functionality of the StarBoost™ analyzer or MAX-iAQ. Please contact applications@maxanalytical.com to discuss your application.