Application note

Ambient air toxics monitoring

Exposure to air toxics, also known as hazardous air pollutants (HAPs), poses a serious risk to human health resulting in the development of lung disease, birth defects, and cancer. Major sources of HAPs compounds include emissions from chemical plants, petroleum refineries, and power plants. These compounds can also exist in ambient air around semiconductor and pharmaceutical manufacturing facilities.

Employees of industries where HAPs are found are at higher risk of health hazards than the surrounding community due to the employees' proximity to the source. In addition, levels of pollutants tend to be significantly higher indoors than outdoors. While laws exist to protect the health and safety of workers, indoor air quality is often overlooked.

Air toxics monitoring challenge

There are several challenges associated with monitoring for multiple air toxics in ambient air. First, the analytical technology must be capable of measuring for many different classes of chemical compounds. Second, the technology must be sensitive enough to measure the compounds at levels below the permissible exposure limit (PEL), which can be ppmv – pptv concentrations, depending on the compound. Third, the technology cannot be affected by cross interferences from atmospheric gases (CO_2, H_2O, CH_4) that dominate the ambient air at levels from ppmv to percent and often obscure detection of trace HAPs.

Solution

The Thermo Scientific™ MAX-iAQ™ Air Quality Monitoring System can simultaneously measure hundreds of HAPs in ambient air. The system includes a sample multiplexer that allows for 20 locations to be sequentially monitored from up to 500 ft (150 m) away. The MAX-iAQ system can also be coupled with the patent-pending MAX-OXT Thermal Oxidizer Module which removes the analysis biases that can be caused by H_2O, CH_4 and CO_2, thus improving the accuracy and reliability of the HAPs measurement.

The MAX-iAQ system is anchored by a state-of-the-art Thermo Scientific™ MAX-iR™ FTIR Gas Analyzer with a deuterated triglycine sulfate (DTGS) detector that can monitor the entire mid-IR spectral range (500-5000 cm^{-1}) while providing percent to single digit ppb dynamic range. Unlike traditional gas chromatography (GC) based solutions, the MAX-iR analyzer is factory calibrated and designed to operate for 10 years with minimal or no maintenance.

An optional sensitivity enhancement called Thermo Scientific™ StarBoost™ Technology allows the MAX-iR analyzer to detect HAPs with compact FTIR gas analysis down to 100 ppt.

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Experimental

To assess the capability of the MAX-iAQ system to measure numerous air toxics simultaneously at relevant levels, the ambient air in a laboratory was measured continuously in 15-second intervals for one hour. A cross section of the compounds monitored in the analysis algorithm are reported in Table 1. Minimum detection limits (MDLs) for each compound were defined as three times the standard deviation of one hour of data. These MDLs are compared to the published NIOSH PELs, where available. In most cases, the MDLs are well below the published PELs, meaning the MAX-iR analyzer meets or exceeds the required precision near the actionable limit..

Conclusions

The MAX-iAQ is a fast, sensitive analytical system capable of simultaneously measuring many air toxics in ambient air. MDLs for most of the toxic compounds are below 0.1 ppm. For arsine, which has a low actionable limit of 50ppb, the MAX-iAQ system can detect down to 3 ppb.

With a typical measurement time of 15-30 seconds per multiplexer channel, the MAX-iAQ system can publish a result for all 20 sample locations in less than 10 minutes. Its speed allows for employees at factories and chemical plants to be immediately alerted to an elevated HAPs concentration in real time, and detailed historical data helps these facilities make informed decisions to minimize workplace exposure to HAPs.

Compound	NIOSH PEL (ppm)	MAX-IR MDL (ppm)
1,2,4-Trichlorobenzene	5*	0.014
1-Methoxy-2-propanol	100	0.011
Acetaldehyde	200	0.051
Acetic acid	10	0.020
Acetone	1000	0.033
Ammonia	50	0.020
Arsine	0.05	0.003
Carbon monoxide	50	0.030
Cyclohexanone	50	0.007
Decamethyltetrasiloxane	-	0.003
Diborane	0.1	0.014
Ethanol	1000	0.110
Ethyl acetate	400	0.004
Ethylene glycol	50	0.051
Ethylene oxide	1	0.030
Formaldehyde	0.75	0.030
Formic acid	5	0.010
Hexamethyldisiloxane	-	0.005
Hydrogen chloride	0.3	0.020
Hydrogen fluoride	3	0.005
Hydrogen bromide	3	0.120
Isopropanol	400	0.020
Nitrogen trifluoride	10	0.006
o-Xylene	100	0.025
Ozone	0.1	0.140
PGMEA	100*	0.005
Phosphine	0.3	0.076
Propylene glycol	-	0.082
R116 Hexafluoroethane	-	0.001
R14 Tetrafluoromethane	-	0.001
Silane	5	0.003
Toluene	200	0.030

* proposed ** CAL PEL

Table 1. Detection limit assessment and comparison to NIOSH PEL.

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