Analysis of Volatile Organic Compounds

Volatile organic compounds (VOCs) are among a number of common contaminants in the indoor environment and can be a source of irritation and odors to building occupants. EPA Method TO-15 may provide useful data for investigators attempting to identify and quantify VOCs to sub-part per billion levels.

Method

Introduced in the Second Edition of the EPA Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air in January 1999, EPA TO-15 is the most current analytical reference for the determination of VOCs in air and other gaseous matrices. TO-15 is larger in scope and better defined for the analysis of VOCs than the earlier method TO-14, which has been revised and replaced by TO-14A.

TO-15 addresses an extensive set of VOCs, including many polar compounds, such as ketones, alcohols and esters. Unless otherwise specified by project documentation, permit requirements or other regulation, TO-15 is the method recommended by Columbia Analytical.

Applications

Volatile organic compounds in the indoor environment may emanate from construction materials, building furnishings (carpeting, paint, fabric), personal care products, pesticides and fuels, as well as subsurface vapor intrusion, and other sources in the outside environment. TO-15 can be used to identify many of these VOCs, including those in the following list:

- Benzene
- Toluene
- Xylene
- Styrene
- Ethyl Benzene
- Trimethylbenzene
- Naphthalene
- Tetrachloroethene (perchloroethylene)
- Trichloroethene (trichloroethylene)
- Chloroform
- Dichlorobenzene
- Methylene Chloride
- Ethyl acetate
- Acrolein
- Undecane
- Acetone
- 2-butanone (methyl ethyl ketone)
- Trichloroethene (trichloroethylene)

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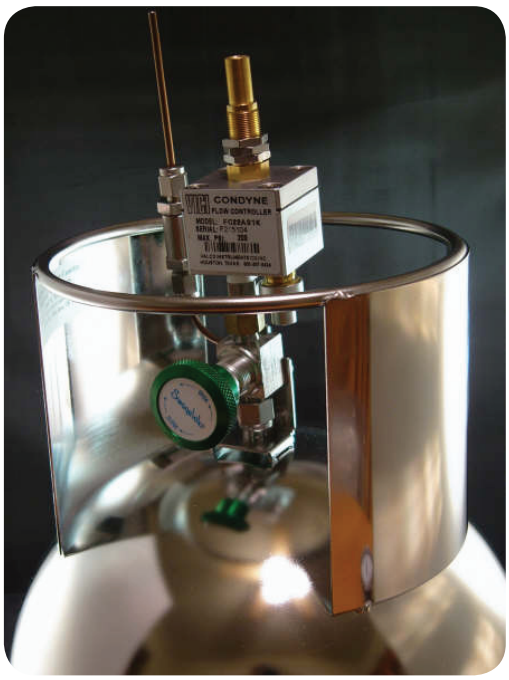

Collection

Volatile organic compounds may be sampled using several different approaches. EPA TO-15 involves collection of a "whole air" sample in an evacuated passivated stainless steel canister, such as a Summa canister. To collect an instantaneous sample, the canister valve is opened, and the vacuum dissipates as the whole air sample is drawn in and captured. The valve is closed, and the sample is contained.

Time-integrated samples may be collected when the Summa canister is equipped with a flow controller. After attaching the flow controller to the canister, the procedure is the same--the valve is opened to allow the vacuum to dissipate and draw in the air sample. At the end of the sampling interval, the valve is closed, and the sample is contained.

Columbia Analytical provides pre-calibrated flow controllers for sampling intervals from 30 minutes up to 24 hours.

Shipping

The Summa canister should be sent back to the lab in the original box in which it was shipped to the client. Indoor air samples may be shipped via standard air carriers such as Federal Express (Fed Ex). These samples are not pressurized gas, so they do not require special shipping containers, labels or paperwork. For any specific questions or constituents, contact the carrier directly.

Analysis

The sample is pre-concentrated, and then analyzed by gas chromatography with a mass spectrometer detector (GC/MS). Quantitative data are generated by calibrating the GC/MS with a standard comprised of the entire list of target compounds.

In addition to the target compound list, non-target compounds may be tentatively identified by comparing the mass spectra of the unknown compounds with those in a mass spectral library. These tentatively identified compounds (TICs) are very useful in situations where the concern is not well characterized and little data are available.

A wide range of compounds may be analyzed by EPA TO-15 including alkanes, alkenes, aromatics, halogenated VOCs, ketones, esters and some alcohols. Some aldehydes and sulfides may also be evaluated using this method.

A list of the compounds analyzed by this method that are commonly found in indoor air, along with the respective reporting limits, is provided in Table 1.

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Low Level Determinations By Sim

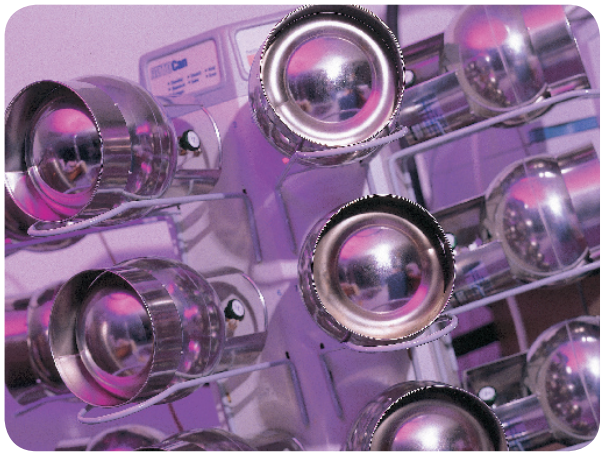
In instances where compounds must be identified and quantified for risk assessment, ultra low-level reporting limits are achievable through selective ion monitoring (SIM). Instead of analyzing the entire range of ions present in the sample, the instrument focuses on specific narrow windows. Many more data points are collected for a given ion, which allows up to 50 times more sensitivity. This approach is well suited for PAHs and polychlorinated compounds, but is not as appropriate for compounds with shared common ions, including many hydrocarbons.

Limitations Of The Method

Many of the standard target lists for EPA TO-15 were developed for ambient (outdoor) air and do not reflect the contaminants that may be present in indoor air. While the US EPA has identified more than 900 VOCs in indoor air, TO-15 does not specify a target compound list. Therefore, compound lists will vary to some degree among laboratories. Investigators should confirm their target analyte list with Columbia Analytical prior to the start of a new project.

The method is generally limited to compounds with a boiling point of less than 200 C. Despite meeting that criterion, however, there are still some compounds or groups of compounds that cannot be successfully analyzed by TO-15, for various reasons:

- Formaldehyde and many other aldehydes are better analyzed by EPA TO-5 or TO-11A.
- Many polyaromatic hydrocarbons (PAHs) cannot be successfully sampled and analyzed by TO-15.
- Certain sulfur compounds, such as such as hydrogen sulfide, are not stable in a Summa canister and yield poor recoveries. Instead, ASTM D5504 is a common method for the analysis of these compounds.



TO-15 acknowledges the difficulty in establishing absolute storage times due to the variability of conditions under which each unique sample is collected. However, the method states, "… Most VOCs can be recovered from canisters near their original concentrations after storage times of up to thirty days."

References

Compendium Method TO-15, Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography Mass Spectrometry (GCMS), Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition, January 1999, US EPA, EPA/625/R-96/010b.

Method available online: www.epa.gov/ttn/amtic/files/ambient/airtox/to-15r.pdf.

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Table 1. List Of Compounds Commonly Found In Indoor Air – EPA TO-15

Compound	MRL, µg/M³	MRL, PPBV	Potential Indoor Sources
1,1,1-Trichloroethane	1.0	0.18	Dry cleaner, solvent
1,1-Dichloroethane	1.0	0.25	PCE degradation
1,1-Dichloroethene	1.0	0.25	PCE degradation
1,2,4-Trichlorobenzene	1.0	0.13	Pesticide
1,2,4-Trimethylbenzene	1.0	0.2	Fuel, solvent
1,2-Dichloroethane	1.0	0.25	Cleaning agent
1,3,5-Trimethylbenzene	1.0	0.2	Fuel, solvent
1,3-Butadiene	1.0	0.45	Fuel
1,3-Dichlorobenzene	1.0	0.17	Deodorant, moth balls
1,4-Dichlorobenzene	1.0	0.17	Deodorant, moth balls
1,4-Dioxane	1.0	0.28	Solvent for certain oils, waxes, etc.,
2-Butanone	1.0	0.34	Solvent, floor/wall coverings, ETS
2-Hexanone	1.0	0.24	
4-Ethyltoluene	1.0	0.2	Petroleum distillates
4-Methyl-2-pentanone	1.0	0.24	Floor/wall coverings
Acetone	5.0	2.1	Lacquer solvent
Acrolein	1.0	0.44	ETS
alpha-Pinene	1.0	0.18	Wax, wood products
Benzene	1.0	0.31	Fuel, ETS
Benzyl Chloride	1.0	0.19	Vinyl tiles
Bromodichloromethane	1.0	0.15	Showering
Bromoform	1.0	0.097	Showering
Bromomethane	2.0	0.52	Pesticide
Carbon Disulfide	1.0	0.32	Rubber compounds
Carbon Tetrachloride	1.0	0.16	
Chlorobenzene	1.0	0.22	Solvent, textile additive
Chloroform	1.0	0.2	Showering
Chloromethane	1.0	0.48	
cis-1,2-Dichloroethene	1.0	0.25	PCE degradation
Cumene (isopropyl benzene)	1.0	0.2	Fuel, solvent
Dibromochloromethane	1.0	0.12	Showering
d-Limonene	1.0	0.18	Odorant, detergent
Ethanol	1.0	0.53	Solvent, beverage, fuel
Ethylbenzene	1.0	0.23	Fuel, floor/wall coverings, caulking compounds, adhesives
Isopropyl Alcohol	1.0	0.41	Particle board
m,p-Xylenes	1.0	0.23	Fuel, adhesives, jointing/caulking, floor coverings, cleaners
Methylene chloride	1.0	0.29	Solvent, furnishings
Naphthalene	1.0	0.19	Solvent, moth balls, fuel
n-Butyl Acetate	1.0	0.21	Floor lacquers
n-Hexane	1.0	0.28	Chipboard, floor coverings, wallboard
n-Nonane	1.0	0.19	Fuel, wallpaper, floor waxes
o-Xylene	1.0	0.23	Fuel, adhesives, jointing/caulking, floor coverings, cleaners
Styrene	1.0	0.23	Fuel, carpets, jointing compound
Tetrachloroethene	1.0	0.15	Dry cleaner, spot remover, adhesives
Toluene	1.0	0.27	Fuel comp, adhesives, wallpaper
Trans-1,2-Dichloroethene	1.0	0.25	PCE degradation
Trichloroethene	1.0	0.19	Spot remover, solvent
Vinyl Chloride	1.0	0.39	

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