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IAQ RADIO+

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William Chapman, PhD

Chemical Monitoring for IAQ and Odors

Good day and welcome to the IAQ Radio+ episode 741 blog. This week we welcomed Dr. William Chapman to discuss chemical monitoring for IAQ and odors.

Air by CC^2 Inc (AbC) was founded by William Chapman, PhD in response to his experiences working in the air testing industry to provide proven solutions to problems in indoor air. He has PhD in Chemistry from Penn State and completed postdoctoral studies at Columbia University. AbC is built on his education and years of industrial experience, mainly developing new and improved methods for point-of-care (i.e. onsite) testing. In previous employment, he became frustrated with the lack of a proven solution to problems that his lab found, especially in the home indoor air setting as well as with the quality of the point-of-care samplers that are in use today.

Nuggets mined from today's episode:

Explain your company name CC^2? Chapman Chemical Consulting

When did you become interested in odors? Studying organic chemistry and found a huge array of smelly chemicals in the lab. Odors are useful for the identification of chemicals during multistep organic synthesis. They are roughly predictable by consideration of functional groups, but the nose is much more complicated than this. Pure aldehydes are sweet, pure amines are fishy etc. In the air testing industry, I found many people frustrated with the inability to identify scent chemicals with standard VOC tests.

When Indoor Environmental Professionals seek to resolve an IAQ problem they typically consider 3 possibilities: chemical, biological or particulate. What other possibilities, if any, should be considered? Let's consider nanoparticulate hazards too. Especially from combustion. Carbon based structures larger than the dreaded pyrene but smaller than PM 2.5. Carbon nanotubes and bucky balls are the ideal forms of these, but the majority are probably more random in structure.

What is your novel sampling strategy? We prefer using diffusive samplers for air sampling.

How do Badge/Wearable sensors compare to air sampling pumps? The diffusive samplers are much easier to use and can be used to sample in places not accessible to a sampling pump, like sealed to a wall with aluminum foil or attached to a string and dropped into a wall or tossed into an area of an attic that is not easily accessible. Sampling times can also be much longer, so we are able to sample during all parts of the day and pick up clouds of chemicals that might not appear during regular working hours.

How were you able to solve odor mysteries others could not? Our new thermal desorption GC-MS system is allowing us to detect chemicals at extremely low concentrations, far lower than first generation systems. We combine this method with a mass spectrometer detection system that can average signal from specific mass ions that are characteristic of a specific chemical of interest.

Post Ozone/Hydroxyl reactions? We understand the effects that ozone has on the indoor environment, while hydroxyls are not well understood. Ozone treatment is a great way to increase formaldehyde levels. Formaldehyde is a well-known biocide that historically has been used to prevent mold growth in cosmetics, soaps etc. Today we know that formaldehyde is a severe irritant and causes cancer in humans. Do hydroxyl radicals do the same thing?

There is short presentation that describes a case study on our website.
https://drive.google.com/file/d/1vunbxa7ne7zNBNdJUdpJfo4zhCByeQc3/view

Remediation of the home in the case study was successful combination of: application of dry sodium carbonate to concrete slab and vacuuming, removal of area rugs with reactive rubber backing and formaldehyde emitting materials.

Does your lab have equipment not usually found in other labs? We use thermal desorption GC MS to analyses diffusive samplers. Our MS allows us to use single ion monitoring to achieve extremely high sensitivity in detection of specific chemicals and is very good at analyzing semi volatiles, like chlordane, iPBC, mold VOCs etc. We also use ion chromatography, which is less common in air testing, especially as applied to IAQ problems.

What are your business niches? We measure specific chemicals that people handle at work, like the vapor anesthetic isoflurane used in vet hospitals and ethylene oxide used to sterilize medical devices.

For the home, let's talk about basic indoor air measurements to start. Like formaldehyde. Our EPA has completed a very complete survey (1000s of pages) and published last august – they conclude that our indoor levels should be less that 5-6 ppb. Average formaldehyde in the US is 20 ppb. Molds make VOC's which we can measure with great sensitivity today.

We can measure m-VOCs now using our ultra-sensitive GC-MS system. We deploy air samplers together with a generic test for mold. The genetic test is used to identify all mold species in the home that could be growing. The growing molds make m-VOCs, so we measure m-VOCs that are specific to the mold spores that are detected to find out which are active in the home.

Opinion on use of Tedlar bags, canister sampling? These methods are useful for sampling of stable VOCs for analysis by EPA TO-15 that are fairly volatile. Very useful for gases, like freons, butane, isobutane, vinyl chloride etc. Will also pickup carbon disulfide and solvents that evaporate readily at RT. More difficult to pick up higher boiling semi-volatile chemicals like m-VOCs. Have challenges with carryover contamination. Good for exploratory studies in environmental science, like studies of landfill gases.

You have a reputation for being able to find minute chemicals in indoor air that others often miss. We look for chemicals that might be causing the problem. This is much different from analyzing a VOC sampler and reporting whatever might be present. By focusing on a specific chemical, we can use signal averaging to reduce noise levels, greatly increasing sensitivity.

How do Badge/Wearable sensors compare to air sampling pumps? The diffusive samplers are much easier to use and can be used to sample in places not accessible to a sampling pump, like sealed to a wall with AL foil (like in Karens case) or attached to a string and dropped into a wall or tossed into an area of an attic that is not easily accessible. Sampling times can also be much longer, so we are able to sample all parts of the day and pick up clouds of chemicals that might not appear during working hours.

How do badge samplers compare to air pump samples? We achieve similar results as confirmed by IFA lab. https://www.dguv.de/ifa/pruefung-zertifizierung/index-2.jsp

Do badge samplers have advantages over air pump sampling? Yes, no air pump or batteries are needed, much longer samples are possible (24, 48 hours or even longer). Badge samplers provide better average samples of clouds of chemicals.

I have been thinking about gas chromatography and have a question regarding the ruling in or ruling out the presence of aldehydes in structure. Do all aldehydes have a chemical commonality or denominator? Then if so; would the GC/mass spec pickup all aldehydes present with the detectable levels of the instrument? Aldehydes specifically are not always detected with GC-MS because of the way the method is typically run and because of the nature of aldehydes.

We look for formaldehyde at parts per billion concentrations but the usual GC-MS run is limited to parts per million sensitivities. This is because of the way the samples are processed. With a charcoal sampler the charcoal is slurried in a solvent to desorb the chemical to be detected. 2 mL of solvent is typical. We then analyze 2 microL of this solvent for the chemical to be detected. We only see 1/1000 of the sample.

Formaldehyde is not always seen in a canister because it polymerizes very quickly. For this reason, it's best detected by capture with a reagent in the sampler. We usually use DNPH which reacts with the aldehyde and produces a stable chemical that can be analyzed. DNPH is bright yellow, making detection of the captured aldehyde very easy using UV/Vis detection. This way we can detect PPB levels of aldehyde even with the solvent desorption method which decreases the sensitivity.

That being said, we often detect hexanal and nonanal with GC-MS because these aldehydes are stable chemicals.

Our new VOC method is called thermal desorption GC-MS. In thermal desorption the adsorbent used to collect the sample is heated to a high temperature in a He stream and analyzed directly without dilution. This gives us a 1000X increase in sensitivity. So, where is the formaldehyde? Not sure, we will see.

How does a GC/Mass spec instrument work? Visualize the gas chromatograph, as a simple distillation column. The sample is introduced into the column using either liquid injection or thermal desorption and the samples coming out of the column are detected using mass spectroscopy. We use the MS in two different ways. One is called total ion count (TIC) where we measure the sum of everything and single ion monitoring (SIM) where we single average on specific masses that we know are boiling out of our column at a specific time. This gives us an additional boost in sensitivity so we can detect mold VOCs and other odor chemicals.

RoundUp-

We are using a new mold test from Realtime labs in Texas that uses generic methods (PCR) to identify mold spores from dust collected by HVAC filters. Spores are usually present in the air and only tell us what might be growing in the home. If molds are growing, they produce VOCs, some of which smell very strongly (like Geosmin), some not. We can use this species information to "train" our mass spec to detect the activity of these specific molds by monitoring specific mold VOCs (m-VOC) at very high sensitivity. This way we can identify the mold species that is actually growing in the home, the growing mold producing the m-VOC. These m-VOCs can then be used in the remediation effort and used to judge the effectiveness of the cleanup.

Z-Man signing off