MONITORING LOW LEVELS OF FORMALDEHYDE IN AMBIENT AIR WITH ULTRA-SENSITIVE PHOTOACOUSTIC SPECTROSCOPY

Formaldehyde can cause acute health problems and possibly even cancer. With the new portable product, GASERA ONE FORMALDEHYDE, it is possible to continuously monitor the indoor and outdoor background levels reliably for the first time. It is based on the unique combination of novel cantilever enhanced photoacoustic detection and a quantum cascade laser source.

We are Exposed to Formaldehyde Everyday

Formaldehyde is a colorless gas with a pungent odor. Formaldehyde levels above 0.1 ppm can cause acute health problems, e.g. sore throat, skin irritation, nausea, scratchy eyes and cough. It is also classified as highly carcinogenic compound. Exposure to moderate amounts of formaldehyde has been linked to cancer, such as leukemia. Formaldehyde exposure is a special concern for children, elderly, and people with breathing problems, such as asthmatics.

Formaldehyde can be found in both small and significant concentrations in various environments. Industrial emissions, traffic, building materials, cooking, and tobacco smoking are sources of formaldehyde. Also many everyday products, such as cosmetics, furniture, and detergents contain formaldehyde. High levels of formaldehyde are often found in new homes or homes with new construction. It is expected that biofuel combustion will have a significant effect on increasing formaldehyde levels, especially in urban areas.

Measurement Challenge

Until today, formaldehyde has been difficult to monitor with existing technologies. Outdoor analysis is currently performed with time-consuming wet chemistry techniques and an automated monitoring solution is desperately needed. The background concentration of formaldehyde in ambient air is only few parts-per-billions (ppb), which requires below ppb-level detection sensitivity from the instrument. Furthermore, in industrial sites where elevated formaldehyde concentrations are expected, aldehydes and other VOCs are present. Conventional spectroscopic techniques have difficulties with cross sensitivity to other aldehydes and especially to acetaldehyde.

The Solution Comes from New Innovations in Photoacoustic Spectroscopy

Now Gasera Ltd, a Finnish high-tech company, launches a disruptive analyzer based on photoacoustic spectroscopy. It offers an affordable and easy-to-use tool for continuous monitoring of the background levels of formaldehyde for the first time. Detection limit of the analyzer is below 1 ppb, which is well below the 16 ppb recommendation for occupational exposure limit by The National Institute for Occupational Safety and Health (NIOSH) in the USA.

Photoacoustic spectroscopy is based on the fact that gas molecules absorb infrared light energy. When the gas absorbs light energy, it heats and expands, which creates pressure variation in an enclosed space. When the infrared radiation is modulated with a certain frequency, the pressure variation in the photoacoustic sample chamber creates an acoustic wave of the same frequency. The light energy is converted into pressure variations, i.e. sound energy, which is then converted into electric signal using a microphone.

A major advantage of the photoacoustic effect is that sensitivity is not dependent on the absorption path length. This allows high sensitivity from a short absorption path length, and highly linear response over a wide dynamic measurement range, all with very low sample volumes (typically few milliliters). This key feature also provides the potential for miniaturization to hand-held size without losing the laboratory-grade sensitivity. Furthermore, the photoacoustic spectroscopy utilizes a so-called zero-background technique where the absorption is measured directly. This enables the development of highly stabile instruments that have a long re-calibration interval, typically years.

In order to achieve ultra-low detection limits Gasera has developed a proprietary MEMS cantilever approach to detect pressure changes in the photoacoustic cell and replace the conventional microphones. The key innovation is a cantilever pressure sensor that is over hundred times more sensitive compared to the membrane, which is conventionally used in microphones.

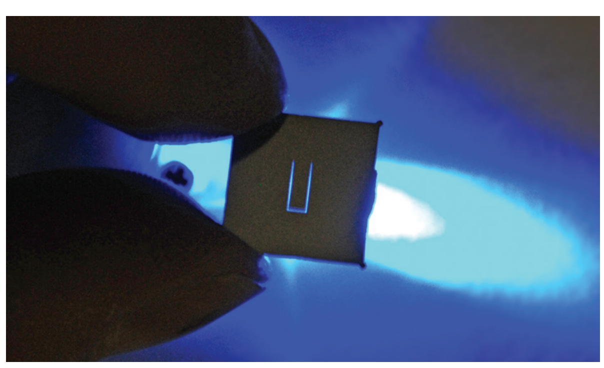

Figure 1: Gasera's patented ultra-sensitive cantilever-type pressure sensor.

An extremely thin cantilever portion moves like a flexible door due to the pressure variations in the surrounding gas. The displacement of the cantilever is measured with an accurate interferometric readout system. This prevents the so-called "breathing effect", which occurs in capacitive measurement principle where the other electrode damps the movement of the sensor and restricts the dynamic range. Gasera's patented laser-based readout interferometer can accurately measure displacement from well under a picometer (1×10^{-12} m) up to millimeters.

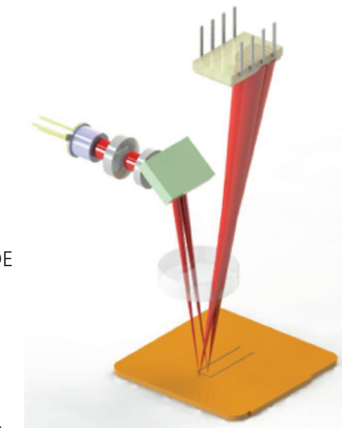

Figure 2: Optical readout interferometer is used to measure the displacement of the cantilever sensor with picometer resolution.

The Gas Analyzer Product

GASERA ONE FORMALDEHYDE photoacoustic gas analyzer is based on the combination of ultra-sensitive cantilever enhanced photoacoustic detection technology and a Quantum Cascade Laser (QCL) source operating at a Mid-IR fundamental spectral absorption line of formaldehyde.

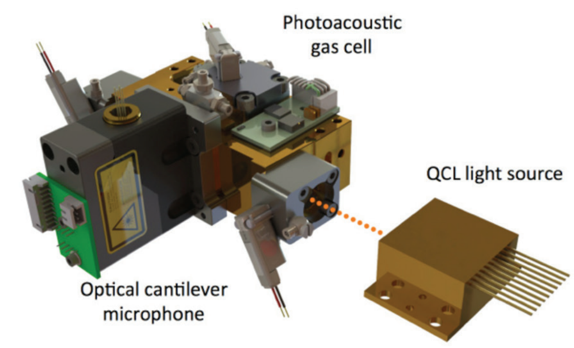

Figure 3: Measurement setup in GASERA ONE FORMALDEHYDE gas analyzer.

This combination provides enough sensitivity to reliably measure ambient background levels of formaldehyde. It also gives an exceptionally high level of stability with a re-calibration period ranging from several months up to years, and thus, it offers a low total cost of ownership. Photoacoustic principle allows low-pressure sampling, and in combination with wavelength modulation technique, the analyzer offers highly selective monitoring of formaldehyde even when aldehydes and other VOCs are also present. Additionally this novel technique has no moving parts, does not require carrier gas or other consumables, and therefore is highly suitable for unattended automated selective monitoring of ambient formaldehyde background levels. It will not miss even the slightest changes created by traffic emissions, wood products, building materials or industrial activities.

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