



ANALYSIS OF MICROBIAL VOLATILE ORGANIC COMPOUNDS IN INDOOR AIR. VALIDATION OF THERMAL DESORPTION GAS CHROMATOGRAPHY-MASS SPECTROMETRY METHOD

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The air quality in indoor air, in both homes and workplaces, can affect people's health in different ways. A source of deteriorating air quality, and thus adverse health effects, is mould that can form in buildings with insufficient ventilation or exposed to moisture damage. The health effects of living in mould-damaged houses have been documented in several studies, including effects on the central nervous system [1] and allergy, asthma and rhinitis [2]. The term Sick Building Syndrome (SBS) is sometimes used to describe the symptoms mainly of the respiratory tract, mucous membranes and eyes that can occur during a stay in certain buildings [3].

Since mould has negative health effects on those who stay indoors, it is essential to demonstrate the presence of mould so that the mould can be removed. There is a method for measuring the mould's volatile metabolites, so-called microbial volatile organic compounds (mVOC - microbial volatile organic compounds). These substances are formed during the metabolism of microorganisms. The microorganisms can be bacteria or fungi. These substances' characteristics are their volatility, which means that they evaporate quickly even at low temperatures and their strong odour and effect on mucous membranes upon exposure. There are some 100's identified substances within the group of mVOCs, and among these are, above all, various hydrocarbons such as ketones, alcohols, and aldehydes, but also some sulphur and nitrogen compounds. No mVOCs are specific to microorganisms, but the substances can also be formed in other ways [4]. Since these substances are volatile and pass through porous materials, such as many building materials, it is possible to measure mVOC through air samples and indirectly demonstrate the presence of mould. Then, there is no need for direct access to the mould, which can be hidden behind walls inside ventilation ducts [4].

Several studies have previously investigated the relationship between the presence of various irritation symptoms and exposure to mVOCs. Sahlberg et al. [5] examines the relationship between SBS and the presence of 16 different mVOCs in indoor air. The study was able to demonstrate a significantly increased occurrence of SBS in residents of buildings with elevated levels of some, but not all 16 investigated, mVOCs: 2-pentanol, 2-hexanone, 1-octen-3-ol, 2-pentylfuran and 3-methylfuran.

The relationship between the content of 8 different mVOCs in indoor air and the occurrence of SBS has also been investigated by Araki et al. [6]. In the study, residents in single-family houses with proven moisture problems were asked about SBS symptoms at the same time as mVOC samples in indoor air were taken. A relationship between the presence of 2 different mVOCs (2-pentanol, 1-octen-3-ol) and SBS could be demonstrated in the study. In a later follow-up study, Araki et al. also examined the relationship between mVOC and the occurrence of allergy. There was a relationship between allergic rhinitis and conjunctivitis and the presence of 1-octen-3-ol [7].

In order to find mould in buildings, several different methods can be applied. The method of measuring the volatile metabolites of mould in the form of mVOC does, however, have several advantages over other methods. To measure mVOC, thermal desorption-gas chromatography-mass spectrometry (TD-GC/MS) is usually used. This work aimed to validate a method used to measure microbial volatile organic compounds with a TD-GC/MS. The method is used by the Occupational and Environmental Medicine Laboratory at Linköping University Hospital. The validation includes determining the analytical properties of the method, such as precision, accuracy, linearity, measurement range, detection limit, quantification limit, selectivity, robustness and stability. The validation includes an analysis package that includes 12 different mVOCs and three other non-microbial VOCs. To perform the validation, standard solutions were prepared in different concentrations which are impregnated onto sorption tubes filled with Tenax TA, which then are analyzed on a TD-GC/MS unit. In order to compare different sorbents, a smaller number of tubes filled with Carbograph and Tenax+Carbograph+Carbosieve are also used.

The results show differing values where linearity varies from low ($R^2=0,550$) to high ($R^2=0,998$), which also the precision ($4\leq CV\%\leq 57$) and accuracy ($34\leq \text{recovery}\%\leq 400$) does. Limits of detection and quantification are also, in several cases, above the levels of concentration of mVOC encountered in indoor air. It is recommended that new sample containers with a different adsorbent of the type Tenax TA+Carbograph 1 start to be used, which is better adapted to the wide range of boiling points of the substances included in the analysis package for mVOC. This would give higher precision, better accuracy, and possibly lower the calculated LOD and LOQ. As for the substance dimethyl sulphide, it should either be removed from the analysis package or the method should be revised so that the substance can be reliably measured, which is not possible with the method in its current form. The method appears sensitive to changing desorption temperature; this must be high enough for complete desorption. When changing the sorbent, the appropriate temperature program should be determined again. The samples are completely storage-stable within three weeks.

References

1. Hyvönen, S., J. Lohi, and T. Tuuminen, *Moist and Mold Exposure is Associated With High Prevalence of Neurological Symptoms and MCS in a Finnish Hospital Workers Cohort*. Safety and Health at Work, 2020. **11**(2): p. 173-177.
2. Hurraß, J., et al., *Medical diagnostics for indoor mold exposure*. International Journal of Hygiene and Environmental Health, 2017. **220**(2): p. 305-328.
3. Borchers, A.T., C. Chang, and M. Eric Gershwin, *Mold and Human Health: a Reality Check*. Clinical Reviews in Allergy & Immunology, 2017. **52**(3): p. 305-322.
4. Korpi, A., J. Järnberg, and A.-L. Pasanen, *Microbial Volatile Organic Compounds*. Critical Reviews in Toxicology, 2009. **39**(2): p. 139-193.
5. Sahlberg, B., et al., *Airborne molds and bacteria, microbial volatile organic compounds (MVOC), plasticizers and formaldehyde in dwellings in three North European cities in relation to sick building syndrome (SBS)*. Science of The Total Environment, 2013. **444**: p. 433-440.
6. Araki, A., et al., *Relationship between selected indoor volatile organic compounds, so-called microbial VOC, and the prevalence of mucous membrane symptoms in single family homes*. Science of The Total Environment, 2010. **408**(10): p. 2208-2215.
7. Araki, A., et al., *The relationship between exposure to microbial volatile organic compound and allergy prevalence in single-family homes*. Science of The Total Environment, 2012. **423**: p. 18-26.