Occupational Hygiene Monitoring of Formaldehyde

Summary

There are no short-cuts to accurate and reliable monitoring of formaldehyde in the working environment or indoor air. The state of the art procedure includes sampling in the field using a proper adsorbent followed by subsequent analysis in a qualified laboratory. This specific procedure utilizes sampling cartridges containing 2,4-dinitrophenylhydrazine (2,4-DNPH). When air is sucked through this cartridge using a calibrated precision air sampling pump, formaldehyde reacts with the 2,4-DNPH to the corresponding formaldehyde-2,4-dinitrophenylhydrazone. This hydrazone is easily analyzed using high performance liquid chromatography (HPLC). The limit of quantification is in the low ppb level and far below all existing and future occupational exposure limits (OEL and STEL) in Europe. The procedure is also applicable to indoor air monitoring.

Note! There are a wide range of detector tubes (field kits) and handheld devices for monitoring of formaldehyde available on the market. The vast majority of these are suffering from severe interferences from other chemicals in the surrounding environment. These direct reading formaldehyde sensors should therefore not be used to determine indoor air or occupational hygiene levels of formaldehyde due to the health and economical consequences erroneous results may lead to.

Overview

The range of test principles for detecting formaldehyde concentrations in air is wide and the number of different test procedures is significant. These can be sorted in detector tubes, handheld gas detectors, spectrophotometric procedures and chromatographic procedures.

The detector tubes are thin glass tubes with calibration scales printed on them which allows you to directly read concentrations of the formaldehyde gas to be measured. Each tube contains detecting reagents that are especially sensitive to formaldehyde and quickly produces a distinct layer color change. The fact is that this reagent also reacts to other chemicals normally found in the industrial surroundings and may lead to severe errors in the measured concentrations. Detector tubes should not be used for determining occupational hygiene levels of formaldehyde.

The market is 'flooded' with handheld gas detectors. These are typically divided into three categories:

- Photoionisation detectors (PID)
- Flame ionisation detectors (FID)
- Electrochemical cells

Neither PID nor FID are specific to a certain substance. Whilst FID will detect almost anything that has a C-H bond, the PID will detect all substances with an ionization potential below 10.6 eV. Both sensor technologies are very sensitive, but since they are not specific to certain gases they will monitor all gases that are present. Therefore the user needs to know exactly which gases are present in the monitoring area. Be aware that not all gases will be detected with the same sensitivity or response, therefore neither the individual nor the total gas concentration will be correct in a complex air sample.

The ionisation potential of formaldehyde is 10,87 eV. Hence, the PID does not respond to formaldehyde. The response of formaldehyde to a FID is negligible.

Electrochemical cells do respond to formaldehyde, but so does a range of other substances frequently found in atmospheres where formaldehyde is present, i.e. electrochemical cells are suffering from interferences from a range of chemicals:

- Other alcohols and aldehydes are always present in the environment of a formalin based industry or users of formaldehyde based products.
- Other aldehydes are always present in working environments and indoor air.

Handheld direct reading formaldehyde sensors can only be used to roughly estimate high concentrations of formaldehyde in air.

Among a fairly large number of spectrophotometric procedures for determination of formaldehyde, the cromotropic acid procedure and the Hantsch reaction or acetylacetone procedure have been widely used. Both involve impinger sampling followed by derivatization and spectrophotometric analysis. Neither of these is suitable for personal sampling, since impingers are used for sampling. The cromotropic acid procedure suffers from interferences from other aldehydes, ketones, alcohols and acids.

The acetylacetone procedure is sensitive and fairly specific to formaldehyde. Utilizing fluorimetric analysis will even enhance the sensitivity of the Hantsch reaction. Using the acetylacetone procedure is accurate and reliable as long as stationary sampling is concerned.

The state of the art procedure involves high performance liquid chromatographic (HPLC) analysis. Formaldehyde is sucked through a cartridge or tube containing 2,4-dinitrophenylhydrazine (2,4-DNPH). Formaldehyde, as other aldehydes and ketones, reacts with the 2,4-DNPH to the corresponding 2,4-dinitrophenylhydrazones. These hydrazones are easily separated and analysed using HPLC. Due to the separation power of the HPLC, the selectivity is excellent. The sensitivity is also very good and good enough to match new and lower OELs. The technique is also very well suited for personal as well as stationary sampling.

NAJ/140610