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Workplace atmospheres — Determination of total isocyanate groups in air using 1-(9-anthracenylmethyl)piperazine (MAP) reagent and liquid chromatography

Air des lieux de travail — Dosage des groupements isocyanates totaux dans l'air par réaction avec la 1-(9-anthracénylméthyl)pipérazine (MAP) et par chromatographie en phase liquide

Reference number
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 2, *Workplace atmospheres*.

This second edition cancels and replaces the first edition (ISO 17735:2009), which has been technically revised. The main changes compared to the previous edition are as follows.

— Additional limit of detection information has been provided (Clause 1).

— The method has been used in high air concentrations successfully with a higher reagent concentration in an impinger (5.3.1).

— During processing of impinger samples, rinsing the SPE cartridge with 6 ml dichloromethane has been changed to rinsing with two consecutive 3 ml aliquots. This is more effective in removing all of the butyl benzoate impinger solvent (7.8).

— The liquid chromatographic system has been adapted to use a smaller diameter analytical column (6.7.3).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

This document specifies the use of 1-(9-anthracenylmethyl)piperazine (MAP) to measure monomeric and oligomeric isocyanate species in workplace atmospheres. MAP was designed to improve the reliability of identification of isocyanate species in sample chromatograms and to improve the accuracy of quantification of these species relative to established reagents. The high performance liquid chromatography (HPLC) analysis uses a pH gradient to selectively accelerate the elution of MAP derivatives of oligomeric isocyanates that might be unobservable in an isocratic analysis. The performance of MAP has been compared to other reagents used for total isocyanate analysis[8], MAP has been found to react with phenyl isocyanate (used as a model isocyanate) as fast as or faster than other reagents commonly used for isocyanate analysis. The UV response of MAP derivatives is comparable to that of 9-(methylaminomethyl)anthracene (MAMA) derivatives and considerably greater than other commonly used reagents [approximately three times greater than 1-(2-methoxyphenyl)piperazine (1-2MP) derivatives of aromatic isocyanates and 14 times greater than 1-2MP derivatives of aliphatic isocyanates]. The compound-to-compound variability of UV response per isocyanate group for MAP derivatives is smaller than the variability of any other commonly used reagent/detector combination (the coefficient of variation is 3,5 % for five model isocyanates). This results in more accurate quantification of detectable non-monomeric isocyanate species based on a calibration curve generated from analysing standards of monomeric species. The monomeric species used for calibration is generally the one associated with the product being analysed, but others could be used due to the very small compound-to-compound response variability of the MAP derivatives. The intensity of fluorescence response of MAP derivatives is comparable to that of MAMA derivatives and considerably greater than other reagents (e.g. approximately 30 times more intense than that of tryptamine derivatives). The compound-to-compound variability in fluorescence response has been found to be smaller than that of MAMA derivatives but larger than that of tryptamine derivatives (MAMA = 59 % coefficient of variation, MAP = 33 % coefficient of variation, and tryptamine = 16 % coefficient of variation for 5 model isocyanates). The compound-to-compound fluorescence variability of MAP derivatives is considered too great for accurate quantification of non-monomeric isocyanate species based on calibration with monomer standards. However, the sensitivity of the fluorescence detection makes it especially suitable for quantification of low levels of monomer, and the selectivity is very useful to designate an unidentified HPLC peak as a MAP derivative. MAP derivatives also give a strong response by electrochemical detection. The pH gradient used in the HPLC analysis selectively accelerates the elution of amines (MAP derivatives are amines) and is very strong (it accelerates MDI more than 100-fold). Re-equilibration to initial conditions is almost immediate. Many oligomeric species can be measured in the 30 min MAP analysis that may be unobservable in a much longer isocratic analysis.

MAP has been used in several studies comparing it side-by-side with other methods. Reference [9] found MAP impingers and NIOSH 5521 impingers (comparable to MDHS 25) to give comparable results in spray painting environments. Reference [9] used MAP reagent, but the pH gradient was not employed. Reference [10] compared MAP impingers with several other impinger methods (NIOSH 5521 and NIOSH 5522) and the double filter method. The average MAP oligomer value was substantially higher than the other impinger methods and slightly higher than the double filter method. The pH gradient was used in these MAP analyses. Reference [11] found that the MAP oligomer results compared favourably against several other methods for measurement of oligomeric isocyanates in the collision repair industry, and agreed well with the reference values.

The MAP method is currently available as NIOSH Method 5525[12]. The performance characteristics of the method have been evaluated in Reference [13].

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Workplace atmospheres — Determination of total isocyanate groups in air using 1-(9-anthracenylmethyl) piperazine (MAP) reagent and liquid chromatography

1 Scope

This document specifies a method for the sampling and analysis of airborne organic isocyanates in workplace air.

This document is applicable to a wide range of organic compounds containing isocyanate groups, including monofunctional isocyanates (e.g. phenyl isocyanate), diisocyanate monomers [e.g. 1,6-hexamethylene diisocyanate (HDI), toluene diisocyanate (TDI), 4,4′-diphenylmethane diisocyanate (MDI), and isophorone diisocyanate (IPDI)], prepolymers (e.g. the biuret and isocyanurate of HDI), as well as chromatographable intermediate products formed during production or thermal breakdown of polyurethane.

In mixed systems of HDI and IPDI products, it is impossible to identify and quantify low levels of IPDI monomer using this document, due to coelution of IPDI monomer with HDI-uretidinedione.

It is known that the method underestimates the oligomer in MDI-based products. Total isocyanate group (NCO) is underestimated in MDI-based products by about 35 % as compared to dibutylamine titration.

The method has been successfully modified to be used with LC-MS-MS for TDI monomer using an isocratic 70 % acetonitrile/30 % 10 mM ammonium formate mobile phase.

The useful range of the method, expressed in moles of isocyanate group per species per sample, is approximately 1×10^{-10} to 2×10^{-7}. The instrumental detection limit for the monomers using both ultraviolet (UV) detection and fluorescence (FL) detection is about 2 ng monomer per sample. The useful limit of detection for the method using reagent impregnated filters is about 10 ng to 20 ng monomer per sample for both UV and FL detection. For a 15 l sample, this corresponds to 0,7 $\mu g/m^{-3}$ to 1,4 $\mu g/m^{-3}$. For impinger samples, which require solid phase extraction, experience has shown that the useful limit of detection is about 30 ng to 80 ng monomer per sample.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1232, *Workplace atmospheres — Pumps for personal sampling of chemical agents — Requirements and test methods*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

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