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# 2-Phenoxyethanol – Method for the determination of 2-phenoxyethanol in workplace air using gas chromatography after thermal desorption

## Air Monitoring Method – Translation of the German version from 2018

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**Keywords:** 2-phenoxyethanol; air analyses; analytical method; workplace measurement; hazardous substance; thermal desorption gas chromatography; flame ionisation detection; mass spectrometry; TD-GC-FID/MS; quartz fibre filter

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# 2-Phenoxyethanol – Method for the determination of 2-phenoxyethanol in workplace air using gas chromatography after thermal desorption

## Air Monitoring Methods

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## Abstract

This analytical method is a validated measurement procedure for the determination of 2-phenoxyethanol [122-99-6] in workplace air in a concentration range of one tenth up to twice the currently valid MAK value of 5,7 mg/m$^3$. With this method simultaneously airborne 2-phenoxyethanol in the gaseous state as well as particles are collected. Sampling is performed by drawing a defined volume of air through a quartz fibre filter located in the sampling head with an adsorption tube filled with Tenax TA® connected downstream using a suitable pump. The flow rate is set to 0.066 L/min with a recommended air sample volume of approx. 4 litres. The collected 2-phenoxyethanol alcohol is thermally desorbed and then analysed by means of gas chromatography using two detectors, a FID for quantification and a MSD to recognise potential interferences. The quantitative determination is based on a calibration function obtained by means of a multi-point calibration. The limit of quantification is 0,095 mg/m$^3$ based on an air sample of approx. 4 litres.

## Keywords

2-phenoxyethanol; workplace measurement; hazardous substances; air analysis; workplace monitoring; glass fibre filter; Tenax TA®; gas chromatography; GC-FID; GC-MSD; thermal desorption; GGP-Mini

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| | |
|---|---|
| **Method number** | 1 |
| **Application** | Air analysis |
| **Analytical principle** | Gas chromatography (thermal desorption) |
| **Completed in** | March 2018 |

## Summary

The analytical method described here enables the determination of 2-phenoxyethanol in workplace air from a tenth up to twice the currently valid MAK value of 5.7 mg/m$^3$ (1 ppm). 2-Phenoxyethanol occurring in the gaseous and particulate state can be simultaneously determined with this method. Sampling is performed using a suitable sampling pump to draw a defined volume of air through an adsorption tube filled with Tenax TA®, which has a GGP-Mini type sampling head fitted with a quartz fibre filter connected upstream to capture the aerosol fraction. 2-Phenoxyethanol occurring in the particulate state is thus deposited onto the filter and the gaseous fraction is adsorbed onto the Tenax TA®.

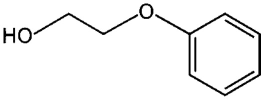
After sampling, the collected 2-phenoxyethanol is thermally desorbed from the sample carrier and analysed by means of gas chromatography and flame ionisation detection (FID). At the same time a mass selective detector (MSD) is used, which can be useful for identification and quantification in the case of chromatographic interferents. A multiple-point calibration with calibration standards of known concentration is carried out for quantitative evaluation. There is a linear relationship between the peak area and the concentration.

## Characteristics of the method

| | | |
|---|---|---|
| Precision: | Standard deviation (rel.): | $s$ = 1.1–2.5% |
| | Expanded uncertainty: | $U$ = 24.5–24.9% |
| | in the concentration range of the limit of quantification up to twice the limit value and $n$ = 6 determinations | |
| Limit of quantification: | 0.095 mg/m$^3$ for an air sample volume of 4 L | |
| Recovery: | $\eta > 0.96$ (> 96%) | |
| Sampling recommendations: | Sampling period: | 60 min |
| | Air sample volume: | 4 L |
| | Flow rate: | 4 L/h |

## Description of the substance

**2-Phenoxyethanol [122-99-6]**



Synonyms: ethylene glycol monophenyl ether, phenylglycol

2-Phenoxyethanol is a colourless, slightly viscous liquid with a slight odour of roses (molar mass 138.17 g/mol, boiling point 245 °C, melting point 14 °C, vapour pressure 0.04 hPa at 20 °C, density 1.11 g/cm$^3$). It is moderately soluble in water (24 g/L at 20 °C); it is however, readily soluble in most organic solvents.

2-Phenoxyethanol has antiseptic and fungicidal properties and is used in dermatological products such as a preservative in skin creams. In the EU a maximum concentration of up to 1.0% is permitted as a preservative for cosmetics in ready-to-use formulations [2]. In the pharmaceutical industry 2-phenoxyethanol is used as a preservative for vaccines. Furthermore, it is used as a component in hydraulic liquids and as a fixative for perfumes and soaps. It is also used as a substitute for sodium azide in biological buffer solutions, as it is less toxic and does not react with copper or lead. 2-Phenoxyethanol is used as an anaesthetic for fish in aquaculture and serves as a solvent in inks, resins, ballpoint pen inks, printing pastes and stamping inks as well as a solubiliser in flooring adhesives.

The MAK value for 2-phenoxyethanol is 5.7 mg/m$^3$ (1 ppm). The short-term exposure value for 2-phenoxyethanol is assigned to Peak Limitation Category I with an excursion factor of 1. Furthermore, the following footnote applies to the substance: "*may occur simultaneously as* vapour and aerosol" [1]. Detailed information on the toxicity of 2-phenoxyethanol can be found in the toxicological-occupational health documentation of MAK values [3, 4, 5].

1 mL/m$^3$ (ppm) $\triangleq$ 5.733 mg/m$^3$ 1 mg/m$^3$ $\triangleq$ 0.174 mL/m$^3$ (ppm)

## Contents

## 1 General principles

The analytical method described here enables the determination of 2-phenoxyethanol in workplace air from a tenth up to twice the currently valid MAK value of 5.7 mg/m$^3$ (1 ppm) [1]. 2-Phenoxyethanol occurring in the gaseous and particulate state can be simultaneously determined with this method. Sampling is carried out using a suitable sampling pump to draw a defined volume of ambient air through a sampling system consisting of a GGP-Mini sampling head fitted with a quartz fibre filter and an adsorption tube filled with Tenax TA® connected downstream. 2-Phenoxyethanol occurring in a particulate state (free or bound) is thus deposited onto the filter and the gaseous fraction is adsorbed onto the Tenax TA®. Deposited particles that evaporate from the filter during sampling are collected downstream by the Tenax TA®.

After sampling, the filter is removed from the sampling head and pushed into the end of the adsorption tube that faces towards the sampling head. Sample preparation is performed by means of thermal desorption, whereby the thermal desorption is carried out in the opposite direction of flow to that during sampling. After thermal desorption and gas chromatographic analysis, the analyte is recorded by means of two detectors. A flame ionisation detector (FID) is used for quantification. At the same time a mass selective detector (MSD) is used, which can be useful for identification and quantification in the case of chromatographic interferences. A multiple-point calibration with calibration standards of known concentration is carried out for quantitative evaluation. There is a linear relationship between the peak area and the concentration.

## 2 Equipment, chemicals and solutions

### 2.1 Equipment

- Pump, suitable for a flow rate of 66 mL/min, e.g. Pocket Pump from Analyt-MTC Messtechnik GmbH, 79379 Müllheim, Germany
- Aerosol monitor for collecting the inhalable aerosols, e.g. GGP-Mini type sampling head with intake cone for 0.066 L/min (e.g. from Analyt-MTC Messtechnik GmbH)
- Quartz fibre filter, Munktell MK 360, Ø = 37 mm (e.g. from Binzer & Munktell Filter GmbH, 35088 Battenberg, Germany)
- Filter punch, Ø = 13 mm
- Muffle furnace
- Adsorption tubes made of stainless steel (6.3 mm x 90 mm, inner diameter of 5 mm), e.g. from PerkinElmer LAS, 63110 Rodgau, Germany
- Gauze loading rig (e.g. from PerkinElmer LAS, Order No. L4070023)
- Metal packing gauze for stainless steel tubes (e.g. from PerkinElmer LAS, Order No. L4071034)
- Retaining spring for metal packing gauze (e.g. from PerkinElmer LAS, Order No. L4071123)
- Gas chromatograph with thermal desorber, flame ionisation detector (FID), mass selective detector (MSD) and evaluation system
- Sealing caps (e.g. Swagelok with PTFE seals, PTFE)
- Capillary column e.g. DB-624: 30 m, film thickness of 1.4 µm; inner diameter of 0.25 mm, e.g. from Agilent, 76337 Waldbronn, Germany
- Gas meter or stopwatch and soap bubble flow meter
- Analytical balance
- Volumetric flasks, nominal volume 100 mL
- Positive displacement pipette, Microman type, 1 to 10 µL, from Gilson, 65555 Limburg, Germany
- Tweezers

### 2.2 Chemicals

- 2-Phenoxyethanol, p.a., purity ≥ 99%, e.g. from Merck, 64293 Darmstadt, Germany
- Methanol, p.a., purity ≥ 99.5%, e.g. from Merck
- Tenax TA® (35–60 mesh), e.g. from Agilent Technologies, 64289 Darmstadt, Germany

Gases for operation of the gas chromatograph/thermal desorber:

- Helium 5.0 (carrier gas)
- Purified or synthetic air (free of hydrocarbons), dew point better than −40 °C
- Hydrogen 5.0
- Nitrogen 5.0

## 2.3 Preparation of the sampling system

The sampling system – consisting of a filter and an adsorption tube connected downstream – is prepared as follows before use:

Adsorption tubes filled with Tenax TA® (75 mg Tenax TA® 35–60 mesh) are not commercially available and must be prepared and conditioned in the laboratory. The quartz fibre filters are conditioned in the muffle furnace at 500 °C for four hours prior to sampling.

### 2.3.1 Adsorption tubes

Adsorption tubes made of stainless steel are filled with 75 mg Tenax TA® (35–60 mesh) and the adsorbent is slightly compressed by tapping. It is important to ensure that the adsorbent is not compressed too much. The individual tubes are fitted into the gauze loading rig and metal packing gauze is carefully pushed to the end of the adsorbent layer. Then a spring is pushed up to the gauze in order to prevent the gauze from falling out of the tube (see Figure 1). The flow resistance must be checked before an adsorption tube is used for the first time. This should not exceed 30 hPa at a flow rate of 1 L/min.

Before their first use, the adsorption tubes filled with Tenax TA® are conditioned for approx. 20 minutes in the thermal desorber at 300 °C and then tested for blank values. Then they are sealed with suitable caps for storage. The tubes can be re-used after analysis is complete.

**Figure 1** Schematic illustration of the adsorption tubes used

**1** Connection to the pump
**2** Retention gauze for the adsorbent
**3** Adsorbent Tenax TA®
**4** Spring for fixation
**5** Sampling opening

### 2.3.2 Quartz fibre filters

Before their use, the quartz fibre filters are conditioned in the muffle furnace for four hours at 500 °C. This preparatory step reduces the background of thermally desorbable compounds to a minimum.

## 2.4 Solutions

**Stock solution:** 2-Phenoxyethanol (11.4 g/L)

1.0 mL of 2-phenoxyethanol is pipetted into a 100 mL volumetric flask and weighed. The volumetric flask is then filled to the mark with methanol and shaken.

**Calibration solutions:**

The calibration solutions are prepared by diluting the stock solution with methanol in the ratio of 1:10 (Calibration Solution I) or 1:100 (Calibration Solution II) (Table 1).

**Table 1** Concentration of the stock solution and calibration solutions

| Substance | Stock solution | Calibration solution I | Calibration solution II |
|---|---|---|---|
| | [g/L] | [µg/µL] | [µg/µL] |
| 2-Phenoxyethanol | 11.4 | 1.14 | 0.114 |

The prepared solutions can be stored in the refrigerator at approx. 4 °C for at least 6 months. The date of preparation must be noted on the volumetric flask.

## 2.5 Calibration standards

For the purpose of calibration adsorption tubes filled with Tenax TA® are spiked with aliquots of 1 to 10 µL of the calibration solutions (see Table 1). Clean air or nitrogen is then drawn through the adsorption tubes at a flow rate of 30 mL/min for 10 minutes in order to remove the excess methanol solvent. The spiked adsorption tubes contain the calibration masses shown in Table 2.

**Table 2** Content of 2-phenoxyethanol in the calibration samples

| Solution | Dosing volume | Spiked mass | Concentration at an air sample volume of 4 L |
|---|---|---|---|
| | [µL] | [µg] | [mg/m³] |
| Calibration solution II | 1 | 0.114 | 0.0285 |
| | 5 | 0.570 | 0.143 |
| | 10 | 1.14 | 0.285 |
| Calibration solution I | 2.5 | 2.85 | 0.713 |
| | 5 | 5.70 | 1.43 |
| | 7.5 | 8.55 | 2.14 |
| | 10 | 11.4 | 2.86 |
| Stock solution | 2.5 | 28.5 | 7.13 |
| | 5 | 57.0 | 14.3 |

## 3 Sampling and sample preparation

The GGP-Mini type sampling head is fitted with a prepared quartz fibre filter and an intake cone suitable for the flow rate of 0.066 L/min at the beginning of sampling. An adsorption tube filled with Tenax TA® is connected to both the tube connection of the sampling head and sampling pump [6]. The connection between the sampling head and adsorption tube is established using a short section of Viton® tube.

The definition of an inhalable dust is fulfilled by this sampling system [7, 8]. The schematic set-up of the sampling system is illustrated in Figure 2.

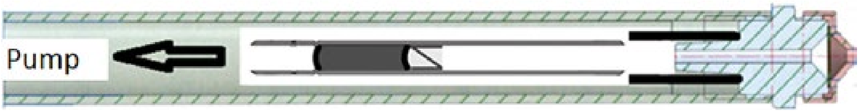


**Figure 2** Schematic illustration of the sampling system consisting of a GGP-Mini sampling head and an adsorption tube connected downstream

The pump and the sampling system are either worn by a person while performing their activities or stationary sampling is carried out. Air from the breathing zone is sampled. The opening of the adsorption tube should be freely accessible. An air sample volume of 4 litres is achieved at a pre-selected flow rate of 0.066 L/min and a sampling period of 60 minutes. The important parameters for the determination of the concentration in air (sample volume, temperature, air pressure and relative humidity) are documented in the sampling record.

After sampling, the filter is removed from the sampling head, folded using tweezers and pushed into the end of the adsorption tube that faces towards the sampling head. Then the tube is sealed at both ends using Swagelok caps with PTFE seals until analysis.

## 4 Operating conditions for chromatography

| | | |
|---|---|---|
| Apparatus: | Clarus 600 gas chromatograph with flame ionisation detector (FID), Clarus 600T mass selective detector (MSD), from PerkinElmer LAS | |
| Column: | Material: | Fused silica capillary |
| | Stationary phase: | DB-624 (6% cyanopropyl-phenylpolysiloxane and 94% dimethylpolysiloxane) |
| | Length: | 30 m |
| | Inner diameter (ID): | 0.25 mm |
| | Film thickness: | 1.4 µm |
| Eluate flow splitter: | Graphpack-3D/2 eluate flow splitter, Order No. GC 08194-40, from Gerstel, Mülheim an der Ruhr, Germany | |
| | Split ratio: | 1:1 (FID/MSD) |

Detectors: Flame ionisation detector (FID)/mass selective detector (MSD)
Detector temperature (FID): 320 °C
Detector gases: Hydrogen (45 mL/min), synthetic air (450 mL/min)
Rate of heating: 10 min at 35 °C, increased by 10 °C/min up to 240 °C, 10 min

**MS operational conditions**

Temperatures: Ion source: 180 °C
Transfer line: 200 °C
Type of ionisation: Electron impact (EI)
Pressure of the ion source: $3 \times 10^{-6}$ kPa
Ionisation energy: 70 eV
Mass range: 35–520 amu

Under the conditions given here the retention time for 2-phenoxyethanol is 26.58 minutes (see Table 7 in the Appendix).

## 5 Analytical determination

The adsorption tubes are heated in the thermal desorber in the opposite direction to that of sampling, whereby 2-phenoxyethanol is transferred by means of a carrier gas into a cold trap packed with Tenax TA®. After complete desorption from the adsorption tube the cold trap is spontaneously heated to 280 °C, so that the analyte is transferred to the separation column as a narrow substance plug.

The thermal desorber is set to the following instrumental conditions:

**Operating conditions for thermal desorption**

Apparatus: Turbomatrix 650 (from PerkinElmer LAS)
Desorption temperature: 280 °C
Desorption period: 20 min
Valve temperature: 220 °C
Temperature of the transfer line: 200 °C
Transfer line: 1.5 m of deactivated non-loaded pre-column, (ID 0.32 mm)
Cold trap (adsorption): −30 °C
Cold trap (injection): 280 °C
Cold trap filling: 20 mg of Tenax TA® (Order No. M0413535)
Heating rate: 40 °C/s
Carrier gas: Helium
Carrier gas flow rate: 1.7 mL/min
Split (before the cold trap): 200 mL/min (input split)
Flow rate (through the cold trap): 10 mL/min (desorption flow)
Split (after the cold trap): 20 mL/min (output split)
Purge drying phase: 1 min at room temperature at 50 L/min

After the thermal desorber and gas chromatograph have been prepared, the calibration and analytical samples are measured. Should other thermal desorption devices be used, then the instrumental conditions must be adapted accordingly.

## 6 Calibration

The calibration samples prepared according to Section 2.5 are analysed as described in Sections 4 and 5. The calibration function is obtained by plotting the peak areas measured versus the respective loaded masses (see Table 2).

The calibration function is linear in the investigated concentration range and should be regularly checked during routine analysis. For this purpose, a calibration standard of known concentration must be analysed in each analytical series.

## 7 Calculation of the analytical result

Based on the determined peak areas, the corresponding mass X in µg per sample is obtained from the respective calibration curve. The corresponding mass concentration (ρ) is calculated according to Equation 1 below:

$$\rho = \frac{\mathrm{X}}{V \times \eta} \qquad (1)$$

Equation 2 below enables calculation of the value at 20 °C and 1013 hPa:

$$\rho_0 = \rho \times \frac{273+t_a}{293} \times \frac{1013}{p_a} \qquad (2)$$

where:

$\rho$ is the mass concentration of 2-phenoxyethanol in the ambient air in mg/m$^3$ at $t_a$ and $p_a$

$\rho_0$ is the mass concentration of 2-phenoxyethanol in mg/m$^3$ at 20 °C and 1013 hPa

$X$ is the mass of 2-phenoxyethanol in the analytical sample in µg

$V$ is the air sample volume (calculated from the flow rate and the sampling period) in L

$\eta$ is the recovery

$t_a$ is the temperature during sampling at the sampling location in °C

$p_a$ is the air pressure at the sampling location during sampling in hPa

## 8 Reliability of the method

The characteristics of the method were calculated as stipulated in DIN EN [9], DIN EN 1076 [10], DIN EN 13936 [7] and DIN 32645 [11]. The precision data and the influence of the humidity were determined in each case on the basis of a series of six sample measurements.

The samples were prepared by spiking the filters with solutions (see Section 2.4; Table 1), which were then each placed into a GGP-Mini sampling head. After attaching the intake cone, the sampling head was connected upstream of the adsorption tube and humidified air was drawn through the sampling system. Analysis was carried out after thermal desorption by means of gas chromatography in accordance with Sections 4 and 5. Storage stability was determined using spiked adsorption tubes.

## 8.1 Precision and expanded uncertainty

For the purpose of determining the precision three experimental series with 2-phenoxyethanol concentrations in the range of one tenth to twice the MAK value were prepared. After spiking the filters and connecting a sampling head upstream of the adsorption tube, 4 litres of air with a relative humidity of 80% were drawn through the sampling system at room temperature (23 °C).

The expanded uncertainty was calculated according to [12] and estimated as stipulated in DIN EN 482 [9] taking all relevant influencing factors into consideration. The expanded uncertainty of the entire method consists principally of the contributions of the sampling uncertainty (e.g. air sample volume, deviation from the sampling convention) and the analytical preparation (scatter of the calibration function, fluctuations in the transfer as well as the reproducibility). The resulting characteristics, such as relative standard deviation and expanded uncertainty, are listed in Table 3.

**Table 3** Standard deviation (rel.), expanded uncertainty *U* and recoveries for 2-phenoxyethanol for *n* = 6 determinations

| Spiked mass | Concentration at V = 4 L of air | Standard deviation (rel.) | Expanded uncertainty *U* | Recovery |
|---|---|---|---|---|
| [µg] | [mg/m$^3$] | [%] | [%] | [%] |
| 2.28 | 0.57 | 1.1 | 23.6 | 96 |
| 22.8 | 5.7 | 2.5 | 23.8 | 96 |
| 45.6 | 11.4 | 1.4 | 24.0 | 94 |

## 8.2 Recovery and influence of the humidity

The recoveries were calculated using the precision experiments (see Section 8.1). The mean recovery was 96%.

## 8.3 Influence of the temperature

The influence of the temperature during sampling was determined by conducting two experimental series. After spiking the filter with 5 µL of stock solution (see Section 2.4), equivalent to 57 µg of 2-phenoxyethanol, and subsequent connection of the filter upstream of the adsorption tube, four litres of air with a relative humidity of 50% were drawn through the sampling system at 10 °C and 40 °C. No influence from the temperature could be detected (see Table 4).

**Table 4** Standard deviation (rel.) and recoveries for 2-phenoxyethanol for *n* = 3 determinations

| Spiked mass | Temperature | Concentration at V = 4 L of air | Standard deviation (rel.) | Recovery |
|---|---|---|---|---|
| [µg] | [°C] | [mg/m$^3$] | [%] | [%] |
| 57 | 10 | 14.3 | 0.60 | 94 |
| 57 | 40 | 14.3 | 2.3 | 99 |

## 8.4 Limit of quantification

The limit of quantification was calculated in the same manner as the calibration line method described in DIN 32645 [11] with a statistical certainty of P = 95% and k = 3.

The limit of quantification was determined by spiking filters with aliquots of 1 to 10 µL of calibration solution II (see Section 2.4; Table 1) and then pushing the filter from the rear side into the end of the adsorption tube using tweezers. Nitrogen is then drawn through the adsorption tubes at a flow rate of 30 mL/min for 10 minutes in order to remove the excess methanol. For this purpose, the rear ends of the adsorption tubes were connected to the nitrogen supply. According to the calibration line method (P = 95%, k = 3) the limit of quantification of 2-phenoxyethanol is 0.095 mg/m$^3$ (0.38 µg absolute) based on an air sample volume of four litres.

## 8.5 Capacity of the sampling system

The capacity of the sampling system was determined by spiking an adsorption tube with 5 µL of the stock solution (see Section 2.4), which is equivalent to 57 µg of 2-phenoxyethanol. A second adsorption tube was then connected downstream and eight litres of air were drawn through the combined tubes at room temperature (23 °C) and a relative humidity of 80%. No breakthrough was observed.

## 8.6 Storage stability

Tests on storage stability of the loaded sampling systems were carried out over periods of two and four weeks. For this purpose, experimental series were prepared with 2.28 µg and 45.6 µg of 2-phenoxyethanol – equivalent to 0.57 mg and 11.4 mg of 2-phenoxyethanol per m$^3$ at an air sample volume of 4 L.

The sample was dosed by applying aliquots in the µL range directly onto the Tenax TA® adsorbent in the adsorption tubes and then four litres of air with a relative humidity of 80% were drawn through the tubes. The tubes were sealed with Swagelok caps and stored at room temperature.

After one day as well as after two and four weeks three adsorption tubes were prepared and analysed according to Sections 4 and 5 in each case. The results are listed in Table 5. During the four-week period no losses could be detected, therefore storage stability over a period of four weeks is ensured.

**Table 5** Recoveries of 2-phenoxyethanol after a storage period of two and four weeks at room temperature

| Spiked mass [µg] | Detected mass [µg] after a storage period of | | |
|---|---|---|---|
| | 1 day | 2 weeks | 4 weeks |
| 2.28 | 2.20 | 2.56 | 2.50 |
| 45.6 | 43.3 | 45.7 | 46.3 |

### 8.7 Interference

On account of the low specificity of flame ionisation detectors, interference is principally possible due to components with the same retention time. The results of the mass selective detection can be used to confirm the analytical results.

## 9 Discussion

2-Phenoxyethanol can be determined in the workplace air in a concentration range of a tenth up to twice the currently valid MAK value of 5.7 mg/m$^3$ (1 ppm) at an air sample volume of 4 L (0.004 m$^3$) with the analytical method described here. Furthermore, the analytical method is suitable for monitoring compliance with the peak limit (short-term exposure limits).

The method described here was examined using two different concentrations. For this purpose, six sample carriers were each spiked with 5.48 µg and 10.96 µg of 2-phenoxyethanol in the laboratory of the developer of the method (LfU—State Environmental Agency Rhineland-Palatinate) and that of the examiner of the method (BASF SE Environmental Analysis). Four litres of ambient air at a humidity of approx. 55% were then drawn through the sample carriers. The sample carriers were sealed and exchanged between the laboratories, so that both laboratories each analysed three samples that had been prepared in-house and three prepared by the other laboratory. The analyses were carried out simultaneously in accordance with Sections 4 and 5 after five days. Recoveries of 87 to 103% were obtained. The exact results can be found in Table 6.

Sampling with the GGP-Mini sampling system ensures that the airborne aerosol fraction is always captured in its entirety [13].

**Table 6** Results of testing the measurement method for 2-phenoxyethanol

| | | Laboratory 1 (LfU*) | | Laboratory 2 (BASF**) | |
|---|---|---|---|---|---|
| | Theoretical concentration | Concentration found | Recovery | Concentration found | Recovery |
| | [mg/m$^3$] | [mg/m$^3$] | [%] | [mg/m$^3$] | [%] |
| Experiment series 1 | 1.37 | 1.23 | 90 | 1.26 | 92 |
| Experiment series 2 | 2.74 | 2.39 | 87 | 2.82 | 103 |

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## Appendix

**Table 7** Retention times of selected solvents (Separation column 30 m DB-624, for analytical conditions see Section 4)

| Retention time [min] | Substance | CAS number |
|---|---|---|
| 3.26 | Methanol | 67-56-1 |
| 4.48 | Ethanol | 64-17-5 |
| 5.22 | Acetone | 67-64-1 |
| 5.63 | 2-Propanol | 67-63-0 |
| 6.03 | Methyl acetate | 79-20-9 |
| 6.66 | *tert*-Butyl alcohol | 75-65-0 |
| 7.86 | n-Hexane | 110-54-3 |
| 8.91 | 1-Propanol | 71-23-8 |
| 10.49 | 2-Butanone | 78-93-3 |
| 10.85 | Ethyl acetate | 141-78-6 |
| 11.27 | Tetrahydrofuran | 109-99-9 |
| 11.37 | *sec*-Butyl alcohol | 78-92-2 |
| 12.03 | Cyclohexane | 110-82-7 |
| 12.98 | Isobutyl alcohol | 78-83-1 |
| 13.26 | Isopropyl acetate | 108-21-4 |
| 13.64 | *n*-Heptane | 142-82-5 |
| 14.33 | 1-Propylene glycol 1-methyl ether | 107-98-2 |
| 14.42 | *n*-Butyl alcohol | 71-36-3 |
| 14.69 | Methylcyclohexane | 108-87-2 |
| 15.26 | Propyl acetate | 109-60-4 |
| 16.46 | 4-Methyl-2-pentanone | 108-10-1 |
| 16.72 | Toluene | 108-88-3 |
| 17.01 | *n*-Octane | 111-65-9 |
| 17.06 | Isobutyl acetate | 110-19-0 |
| 17.86 | 2-Hexanone | 591-78-6 |
| 18.10 | *n*-Butyl acetate | 123-86-4 |
| 18.18 | Cyclopentanone | 120-92-3 |
| 18.92 | Ethylene glycol monomethyl ether acetate | 110-49-6 |
| 19.20 | Ethylbenzene | 100-41-4 |
| 19.38 | m+p-Xylene | 108-38-3; 106-42-3 |
| 19.46 | n-Nonane | 111-84-2 |

**Table 7** (continued)

| Retention time [min] | Substance | CAS number |
|---|---|---|
| 19.51 | Propylene glycol 1-methyl ether-2-acetate | 108-65-6 |
| 19.98 | o-Xylene | 95-47-6 |
| 20.16 | Ethylene glycol monoethyl ether acetate | 111-15-9 |
| 20.33 | Cyclohexanol | 108-93-0 |
| 20.56 | Cumene | 98-82-8 |
| 20.61 | Ethylene glycol monobutyl ether | 111-76-2 |
| 20.67 | Cyclohexanone | 108-94-1 |
| 21.17 | *n*-Propyl benzene | 103-65-1 |
| 21.44 | 1,3,5-Trimethylbenzene | 108-67-8 |
| 21.47 | *n*-Decane | 124-18-5 |
| 21.64 | Diisobutyl ketone | 108-83-8 |
| 21.99 | 1,2,4-Trimethylbenzene | 95-63-6 |
| 22.62 | 1,2,3-Trimethylbenzene | 526-73-8 |
| 23.58 | Benzyl alcohol | 100-51-6 |
| 23.61 | Ethylene glycol monobutyl ether acetate | 112-07-2 |
| 24.48 | Nitrobenzene | 98-95-3 |
| 25.20 | Tetrahydronaphthalene | 119-64-2 |
| 26.58 | 2-Phenoxyethanol | 122-99-6 |