

# MIDHS

## *Methods for the Determination of Hazardous Substances*

Health and Safety Laboratory



# 62

## **Aromatic carboxylic acid anhydrides in air**

Laboratory method using glass-fibre  
filter/Tenax tube sampling and high  
performance liquid chromatography

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### INTRODUCTION

#### Properties and uses

1 Aromatic carboxylic acid anhydrides are a group of compounds including, in decreasing order of industrial usage, phthalic anhydride, trimellitic anhydride and tetrachlorophthalic anhydride.

2 Phthalic anhydride, 1,2-benzene dicarboxylic acid 1,2-anhydride, is a white solid, mp 130°C. It has significant, but low, vapour pressure at room temperature (<0.05 mm Hg; <0.01 kPa). It is used in vinyl plasticisers, unsaturated polyesters, dyes, alkyl resins and in the manufacture of some pesticides.

3 Trimellitic anhydride, 1,2,4-benzenetricarboxylic acid 1,2-anhydride, is a white solid, mp 161-164°C. Its vapour pressure at room temperature is negligible,<sup>1</sup> less than  $7 \times 10^{-9}$  mm Hg ( $1 \times 10^{-6}$  Pa). Trimellitic anhydride is used as a curing agent for epoxy and other resins; in vinyl plasticisers, paints and coatings, polymers, polyesters, agricultural chemicals, dyes and pigments, pharmaceuticals, surface active agents, modifiers, intermediates and speciality chemicals.

4 Tetrachlorophthalic anhydride, 3,4,5,6,-tetrachloro-1,2-benzenedicarboxylic acid 1,2-anhydride, is manufactured by the reaction of phthalic anhydride with chlorine at high temperatures. The anhydride imparts fire-resistance to polyester resins, polyurethane foams and surface coatings.

**NOTE:** Acronyms used in this text:

- PA : Phthalic anhydride  
Pacid : Phthalic acid (1,2-benzenedicarboxylic acid)  
TMA : Trimellitic anhydride  
TMacid : Trimellitic acid (1,2,4-benzenetricarboxylic acid)  
TCPA : Tetrachlorophthalic anhydride

- TCPacid : Tetrachlorophthalic acid  
ACA and : Generic aromatic carboxylic acid  
ACacid anhydrides and acids respectively

#### Toxicity

5 PA is an irritant to the eyes and skin and especially to moist tissue.<sup>1</sup> If in contact with the skin for a significant time, the solid may burn the tissues. Repeated exposure may result in asthma, irritation of the mucous membranes and diseases of the respiratory and digestive organs.<sup>2</sup> Workers may become sensitised to PA and should then avoid further contact with it.

6 TMA is an irritant to the respiratory tract. Pulmonary oedema may result. Symptoms include runny nose and/or asthma; cough, wheezing and laboured breathing may occur some hours after work has finished. Acute exposure may lead to a running nose, nose bleed, cough, laboured breathing and wheezing. Workers may become sensitised to TMA and should then avoid further contact with it. Further details on its toxicity may be found in Ref 3.

#### First aid

7 Remove from exposure and wash exposed areas of the skin and eyes immediately with large quantities of water. Remove dust-contaminated clothing. If breathing becomes very difficult, oxygen may be administered. Medical advice should be sought or the patient sent to hospital by ambulance.

#### Analytical methods

8 This is not an HSE 'reference' method in the strict analytical sense of the word. There are frequently several alternative methods for determining a particular analyte. With the exception of a few special cases, where an exposure limit is linked to a specific analytical method (eg

rubber fume and asbestos), the use of methods not included in the MDHS series is acceptable, provided they have the accuracy and reliability appropriate to the application.

### Principle

9 A measured volume of sample air is drawn through a GF/A filter and a back-up Tenax tube contained in series in a sampling train. After sampling, the filter is placed in a desorption vial and 1% phosphoric acid solution in acetonitrile/water (HPLC mobile phase) is added. The Tenax tube is desorbed with acetone and, after evaporation, the residue is redissolved in HPLC mobile phase. Any ACA collected on the filter or Tenax tube is converted to ACacid. The resultant solution is analysed with a high performance liquid chromatograph (HPLC) equipped with an ultra-violet (UV) detector. The peak response obtained from an injection of this solution is compared to those obtained from a range of similar injections of standard solutions.

### SCOPE

10 The method described is for the determination of the time-weighted-average concentrations of ACA dust and fume in workplace atmospheres. The method is suitable for sampling over periods in the range 10 min to 8 h. Although described for the determination of personal exposure, the method may be used for fixed location monitoring by suitable modification.

11 The method is suitable for the measurement of airborne PA in a concentration range of approximately 4 to 1600 µg/m<sup>3</sup> for samples of 10 litres of air. The method is suitable for the measurement of airborne TMA in a concentration range of approximately 4 to 1200 µg/m<sup>3</sup> for samples of 30 litres of air.

12 The method is expected to be suitable for a range of other, similar, anhydrides, eg pyromellitic dianhydride, 1,4,5,8-naphthalene tetracarboxylic acid dianhydride 1,8-naphthalic anhydride, and tetrachlorophthalic anhydride. Some modifications to the HPLC mobile phase composition may be necessary to achieve optimal separation or convenient retention times.

13 In laboratory trials on TMA,<sup>4</sup> within-batch coefficients of variation of 4% (81 µg/filter), 7% (8.1 µg/filter) and 12% (0.81 µg/filter) were obtained. In laboratory trials on PA, a within-batch coefficient of variation of 11% was obtained. Sampling (pump) error of about 5% is anticipated.

14 The mean analytical recovery from 30 spiked filters over the range 0.81-81µg of TMA loaded onto the filters was 95% (CV of 7%, Ref 4). The mean analytical recovery of PA loaded onto Tenax tubes was 91%.

### Interferences

15 Any compound that co-elutes with the ACA (as ACacid) at the operating conditions chosen by the analyst is a potential interferent; changing the composition of the mobile phase or changing the separating column may

remove this interference. Correspondence of retention time on a single column cannot be regarded as proof of identity. When interfering compounds are known to be present in the air, or are suspected of being present, notes on the identity or suspected identity of the compounds should be transmitted with the sample. Cross-interferences from compounds such as PA, TMA and TCPA and epoxy resins are not apparent. Resorcinol is a possible interferent with TMA.

16 The method does not distinguish between ACA and ACacid. Possible conversion of ACA to ACacid may occur in the ambient air prior to the ACA being sampled.

### REAGENTS AND STANDARDS

17 The following reagents are required for this method.

Aromatic anhydride (ACA), analytical grade  
Phosphoric acid, concentrated  
Acetonitrile, HPLC grade  
Acetone, reagent grade  
Water, HPLC grade

### HPLC mobile phase

18 Add 840 ml water to 150 ml acetonitrile in a screw-cap flask (1 litre) and mix thoroughly. Add slowly, with shaking, 10 ml of concentrated phosphoric acid and again mix thoroughly. De-gas by filtration under vacuum.

**NOTE:** *Phosphoric acid is a strong and corrosive acid; take suitable precautions to protect hands and eyes.*

### ACA standard solution A (1 g/litre)

19 Accurately weigh approximately 100 mg of ACA and transfer to a 100 ml volumetric flask with acetonitrile and make up to the mark. Shake to mix.

### ACA standard solution B (100 mg/litre)

20 Transfer 1 ml of solution A to a 10 ml volumetric flask and make up to the mark with acetonitrile. Shake to mix.

**NOTE:** *Both solutions A and B will be used to spike standard filters and tubes (paras 33 and 35). These solutions are stable at room temperature for at least 80 days, although they are better stored in the refrigerator. TMA and PA can be stored indefinitely as the sodium salts of the ACacids in a 0.1M NaOH solution.*

### APPARATUS

21 A 25 mm GF/A glass fibre filter paper contained in a modified UKAEA sampling head (Ref 5; Fig 1). A labelled tin will be required for transport and storage.

22 A pump is required that is capable of being worn by a person while carrying out his normal work, and capable of running continuously for 8 h in the range 0.5 to 2 litres/min. This flow rate should be constant to ±5%; a flow-stabilised pump may be necessary to achieve this.

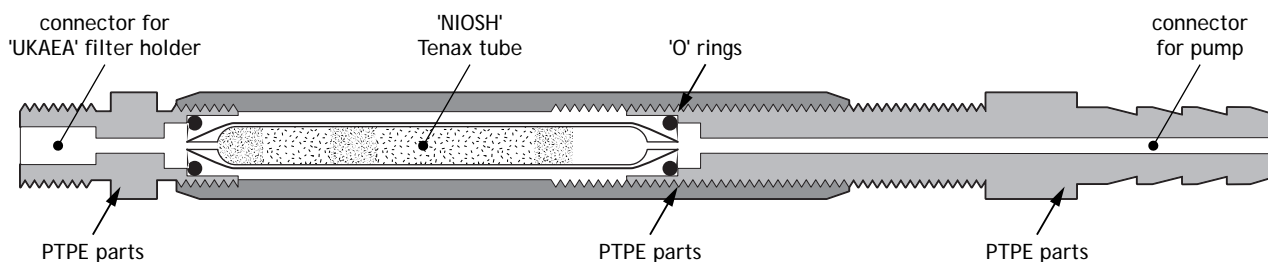


Fig 1 PTPE holder for Tenax back-up tube

### Desorption vials

23 Wide-necked glass bottles, about 10 ml capacity ('McCarthy' bottles) with PTFE-lined screw caps.

### Tenax tubes

24 NIOSH style tubes may be used. These consist of a glass tube with both ends flame sealed, 70 mm long with 6 mm OD and 4 mm ID, containing two sections of 0.4-0.8 mm Tenax separated by a 2 mm portion of urethane foam. The adsorbing section contains 30 mg of Tenax, the back-up section 15 mg. A 3 mm portion of silylated glass wool is placed in front of the adsorbing section. The pressure drop across the tube should be not less than 3 kPa (25 mm of mercury) at an airflow of 0.5 litres/min.

25 Tubes similar to those commercially available may be made by the user. Glass tubes must be held in protective holders to prevent breakage.

### Tube holder

26 A suitable tube holder, with a screw fitting to take a UKAEA filter head, is illustrated in Figure 1. This is obtainable by special order from Production Techniques Limited, Fleet.

### High performance liquid chromatograph

27 An HPLC fitted with an ultra violet detector is suitable. A closed loop facility or alternatively an autosampler is recommended.

28 Chromatographic conditions that have been found to be suitable are:

Column dimensions	250 mm x 8 mm ID
Column packing	Merck/BDH standard cartridge containing 7µ Lichrosorb RP18
Mobile phase	15:1:84 acetonitrile: phosphoric acid: water
Flow rate	1.5 ml/min
UV detector	230 nm

The retention times of various aromatic acids under these conditions are given in Table 1.

**Table 1** Retention times of anhydrides at various mobile phase acetonitrile concentrations (conditions otherwise as in para 28)

Anhydride	Retention time (min)		
	8% CH <sub>3</sub> CN	15% CH <sub>3</sub> CN	30% CH <sub>3</sub> CN
Pyromellitic dianhydride	6.2	-	-
1,4,5,8-Naphthalene tetracarboxylic acid dianhydride	-	5.0	-
Trimellitic anhydride	15	6.1	-
Phthalic anhydride	-	11.9	4.7
1,8-Naphthalic anhydride	-	-	6.9
Tetrachloro-phthalic anhydride	-	-	32

### PROCEDURE

#### Calibration of sampling pumps

29 Measurement of the volume of air sampled may be a significant source of error in the final calculation of ACA concentrations. About 15 minutes before sampling is to begin, the pump is connected to the filter holder (with a filter in place) by means of a flexible tube, and the flow rate adjusted to approximately 0.5 litres/min by attaching a suitable calibrated airflow meter to the front of the filter holder. The pump should then be allowed to run for 15 minutes to stabilise the flow rate. Before taking the actual sample, a filter holder with a clean filter is then fitted, and the flow rate readjusted to 0.5 litres/min.

#### Collection of samples

30 When used for personal sampling, the sampling head should be mounted in the worker's breathing zone,

for example on the label. The pump is attached to the worker as appropriate to minimise inconvenience.

31 Draw a measured volume of air through the GF/A filter paper and Tenax tube in series. The recommended air sampling rate is 0.5 litres/min.

### Blanks

32 Blanks should be prepared by using filters and Tenax tubes identical to those used for sampling and subjecting them to the same handling procedure except for the actual period of sampling.

### Pre-reaction of filter samples and standards before HPLC analysis

33 Remove sample filters from sample tins carefully with tweezers and place flat in the bottom of the desorption vials (para 23). Do the same with the blank filters and also include four clean filters which should be labelled as standards. Prepare standards as below by adding the stated volume of ACA solution directly to the surface of one of the clean filters, using a 10 µl syringe.

Standard	Vol ACA soln (µl)	ACA soln	µg ACA
F1	0	-	0
F2	10	B	1
F3	10	A	10
F4	50	A	50

The standard filters are then dried under a gentle stream of air, for about five minutes.

34 Add 2 ml of HPLC mobile phase (para 13) to each desorption vial, ensuring that each filter is completely covered, and cap. Allow the vials to stand for at least 60 min.

### Pre-reaction of Tenax tube samples and standards before HPLC analysis

35 Remove sample tubes from the tube holders and position vertically in a suitable stand, large Tenax section uppermost. Do the same with the blank tubes and also include four clean tubes which should be labelled as standards. Prepare standards as below by adding the stated volume of ACA solution directly to the top surface of the Tenax in one of the clean tubes using a 1 or 10 µl syringe.

Standard	Vol ACA soln (µl)	ACA soln	µg ACA
T1	0	-	0
T2	1	B	0.1
T3	10	B	1
T4	10	A	10

The standard tubes are then dried under a gentle stream of air, for about five minutes.

36 Add 4 ml of acetone dropwise to each Tenax tube and collect the eluate in a desorption vial (para 23). 200 µl of mobile phase (para 18) is added, and the solution

allowed to stand for 60 min and then evaporated to dryness. The addition of mobile phase converts the ACA to ACacid and helps to reduce evaporation losses (particularly of phthalic anhydride, if present). The residue is redissolved in 500 µl mobile phase and the analysis continued as in para 37.

**NOTE:** The desorbed solutions are stable for at least 30 days, so that the vials may be left to stand for longer than 60 min if convenient.

### Analysis

37 Analyse a suitable volume of each standard, sample and blank solution, using the same injection volume for each. An injection volume of 20 µl is recommended. The HPLC conditions may need to be adjusted slightly for an optimal separation of the ACAs (as ACacids) from other components to be achieved. Alternatively, a different HPLC system may be used, eg an ion-pair system using acetonitrile-tetrabutylammonium phosphate buffer mobile phase and a Partisil 10-PAC column.<sup>6</sup>

**NOTE:** All injections must be made with the sample in the appropriate HPLC mobile phase. Any other solvent is liable to cause unacceptable baseline fluctuations.

### CALCULATIONS

38 Calculate the weight, in µg, of ACA in the samples by comparison with the standard solutions. Correct for blanks as follows:

$$\text{Concentration of ACA in air (}\mu\text{g/m}^3\text{)} = \frac{(m - m_{\text{blank}}) \times 1000}{V}$$

where

m = weight (µg) of ACA in sample (total of filter and tube)

m<sub>blank</sub> = weight (µg) of ACA in blank (total of filter and tube)

V = volume of air sampled (litres)

**NOTE:** ACA in the sample includes any ACacid present (para 16).

### Alternatives to filter and tube sampling

39 In some processes, only TMA is expected to be present. In this case, if the occupational hygiene circumstances suggest that only particulate TMA will be present (because of the very low vapour pressure of TMA at room temperature), then the Tenax tube back-up may be dispensed with. The use of a filter alone enables higher airflow rates (2 litres/min is suggested) to be employed during sampling.

### REPORT

40 Report the ACA in air concentration(s) to the nearest µg/m<sup>3</sup>.

## ADVICE

Advice on this method and the equipment used can be obtained from the Health and Safety Laboratory, Broad Lane, Sheffield S3 7HQ (tel: 0114 2892000). Suggestions for improvement should be sent to the same address.

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