Withdrawn
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Trimethylbenzenes

Method number:	PV2091
Control number:	T-PV2091-01-8709-CH
Target concentration:	25 ppm (125 mg/m^3) ACGIH TLV
Procedure:	Samples are collected by drawing a known volume of air through a charcoal tube. Samples are desorbed with carbon disulfide and analyzed by gas chromatography with FID.
Recommended air volume and sampling rate studied:	100 minutes at 0.1 L/min. (10 L)
Status of method:	Partially validated method. This method has been only partially evaluated and is presented for information and trial use.

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Note: OSHA no longer uses or supports this method (March 2021).

1 General Discussion

1.1 Background

1.1.1 History of procedure

Over the past several years, the OSHA Laboratory has received requests to analyze samples for "trimethylbenzene." These have primarily been air samples collected on charcoal. Since several related aromatic compounds are routinely collected on charcoal, desorbed with carbon disulfide, and analyzed by gas chromatography, it was decided to try the same with all three trimethylbenzenes. The three isomers are 1,2,3-, 1,2,4-, and 1,3,5-trimethylbenzene.

1.1.2 Toxic Effects (This section is for information purposes and should not be taken as the basis for OSHA policy.)

Both the 1,2,4- and the 1,3,5- isomers are (Ref 5.1) highly toxic by inhalation and by ingestion. Both are skin and eye irritants. Both isomers are central nervous system depressants and may cause respiratory disorders. The 1,2,4-isomer may also be narcotic. Other effects of exposure to these compounds include headache, tension, nervousness, inflammation, and hemorrhaging of mucous membranes, convulsions, and ultimately death. No specific information about the toxic effects of the 1,2,3-isomer was available.

1.1.3 Potential workplace exposure: (Ref. 5.2)

1,2,4-Trimethylbenzene is used as a chemical intermediate in the manufacture of trimellitic anhydride, pseudocumidine and various dyes and pharmaceuticals. 1,3,5-Trimethylbenzene is used as an intermediate in the production of anthraquinone vat dyes and ultraviolet oxidation stabilizers for plastics. 1,2,3-Trimethylbenzene is a precursor for a musk. 1,2,4-Trimethylbenzene is produced at about 22,500 tons/year in the United States. 'The other Trimethylbenzenes are produced at much lower rates.

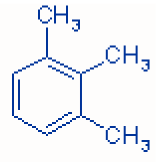
1.1.4 Physical properties: (Ref. 5.3)

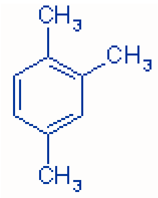
Molecular Weight:	120.186 (all isomers)
Odor:	Characteristic of aromatic hydrocarbons.
Color:	Each is a clear liquid.
Molecular Formula:	C_9H_{12}

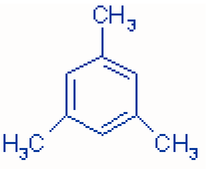
<u>Compounds:</u>	1,2,3-Trimethylbenzene;	1,2,4-Trimethylbenzene;	1,3,5-Trimethylbenzene
Density:	0.8944	0.8758	0.8652
Freezing Point:	- 25.37 °C	- 43.8 °C	- 44.7 °C
Boiling Point:	176.1 °C	169.35 °C	164.7 °C
Flash Point	51 °C	46 °C	44 °C (closed cup)
CAS Number:	526-73-8,	96-63-6,	108-67-8
IMIS Number:	T205	T306	T407

(2505 for mixture of all three)

Structures:







1.2 Limit defining parameters

1.2.1 The detection limit of the analytical procedure is 2 ng/injection for each isomer. This is the smallest amount of analyte which will produce a peak height 5 times the baseline noise.

1.2.2 The detection limit of the overall procedure is 1 µg/sample for each isomer, assuming a 1-mL sample volume, a 2-µL injection volume, and nearly 100% retention and desorption efficiencies.

1.3 Advantages

1.3.1 The sampling procedure is convenient for both the industrial hygienist and the employee being sampled.

1.3.2 No reagents and only a small amount of apparatus are required for sampling.

1.3.3 Samples are convenient to ship.

1.3.4 The analytical method is reproducible, sensitive and does not require extensive handling of samples or standards.

1.3.5 It is possible to analyze, at the same time, other analytes which are collected and desorbed by the same procedure and which are separable from the trimethylbenzenes by gas chromatography, through the proper choice of column and GC parameters.

1.3.6 Samples can be reanalyzed if necessary.

1.4 Disadvantages

None was encountered during these studies.

2 Sampling procedure

2.1 Apparatus

2.1.1 A calibrated personal sampling pump, the flow of which can be determined within ±5% at the recommended flow.

2.1.2 Charcoal tubes: glass tube with both ends flame sealed, 7-cm x 6-mm o.d., and a 4-mm i.d., containing 2 sections of 20/40 mesh charcoal separated by a 2-mm portion of urethane foam. The front section contains 100 mg of charcoal; the backup section contains 50 mg. A plug of silane treated glass wool is placed ahead of the front section and a 3-mm portion of urethane foam is placed behind the backup section

2.2 Sampling technique

2.2.1 The ends of the tube are opened immediately before sampling.

2.2.2 Connect the backup end of the tube to the sampling pump with flexible tubing.

2.2.3 Tubes should be placed in a vertical position to minimize channeling.

2.2.4 Air being sampled should not pass through any hose or tubing before entering the charcoal tube.

2.2.5 Place plastic caps on each end of the tube immediately after sampling. Wrap each sample lengthwise with Form OSHA-21 seal.

2.2.6 With each batch of samples, submit at least one blank tube from the same lot used for samples. This tube should be subjected to exactly the same handling as the samples (break ends, seal, & transport) except that no air is drawn through it.

2.2.7 Send the samples (and corresponding paperwork) to the laboratory for analysis.

2.2.9 If any bulk samples are submitted for analysis they must be shipped in a separate container from the air samples and blanks.

2.3 Desorption efficiency

Eighteen charcoal tubes and a blank were studied. Six tubes were injected with 2.8 µL each of a 1/1/1 mixture (v/v/v) of the isomers. The mixture was then diluted 9:1 (v/v) with carbon disulfide. Each of six tubes was injected with 7.0 µL of this dilution and six more tubes were injected with 1.4 µL. The tubes were refrigerated about 18 hours and then desorbed with 1 mL of 0.1% (v/v) n-hexylbenzene in carbon disulfide. The following results are listed in percent recovered.

Table 2.3
Desorption Efficiency

sample #	1,2,3-isomer (0.835 mg)	1,2,4-isomer (0.817 mg)	1,3,5-isomer (0.808 mg)
1	92.34	94.69	96.80
2	95.65	98.67	101.24
3	92.23	94.66	96.86
4	95.94	98.48	100.57
5	90.10	92.43	94.38
6	90.99	93.59	95.87
average	92.88%	95.42	97.62
S.D.	±2.412	±2.579	±2.707
sample #	1,2,4-isomer (0.209 mg)	1,2,4-isomer (0.204 mg)	1,3,5-isomer (0.202 mg)
1	112.69	117.08	119.65
2	108.33	112.74	115.00
3	108.44	110.93	113.66
4	109.29	111.92	114.17
5	114.04	116.87	119.83
6	108.99	112.05	114.78
average	110.30	113.60	116.18
S.D.	±2.441	±2.680	±2.796
sample #	1,2,3-isomer (0.0417 mg)	1,2,4-isomer (0.0409 mg)	1,3,5-isomer (0.0404 mg)
1	111.44	117.56	116.16
2	102.68	110.40	106.90
3	106.32	114.70	111.58
4	107.06	111.30	113.42
5	110.68	116.16	115.92
6	112.36	119.76	119.86
average	108.42	114.98	113.97
S.D.	±3.714	±3.619	±4.456

2.4 Retention efficiency

A retention efficiency study of six tubes, each injected with 2.8 µL of the 1/1/1 (v/v/v) isomer mixture, and a blank was then performed. Each tube was exposed to a 0.1 L/min flow of air of approximately 83% relative humidity at 23 °C for 100 minutes, corresponding to an air volume of about 10 L. The data were obtained are listed in percent recovered.

Table 2.4
Retention Efficiency

sample #	1,2,3-isomer (0.835 mg)	1,2,4-isomer (0.817 mg)	1,3,5-isomer (0.808 mg)
1	91.46	94.06	96.08
2	92.46	94.84	96.98
3	95.02	97.71	100.13
4	92.84	95.26	97.40
5	91.94	94.32	97.02
6	92.65	94.50	>96.54
average	92.65	95.12	97.36

These averages were nearly identical to desorption efficiencies for the same loading of the corresponding isomers. Water vapor appears to have very little effect in dislodging trimethylbenzene from activated charcoal.

2.5 Storage

Two sets of six samples, each injected with 1.4 µL of the isomer mixture, and one blank, were prepared and stored under refrigeration for three days. One set was exposed to humid air as was done with the retention study samples while the other set was not. There was no loss on storage. The results are listed in percent recovered.

Table 2.5
Storage Study

no air drawn			
sample #	1,2,3-isomer (0.417 mg)	1,2,4-isomer (0.409 mg)	1,3,5-isomer (0.404 mg)
1	90.76	93.72	96.00
2	91.36	94.33	96.50
3	93.20	96.27	98.38
4	91.88	95.22	97.48
5	95.75	99.24	101.64
6	90.67	92.15	95.67
average	92.27	95.16	97.61
humid air drawn			
sample #	1,2,3-isomer (0.417 mg)	1,2,4-isomer (0.409 mg)	1,3,5-isomer (0.404 mg)
1	91.73	93.60	96.28
2	92.75	96.60	99.21
3	96.31	99.93	102.29
4	99.05	102.29	105.06
5	94.92	97.72	100.46
6	93.96	96.91	99.54
average	94.79	97.90	100.47

2.6 Air volume and sampling rate studied

2.6.1 The air volume studied is 10 L.

2.6.2 The sampling rate studied is 0.1 liters per minute.

2.7 Suspected interferences should be listed on sample data sheets.

2.8 Safety precautions

2.8.1 Sampling equipment should be placed on an employee in a manner that does not interfere with work performance or safety.

2.8.2 Safety glasses should be worn at all times.

2.8.3 All safety procedures that apply to the workplace being sampled should be followed.

3 Analytical Method

3.1 Apparatus

3.1.1 Gas chromatograph equipped with a flame ionization detector.

3.1.2 GC column capable of separating the solvent, an internal standard and three trimethylbenzenes from each other and from any interference.

3.1.3 An electronic integrator or some other suitable means of measuring detector response.

3.1.4 Two-milliliter vials with PTFE-lines caps.

3.1.5 A syringe of 2-µL or other convenient size for sample injection.

3.1.6 A repipet for accurately dispensing a known volume of desorbing solution to all the samples. In this work, a 1-mL Glenco dispenser was used.

3.1.7 A syringe of 10-µL or other convenient size to inject pure standards into volumetric flasks.

3.1.8 Volumetric flasks, 5-mL, and other convenient sizes to prepare standards.

3.2 Reagents

3.2.1 Nitrogen, hydrogen, and oxygen of GC grade purity.

3.2.2 Carbon disulfide, reagent grade.

3.2.3 An internal standard must elute separate from the analytes and any contaminants. Reagent grade n-hexylbenzene was used as the internal standard.

3.2.4 Analytes, reagent grade. 1,2,4- and 1,3,5-trimethylbenzene are readily available at 99% purity each. However, there seems to be a problem in obtaining 1,2,3-trimethylbenzene above 90X purity. It appears to contain significant amounts of the 1,2,4-isomer as well as other aromatic compounds.

3.3 Standard preparation

3.3.1 Standards of the trimethylbenzenes are prepared by injecting a known volume of each isomer, usually 5 µL, into a volumetric flask, usually 5 mL, partly filled with the desorbing solution (carbon disulfide plus internal standard), then filling the flask to the mark and mixing the analytes with the desorbing solution by a few successive inversions of the flask.

3.3.3 By preparing standards of various concentrations and running them, a calibration curve may be prepared.

3.3.4 At least two initial standards which are theoretically equal and are within ±5% agreement must be prepared and run.

3.4 Sample preparation

3.4.1 The front and back sections of charcoal from each tube are transferred to separate 2-mL vials.

3.4.2 To each vial is added 1 mL of desorbant.

3.4.3 Each vial is sealed immediately with a PTFE-lined cap and allowed to desorb for 30 minutes with occasional shaking.

3.5 Analysis

3.5.1 Gas chromatographic conditions

Instrument:	Hewlett-Packard 5840 with FID
Column:	10-ft × 1/8-in FFAP/Chrom WAW
Temperature program	
Injector temperature:	200 °C
Oven Program:	120 °C for 6 min, increase at 5 °C/min to 150 °C, hold 5 min
Detector temperature:	250 °C
Gas flows	
Nitrogen flow rate:	25 mL/min.
Hydrogen flow rate:	40 mL/min.
Air:	300 mL/min.
Attenuation:	7^2
Injection size:	2.0 µL
Elution times:	
1,3,5-trimethylbenzene:	5.37 min.
1,2,4-trimethylbenzene:	6.30 min.
1,2,3-trimethylbenzene:	7.82 min.
n-hexylbenzene (ISTD):	12.70 min.

3.5.2 Chromatogram (See Figure 1.)

3.5.3 Detector response is measured by electronic integration of peak areas or other suitable means.

3.5.4 An internal standard is used to compensate for small differences in injection sizes. The integrator is calibrated in ppm for a 10 L air volume after correction for desorption efficiency.

3.5.5 Precision

A precision study, involving six injections each of standards at four, twice, one-half, and one-tenth of the target concentration was performed.

Table 3.5.5
Precision Study

4x target

sample #	1,2,3-isomer (0.835 mg/mL)	1,2,4-isomer (0.817 mg/mL)	1,3,5-isomer (0.808 mg/mL)
1	101.74	100.92	100.55
2	99.83	99.55	99.30
3	99.83	99.33	99.09
4	99.62	98.80	94.41
5	98.13	97.91	97.60
6	98.13	97.88	97.64
average	99.51	99.06	98.77
S.D.	1.336	1.146	1.124
CV	1.343	1.157	1.138

2x target

sample #	1,2,3-isomer (0.417 mg/mL)	1,2,4-isomer (0.409 mg/mL)	1,3,5-isomer (0.404 mg/mL)
1	48.55	48.12	48.20
2	48.77	48.89	48.73
3	49.19	49.39	49.20
4	48.95	48.64	48.77
5	48.77	48.81	48.70
6	48.90	49.05	48.96
average	48.84	48.82	48.76
S.D.	0.221	0.424	0.334
CV	0.454	0.868	0.684

0.5x target

sample #	1,2,3-isomer (0.208 mg/mL)	1,2,4-isomer (0.204 mg/mL)	1,3,5-isomer (0.202 mg/mL)
1	24.31	24.17	24.10
2	24.36	24.27	24.18
3	24.19	24.09	23.99
4	24.17	24.11	24.02
5	24.32	24.29	24.15
6	24.28	24.22	24.05
average	24.27	24.19	24.08
S.D.	0.076	0.082	0.076
CV	0.314	0.338	0.315

0.1x target

sample #	1,2,3-isomer (0.0417 mg/mL)	1,2,4-isomer (0.0409 mg/mL)	1,3,5-isomer (0.0404 mg/mL)
1	3.30	3.41	3.26
2	3.31	3.45	3.25
3	3.29	3.42	3.25
4	3.68	3.71	3.54
5	3.68	3.87	3.60
6	3.64	3.74	3.56
average	3.48	3.60	3.41
S.D.	0.202	0.198	0.173
CV	5.804	5.508	5.08

3.6 Interferences

3.6.1 Any compound which produces a peak which partially or completely overlaps a peak produced by an analyte or the internal standard is an analytical interference. Possible interferences should be listed on the sample data sheet. GC parameters should be adjusted in whatever way necessary to eliminate any such interference.

3.6.2 Since the title compounds are most frequently derived from coal tar naphtha's, other alkylated benzenes, styrenes and cycloalkylated benzenes which have similar boiling points and/or molecular formulae may be interferences. Many such compounds are theoretically possible, but relatively few are available in a high degree of purity.

3.6.3 Retention time data on a single column does not alone prove chemical identity. Samples over the target concentration must be confirmed by GC/Mass Spec or other conclusive means.

3.7 Calculations

3.7.1 To calculate the ppm of analyte based on a 10 L air volume and a 1 mL desorption volume, in standards.

$$ppm = \frac{(\mu g / mL)(DV)(24.46)}{(L)(DE)(MW)}$$

Where:

μg/mL = concentration of analyte in sample
24.46 = Molar volume (liters/mole) at 25 °C and 760 mmHg
MW = Molecular weight (g/mole)
DV = Desorption volume, mL
10 L = Air volume, L
DE = Desorption efficiency, decimal

3.7.2 Values in mg/m3 for samples are calculated using the following equation.

$$mg / m^3 = \frac{(\mu g / mL,\ blank\ corrected)(desorption\ volume,\ mL)}{(air\ volume,\ L)(desorption\ efficiency,\ decimal)}$$

3.8 Safety precautions

3.8.1 All solvents should be handled in a hood.

3.8.2 Skin contact with any solvent is to be avoided.

3.8.3 Safety glasses, gloves, and lab coat are to be worn at all times in designated areas.

4 Recommendations for further study

4.1 Further work should be done to eliminate interferences, since there are many possible interferences. Capillary columns could be investigated.

4.2 Additional work should be done with each isomer separately to determine whether any given isomer contains trace amounts of any other isomer. This can't be seen when all three are mixed.

5 References

5.1 Material Safety Data Sheets for 1,2,4- and 1,3,5-Trimethylbenzene from OCIS file.

5.2 Kirk-Othmer Encyclopedia of Chemical Technology (1982), exec. Ed. Martin Grayson, vol. 18, pp. 881.5.

5.3 CRC Handbook of Chemistry and Physics, 53rd Edition, ed. by Robert C. Weast, pp. C-165-6.

Figure 1. Chromatogram of Trimethylbenzenes and internal standard

Note: OSHA no longer uses or supports this method (March 2021).