



CARBOFURAN (FURADAN)

Method no. PV2127

Target concentration: 0.1 mg/m³ (ACGIH TLV-TWA)

Procedure: Samples are collected by drawing known volumes of air through OSHA versatile sampler (OVS-2) tubes, each containing a glass fiber filter and two sections of XAD-2 adsorbent. Samples are desorbed with acetonitrile and analyzed by high performance liquid chromatography (HPLC) using an ultraviolet (UV) detector.

Recommended air volume and sampling rate: 480 minutes at 1.0 L/min (480 Liters)

Detection limit of the overall procedure based on the recommended air volume and the analytical detection limit: 0.0013 mg/m³

Status of method: Partially Validated. This method has been partially evaluated and is presented for information and trial use only.

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1 General Discussion

1.1 Background

1.1.1 History of procedure

This evaluation was undertaken to determine the effectiveness of the OVS-2 tube as a sampling device for carbofuran. It follows the procedure developed for carbaryl. (Ref. 5.1)

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

The toxic effects of carbamate pesticides parallel those of organophosphorus pesticides. Both classes of compounds inhibit cholinesterase, thereby allowing the accumulation of large amounts of acetylcholine. The major difference being that this inhibition is reversible for carbamates and irreversible for organophosphates. (Ref. 5.2)

The following paragraph describing the results of this cholinesterase inhibition is excerpted from the book "OCCUPATIONAL DISEASES, A Guide to Their Recognition" and is applicable to both carbamates and organophosphates. (Ref. 5.2)

When a critical level of cholinesterase depletion is reached, usually about 20% of normal, symptoms and signs of acetylcholine accumulation poisoning become manifest. Symptoms may include blurred vision, weakness, nausea, headache, abdominal cramps, chest discomfort, and diarrhea. Signs may include miosis, muscle twitching, salivation, sweating, tearing, cyanosis, convulsions, and coma. Carbamate pesticides can have low oral LD₅₀s, but in general, their dermal LD₅₀s are higher than other cholinesterase inhibiting pesticides, such as organophosphates.

Carbofuran has an acute oral LD₅₀ of 8 to 9 mg/kg for rats and an acute dermal LD₅₀ of 10,200 mg/kg for rabbits. (Refs. 5.3-5.4) In addition, carbofuran is highly toxic by the inhalation route with significant cholinesterase depression in the Rhesus monkey at 0.86 mg/m³ for a 75% wettable powder. (Ref. 5.3) Due to these factors, carbofuran has been given a TLV-TWA of 0.1 mg/m³ by the ACGIH. (Ref. 5.3) OSHA adopted this same value as its PEL in March 1989.

Editorial Note: These March 1989 PELs were vacated on July 7, 1992 and ceased to be enforceable on March 23, 1993 (FR 58:35338-35351, 6/30/1993).

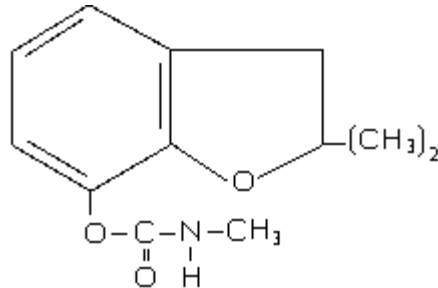
1.1.3 Potential workplace exposure

No estimate of worker exposure to carbofuran could be found. Carbofuran is used as an insecticide. (Ref. 5.4)

1.1.4 Physical properties (Ref. 5.3 - 5.5)

Molecular weight:	221.26
Molecular formula:	C ₁₂ H ₁₅ NO ₃
CAS #:	1563-66-2
IMIS #:	0526
Melting point:	150 to 152 °C
Vapor Pressure:	0.0027 kPa (0.00002 mm Hg) at 33 °C
Appearance:	white crystalline solid

Solubility: 700 ppm in water at 25 °C unstable in alcohols
Synonyms: Bay 70143, Curaterr, D 1221, ENT 27164, FMC 10242, Furadan, NIA 10242, Yalox
Chemical name: 2,3-Dihydro-2,2-dimethyl-7-benzofuranol-methylcarbamate
UV spectrum: See Figure 1.
Structure:



1.2 Limit defining parameters

The detection limit of the analytical procedure is 3.1 ng per injection. This is the amount of analyte which will give a peak whose height is approximately five times the baseline noise.

2 Sampling Procedure

2.1 Apparatus

2.1.1 A personal sampling pump that can be calibrated to within $\pm 5\%$ of the recommended flow rate with the sampling device in line.

2.1.2 OVS-2 tubes, which are specially made 13-mm o.d. glass tubes that are tapered to 6-mm o.d. They are packed with a 140-mg backup section and a 270-mg sampling section of cleaned XAD-2. The backup section is retained by two foam plugs and the sampling section is between one foam plug and a 13-mm diameter glass fiber filter. The glass fiber filter is held next to the sampling section by a polytetrafluoroethylene (PTFE) retainer. (See Figure 2.)

2.2 Reagents

No sampling reagents are required.

2.3 Sampling technique

2.3.1 Attach the small end of the OVS-2 sampling tube to the sampling pump with flexible, plastic tubing such that the large, front section of the sampling tube is exposed directly to the atmosphere. Do not place any tubing in front of the sampler.

2.3.2 Attach the sampler vertically (large end down) in the worker's breathing zone in such a manner that it does not impede work performance.

2.3.3 After sampling for the appropriate time, remove the sampling device and seal the tube with plastic end caps.

2.3.4 Wrap each sample end-to-end with an Form OSHA-21 seal.

2.3.5 Submit at least one blank with each set of samples. Handle the blank the same as the other samples but do not draw air through it.

2.3.6 Submit any bulk samples in a separate container. Do not ship them with the air samples.

2.4 Extraction and desorption efficiencies

2.4.1 Glass fiber filter

Six 13-mm glass fiber filters were placed in separate 4-mL vials. Five of these filters were each liquid spiked with 26 μL of a 1.84 mg/mL solution of carbofuran in acetonitrile. These six vials were then sealed with PTFE-lined septa and stored overnight, in a drawer at room temperature. They were then extracted with 2.0 mL of acetonitrile and analyzed as in Section 3.5.

table 2.4.1
glass fiber filter extraction study

filter #	amount spiked (μg)	amount recovered (μg)	% recovered
F1	47.84	47.12	98.5
F2	47.84	47.12	98.5
F3	47.84	47.46	99.2
F4	47.84	48.56	101.5
F5	47.84	47.12	98.5
F6	0.00	0.00	blank

average recovery = 99.2%

2.4.2 XAD-2 adsorbent

An amount of XAD-2 adsorbent equal to the sampling section (270 mg) of an OVS-2 tube was placed in each of six 4-mL vials which were then sealed with PTFE-lined septa. Five of these vials were then each liquid spiked with 26 μL of a 1.84 mg/mL solution of carbofuran in acetonitrile by injecting the solution onto the adsorbent through the septum. After replacing the punctured septa, these vials were allowed to equilibrate overnight in a drawer at room temperature. They were then desorbed with 2.0 mL of acetonitrile and analyzed as in Section 3.5.

table 2.4.2
XAD-2 adsorbent desorption study

adsorbent #	amount spiked (μg)	amount recovered (μg)	% recovery
AD1	47.84	45.69	95.5
AD2	47.84	45.69	95.5
AD3	47.84	45.69	95.5
AD4	47.84	45.69	95.5
AD5	47.84	46.40	97.0
AD6	0.00	0.00	blank

average recovery 95.8%

2.5 Retention efficiency

Six OVS-2 tubes were each liquid spiked with 26 μL of a 1.84 mg/mL solution of carbofuran in acetonitrile by spiking the glass fiber filter. These tubes were then sealed with plastic end caps and placed in a drawer at room temperature. After overnight storage, 480 liters of humid air

(approximately 70% relative humidity) were drawn through each tube. Three of these tubes, along with a blank tube, were then desorbed and analyzed as in Section 3. No carbofuran was recovered from the backup section of these tubes.

table 2.5
retention efficiency study

tube #	amount spiked (μg)	amount recovered (μg)	% recovery
RET1	47.84	45.16	94.4
RET2	47.84	45.64	95.4
RET3	47.84	45.93	96.0
RET4	0.00	0.00	blank

average recovery = 95.3%

2.6 Sample storage

The remaining three spiked tubes from Section 2.5 (and a blank tube) were stored for a total of 7 days in a drawer at room temperature. They were then desorbed and analyzed as in Section 3. No carbofuran was recovered from the backup section of these tubes.

table 2.6
storage study

tube #	amount spiked (μg)	amount recovered (μg)	% recovery
ST1	47.84	48.51	101.4
ST2	47.84	44.40	92.8
ST3	47.84	46.79	97.8
ST4	0.00	0.00	blank

average recovery = 97.3%

2.7 Recommended air volume and sampling rate

2.7.1 The recommended air volume is 480 L.

2.7.2 The recommended flow rate is 1.0 L/min.

2.8 Interferences (sampling)

It is not known if any compounds will interfere with the collection of carbofuran. Suspected interferences should be reported to the laboratory with submitted samples.

2.9 Safety precautions (sampling)

2.9.1 Attach the sampling equipment in such a manner that it will not interfere with work performance or employee safety.

2.9.2 Follow all safety practices that apply to the work area being sampled.

3 Analytical Procedure

3.1 Apparatus

- 3.1.1 An HPLC equipped with a UV detector, and a manual or automatic injector. A Waters 510 pump, Waters 712 autosampler, and Waters 490E UV detector were used in this evaluation.
- 3.1.2 An HPLC column capable of separating carbofuran from any interference. A (25 cm x 4.6 mm i.d.) Chromasil C18 (5 micron) column was used in this evaluation.
- 3.1.3 An electronic integrator or other suitable means of measuring detector response. A Hewlett-Packard 3357 data system was used in this evaluation.
- 3.1.4 Vials, 4-mL glass with PTFE-lined septa.
- 3.1.5 Volumetric flasks, pipettes, and syringes.
- 3.2 Reagents
 - 3.2.1 Acetonitrile, HPLC grade.
 - 3.2.2 Water, HPLC grade. A Millipore Milli-Q system was used to prepare the water in this evaluation.
 - 3.2.3 Carbofuran. A 99.6% pure standard from EPA was used in this evaluation.
- 3.3 Standard preparation

Prepare stock standard solutions by adding acetonitrile to preweighed amounts of carbofuran. Prepare working range standards by diluting stock solutions with acetonitrile. Store stock and dilute standards in a freezer.
- 3.4 Sample preparation
 - 3.4.1 Transfer the 13-mm glass fiber filter and the 270-mg sampling section of the OVS-2 tube to a 4-mL vial. Place the first foam plug and the 140-mg backup section in a separate vial. A small glass funnel can be used to facilitate the transfer of the adsorbent. Discard the rear foam plug. Do not discard the glass sampling tube; it can be reused.
 - 3.4.2 Add 2.0 mL of acetonitrile to each vial.
 - 3.4.3 Seal the vials with PTFE-lined septa and allow them to desorb for one hour. Shake the vials by hand periodically during the one hour desorption time.
- 3.5 Analysis
 - 3.5.1 Liquid chromatographic conditions

Column:	25 cm x 4.6 mm i.d. stainless steel column packed with 5 micron Chromasil C18
Mobile Phase:	25% acetonitrile / 75% water
Flow rate:	1 mL/min
UV detector:	210 nm
Retention time:	13 min
Injection volume:	10 µL
 - 3.5.2 Chromatogram (See Figure 3)

3.6 Interferences (analytical)

3.6.1 Any compound having a retention time similar to that of the analyte is a potential interference. Generally, chromatographic conditions can be altered to separate interferences from the analyte.

3.6.2 Retention time on a single column is not proof of chemical identity. Analysis by an alternate HPLC column, detection at another wavelength (for comparison of absorbance response ratios) and confirmation by mass spectrometry are additional means of identification.

3.7 Calculations

3.7.1 Construct a calibration curve by plotting detector response versus standard concentration.

3.7.2 Determine the concentration of carbofuran in each sample from the calibration curve. If carbofuran is found on the backup section, make blank corrections for each section separately before adding the results together.

3.7.3 Determine the air concentration by the following formula.

$$\text{mg} / \text{m}^3 = \frac{(\mu\text{g} / \text{mL in sample}) \times (\text{desorption volume, mL})}{(\text{air volume, L}) \times (\text{desorption efficiency, decimal})}$$

3.8 Safety precautions (analytical)

3.8.1 Avoid exposure to all standards.

3.8.2 Avoid exposure to all solvents.

3.8.3 Wear safety glasses at all times.

4 Recommendations for Further Study

4.1 Even though the UV spectrum indicates higher absorbance at either 280 nm or 230 nm (See Figure 1), 210 nm was a more sensitive wavelength for the analysis of carbofuran. This behavior should be investigated further. For example, analysis on a diode array UV detector to determine the most sensitive analytical wavelength.

4.2 A desorption study determining the recovery from a 13-mm glass fiber filter in combination with 270 mg of XAD-2 should be done. This is the desorption efficiency used in Section 3.7.3.

4.3 The literature indicates that carbofuran is unstable in alcohols. It was observed in the HPLC analysis of a carbofuran standard in acetonitrile that the analyte peak got smaller and a secondary peak grew in size. This did not occur until after several weeks at room temperature. Carbofuran appears stable enough in acetonitrile but this slow decomposition with time should be kept in mind.

4.4 This method should be fully validated.

5 References

5.1 Burreight, D.; Method #63, "Carbaryl"; OSHA Analytical Laboratory, unpublished, 1987.

- 5.2 "OCCUPATIONAL DISEASES, A Guide to their Recognition;" U.S. Department of Health, Education, and Welfare; Public Health Service, Public Health Service Publication No. 1097, U.S. Government Printing Office: Washington, D.C., 1964; p 245.
- 5.3 "Documentation of the Threshold Limit Values and Biological Exposure Indices", 5th ed.; American Conference of Governmental Industrial Hygienists: Cincinnati, OH, 1986; p 100.
- 5.4 "Farm Chemicals Handbook"; Meister Publishing Co.: Willoughby, OR, 1986; p C48.
- 5.5 Windholz, M., Ed.; "Merck Index", 10th ed.; Merck and Co.: Rahway, NJ, 1983; p 250.

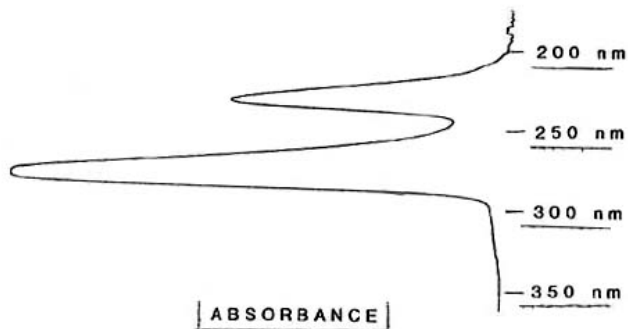


Figure 1. UV Spectrum of Carbofuran in the HPLC Mobile Phase.

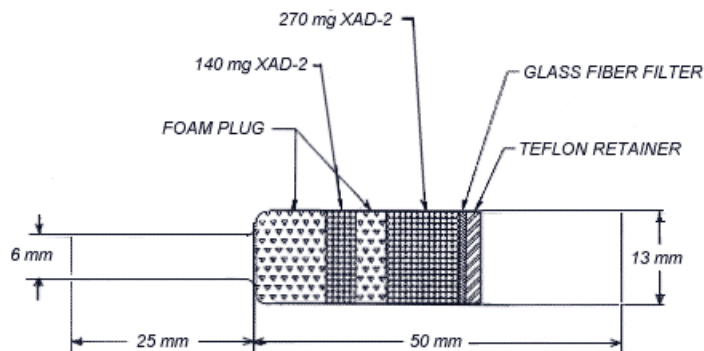


Figure 2. OVS-2 Sampling Device

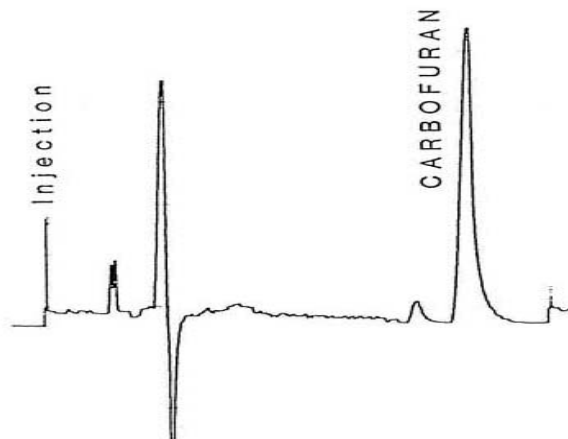


Figure 3. HPLC Chromatogram of Carbofuran