NICOTINE 2551

$C_{10}H_{14}N_2$ MW: 162.2   CAS: 54-11-5   RTECS: QS5250000

METHOD: 2551, Issue 1	EVALUATION: PARTIAL	Issue 1: 15 January 1998

OSHA : 0.5 mg/m³
NIOSH: 0.5 mg/m³, group I pesticide
ACGIH: 0.5 mg/m³
(1 ppm = 6.74 mg/m³ @ NTP)

PROPERTIES: liquid; d = 1.009 g/mL @ 20 °C; BP = 245.5 °C; VP = 0.08 mm Hg; FP = -29 °C; range of explosive limits: 0.7 to 4.0% in air.

SYNONYMS: 3-(1-methyl-2-pyrrolidyl)-pyridine

SAMPLING

SAMPLER:	SORBENT TUBE (XAD-4, 80/40 mg)
FLOW RATE:	0.1 to 1.0 L/min [1-3]
VOL-MIN:	0.5 L
-MAX:	600 L
SHIPMENT:	Keep cold. Protect from prolonged exposure to light.
SAMPLE STABILITY:	14 days at 5 °C in dark [4]
BLANKS:	2 to 10 field blanks per set

ACCURACY

RANGE STUDIED:	not determined.
BIAS:	not determined.
OVERALL PRECISION ($\hat{S}_{rT}$):	not determined.
ACCURACY:	not determined.

MEASUREMENT

TECHNIQUE:	GAS CHROMATOGRAPHY, NPD
ANALYTE:	nicotine
DESORPTION:	1 mL ethyl acetate with 0.01% triethylamine
INJECTION VOLUME:	1 µL
TEMPERATURE-INJECTION:	200 °C
-DETECTOR:	300 °C
-COLUMN:	60 to 200 °C (20 °C/min); hold @ 200 °C for 3 min
CARRIER GAS:	helium, 2.4 mL/min
COLUMN:	capillary column, 30 m, x 0.32-mm ID, 1.0-µm film, crossbond® 5% diphenyl 95% dimethyl polysiloxane, Rtx-5® or equivalent
CALIBRATION:	solutions of nicotine in desorbing solution
RANGE:	0.050 to 20 µg/sample [4]
ESTIMATED LOD:	0.013 µg/sample (instrumental) [4]
PRECISION ($\hat{S}_r$):	0.024

APPLICABILITY: Under the GC parameters stated in the method, nicotine can be identified based upon retention time. Nicotine is quantified using quinoline as an internal standard [1]. At high sample concentration, XAD-4 sorbent tube capacity (300 µg) may be exceeded and breakthrough may occur [1].

INTERFERENCES: No specific interferences were identified. However, any compound with a similar retention time may interfere. Positive identification can be confirmed by dual column chromatography with an appropriate alternative capillary column. In this method development a Rtx-1 capillary column was used. Mass spectrometry also may be used as a confirmation aid.

OTHER METHODS: Other methods for nicotine are NMAM 2544 (August 15,1994) [2] and Method S293 [5] on which it was based. This method replaces the XAD-2 sorbent with XAD-4, and uses a capillary column in place of a packed GC column. The ethyl acetate desorption solvent was modified to improve nicotine recovery from sides of glass sorbent tube, and to improve recoveries for the lower DE levels.

REAGENTS:

1. Ethyl acetate, chromatographic grade.*
2. Triethylamine, reagent grade.*
3. Desorbing solution (modified ethyl acetate solution). 0.01% triethylamine in ethyl acetate.
4. Nicotine* primary stock solution (1.0 mg/mL). Dilute 100 mg nicotine to 100 mL with desorbing solution.
5. Nicotine* secondary stock solution (10 µg/mL). Dilute 1.0 mL nicotine primary stock solution to 100 mL with desorbing solution.
6. Quinoline* (Internal standard) primary stock solution (1.0 mg/mL). Dilute 100 mg quinoline to 100 mL with desorbing solution.
7. Quinoline* secondary stock solution (100 µg/mL). Dilute 10.0 mL quinoline primary stock solution to 100 mL with desorbing solution.
8. Helium, purified.
9. Hydrogen, prepurified.
10. Air, filtered.

    * See SPECIAL PRECAUTIONS

EQUIPMENT:

1. Sampler: Glass tube, 70 mm, 7-mm OD, containing two sections of XAD-4 (front = 80 mg, back = 40 mg) separated by a silylated glass wool. A silylated glass wool plug precedes the front section and follows the back section. (Glass wool plugs must be specified when ordering XAD-4 tubes.) Tubes are commercially available (SKC, Inc., Cat. No. 226-93, or equivalent).
2. Personal sampling pump, 0.1 to 1.0 L/min, with flexible connecting tubing.
3. Gas chromatograph, nitrogen-phosphorous detector, integrator, and Rtx-5® capillary column or equivalent (page 2551-1).
4. Ultrasonic bath.
5. Vials, autosampler, with PTFE-lined caps.
6. Microliter syringes, 10-µL and other sizes as needed, readable to 0.1 µL.
7. Flasks, volumetric, various sizes.
8. Pipets, various sizes.
9. Refrigerant packs.

SPECIAL PRECAUTIONS: Nicotine is classified as a neurotoxin and possible teratogen [6]. Avoid inhalation, skin contact, and ingestion. Quinoline is classified as moderately toxic, a severe eye irritant, and possible carcinogen [6]. Avoid skin contact (readily adsorbed), inhalation, and ingestion. Ethyl acetate is flammable and a fire hazard. Triethylamine is an eye, skin, and respiratory irritant. Wear appropriate protective clothing and work with these compounds in a well ventilated hood.

SAMPLING:

1. Calibrate each personal sampling pump with a representative sampler in line.
2. Break ends of tubes immediately before sampling. Attach tubes to personal sampling pump with flexible tubing.
3. Sample at an accurately known flow rate between 0.1 and 1.0 L/min for a total sample size of 0.5 to 600 L.
4. Cap the tubes with plastic caps and pack securely for shipment. Protect from exposure to light. Ship with refrigerant packs to keep samples cold.

SAMPLE PREPARATION:

5. Place front (include glass wool plug) and back sorbent sections of the sampler in separate vials. Discard middle and back glass wool plugs.
6. Add 1 mL of desorbing solution (modified ethyl acetate) to each vial.
7. Add aliquots (10 to 50 µL) of the quinoline secondary stock internal standard solution to both the calibration standards and sample vials and attach PTFE-lined crimp caps.
   NOTE: Determine the approximate level of nicotine that will be in the samples and add a similar amount of quinoline. Environmental tobacco smoke usually has low nicotine levels. Pesticide operations usually have relatively high levels.
8. Place vials in an ultrasonic bath for 30 min to aid desorption.

CALIBRATION AND QUALITY CONTROL:

9. Calibrate daily with at least six working standards over the range of interest.
    a. Add known amounts of the nicotine stock solution to 1.0 mL of desorbing solution in separate vials.
    b. Add amount of quinoline secondary stock solution equal to amount used in Step 7 to each vial.
    c. Seal vials with PTFE-lined crimp caps.
    d. Analyze together with samples and blanks (steps 12 through 14).
    e. Prepare calibration graph (ratio of nicotine/quinoline areas vs. µg nicotine).
10. Determine desorption efficiency (DE) at least once for each lot of XAD-4 tubes used for sampling in the calibration range (step 9). Prepare three samplers at each of six levels plus three media blanks.
    a. Remove and discard the back sorbent section of the sampler.
    b. Inject a known volume of calibration stock solution directly onto the front sorbent bed of each XAD-4 tube.
    c. Allow the tubes to air equilibrate for several minutes, then cap the ends of the tubes and allow to stand overnight.
    d. Desorb (steps 6 through 8) and analyze together with standards and blanks (steps 12 through 14).
    e. Prepare a graph of DE vs. µg nicotine recovered.
11. Analyze three quality control blind spikes and three analyst spikes to ensure that the calibration graph and DE graphs are in control.

MEASUREMENT:

12. Set gas chromatograph according to manufacturer's recommendations and to conditions given on page 2551-1.
13. Inject a 1-µL sample aliquot manually using solvent flush technique or with an autosampler.
    NOTE: If peak area is above the linear range of the working standards, dilute with desorbing solution, reanalyze, and apply the appropriate dilution factor in the calculations.
14. Measure peak areas and calculate ratio of nicotine peak area to quinoline peak area.

CALCULATIONS:

15. Determine the mass, µg (corrected for DE), for nicotine found in the sample front (W_f) and back (W_b) sorbent sections, and in the average media blank front (B_f) and back (B_b) sorbent sections.
    NOTE: If $W_b > W_f/10$, report breakthrough and possible sample loss.
15. Calculate concentration, C, of nicotine in the air volume sampled, V (L):

$$C = \frac{W_f + W_b - B_f - B_b}{V}, \ mg/m^3$$

NOTE: µg/L ≡ mg/m³

EVALUATION OF METHOD:

This method development was based upon a request to measure nicotine in environmental tobacco smoke and an HHE request to measure nicotine in a greenhouse pesticide application. Desorption efficiency (DE) was determined for 5 levels: 2 x LOQ; 0.1, 0.5, 1.0, and 2.0 x Recommended Exposure Limit (REL) using the analytical parameters stated on page 2551-1. The average DE for nicotine was determined to be 0.924. The instrumental LOD was determined at 0.013 µg/sample. The precision, as determined from the pooled relative standard deviation ($\hat{S}_r$) was 0.024. Nicotine storage stability at 5°C and at a concentration of 0.5 x REL was acceptable after 14 days with a mean recovery of 91%.

This method was employed to analyze nicotine that was used as a greenhouse pesticide and applied by a fogging procedure. In addition to XAD-4 sorbent tubes, nicotine was collected on glass fiber filters, gauze wipes, and cotton gloves. Nicotine was not stable on these media for more than 1 h. Recovery data for nicotine spiked on these media is contained in the method backup data report [4].

The maximum sampling volume of 600 L was calculated based on the XAD-4 sampling tube capacity of 300 µg nicotine [7] and the NIOSH REL of 0.5 mg/m^3. Concentrations of environmental tobacco smoke (ETS) typically range from 1 to 100 µg/m^3 [1]. At the highest ETS concentration and a sampling rate of 1 L/min, over 3000 L of air would need to be sampled to reach the sampling tube capacity. Sampling rates and times typically employed in field studies would almost never exceed the capacity of the XAD-4 sampling tube.

When sampling for nicotine in ETS, only the XAD-4 sampling tube is employed. However, when sampling for nicotine where particulate matter is present, such as in the greenhouse study, it may be necessary to use a glass fiber filter (GFF) in series with the XAD-4 sorbent tube. When a GFF is used, it also should be analyzed for nicotine as studies have indicated that nicotine can be adsorbed on particulate matter.

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METHOD WRITTEN BY:

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