METHAMPHETAMINE and Illicit Drugs, Precursors and Adulterants on Wipes by Liquid-Liquid Extraction

9106

FORMULA: Table 1 MW: Table 1 CAS: Table 1 RTECS: Table 1

METHOD: 9106, Issue 1 **EVALUATION: Partial** **Issue 1: 17 October 2011**

U.S. regulatory OELS
OSHA or MSHA: none for surfaces
Other published OELs and guidelines
NIOSH, ACGIH, or AIHA: none for surfaces
States: Table 2

PROPERTIES: Table 3

SYNONYMS: Table 4

SAMPLING

SAMPLER: Wipe

SAMPLE AREA: 100 cm^2 or 1000 cm^2

SHIPMENT: Preferably ship refrigerated, <6 °C

SAMPLE STABILITY: 30 days at <6 °C (See Table 5)

FIELD BLANKS: 2 to 10 blanks per sample set

MEASUREMENT ACCURACY

LEVEL STUDIED: 3 µg/sample on smooth surfaces

BIAS: Table 11a and 11b

OVERALL PRECISION ($\hat{S}_{rT}$): Table 8a and 8b [1]

ACCURACY: Table 8a and 8b [1]

MEASUREMENT

TECHNIQUE: GAS CHROMATOGRAPHY/MASS SPECTROMETRY

ANALYTES: Table 1

DESORPTION: 0.1 M sulfuric acid

CLEANUP/ EXTRACTION: Hexane cleanup followed by methylene chloride extraction

DERIVATIZATION: Chlorodifluoroacetic anhydride

INJECTION: 2 µL, splitless

TEMPERATURE - Injection: 265 °C
- Detector: 285 °C
- Column: 90 °C (2 min), 310 °C (10 °C/min), hold for 11 min

MASS SPECTROMETER: Scan mode (29 – 470 AMU), 2 scan per sec, Selected ion monitoring (SIM) mode Table 6

CARRIER GAS: Helium, 1.5 mL/min

COLUMN: Capillary, fused silica, 30 m × 0.32 mm ID; 0.5 µm film DB-5ms or equivalent

CALIBRATION: Standards from spiked wipes with internal standard, See Table 7

RANGE: Table 8a and 8b [1]

ESTIMATED LOD: Table 5

PRECISION ($\bar{S}_r$): Table 8a and 8b [1]

APPLICABILITY: For methamphetamine, the range is 0.05 to 60 µg/sample (sample = 100 cm^2 or 1000 cm^2). This method was developed for the analysis of selected drugs and precursors on surfaces in clandestine drug labs. [1, 2] Sampling methodology was tested using wipes on smooth, non-porous surfaces. The APPENDIX contains sampling information for other types of surfaces.

INTERFERENCES: No chromatographic interferences detected. Water, surfactants and polyols inhibit derivatization.

OTHER WIPE METHODS: NIOSH 9109 uses solid-phase extraction and gas chromatography/mass spectrometry (GC/MS) to measure multiple drugs [3]. NIOSH 9111 uses liquid chromatography/mass spectrometry (LC/MS) to measure methamphetamine [4].

REAGENTS:

NOTE: See APPENDIX A for special instructions on reagents.

1. Analytes listed in Table 1.*
2. Internal standards from those listed in Table 9.
3. Solvents, residue free analytical grades:
   a. Hexane *
   b. Isopropanol (IPA)*
   c. Methanol *
   d. Methylene chloride (CH_2Cl_2) *
   e. Toluene *
   f. Acetone*
4. Concentrated sulfuric and hydrochloric acids (AR or trace metals analysis grades).*
5. Sodium hydroxide, A.C.S. grade.*
6. Anhydrous granular sodium sulfate, AR grade.
7. Anhydrous granular potassium carbonate, AR grade.
8. Bromothymol Blue, ≥95%, A.C.S., phenolphthalein, A.C.S.; crystal violet (Gentian Violet), ≥95%, A.C.S.
9. Purified gases: helium for carrier gas, nitrogen for drying.
10. Chlorodifluoroacetic anhydride, 98%* derivatizing agent. Moisture sensitive!
11. 4,4′-Dibromooctafluorobiphenyl, 99%, instrument internal standard (IIS).
12. Deionized water (ASTM type II).

SOLUTIONS:

NOTE: See APPENDIX A for special instructions on solutions.

1. Prepare solutions of analytes of interest. Calculate concentrations as the free base. Keep refrigerated (<6 °C). Protect solutions from light.
   a. Stock solutions are prepared at about 1-2 mg/mL in methanol.
   b. Analyte spiking solutions are prepared by diluting the stock solutions to about 200 µg/mL each in methanol.
2. Prepare internal standard spiking solution in methanol at about 200 µg/mL. (Note: Add about 2 milligrams of crystal violet per 20 mL of internal standard spiking solution to help indicate which samples have been spiked.)
3. Desorption solution: 0.1 M H_2SO_4 (sulfuric acid.) Add 22 mL conc. sulfuric acid to 4 L deionized water.
4. Bromothymol blue and phenolphthalein pH indicator solution: 1 mg/mL each in 4:1 isopropanol: deionized water.
5. Sodium hydroxide*, 10 M: Dissolve 40 grams sodium hydroxide in enough deionized water to make 100 mL. Do not store in glass-stoppered bottle.
6. Hydrochloric acid, 0.3 M, in methanol: Dilute 2.5 mL conc. hydrochloric acid in about 80 mL methanol; dilute to 100 mL with methanol.
7. Crystal violet indicator: 2-3 mg/mL in isopropanol.
8. Reconstitution solvent: 10% acetone in toluene with 4 µg/mL of 4,4′-dibromooctafluorobiphenyl (optional).*

* See SPECIAL PRECAUTIONS

EQUIPMENT:

NOTE: See APPENDIX B for special instructions on equipment.

1. Wipe, (7.6 cm × 7.6 cm) 12-ply or equivalent.
2. Sample storage and shipping container: 50-mL polypropylene centrifuge tubes with PTFE-lined caps.
3. Extraction tubes and vials:
   a. Glass test tubes, 25-mL (20 × 120 mm), with PTFE-lined caps;
   b. Glass test tubes, 14-mL (16 × 100 mm), with PTFE- lined caps, (ASTM Specification E982, or equivalent, suitable for repeated autoclaving);
   c. Amber GC autosampler vials (2-mL) and caps.
4. Gas chromatograph/mass spectrometer detector, with column and integrator, see p. 9106-1.
5. Liquid Transfer:
   a. Syringes: 10-, 25-, 100-, and 500-µL sizes.
   b. Mechanical pipette with disposable tips or repeating dispenser: 0.5-, 2.5-, and 10-mL sizes.
   c. Repeating dispenser: 1- to 5-mL.
   d. Three repeating dispensers: 10 to 20-mL each.
6. Volumetric flasks: 10-, 100-, and 250-mL.
7. Forceps.
8. Gloves, latex or nitrile. Avoid vinyl gloves (see 9106-3, Sampling step 1, NOTE 2).
9. Scoop for solid reagents.
10. Empty drying columns: 1 cm i.d. × 12-15 cm length polypropylene plastic columns having a fritted polyethylene disc or equivalent (e.g. 10-mL pipette tip with small wad of silanized glass wool packed into the tip).
11. Nitrogen blow-down apparatus with water bath capable of maintaining 35 °C.
12. Vortex mixer.
13. Rotating mixer capable of 10-30 rpm.
14. Aspirator flask: 1-L, with aspirator tubing and a 12.5 cm long 16 gauge needle.
15. Centrifuge: capable of up to 4000 x g and of holding 25-mL glass test tubes.
16. Oven capable of 70 to 90 °C ± 2 °C.
17. Test tube racks, heat resistant to 90 °C.
18. Pasteur pipettes.
19. pH paper.
20. Template: 10 cm × 10 cm or 31.7 cm × 31.7 cm opening, made of relatively rigid disposable cardstock or sheet of PTFE.
21. Ice or other cold media for shipping.

SPECIAL PRECAUTIONS: The solvents are flammable and have adverse health effects. Phenethylamines target the nervous system at very low concentrations and are easily absorbed through the skin. Avoid breathing vapors. Avoid skin contact. Work should be performed in a hood with adequate ventilation. Analysts must wear proper eye and hand protection (e.g. latex gloves) to prevent absorption of even small amounts through the skin. Dissolving sodium hydroxide and concentrated hydrochloric or sulfuric acid in water is highly exothermic. Goggles must be worn. The derivatization reagents react violently with water.

Caution must also be exercised in the collecting, handling, and analysis of samples. Clandestine drug labs may produce unknown and seriously toxic by-products. For example, in the manufacture of designer drugs (e.g., MPPP, a homolog of Alphaprodine), at least one very neurotoxic by-product, 1-methyl-4-phenyl-1,2,5,6-tetrahydropyridine (MPTP), has been identified that specifically and irreversibly causes Parkinson's disease [5, 6].

SAMPLING:

See APPENDIX C for special instructions on sampling.

1. Using a new pair of gloves, remove a gauze wipe from its protective package. Moisten the wipe with approximately 3 to 4 mL of methanol (or isopropanol).
   NOTE 1: Apply no more solvent than that needed to moisten approximately the central 80% of the area of the gauze wipe. Excess solvent may cause sample loss due to dripping from the wipe.
   NOTE 2: Do not use vinyl gloves due to the potential for leaching of phthalate plasticizers and contamination of the samples.
2. Place the template over the area to be sampled (may tape in place along outside edge of template). Wipe the surface to be sampled with firm pressure, using vertical S-strokes. Fold the exposed side of the pad in and wipe the area with horizontal S-strokes. Fold the pad once more and wipe the area again with vertical S strokes.
3. Fold the pad, exposed side in, and place in shipping container and seal with cap.
   NOTE: Keep samples refrigerated (<6 °C). While methamphetamine and several related amines are stable on the recommended wipe media for at least 7 days at room temperature, refrigeration is recommended as soon as possible (see Table 5).
4. Either clean the template before use for the next sample or use a new disposable template.
5. Label each sample clearly with a unique sample identifier.
6. Prepare a minimum of two field blanks with one field blank for every ten samples.
   NOTE: In addition, include at least 3 media blanks for the analytical laboratory to use for their purposes. The wipes used for the media blanks should be from the same lot as the field samples.

SAMPLE PREPARATION:

See APPENDIX D for special instructions on sample preparation.

7. Desorption from media:
   a. Remove cap from shipping container.
      NOTE: Sample wipe should fit loosely in the container. If not, transfer sample to a larger container.
   b. Spike 60 µL of internal standard spiking solution onto each wipe sample.
   c. Add 30 mL desorption solution (0.1 M sulfuric acid).
      NOTE: If the samples were transferred to a larger container, rinse the original shipping container with the desorption solution, shake, and decant the rinsate into the larger container.
   d. Cap securely and mix contents by inverting the tubes end over end on a rotary mixer or equivalent at 10-30 rpm for at least one hour.

e. Check the pH which should be about ≤ 4. Adjust the pH with diluted (2.5 to 3 M) sulfuric acid drop-wise, mixing the contents by shaking or inversion a few times after each addition of acid before checking the pH.
f. After mixing, transfer 10 mL of supernatant to a 25-mL glass centrifuge tube.
NOTE: If cleanup is to be performed on a subsequent day, store samples in a refrigerator. Analytes are stable in the desorption solution for at least one week refrigerated.

8. Cleanup: Potential contamination from oils, triglycerides, plasticizers and other hydrocarbons are reduced through a hexane back-extraction step.
a. To each 10-mL aliquot of acid desorbate, add 10 mL of hexane, cap and mix on a rotary mixer for one hour. Allow to stand for 15-30 minutes for the phases to separate. If an emulsion forms, centrifuge the tubes at 1500-2000 rpm for a few minutes. If the emulsion persists, add about 0.5 mL of acetonitrile to the surface of the emulsion and gently mix the layers at the interface of the emulsion. Centrifuge again if necessary.
b. Aspirate the (upper) organic layer to waste. Exercise care to not remove any of the aqueous layer.
9. Extraction of analytes into methylene chloride:
a. Add 1-2 drops (20-50 µL) of the mixed pH indicator (phenolphthalein + bromothymol blue) solution to each sample. The color of the samples should be yellow, which indicates that the samples are sufficiently acidic for desorption of the analytes from the wipe samples.
b. Add 0.5 mL of 10 M sodium hydroxide to each sample. The color of the samples should turn brilliant purple or magenta, confirming that the pH is greater than 9-9.5 (necessary for the extraction of the amines into methylene chloride). If the color remains yellow, or only turns green or light blue, check the pH with pH paper to confirm that it is greater than 9.5. If it is not, add another 0.5 mL of 10 M sodium hydroxide, mix, and check the pH again.
NOTE: The color of the solution will gradually fade from purple to deep blue within about 20-30 minutes. This is due to the known tendency of phenolphthalein to fade at high pH.
c. Add 10 mL of methylene chloride to each sample. Cap and mix on a rotary mixer for one hour. Allow to stand for 15 to 30 minutes. If an emulsion forms, centrifuge as described above (step 8a).
d. Aspirate the aqueous (upper) layer to waste as described above, being careful to not remove any of the lower methylene chloride layer.
10. Removal of water from the methylene chloride extract:
a. Prepare potassium carbonate-sodium sulfate drying columns.
Note: See APPENDIX E for preparation of drying columns.
b. Rinse the packed columns with about 6 mL of methylene chloride. Dry columns afterwards by forcing dry nitrogen or clean air through the top for 10-20 seconds.
c. Arrange 14-mL collection tubes (16 × 100 mm test tube) in test tube racks. Add 6 µL of crystal violet solution and 100 µL of 0.3 M hydrochloric acid in methanol to each collection tube.
NOTE: Crystal violet is not critical but helps later on as a visualizing aid for monitoring the progress of drying. Hydrochloric acid is critical to prevent loss of the amphetamines during evaporative concentration.
d. Position the drying columns over the collection tubes.
e. Transfer (decant) the methylene chloride layer into the drying column reservoir. After the last of the sample passes into the bed of the column, rinse the drying column twice with 1 mL of methylene chloride each time and combine with sample eluate.
11. Derivatization:
See APPENDIX F for special instructions on derivitization.
a. Evaporate the methylene chloride eluates in a nitrogen blow-down apparatus with the water bath set at 35 °C. Rinse the tips of the evaporation needles thoroughly with methanol or acetone between samples to prevent cross-contamination. When the samples are dry, remove and cap the tubes immediately.

NOTE: The dark color of the crystal violet helps make the residue more visible when it is dried. If at least 0.1 mL of isopropanol was present in the eluates, the crystal violet will also go through a series of color changes that helps in monitoring the drying process.

b. To each dried sample, add 100 µL of chlorodifluoroacetic anhydride and recap tubes. Mix the contents by vortexing briefly.

NOTE 1: It is recommended that the tubes be kept capped and to only uncap about 5 at a time for the addition of the derivatizing reagent. Do not leave the acid anhydride bottle open between taking aliquots since the reagent is moisture sensitive.

NOTE 2: If incomplete derivatization is routinely experienced, increase volume of reagent to 150 or 200 µL. The color of the crystal violet will turn yellow or yellow-green with the addition of chlorodifluoroacetic anhydride.

c. Heat in an oven at 70-75 °C for 20-30 minutes.

d. After heating, allow the tubes to cool to room temperature. Remove caps and evaporate the contents to dryness under a stream of nitrogen at room temperature. As the solution concentrates it turns from a yellow or yellowish-green solution to a bluish-green just before going to dryness. At the point of dryness the color of the residue normally turns rapidly to blue or violet, depending upon the amount of coextractants (the more co-extractants, the more blue the color and the less likely a violet color will develop). Remove the tubes just as soon as the blue or violet color becomes apparent. Losses have been experienced if blowing is continued for more than 2 minutes beyond the blue or violet color stage.

NOTE: If an oil-like residue or film persists, then the sample may have too many contaminants that were not removed at the cleanup step or were introduced subsequent to cleanup. In such a case, return to step 7f and perform the clean-up (step 8) on another 10-mL aliquot of the sample desorbate using methylene chloride as the cleanup solvent instead of hexane. Discard the (lower) organic layer to waste before proceeding to steps 9 through 11.

e. Reconstitute the dried residue with 1 mL of the reconstitution solvent. The reconstituted solution normally will become deep blue in color. Mix by vortexing briefly a couple of times. Transfer the solutions to 2-mL amber-colored GC vials containing 200 to 250 mg anhydrous sodium sulfate. Cap vials, label, and analyze by GC/MS (See MEASUREMENT, steps 15-17).

NOTE: Derivatives of phenylpropanolamine (norephedrine) break down significantly over several days at room temperature. GC vials containing derivatives should be kept refrigerated until analysis.

CALIBRATION AND QUALITY CONTROL:

12. Determine retention times for the derivatives of the analytes of interest using the column and chromatographic conditions specified on page 9106-1. Table 10 gives typical retention times for various drugs, precursors, and adulterants.
13. Calibrate daily with at least six calibration standards plus a blank (CS0) selected from Table 7 to cover the analytical range.
    a. Prepare the analyte spiking solution as follows: Add known amounts of individual drug stock solutions to a volumetric flask and dilute to volume with methanol. A recommended final concentration for this solution is approximately 200 µg each per mL.
    b. Prepare calibration standards and media blanks in clean shipping containers (e.g. 50-mL polypropylene centrifuge tubes or equivalent).

    NOTE: Liquid standards (standards without added blank wipe media) may be prepared in lieu of media standards if cotton gauze was used for the samples.

    c. Add 3 mL methanol (or isopropanol if isopropanol was used with the samples in the field) to each calibration standard and media blank.

d. Spike a known volume of analyte spiking solution into each calibration standard by spiking directly onto the media or into solution. Use the spiking volumes suggested in Table 7 to cover the desired range.
e. Process each of these through steps 7 through 11 (same as the field samples.)
f. Analyze these along with the field samples. (See MEASUREMENT, steps 15-17.)

14. Prepare matrix-spiked (QC) and matrix-spiked duplicate (QD) quality control samples [7].
    a. Cotton gauze from the same lot used for taking samples in the field should be provided to the analytical laboratory to prepare these matrix-spiked quality control samples.
    b. The quality control samples (QC and QD) must be prepared independently at concentrations within the analytical range. (See Table 7 for applicable concentration ranges.)
    c. One quality control media blank (QB) must be included with each QC and QD pair.
        i. Transfer clean gauze wipes to new shipping containers.
        ii. Add 3 mL of isopropanol (or methanol if methanol was used in wiping) to each gauze wipe.
        iii. Spike QC and QD with a known amount of analyte as suggested in Table 7.
    d. Process each of these through steps 7 through 11 (same as the field samples).
    e. Analyze these along with the field samples. (See MEASUREMENT, steps 15-17.)

MEASUREMENT:

See APPENDIX G for special instructions on measurement.

15. Analyze the calibration standards, quality control samples, blanks, and samples by GC/MS.
    a. Set gas chromatograph according to manufacturer's recommendations and to conditions listed on page 9106-1.
    b. Set mass spectrometer conditions to manufacturer's specifications and those given on page 9106-1 for the scan mode or those in Table 6 for the SIM mode.
    c. Inject sample aliquot with autosampler or manually.
        NOTE: After the derivatives are prepared and just before analyzing any samples or standards, inject the highest concentrated standard several times in order to prime or deactivate the GC column and injection port. This will help minimize any drift in the instrument's response to target analytes relative to their internal standards.
    d. After analysis, the vials should be recapped promptly and refrigerated if further analysis is anticipated.
16. Using extracted ion current profiles for the primary (quantification) ions specific to each analyte, measure GC peak areas of analyte(s) and internal standard(s) and compute relative peak areas by dividing the peak area of the analyte by the area of the appropriate internal standard. Recommended primary (quantification) ions and internal standards are given in Tables 6, 8, and 9. Prepare calibration graph (relative peak area vs. µg analyte per sample).
17. Samples from initial investigations of clandestine laboratories are likely to include highly contaminated samples. If sample results exceed the upper range of the calibration curve, the sample in the GC vial may be diluted and reanalyzed or a smaller aliquot of the initial acid desorbate diluted, re-extracted, derivatized, and analyzed. Refer to APPENDIX H for instructions and limitations on making dilutions.

CALCULATIONS:

18. Determine the mass (in µg/sample) of respective analyte found in the wipe samples, and in the media blank from the calibration graph.
19. Calculate final concentration, C, of analyte in µg/sample:

$$C = c\frac{V_1}{V_2}\frac{V_3}{V_4} - b\frac{V_5}{V_2}$$

Where: c = concentration in sample (in µg/sample determined from the calibration curve).

$\frac{V_1}{V_2}$ = volume correction factor (needed only when the volume of internal standard spiking solution used for spiking the samples – such as for composite samples requiring larger desorption solution volumes – is different from that used for spiking the calibration standards). (See Table 7, footnote 4.)

V_1 = volume in µL of internal standard spiking solution used to spike samples.
V_2 = volume in µL of internal standard spiking solution used to spike the standards.

$\frac{V_3}{V_4}$ = dilution factor, if applicable

V_3 = 10 mL (volume of desorbate taken for cleanup in step 8).
V_4 = volume in mL of desorbate actually taken for cleanup and diluted to 10 mL with blank desorbing solution containing internal standard.
b = concentration in media blank (in µg/sample determined from the calibration curve).
$\frac{V_5}{V_2}$ = volume correction factor for the media blank (needed only if the volume of internal standard spiking solution used for spiking the media blank is different from that used for spiking the calibration standards.)
V_5 = volume in µL of internal standard spiking solution used to spike media blank.

20. Report concentration, C′, in µg per total area wiped (in cm²) as follows:

$$C' = \frac{C}{A}$$

Where: C = µg/sample (step 19).
A = Total area wiped in cm² per sample.

NOTE: For example, if the sample was a composite sample and the area was 400 cm², report results as µg/400 cm² and not averaged to µg/100 cm². In general, if the area wiped was greater than or less than 100 cm², do not convert value to µg/100 cm². To avoid confusion, report separately both µg/sample (C) and the total area wiped in cm² per sample (A) for both discrete and composite samples.

EVALUATION OF METHOD:

This method was evaluated for those analytes listed in Tables 8a and 8b over a range of approximately 0.1 µg/sample to 30 µg/sample. These concentration levels represent approximately the 1 through 300 times the limit of quantitation (LOQ) level for most of the analytes [8]. Results are reported in the Backup Data Report for NIOSH 9106 [1].

The limits of detection (LOD and LOQ) were determined by preparing a series of liquid standards in desorption solution, processing them through the liquid-liquid extraction procedure of NIOSH 9106, and analyzing in both the scan and SIM modes. The LODs were estimated using the procedure of Burkart [8]. An LOD of 0.05 µg/sample for methamphetamine on wipes was achieved in either scan or SIM mode. The LOD was set at 0.05 µg/sample because that was the level of the lowest calibration standard for the LOD study. Lower LODs (e.g. 0.02 µg/sample) have been achieved in practice by including calibration standards at lower concentration levels. The cleanliness and performance of the mass spectrometer must be maintained such that at 0.1 µg/sample, a signal of at least 5 to 10 times the baseline noise is achievable. This is more easily accomplished in the SIM mode with the mass spectrometer.

Six different wipe media were evaluated. These were 3″×3″ 12-ply cotton gauze, 4″×4″ AlphaWipes® (TX® 1004), 4″×4″ 4-ply NU GAUZE®, 4″×4″ 4-ply MIRASORB®, 4″×4″ 6-ply SOF-WICK®, and 4″×4″ 4-ply TOPPER® sponges. Results are given in the Backup Data Report [1]. No synthetic media performed

better than cotton gauze. Some media (TOPPER® and SOF-WICK®) did not perform well, possibly due to co-extracted nonionic (polyethoxyethylene type) surfactants that are not removed using hexane and incompletely removed using methylene chloride in the cleanup step.

Precision and accuracy were determined by analyzing 6 replicates at each of 6 concentration levels (nominally 0.1, 0.3, 1, 3, 10, and 30 µg/sample). Results are presented in Tables 8a and 8b for cotton gauze. The best precision and accuracies were dependent upon the use of carefully chosen internal standards, especially where there is steric hindrance of the amine (e.g. having *N*-ethyl and *N*-propyl groups).

Long term sample storage stability was determined for periods up to 30 days under refrigeration (4 °C ± 2 °C) and for up to 7 days at room temperature (22-24 °C). Results are given in Table 5. The precision and accuracy and long term storage stability evaluations were conducted using isopropanol as the wetting solvent. A second precision and accuracy study using methanol confirmed that methanol is an acceptable substitute for isopropanol.

Recovery of amphetamines from six different types of surfaces using cotton gauze was evaluated (see Tables 11a and 11b). The practice of serial wiping (wiping the same surface area a second time with a second gauze wipe and combining both wipes as a single sample) was evaluated. Four solvents for wetting the gauze were tested (distilled water, 5% distilled white vinegar, isopropanol, and methanol). Six replicate samples were made on a latex painted wall. Recoveries and precisions are given in Table 11a. The recoveries with 5% distilled white vinegar were better than for distilled water, but not as good as for isopropanol. Methanol is superior to isopropanol. Recoveries with isopropanol are greatly improved with a repeat (serial) wipe (11% improvement compared to only about 6% improvement with methanol). The study and results are reported in the Backup Data Report for NIOSH 9109 [9]. Additional research on surface sample recovery and solvent effectiveness has been reported by Martyny [11, 12].

REFERENCES:

[1] Reynolds JM, Siso MC, Perkins JB [2004]. "Backup data report for NIOSH 9106, Methamphetamine and illicit drugs, precursors, and adulterants on wipes by liquid-liquid extraction, Abridged," prepared under NIOSH Contract 200-2001-0800, (Unpublished, 2004).

[2] Martyny JW, Arbuckle SL, McCammon CS Jr., Esswein EJ, Erb N [2003]. Chemical exposures associated with clandestine methamphetamine laboratories. http://www.njc.org/pdf/chemical_exposures.pdf [2005].

[3] NIOSH [2011]. Methamphetamine and illicit drugs, precursors, and adulterants on wipes by solid phase extraction: Method 9109. In: Ashley KA, O'Connor PF, eds. NIOSH manual of analytical methods. 5th ed. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, [www.cdc.gov/niosh/nmam/].

[4] NIOSH [2011]. Methamphetamine on Wipes by Liquid Chromatography/Mass Spectrometry: Method 9111. In: Ashley KA, O'Connor PF, eds. NIOSH manual of analytical methods. 5th ed. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, [www.cdc.gov/niosh/nmam/].

[5] Baum RM [1985]. New variety of street drugs poses growing problem. Chemical and Engineering News, 63(63):7-16.

[6] Buchanan JF, Brown CR [1988]. Designer drugs, a problem in clinical toxicology. Medical Toxicology 3:1-17.

[7] NIOSH [1994]. Chapter C: Quality Assurance. In: Eller PM, Cassinelli ME, eds. NIOSH Manual of Analytical Methods, 4th ed. Cincinnati, OH: Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-113. [www.cdc.gov/niosh/nmam/].

[8] Burkart JA [1986]. General procedures for limit of detection calculations in the industrial hygiene chemistry laboratory. Applied Industrial Hygiene 1(3):153-155.

[9] Reynolds JM, Siso MC, Perkins JB [2004]. Backup data report for NIOSH 9109, Methamphetamine and illicit drugs, precursors, and adulterants on wipes by solid phase extraction. Unpublished. Prepared under NIOSH Contract 200-2001-0800.
[10] *Merck Index*, 11th ed., S. Budavari, Ed., Merck and Co., Rahway, NJ (1989).
[11] Martyny JW. Decontamination of building materials contaminated with methamphetamine [http://health.utah.gov/meth/html/Decontamination/DecontaminationofBuildingMaterialsContaminatedwithMeth.pdf]. Date accessed: May, 2007.
[12] Martyny JW [2008]. Methamphetamine sampling variability on different surfaces using different solvents [http://health.utah.gov/meth/html/Decontamination/MethSamplingVariabilityonDifferentSurfaces.pdf] Date accessed: May, 2011.
[13] Sweet DV, ed. [1997]. Registry of toxic effects of chemical substances. DHHS (NIOSH) Publ. No. 97-119. http://www.cdc.gov/niosh/pdf/97-119.pdf.
[14] Sigma-Aldrich MSDS sheets, http://www.sigma-aldrich.com [May 10, 2004].
[15] Cerilliant Analytical Reference Materials. 811 Paloma Drive, Suite A, Round Rock, Texas 78664 (www.cerilliant.com).
[16] NAMSLD 2007. State Controlled Substance(s) Environmental Issues Bill – Status Update, (http://www.natlalliance.org/) The National Alliance for Model State Drug Laws, Alexandra, Va. Access via the web on March 11, 2008.
[17] Howard PH, Meylan WM [1997]. Handbook of physical properties of organic chemicals. Boca Raton, Florida: CRC/Lewis Publishers. See also Syracuse Research Corporation's website http://www.syrres.com/esc/physdemo.htm (May 10, 2004) for demos and updates.
[18] Zhang JS, Tian Z, Lou ZC [1989]. Quality evaluation of twelve species of chinese ephedra (Ma Huang). Acta Pharmaceutic Sinica 24(11):865-871.
[19] Cui JF, Zhou TH, Zhang JS, and Lou ZC. [1991]. Analysis of alkaloids in chinese ephedra species by gas chromatographic methods. Phytochemical Analysis 2:116-119.
[20] Andrews KM [1995]. Ephedra's role as a precursor in the clandestine manufacture of methamphetamine. Journal of Forensic Sciences 40(4):551-560.
[21] OSHA [2001]. Evaluation guidelines for surface sampling methods. Industrial Hygiene Chemistry Division, OSHA Salt Lake Technical Center, Salt Lake City, Utah. [http://www.osha.gov/dts/sltc/methods/surfacesampling/surfacesampling.pdf] Date accessed: May 2011.

METHOD DEVELOPMENT BY:

John M. Reynolds, Maria Carolina Siso, and James B. Perkins, DataChem Laboratories, Inc., Salt Lake City, Utah under NIOSH Contract CDC 200-2001-0800.

Table 1. Formula and registry numbers of analytes.

Compound (alphabetically)	MW[1] (Daltons) Free base	HCl salt	Hemisulfate salt	Structural Formula As free base	CAS #[2]	RTECS[6]
(DL)-Amphetamine	135.21	171.67	184.25	$C_6H_5{\cdot}CH_2{\cdot}CH(CH_3){\cdot}NH_2$	300-62-9[3] 60-13-9[5]	SH9450000 SI1750000
(D)-Amphetamine[7]	135.21	171.67	184.25	$C_6H_5{\cdot}CH_2{\cdot}CH(CH_3){\cdot}NH_2$	51-64-9[3] 51-63-8[5]	SI1400000
(L)-Amphetamine	135.21	171.67	184.25	$C_6H_5{\cdot}CH_2{\cdot}CH(CH_3){\cdot}NH_2$	156-34-3[3]	SH9050000
Caffeine	194.19			$(CH_3)_3{\cdot}[C_5HN_4O_2]$	58-08-2[3]	EV6475000
(DL)-Ephedrine	165.24	201.70	214.28	$C_6H_5{\cdot}CH(OH){\cdot}CH(CH_3){\cdot}NH{\cdot}CH_3$	90-81-3[3] 134-71-4[4]	
(L)-Ephedrine[8]	165.24	201.70	214.28	$C_6H_5{\cdot}CH(OH){\cdot}CH(CH_3)NH{\cdot}CH_3$	299-42-3[3] 50-98-6[4] 134-72-5[5]	KB0700000 KB1750000 KB2625000
(D)-Ephedrine	165.24	201.70	214.28	$C_6H_5{\cdot}CH(OH){\cdot}CH(CH_3)NH{\cdot}CH_3$	321-98-2[3] 24221-86-1[4]	KB0600000 KB1925000
(±)-MDEA	207.27	243.73		$CH_2O_2C_6H_3{\cdot}CH_2{\cdot}CH(CH_3)NH{\cdot}C_2H_5$	82801-81-8[3] 116261-63-2[4]	
(±)-MDMA	193.24	229.71		$CH_2O_2C_6H_3{\cdot}CH_2{\cdot}CH(CH_3){\cdot}NH{\cdot}CH_3$	42542-10-9[3] 92279-84-0[4]	SH5700000
(+)-MDMA[7]	193.24	229.71		$CH_2O_2C_6H_3{\cdot}CH_2{\cdot}CH(CH_3){\cdot}NH{\cdot}CH_3$	64057-70-1[4]	SH5700000
(DL)-Methamphetamine	149.24	185.70	198.28	$C_6H_5{\cdot}CH_2{\cdot}CH(CH_3){\cdot}NH{\cdot}CH_3$	4846-07-5[3]	
(D)-Methamphetamine[7]	149.24	185.70	198.28	$C_6H_5{\cdot}CH_2{\cdot}CH(CH_3){\cdot}NH{\cdot}CH_3$	537-46-2[3] 51-57-0[4]	SH4910000 SH5455000
(L)-Methamphetamine	149.24	185.70	198.28	$C_6H_5{\cdot}CH_2{\cdot}CH(CH_3){\cdot}NH{\cdot}CH_3$	33817-09-3[3]	SH4905000
Phencyclidine	243.39	279.85		$C_6H_5{\cdot}C[C_5H_{10}]{\cdot}N[C_5H_{10}]$	77-10-1[3] 956-90-1[4]	TN2272600 TN2272600
Phentermine	149.24	185.70		$C_6H_5{\cdot}CH_2{\cdot}C(CH_3)_2{\cdot}NH_2$	122-09-8[3] 1197-21-3[4]	SH4950000
(DL)-Norephedrine	151.21	187.67	200.25	$C_6H_5{\cdot}CH(OH){\cdot}CH(CH_3){\cdot}NH_2$	14838-15-4[3] 154-41-6[4]	RC2625000 DN4200000
1R,2S (-)-Norephedrine	151.21	187.67	200.25	$C_6H_5{\cdot}CH(OH){\cdot}CH(CH_3){\cdot}NH_2$	492-41-1[3]	RC2275000
1S,2R (+)-Norephedrine	151.21	187.67	200.25	$C_6H_5{\cdot}CH(OH){\cdot}CH(CH_3){\cdot}NH_2$	37577-28-9[3]	
1S,2S (+)-Norephedrine	151.21	187.67	200.25	$C_6H_5{\cdot}CH(OH){\cdot}CH(CH_3){\cdot}NH_2$	36393-56-3 2153-98-2[4] 492-39-7[4]	RC9275000
(D)-Pseudoephedrine[8,9]	165.24	201.70	214.28	$C_6H_5{\cdot}CH(OH){\cdot}CH(CH_3){\cdot}NHCH_3$	90-82-4[3] 345-78-8[4]	UL5800000 UL5950000
(L)-Pseudoephedrine[10]	165.24	201.70	214.28	$C_6H_5{\cdot}CH(OH){\cdot}CH(CH_3){\cdot}NH{\cdot}CH_3$	321-97-1[3]	

(1) Molecular weights are calculated from the empirical formula using the 1987 IUPAC Atomic Weights of the Elements, Merck Index [9]. The molecular weight of the hemisulfate is ½ the weight of the 2:1 sulfate salt (2 moles amine + 1 mole H_2SO_4).
(2) CAS from various sources: Merck Index [10], NIOSH RTECS [13], MSDS sheets from Sigma/Aldrich [14], Cerilliant [15], and other sources [18].
(3) Free base form.
(4) Hydrochloride salt.
(5) 2:1 Sulfate salt (2 moles amine + 1 mole H_2SO_4.
(6) RTECS = NIOSH Registry of Toxic Effects of Chemical Substances [13].
(7) More active isomer.
(8) Naturally occurring isomer.
(9) The D form of pseudoephedrine is a decongestant.
(10) The L form of pseudoephedrine is a bronchodilator. Dehydroxylation forms the less active L-methamphetamine.

Table 2. Methamphetamine Regulations by State (Jan 2008)*

State	Standard	State	Standard
Alaska**	0.1 µg/100 cm^2	Minnesota	0.1 µg/100 cm^2 (meth labs), < 1.5 µg/100 cm^2 (meth use)
Arizona	0.1 µg/100 cm^2	Montana	0.5 µg/ft^2
Arkansas	0.1 µg/100 cm^2	New Mexico	1.0 µg/ft^2
California***	< 1.5 µg/100 cm^2	North Carolina	0.1 µg/100 cm^2
Colorado	0.5 µg/100 cm^2	Oregon	0.5 µg/ft^2
Connecticut	0.1 µg/100 cm^2	South Dakota	0.1 µg/100 cm^2
Hawaii	0.1 µg/100 cm^2	Tennessee	0.1 µg/100 cm^2
Idaho	0.1 µg/100 cm^2	Utah	0.1 µg/100 cm^2
Kentucky	0.1 µg/100 cm^2	Washington	<0.1 µg/100 cm^2

The following states have no standard: Alabama, Delaware, D.C., Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Texas, Vermont, Virginia, West Virginia, Wisconsin, Wyoming.

* NIOSH has not established health-based or feasibility-based airborne Recommended Exposure Limits (RELs) or surface contamination guidelines for clandestine drug laboratories. State surface contamination limits are provided as an aid to those seeking additional information and does not constitute endorsement by NIOSH. The National Alliance for Model State Drug Laws (NAMSDL) website: http://www.namsdl.org/home.htm periodically summarizes state feasibility-based decontamination limits and proposed state legislative requirements and guidelines [16]. However, state information is subject to change, and specific state's surface contamination limits, and other state decontamination requirements and guidelines should be obtained directly from each state.

** Guidance and Standards for Cleanup of Illegal Drug-Manufacturing Sites Revision 1 April 19, 2007 Alaska Department of Environmental Conservation, Spill Prevention and Response Division, Prevention and Emergency Response Program. http://www.dec.alaska.gov/spar/perp/methlab/druglab_guidance.pdf

*** In Oct 2009 House Bill 1489 was passed into law to incorporate the new standard as the state limit. All other states: Data source: http://health.utah.gov/meth/html/Resources/OtherStates/Nationalcomparison (downloaded April 2011).

Table 3. Physical properties of analytes[1]

Compound (alphabetically)	CAS	m.p.(°C)	Vapor Pressure (mm Hg)	pK_a[4]	Log P[5]	Solubility in Water, g/100 mL
(DL)-Amphetamine	300-62-9	—	—	10.1 @ 20 °C	1.76	2.8 @ 25 °C
(D)-Amphetamine	51-64-9	<25	—	9.9	1.76	—
(D)-Amphetamine sulfate	51-63-8	>300	—	—	6.81	—
(L)-Amphetamine	156-34-3	—	0.201 @ 25 °C	10.1 @ 20°C	1.76	2.8 @ 25°C
Caffeine	58-08-2	238	15 @ 89°C	10.4 @ 40°C	-0.07	2.16 @ 25°C
(DL)-Ephedrine	90-81-3	76.5	—	—	0.68	—
(L)-Ephedrine	299-42-3	34	0.00083 @ 25°C	10.3 @ 0°C	1.13	6.36 @ 30°C
(L)-Ephedrine HCl	50-98-6	218	2.04E-10 @ 25°C	pH 5.9 @ 1/200 dil.[3]	-2.45	25[6]
MDEA	82801-81-8	—	—	—	—	—
MDMA HCl	42542-10-9	148-149[2]	—	—	—	—
(D)-Methamphetamine	537-46-2	—	0.163 @ 25°C	9.87 @ 25°C	2.07	1.33 @ 25°C
(D)-Methamphetamine HCl	51-57-0	170-175[2]	—	—	—	—
Phencyclidine	77-10-1	46.5	—	8.29	4.69	—
Phencyclidine HCl	956-90-1	233-235[2]	—	—	—	—
Phentermine	122-09-8	—	0.0961 @ 25°C	—	1.90	1.86 @ 25°C
Phentermine HCl	1197-21-3	198[2]	—	—	—	—
(±) Phenylpropanolamine	14838-15-4	—	0.000867 @ 25°C	9.44 @ 20°C	0.67	14.9 @ 25°C
(±) Phenylpropanolamine HCl	154-41-6	194	—	—	-2.75	—
(L)-Norephedrine	492-41-1	51-53[3]	—	—	—	—
1S,2S (+)-Norephedrine	36393-56-3	77.5-78	0.000867 @ 25°C	9.44 @ 20	0.83	14.9 @ 25
1S,2S (+)-Norephedrine HCl	492-39-7	—	—	pH 5.9-6.1 in aq. soln.[3]	0.22	2 @ 25
(D)-Pseudoephedrine	90-82-4	119	0.00083 @ 25°C	10.3 @ 0°C	0.89	10.6 @ 25°C
(D)-Pseudoephedrine HCl	345-78-8	181-182[2]	—	pH 5.9 @ 1/200 dil.[3]	—	—

(1) Handbook of Physical Properties of Organic Chemicals unless otherwise noted [17].
(2) Merck Index [10].
(3) Sigma-Aldrich MSDS [14].
(4) Negative log of the acid dissociation constant for the amine in aqueous solution.
(5) Log P = octanol-water partition coefficient.
(6) Temperature not given in source.

Table 4. Synonyms of analytes

Generic names[1]	Trade and street names[2]	Additional names[3]
(DL)-Amphetamine; (±)-Amphetamine	Benzedrine; Phenedrine; Bennies	(±)-α-Methylbenzeneethanamine[4]; dl-α-Methylphenethylamine[4]; dl-1-Phenyl-2-aminopropane; (±)-Desoxynorephedrine
(D)-Amphetamine; (+)-Amphetamine	Dextroamphetamine; Dexedrine; dexies	(S)-α-Methylbenzeneethanamine[4]; d-α-Methylphenethylamine[4]; d-1-phenyl-2-aminopropane; d-β-Phenylisopropylamine
(L)-Amphetamine; (-)-Amphetamine	Levoamphetamine; component of Adderall	(R)-α-Methylbenzeneethanamine[4]; l-α-Methylphenethylamine[4]; l-1-phenyl-2-aminopropane; (-)-1-phenyl-2-aminopropane
Caffeine	Component (with ephedrine) of cloud 9 and herbal XTC	3,7-Dihydro-1,3,7-trimethyl-1H-purine-2,6-dione[4]; 1,3,7-Trimethylxanthine
(DL)-Ephedrine; (±)-Ephedrine	Ephedral; Racephedrine; Sanedrine	(R*,S*)-(±)-alpha-[2-(Methylamino)ethyl]benzenemethanol; DL-alpha-[1-(Methylamino)ethyl]benzyl alcohol; dl-Ephedrine
(L)-Ephedrine; (-)-Ephedrine; (1R,2S)-(-)-Ephedrine; l-Ephedrine	Primatene; Xenadrine; Ma Huang (Ephedra sinica and other species(5)); (with caffeine) cloud 9 and herbal ecstasy	(R-(R*,S*))-α-(1-Methylaminoethyl)benzenemethanol; L-erythro-2-(Methylamino)-1-phenylpropan-1-ol; (1R,2S)-(-)-2-Methylamino-1-phenyl-1-propanol; (-)-alpha-(1-Methylamino-ethyl)-benzyl alcohol; (-)-1-hydroxy-2-methylamino-1-phenylpropane; L-(-)-Ephedrine
(D)-Ephedrine		(1S,2R)-(+)-2-Methylamino-1-phenyl-1-propanol; (+)-Ephedrine
MDEA	MDE; Eve	(±)-3,4-Methylenedioxy-N-ethylamphetamine; N-ethyl-alpha-methyl-1,3-benzodioxole-5-ethanamine
MDMA	Adam, ecstasy, X, XTC	N,α-Dimethyl-3,4-1,3-benzodioxole-5-ethanamine; 3,4-Methylenedioxymethamphetamine
(DL)-Methamphetamine; (±)-Methamphetamine		N,α-Dimethylbenzeneethanamine[4]; N,α-Dimethylphenethylamine; dl-Desoxyephedrine; N-methyl-β-phenylisopropylamine
(D)-Methamphetamine; (+)-Methamphetamine; d-Methamphetamine	Methedrine; Desoxyn; chalk; crank; crystal; glass; ice; meth, speed; upper	(S)-N,α-Dimethylbenzeneethanamine; (S)-(+)-N,α-Dimethyl-phenethylamine[4]; d-1-Phenyl-2-methylaminopropane; d-Desoxyephedrine; d-N-methyl-β-phenyl-isopropylamine
(L)-Methamphetamine; (-)-Methamphetamine	Component in decongestant vapor inhaler (Vick's brand)	(R)-(-)-N,α-Dimethylphenethylamine; (-)-Deoxyephedrine; (-)-2-(Methylamino)-1-phenylpropane
Phencyclidine	Sernylan; Sernyl; angel dust; PCP; peace pill	1-(1-Phenylcyclohexyl) piperidine[4]
Phentermine	Fastin; Normephentermine	α,α-Dimethylbenzeneethanamine[4]; α,α-Dimethylphenethylamine[4]; 1,1-Dimethyl-2-phenylethylamine; α-Benzylisopropylamine
(DL)-Norephedrine; (±)-Norephedrine	(±)-Phenylpropanolamine; Obestat; Phenedrine;	(R*,S*)-(±)-α-(1-Aminoethyl)benzenemethanol[4]; -(±)-α-(1-Amino-ethyl)benzyl alcohol[4]; (±)-2-Amino-1-phenyl-1-propanol
(L)-Norephedrine; (-)-Norephedrine	Natural form found in Ephedra sinica and other species[5]	(1R,2S)- 2-Amino-1-phenyl-1-propanol; (1R,2S)-Norephedrine; l-erythro-2-Amino-1-phenylpropan-1-ol
(D)-Norephedrine; (+)-Norephedrine	Metabolite of cathinone in urine of Khat users.	(1S,2R)- 2-Amino-1-phenyl-1-propanol; (1S,2R)-Norephedrine; d-erythro-2-Amino-1-phenylpropan-1-ol
(+)-Norpseudoephedrine; Cathine	Amorphan; Adiposettin; Reduform; found naturally in Khat plant	(R*,R*)-α-(1-Aminoethyl)benzenemethanol[4]; d-threo-α-2-Amino-1-hydroxy-1-phenylpropane; 1S,2S-(+)-Norpseudoephedrine
L-(+)-Pseudoephedrine; (+)-Pseudoephedrine; d-Pseudoephedrine	Afrinol; Novafed; Sinufed; Sudafed; natural form found in Ephedra sinica and other species[5]	(S-(R*,R*))- α-[1-(Methylamino)ethyl]benzenemethanol; (1S,2S)-(+)-2-Methylamino-1-phenylpropanol; d-(alpha-(1-Methylamino)-ethyl)benzyl alcohol; (1S,2S)-(+)-Pseudoephedrine; d-threo-2-Methylamino-1-phenylpropan-1-ol; (+)-ψ-Ephedrine
D-(-)-Pseudoephedrine; (-)-Pseudoephedrine		(1R,2R)-(-)-Pseudoephedrine; (-)-ψ-Ephedrine; l-threo-2-Methylamino-1-phenylpropan-1-ol; (+)-ψ-Ephedrine

(1) Common or generic names. Salts forms are not given for simplicity.

(2) Trade and street names are exemplary, not exhaustive. Street names change over time and by locality. Salts and free base forms are not distinguished.

(3) Other names from Merck Index [10], NIOSH Registry of Toxic Effects of Chemical Substances [13], and MSDS sheets [14] and other reference materials [15]. NOTE: For amphetamine and methamphetamine the prefixes R-, D-, d-, and (+)- , although they mean different things, are essentially synonymous for the dextrorotatory stereoisomer and S-, L-, l-, and (-) are essentially synonymous for the levorotary stereoisomer. Many other synonyms exist.

(4) Uninverted CAS name as given in Merck Index [10].

(5) Extracts of Ephedra species contain various amounts of (+)-Norephedrine, (-)-N-methylephedrine, and (+)-N-methylpseudoephedrine. (+)-Norephedrine is reduced to amphetamine and N-methylephedrine and N-methylpseudoephedrine reduce to N,N-dimethylamphetamine [18, 19]. The presence of these latter two compounds in methamphetamine samples indicate that Ephedra spp. extracts may have been used in the synthesis [20].

Table 5. Limit of detection (LOD), method detection limit (MDL), and sample storage stability on cotton gauze. [1]

Compound	Int. std.[2]	Estimated LOD[3]		Estimated MDL[4]		Storage Stability[5]	
		Scan Mode (µg/sample)	SIM Mode (µg/sample)	Scan Mode (µg/sample)	SIM Mode (µg/sample)	30 days 4 °C	7 days 22 °C
(D)-Amphetamine	D11-Amp	0.07	0.05	0.04	0.02	100.5	94.5
	D14-Met	0.06	0.06	0.03	0.03	99.7	87.9
Caffeine	D11-Amp	1	0.2	0.4[6]	0.02	99.3	98.8
	D14-Met	1	0.2	0.4[6]	0.03	98.5	91.9
(L)-Ephedrine	D11-Amp	0.09	0.1	0.02	0.01	95.6	97.2
	D14-Met	0.08	0.09	0.01	0.06	94.8	90.5
MDEA	N-PAmp	0.05	0.07	0.1	0.02	98.9	102.1
MDMA	D11-Amp	0.05	0.06	0.04	0.02	99.7	111.1
	D14-Met	0.05	0.07	0.03	0.02	98.9	103.2
(D)-Methamphetamine	D11-Amp	0.07	0.05	0.03	0.02	98.7	100.6
	D14-Met	0.05	0.05	0.03	0.02	98.0	93.5
Phencyclidine	D11-Amp	0.3	0.06	0.03	0.02	103.7	105.2
	D14-Met	0.3	0.07	0.03	0.02	102.9	97.7
Phentermine	D11-Amp	0.06	0.05	0.02	0.02	102.0	101.5
	D14-Met	0.05	0.05	0.02	0.02	101.1	94.3
		0.06	0.05	0.01			
(±)-Norephedrine[7]	D11-Amp	0.2	[8]	0.1[9]	[8]	94.3	92.7
	D14-Met	0.2		0.2[10]	[8]	93.6	86.2
Pseudoephedrine	D11-Amp	0.08	0.07	0.03	0.02	100.4	97.9
	D14-Met	0.07	0.09	0.05	0.03	99.6	91.1
	NMPhen	0.06	0.09	0.05	0.02	-	-

(1) Backup Data Report [1].

(2) Internal standards: D11-Amp = Amphetamine-D_{11}, D14-Met = Methamphetamine-D_{14}, NMPhen = N-Methyl phenethylamine, N-PAmp = N-Propyl amphetamine.

(3) LODs vary according to individual GC columns, instrument conditions and cleanliness, media interferences, and internal standards used. The lowest calibration standard for these determinations was 0.05 µg/sample. Lower LODs are achievable with lower concentration calibration standards and operation of the mass spectrometer in the SIM mode. LODs were calculated on liquid standards using the procedure of Burkart [8].

(4) MDLs are provided as an alternate expression of sensitivity. These MDLs are calculated as the standard deviation of six replicates on spiked media analyzed at the 0.1 µg/sample level (except as noted) times the Student's t value for 6 replicates (3.365). (Normally 7 replicates are used.)

(5) Cotton gauze samples were spiked at 3 µg/sample per analyte. Six samples were analyzed immediately after preparation. Six samples were stored at room temperature (about 22 °C) for 7 days and then analyzed. Eighteen samples were stored at +4 °C (±2 °C). Of the 18 samples stored at +4 °C, six each were analyzed at 7 and 21 days and three each were analyzed at 14 and 30 days. (Backup Data Report [1].) Apparent recoveries vary according to internal standard used.

(6) The 0.3 µg/sample level was undetectable in the scan mode. MDLs were calculated from the 1 µg/sample level.

(7) (±)-Norephedrine = (±)-phenylpropanolamine.

(8) (±)-Norephedrine was not evaluated in the SIM mode due to breakdown of derivative with room temperature storage for one week.

(9) MDL calculated from the 0.3 µg/sample level. (Recoveries were >120% at the 0.1 µg/sample level.)

(10) MDL calculated from the 1 µg/sample level. (Recoveries were >120% at the 0.1 and 0.3 µg/sample levels.)

Table 6. Example of mass spectrometer operation parameters for selected ion monitoring mode.[1]

Chlorodifluoroacetyl derivatives	Scan window[2]	Acquisition ions (*m/z*) per group[3]							
Acquisition Group 1	10.5 to 13.0	104	118	128	156	160	170	172	177
Acquisition Group 2	13.0 to 15.2	104	156	158	170	172	198	296	
Acquisition Group 3	15.2 to 18.0	109	135	162	170	184	194	200	242

GC Peak No.[4]	Target Analytes and Internal Standards:[5]	Retention Time[6] (min)	Primary Ion (*m/z*)[7] (Quantification Ion)	Secondary ion and approximate relative abundance[8] (relative to the Primary Ion)	
	Acquisition Group 1				
2	Amphetamine-D_{11} (I$)[9]	11.07	160	128	85%
3	Amphetamine	11.15	156	118	85%
5	Phentermine	11.34	170	172	33%
8	n-Methyl phenethylamine (I$)[9]	12.20	156	104	95%
9	Methamphetamine-D_{14} (I$)[9]	12.51	177	128	32%
10	Methamphetamine	12.61	170	118	32%
	Acquisition Group 2:				
18	Phenylpropanolamine	13.27	156	246	25%
20	Dibromooctafluorobiphenyl[10]	13.63	296	456	115%
21	N-n-Propylamphetamine (I$)[9]	13.8	198	156	75%
25	Ephedrine	14.27	170	172	33%
28	Pseudoephedrine	14.74	170	172	33%
	Acquisition Group 3:				
32	Caffeine	15.66	194	109	50%
40	Phencyclidine	16.41	200	242	35%
41	MDMA	16.48	170	162	95%
43	MDEA	16.87	184	162	75%

(1) In this example, 10 analytes and 5 internal standards are grouped into 3 acquisition groups having no more than 8 primary and secondary ions per acquisition group. For 6 analytes and internal standards or less, one acquisition group may be sufficient.

(2) Scan window is in minutes. Actual times are dependant upon GC column and instrument conditions.

(3) Ions (*m/z*) in bold numbers are suggested primary (quantification) ions. For best signal to noise ratio, do not exceed 10 ions per acquisition group. Dwell times per ion (*m/z*) is 50 milliseconds.

(4) GC peak numbers are those in Figure 1 and Table 10.

(5) The list of analytes and internal standards shown is an example. Analyte(s) and internal standard(s) must be selected according to analytical objectives.

(6) Retention times are dependant upon GC column and instrument conditions.

(7) The better ions for quantification are usually the base peak or those with masses >100 *m/z* and relative abundances >50% of the base peak. These minimize interference from co-eluting hydrocarbons. The suggested primary ions are not necessarily the base peaks in the mass spectra of the analytes, especially if the base peaks are ions common to aromatics (e.g. *m/z* 91) and paraffinic or olefinic hydrocarbons (e.g. *m/z* 42, 57, and 58). Suggested ions for other analytes and internal standards are given in Tables 9 and 10.

(8) Secondary ions may be used for quantification if the primary ion encounters interference. Secondary ions improve qualitative identification for SIM analyses. The relative abundances given are approximate (±10 to 20%) and depend upon specific instrument tuning and conditions. They are relative to the primary ion and not necessarily to the base peak in the mass spectrum of each analyte. The relative abundance of secondary ions for each analyte needs to be determined from a mass spectrum acquired on the instrument to be used.

(9) (I$) = internal standard. Internal standards must be paired with the appropriate analytes. Tables 8a and 8b give precision and accuracy data for various pairings. Other potentially useful internal standards are given in Table 9. Highly deuterated analogs of the target analytes are preferred, where available.

(10) Dibromooctafluorobiphenyl is an optional secondary internal standard useful for monitoring autosampler performance and instrument tuning. A shift in the mass axes or the relative abundance of *m/z* 296 to that of *m/z* 456 throughout an analytical sequence will help signal degraded tuning.

Table 7. Suggested spiking schedule for calibration standards and quality control samples

	Add the following to clean shipping containers (e.g. 50-mL polypropylene centrifuge tubes) in the following order.						
Calibration Standards[10]	Number of Wipes[1,2]	Volume[2] of Isopropanol or Methanol[3]	Volume[2] of Internal Standard Spiking Solution[4,5]	Volume of Target Analyte Spiking Solution[5,6]	Volume of Spiking Solution diluted 1/20[5,7]	Volume[2] of Desorption Solution[8]	Resulting µg/sample as Free Base[9]
CS0	0	3 mL	60 µL		0.0 µL	30 mL	0.00
CS1	0	3 mL	60 µL		2 µL	30 mL	0.02
CS2	0	3 mL	60 µL		5 µL	30 mL	0.05
CS3	0	3 mL	60 µL		10 µL	30 mL	0.1
CS4	0	3 mL	60 µL		20 µL	30 mL	0.2
CS5	0	3 mL	60 µL		60 µL	30 mL	0.6
CS6	0	3 mL	60 µL	10 µL		30 mL	2.0
CS7	0	3 mL	60 µL	30 µL		30 mL	6.0
CS8	0	3 mL	60 µL	100 µL		30 mL	20
CS9	0	3 mL	60 µL	300 µL		30 mL	60
CS10	0	3 mL	60 µL	1000 µL		30 mL	200
Quality Control Samples[11]							
QB (media blank)	1	3 mL	60 µL	0.0 µL		30 mL	0.0
QC (matrix spike)	1	3 mL	60 µL	3-300 µL	or 20-60 µL	30 mL	0.2-60
QD (matrix spike duplicate)	1	3 mL	60 µL	3-300 µL	or 20-60 µL	30 mL	0.2-60

(1) Gauze wipes may be added to the calibration standards but are not necessary if cotton gauze is used. Blank gauze wipes must always be added to the quality control samples, QB, QC, and QD.

(2) a.) If a sample consists of 2 gauze wipes, the volume of desorption solution must be increased to 40 mL to accommodate the second wipe. The shipping container should be a 50-mL polypropylene centrifuge tube or equivalent to accommodate the extra volume of desorption solution for 2 wipes. It is not critical to know the exact volume of desorption solution and wetting alcohol used per sample. It only needs to be enough to cover the samples and to permit free percolation through the samples. See step 7.
b.) If a set of samples consists predominantly of 2 gauze wipes, the QB, QC, and QD should also consist of 2 wipes and treated as per the samples. The volume of isopropanol (or methanol) added to the QC samples should be increased to 4 mL for two gauze wipes to simulate samples containing two gauze wipes.

(3) If methanol was used for wipe sampling, it should also be used in the calibration standards, blanks, and QCs instead of isopropanol.

(4) Concentration of internal standards in the internal standard spiking solution is approximately 200 µg/mL as the free base. It is critical to know the exact volume of internal standard spiking solution that is added to the calibration standards, samples, blanks, and quality control samples. The volume spiked into the samples may vary with sample size but the volume spiked into each of the calibration standards must not vary. See step 7b.

(5) For quality control samples, spike onto wipe media within the shipping container. For liquid calibration standards (in lieu of media calibration standards), spike into the isopropanol (or methanol).

(6) Concentration of analytes in the target analyte spiking solution is approximately 200 µg/mL as the free base.

(7) Concentration of analytes in the diluted spiking solution for this table is approximately 10.0 µg/mL as the free base and can be prepared by diluting 100 µL of the target analyte spiking solution to 2 mL in methanol.

(8) Desorption solution is 0.1 M sulfuric acid in deionized water.

(9) This is µg per total sample irrespective of the total desorption solution volume or the area wiped.

(10) Select 6 calibration standards from the list to cover the analytical range plus the blank.

(11) Prepare one set of quality control samples for every 20 samples or less.

Table 8a. Precision and accuracy in scan mode.[1]

Compound	Internal Standard[2]	Range[3] µg/sample	Accuracy	Overall Precision $\hat{S}_{rT}$	Bias	
					Average	Range
(D)-Amphetamine	D11-Amp	0.1-30	17.1	0.0670	-0.0613	-0.1048 - -0.0170
	D14-Met	0.1-30	13.7	0.0610	+0.0338	-0.0151 - +0.1056
	NMPhen	0.1-30	12.5	0.0559	-0.0310	-0.0651 - +0.0177
Caffeine	D11-Amp	1.0-30	20.0	0.0708	-0.0832	- 0.1476 - -0.0542
	D14-Met	1.0-30	12.5	0.0636	-0.0014	- 0.0274 - +0.0381
	NMPhen	1.0-30	15.6	0.0796	-0.0040	-0.0789 - +0.1321
(L)-Ephedrine	D11-Amp	0.1-10	15.4	0.0627	+0.0510	-0.0148 - +0.1128
	D14-Met	0.3-10	17.8	0.0674	+0.0666	+0.0261 - +0.1660
	NMPhen	0.3-30	15.0	0.0707	+0.0293	-0.0259 - +0.0973
MDEA	N-PAmp	0.3-29	16.6	0.0817	-0.0224	-0.0656 - +0.0657
MDMA	D11-Amp	0.3-27	20.2	0.0778	-0.0739	-0.1011 - -0.0489
	D14-Met	0.3-27	16.6	0.0652	+0.0589	-0.0947 - +0.0036
	NMPhen	0.3-27	22.0	0.0722	-0.1017	-0.1486 - -0.0315
(D)-Methamphetamine	D11-Amp	0.1-30	14.7	0.0631	-0.0435	-0.0657 - -0.0060
	D14-Met	0.1-30	12.5	0.0546	-0.0348	-0.1144 - +0.0188
	NMPhen	0.1-10[5]	14.9	0.0503	-0.0665	-0.1179 - +0.0110
Phencyclidine	D11-Amp	0.1-10	18.2	0.0690	-0.0683	-0.1257 - -0.0136
	D14-Met	0.3-3	13.4	0.0465	-0.0577	-0.0662 - -0.0493
	NMPhen	0.3-10	16.8	0.0609	-0.0682	-0.1137 - +0.0091
Phentermine	D11-Amp	0.1-30	15.2	0.0486	-0.0720	-0.1010 - +0.0291
	D14-Met	0.1-30	10.7	0.0509	+0.0190	-0.0395 - +0.0671
	NMPhen	0.1-30	9.6	0.0420	-0.0269	-0.0612 - +0.0340
(±)-Norephedrine[4]	D11-Amp	1-30	6.5	0.0328	+0.0061	-0.0070 - +0.0248
Pseudoephedrine	D11-Amp	0.3-30	17.2	0.0571	-0.0783	-0.1273 - -0.0560
	D14-Met	0.3-30	14.9	0.0649	-0.0422	-0.0888 - +0.0395
	NMPhen	0.3-30	18.7	0.0488	-0.1068	-0.1505 - -0.0422

(1) Backup Data Report [1]. Values are for chlorodifluoroacetyl derivatives and analysis by GC-MS in scan mode. Each sample consisted of a pair of 3″ x 3″ 12-ply cotton gauze pads. There were 6 replicate samples per concentration level and six concentration levels evaluated from approximately 0.1 to 30 µg/sample.

(2) Internal Standards Deuterated: Non-deuterated:
D11-Amp = Amphetamine-D_{11} NMPhen = N-Methyl phenethylamine
D14-Met = Methamphetamine-D_{14} N-PAmp = N-Propyl amphetamine

(3) Range used for calculation of precision, accuracy, and bias. The entire range studied for all analytes was approximately 0.1 to 30 µg/sample (1xLOQ to 300xLOQ).

(4) (±)-Norephedrine = (±)-phenylpropanolamine.

(5) One or more higher level concentrations were omitted from the computations due to inlier CVs (<0.0200.)

Table 8b. Precision and accuracy in SIM mode.[1]

Compound	Internal Standard[2]	Range[3] µg/ sample	Accuracy[4]	Overall[4] Precision $\hat{S}_{rT}$	Bias	
					Average	Range
(D)-Amphetamine	D11-Amp	0.1-30	14.3	0.0412	-0.0750	-0.1153 - -0.0351
	D14-Met	0.1-30	10.1	0.0508	-0.0074	-0.0500 - +0.0389
	NMPhen	0.1-30	13.3	0.0439	-0.0606	-0.1117 - -0.0318
Caffeine	D11-Amp	0.1-30	21.3	0.0578	-0.1182	-0.1949 - -0.0697
	D14-Met	0.1-30	14.4	0.0534	-0.0558	-0.1061 - -0.0170
	NMPhen	0.3-30	19.8	0.0387	-0.1338	-0.1775 - -0.0820
(L)-Ephedrine	D11-Amp	0.3-30	9.1	0.0421	-0.0199	-0.0423 - +0.0157
	D14-Met	0.3-30	20.5	0.0503	0.1226	+0.0637 - +0.1883
	NMPhen	0.3-30	10.2	0.0449	+0.0260	-0.0075 - +0.0769
MDEA	N-PAmp	0.3-29	10.3	0.0264	-0.0597	-0.0879 - -0.0095
MDMA	D11-Amp	0.1-27	16.2	0.0503	-0.0750	-0.1423 - -0.0292
	D14-Met	0.1-0.9[5]	15.4	0.0503[6]	-0.0712	-0.1247 - +0.0032
	NMPhen	0.1-27	15.4	0.0496	-0.0722	-0.1136- -0.0108
(D)-Methamphetamine	D11-Amp	0.1-10[5]	16.5	0.0379	-0.1030	-0.1414 - -0.0660
	D14-Met	0.1-30	9.2	0.0351	-0.0343	-0.0767 - +0.0006
	NMPhen	0.1-30	13.6	0.0322	-0.0827	-0.1221 - -0.0403
Phencyclidine	D11-Amp	0.1-10[5]	17.7	0.0428	-0.1068	-0.1303 - -0.0586
	D14-Met	0.1-3	11.3	0.0450	-0.0393	-0.0683 - -0.0205
	NMPhen	0.1-3[5]	16.1	0.0449	-0.0871	-0.1279 - -0.0383
Phentermine	D11-Amp	0.1-30	12.8	0.0394	-0.0637	-0.0982 - -0.0433
	D14-Met	0.1-30	9.8	0.0495	-0.0051	-0.0375 - +0.0556
	NMPhen	0.1-30	11.0	0.0394	-0.0451	-0.0766 - -0.0163
Pseudoephedrine	D11-Amp	0.3-30	17.3	0.0402	-0.1073	-0.1496 - -0.0514
	D14-Met	0.3-30	11.7	0.0519	-0.0294	-0.0559 - +0.0532
	NMPhen	0.3-30	17.0	0.0450	-0.0956	-0.1197 - -0.0576

(1) Backup Data Report [1]. Values are for chlorodifluoroacetyl derivatives and analysis by GC-MS in SIM mode (see Table 6 for MS conditions). Each sample consisted of a pair of 3" × 3" (7.5 cm x 7.5 cm) 12-ply cotton gauze pads. There were 6 replicate samples per concentration level and six concentration levels evaluated from approximately 0.1 to 30 µg/sample. Norephedrine (phenylpropanolamine) was not evaluated in the SIM mode due to breakdown at room temperature storage for several days prior to analysis.

(2) Internal Standards,

Deuterated:	Non-deuterated:
D11-Amp = Amphetamine-D_{11}	NMPhen = N-Methyl phenethylamine
D14-Met = Methamphetamine-D_{14}	N-PAmp = N-Propyl amphetamine

(3) Range used for calculation of precision, accuracy, and bias. The entire range studied for all analytes was approximately 0.1 to 30 µg/sample (1×LOQ to 300×LOQ).

(4) NIOSH [1995]. NIOSH Technical Report: Guidelines for Air Sampling and Analytical Method Development and Evaluation. By Kennedy ER, Fischbach TJ, Song R, Eller PM, Shulman SA. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 95-117.

(5) One or more higher level concentrations were omitted from the computations due to inlier CVs (<0.0200).

(6) The overall precision, $\hat{S}rT$, is an estimate due to inlier precisions (<0.02) at several higher concentration levels.

Table 9a. Recommended internal standards and best application[1]

COMPOUND NAME	CAS	MW as free base	Quant. Ion	Secondary Ion	COMMENTS
(±)-Amphetamine-D_{11}	Not available	146.12	160	128	Preferred analog for amphetamine
(±)-Amphetamine-D_8	145225-00-9	143.15	126[3]	159[3]	Alternate for amphetamine-D_{11}
(±)-Amphetamine-D_6	Not available	141.16	160	123	Alternate for amphetamine-D_{11}
(±)-Methamphetamine-D_{14}	Not available	163.12	177	128	Preferred methamphetamine analog
(±)-Methamphetamine-D_{11}	152477-88-8	160.15	176	126	Alternate for methamphetamine-D_{14}
(±)-Methamphetamine-D_9	Not available	158.16	177	123	Alternate for methamphetamine-D_{14}
N-Methylphenethylamine	589-08-2	135.23	156	104	Alternate for methamphetamine-D_{14}
Phencyclidine-D_5	60124-86-9	248.35	205	247	Use only for phencyclidine.
MDEA-D_6[2]	160227-44-1	213.22	190	165	Use only for MDEA.
N-Propylamphetamine[2]	Not available	177.29	198	156	Alternate for MDEA-D_6

(1) Care must be exercised in the selection of internal standards for each analyte because of differences in derivatization efficiencies due to structural differences.
   a. Deuterated analogs of each target analyte may be acceptable as internal standards if they are isotopically pure enough and their ions do not interfere with the quantification ions (usually base peaks) of the target analyte, especially at the limit of detection for the target analyte. Conversely it is also important that ions in the target analyte, especially at high concentrations, do not interfere with the quantification ion (usually base peaks) of any deuterated analog used as the internal standard.
   b. The more highly deuterated an analog, the more it will chromatographically separate from the target analyte, reducing interference from common ions.
   c. Phentermine and mephentermine have been used as internal standards. Such use is not advised in this method because of their reported occasional use as adulterants in certain illicit drugs such as MDMA.

(2) N-Propylamphetamine and MDEA-D_6 are only applicable to MDEA and other hindered amines (e.g. fenfluramine and MBDB) due to similar steric hindrance at the nitrogen (N-ethyl or N-propyl substitution) which affects derivatization efficiency.

(3) It is better to use m/z 126 because at high concentration levels unlabelled amphetamine contributes significant interference to m/z 159 of amphetamine-D_8.

Table 9b. Recommended best application of internal standards

	Recommended Deuterated Internal Standards				Recommended Alternate Non-deuterated Internal Standards[3]		
TARGET ANALYTE	Amphet-amine-D_{11}[2]	Metham-phetamine-D_{14}[2]	MDEA-D_6[1]	Phency-clidine-D_5	N-Methyl-phenethyl-amine	4-Phenyl-1-butyl-amine	N-Propyl-amphet-amine[1]
Amphetamine	X	X			X		
Caffeine		X			X		
Ephedrine	X	X			X	X	
MDEA			X				X
MDMA		X			X		
Methamphetamine	X	X			X		
Phencyclidine		X		X	X		
Phentermine	X				X		
(±)-Norephedrine[4]	X					X	
Pseudoephedrine		X			X		

(1) N-Propylamphetamine and MDEA-D_6 are only applicable to MDEA and other hindered amines (e.g. fenfluramine and MBDB) due to similar steric hindrance at the nitrogen (N-ethyl or N-propyl substitution) which affects derivatization efficiency.

(2) The alternate deuterated compounds listed in part A above may be used. Avoid ring-labeled amphetamine-D_5 (CAS 65538-33-2) since the primary (quantification) ion is the same as for amphetamine and GC peaks overlap significantly. Also avoid methamphetamine-D_5 (CAS 60124-88-1) since GC peaks significantly overlap and secondary ions for the chlorodifluoroacetyl derivative are not baseline resolved.

(3) The listed non-deuterated compounds are effective as internal standards for the listed target analytes. Non-deuterated internal standards might not be permissible.

(4) (±)-Norephedrine is the same as (±)-phenylpropanolamine.

Table 10. Gas chromatographic retention times for chlorodifluoroacetyl derivatives of amphetamines, precursors, adulterants, and miscellaneous drugs of abuse.[1]

GC Peak No.[2]	Compound	Recommended Quantification (1′) and Confirmation(2′, 3′) Ions (*m/z*)[3]			Form[4]	Retention Time in Minutes	Relative Retention Time[5]	Relative Retention Time[6]
		1′	2′	3′				
1	Nicotine	84	133	162	parent	8.92	0.396	0.757
2	(DL)-Amphetamine-D_{11}(I$)[7]	160	128	162	derivative	10.26	0.800	0.870
3	(DL)-Amphetamine	156	118	158	derivative	10.34	0.807	0.877
4	Phenethylamine[8]	104	91	-	derivative	10.38	0.810	0.880
5	Phentermine[8]	170	172	132	derivative	10.52	0.821	0.892
6	N-Methyl pseudoephedrine[9]	134	162	75	derivative	10.54	0.822	0.894
7	N-Methyl pseudoephedrine[9]	72	-	-	parent	abt 11	0.86	0.93
8	N-Methyl phenethylamine (I$)[7]	156	104	158	derivative	11.37	0.887	0.964
9	(DL)-Methamphetamine-D_{14} (I$)[7]	177	98	179	derivative	11.70	0.913	0.992
10	(DL)-Methamphetamine	170	172	118	derivative	11.79	0.920	1.000
11	Fenfluramine[8]	184	186	159	derivative	11.83	0.923	1.003
12	S-(-)-Cathinone (from Khat plant)	105	77	132	derivative	11.99	0.935	1.017
13	Bupropion (Wellbutrin®, Zyban®)	44	100	111	parent	12.14	0.947	1.030
14	N-Ethyl amphetamine	184	186	118	derivative	12.22	0.953	1.036
15	Ecgonine, methyl ester	182	82	311	derivative	12.36	0.964	1.048
16	S-(-)-Methcathinone ("Cat")	170	105	172	derivative	12.38	0.966	1.050
17	Norpseudoephedrine (Cathine)	156	158	246	bis-derivative	12.46	0.972	1.057
18	(±)-Norephedrine	156	158	246	bis-derivative	12.49	0.974	1.059
19	Aminorex	107	79	232	derivative (-CN)	12.70	0.991	1.077
20	Dibromooctafluorobiphenyl (I$)[7]	296	456	454	parent	12.82	1.000	1.087
21	N-Propyl amphetamine (I$)[7]	198	156	200	derivative	12.97	1.012	1.100
22	4-Methoxyamphetamine	121	148	78	derivative	13.22	1.031	1.121
23	4-Phenyl-1-butylamine (I$)[7]	176	104	-	derivative	13.27	1.035	1.126
24	1S,2R(+)-Ephedrine-D_3 (I$)[7]	173	175	85	derivative	13.44	1.048	1.140
25	(DL)-Ephedrine	170	172	260	bis-derivative	13.48	1.052	1.143
26	Acetaminophen[8]	108	221	263	derivative	13.67	1.066	1.159
27	Methyl phenidate (Ritalin®)	84	56	91	parent	13.81	1.077	1.171
28	Pseudoephedrine	170	172	260	bis-derivative	13.93	1.087	1.182
29	Meperidine (Demerol® etc.)	71	247	172	parent	13.99	1.091	1.187
30	Atropine	124	94	103	parent (-H_2O)	14.25	1.112	1.209
31	(±)-MDA	135	162	291	derivative	14.36	1.120	1.218
32	Caffeine[8]	194	109	67	parent	14.84	1.158	1.259
33	N,N-Dimethyltryptamine (DMT)	58	129	102	derivative	14.97	1.168	1.270
34	(±)-BDB	135	176	170	derivative	15.11	1.179	1.282
35	Ketamine ("special K")[8,11]	180	182	209	parent	15.20	1.186	1.289
36	Lidocaine[8]	86	58	120	parent	15.28	1.192	1.296
37	Trifluoromethylphenyl piperazine[11]	200	145	172	derivative	15.46	1.206	1.318
38	Benzyl piperazine[11] ("Legal XTC")	91	197	175	derivative	15.54	1.202	1.318
39	Phencyclidine-D_5 (I$)[7]	205	96	246	parent	15.59	1.216	1.322
40	Phencyclidine (PCP)	200	242	243	parent	15.62	1.218	1.325
41	MDMA[11]	170	162	135	derivative	15.66	1.221	1.328

Table 10 continued,

Table 10, continued. Gas chromatographic retention times for chlorodifluoroacetyl derivatives of amphetamines, precursors, adulterants, and miscellaneous drugs of abuse.[1]

GC Peak No.[2]	Compound	Recommended Quantification (1') and Confirmation (2', 3') Ions (m/z)[3] 1'	2'	3'	Form[4]	Retention Time Minutes	Relative Retention Time[5]	Relative Retention Time[6]
42	MDEA-D_6 (I$)[7]	190	165	135	derivative	16.01	1.249	1.358
43	MDEA[11]	184	162	135	derivative	16.04	1.251	1.360
44	Phenylephrine[8]	156	158	374	tris-derivative	16.10	1.256	1.366
45	(±)-MBDB	184	176	135	derivative	16.29	1.271	1.382
46	Theophylline[8]	180	95	68	parent	16.34	1.275	1.386
47	Mescaline	181	194	179	derivative	16.43	1.282	1.394
48	Phenylephrine[8]	156	248	158	bis-derivative	16.65	1.299	1.412
49	Chlorpheniramine[8]	203	205	167	parent	16.73	1.305	1.419
50	Methyl phenidate	196	198	-	derivative	17.20	1.322	1.459
51	4-Bromo-2,5-DMPEA[10] (Nexus)	242	244	229	derivative	17.57	1.370	1.490
52	cis-(±)-4-Methylaminorex ("U4Euh")	203	160	117	derivative	17.89	1.396	1.517
53	Dextromethorphan[8]	271	59	150	parent	18.09	1.411	1.534
54	Methaqualone	235	250	233	parent	18.27	1.425	1.550
55	Cocaine	82	182	303	parent	18.62	1.452	1.579
56	Atropine[8]	124	82	94	derivative	19.10	1.490	1.620
57	Diazepam (Valium® etc.)	256	283	284	parent	20.76	1.619	1.761
58	Hydrocodone (Lortab® etc.)	299	242	284	parent	20.91	1.631	1.774
59	Hydromorphone (Dilaudid®)	285	228	229	parent	21.04	1.641	1.785
60	Hydrocodone (Lortab® etc.)	411	354	298	derivative	21.13	1.648	1.792
61	Morphine	268	397	269	derivative	21.20	1.654	1.798
62	Codeine	282	411	283	derivative	21.28	1.660	1.805
63	Oxycodone (OxyContin®)	315	230	316	parent	21.57	1.682	1.830
64	Hydromorphone (Dilaudid®)	397	341	398	derivative	21.78	1.699	1.847
65	Flunitrazepam (Rohypnol®, roofies)[11]	312	285	286	parent	22.19	1.731	1.882
66	Morphine	380	382	509	bis-derivative	22.26	1.736	1.888
67	Fentanyl (Sublimaze® etc.)	245	146	189	parent	22.96	1.791	1.947

(1) Actual retention times may vary depending on individual GC column and GC conditions. Gas chromatographic conditions used are on p. 9106-1. The mass spectrometer was operated under the conditions given on p 9106-1 (or see the Backup Data Report [1].)

(2) GC peak numbers represent peaks as numbered in Figure 1.

(3) Use extracted ion chromatograms of the primary ions (1') for quantifying peaks in either the scan mode or the SIM mode. Use the secondary and tertiary ions (2' and 3') for qualitative identification when necessary. These ions are selected for nearness to the primary ion to minimize false negatives from skewed spectra and from low mass interference from hydrocarbons.

(4) Not all forms are presented. Parent compounds are not presented that have irregular or overly broad GC peak shapes under the GC conditions used. Spectra for chlorodifluoroacetyl derivatives are given in the Backup Data Report [1]

(5) Retention time relative to 4,4'-dibromooctafluorobiphenyl.

(6) Retention time relative to the chlorodifluoroacetyl derivative of methamphetamine.

(7) I$ = Internal standard.

(8) Intentional or unintentional adulterants. For example, phentermine may be added to MDMA and caffeine added to methamphetamine. Chlorpheniramine is an unintentional adulterant when pseudoephedrine containing chlorpheniramine is used as a methamphetamine precursor.

(9) Presence of (+)-Norephedrine, N-methylpseudoephedrine and/or N-methylephedrine in pseudoephedrine or ephedrine indicates extracts of Ephedra species (spp.) as source. Presence of amphetamine and N,N-dimethylamphetamine in methamphetamine final product also indicates the same source.[18, 19, 20]

(10) 4-Bromo-2,5-dimethoxyphenethylamine

(11) Typical "club drugs" (piperazine analogs as ecstasy substitutes, ketamine and flunitrazepan as predatory drugs).

Table 11a. Recovery from latex-painted wall with various solvents; one gauze wipe compared with the sum of two gauze wipes[1,2]

	Water[3]			Isopropanol			Methanol		
	First Gauze Wipe		Plus Second Wipe[4]	First Gauze Wipe		Plus Second Wipe[4]	First Gauze Wipe		Plus Second Wipe[4]
Test Compound[5]	Percent	%RSD	Percent	Percent	%RSD	Percent	Percent	%RSD	Percent
Amphetamine	51	14	56	67	6.0	78	90	4.0	96
Cocaine	36	22	36	69	22	80	89	9.1	94
Ephedrine	48	23	52	76	7.4	85	91	4.4	96
MDMA	40	20	44	61	9.0	70	88	5.3	94
MDEA	45	22	50	69	12	80	90	11	97
Methamphetamine	46	16	50	64	7.4	75	87	3.5	94
Phencyclidine	27	26	30	64	9.6	73	86	5.2	91
Phentermine	53	9.2	58	78	6.6	91	95	2.9	101
Phenylpropanolamine	58	21	62	80	9.3	95	85	5.0	94
Pseudoephedrine	49	20	53	73	7.0	85	95	3.3	101

(1) Backup Data Report for NIOSH 9109 [8]. Area of each sample was 100 cm^2.
(2) Wall was an existing standard gypsum board wall painted with a latex based paint. Painted surface was at least one year old. There were six replicates for each solvent tested.
(3) Water was deionized water (ASTM type II). Note low recovery and high %RSD.
(4) For the serial wipe study, each 100-cm^2 area was wiped again with a fresh pre-wetted gauze wipe and the amount recovered was determined separately. In practice, a second (serial) wipe is included with the first gauze wipe; both gauze wipes constitute a single sample. The percent recoveries shown in the column represent the sum of the amounts recovered in both the first and second wipes.
(5) Each pre-measured area was spiked with 3 µg of each analyte in methanol and the methanol allowed to dry for several minutes prior to wipe sampling.

Table 11b. Recovery from various surfaces with various solvents; one gauze wipe compared with the sum of two gauze wipes[1]

		Isopropanol			Methanol		
		First Gauze Wipe		Plus Second Wipe[2]	First Gauze Wipe		Plus Second Wipe[2]
Surface Material[3]	Replicates	Percent	%RSD	Percent	Percent	%RSD	Percent
Enamel (lid of washing machine)	4[3]	58	5.7	68	81	2.4	87
Vinyl veneer on particle board	4[4]	60	5.2	68	81	4.8	89
Latex painted wall	6[3]	64	7.4	75	87	3.5	94
Refrigerator door	2[4]	65	2.9	76	91	4.0	92
Varnished hardwood panel	2[5]	72	5.4	76	82	3.7	86
Formica® countertop	4[4]	75	4.9	82	87	3.8	91

(1) Backup Data Report for NIOSH 9109 [8]. Area of each sample was 100 cm^2.
(2) For the serial wipe study, each 100-cm^2 area was wiped again with a fresh pre-wetted gauze wipe and the amount recovered was determined separately. In practice, a second (serial) wipe is included with the first gauze wipe; both gauze wipes constitute a single sample. The percent recoveries shown in the column represent the sum of the amounts recovered in both the first and second wipes.
(3) The Refrigerator door and the washing machine lid were from used appliances. The vinyl-veneered particle board (a book shelf), the Formica® countertop, and the varnished hardwood paneling were all purchased new. All surfaces of used and new materials were pre-cleaned with multiple rinses of methanol prior to spiking. Each pre-measured 100-cm^2 square was spiked with 3 µg methamphetamine.
(4) Samples were taken using the side-to-side and then top-to-bottom wiping technique.
(5) Half of the samples were wiped using the side-to-side wiping technique and half were wiped using the concentric squares wiping technique. There were no significant differences in recoveries. Percent recoveries and %RSDs are for both techniques combined.
(6) Samples were taken each time using only top-to-bottom wiping with the grain of the wood in an "N" pattern.

Figure 1. Typical chromatograms of chlorodifluoroacetyl derivatives by GC-MS in scan mode

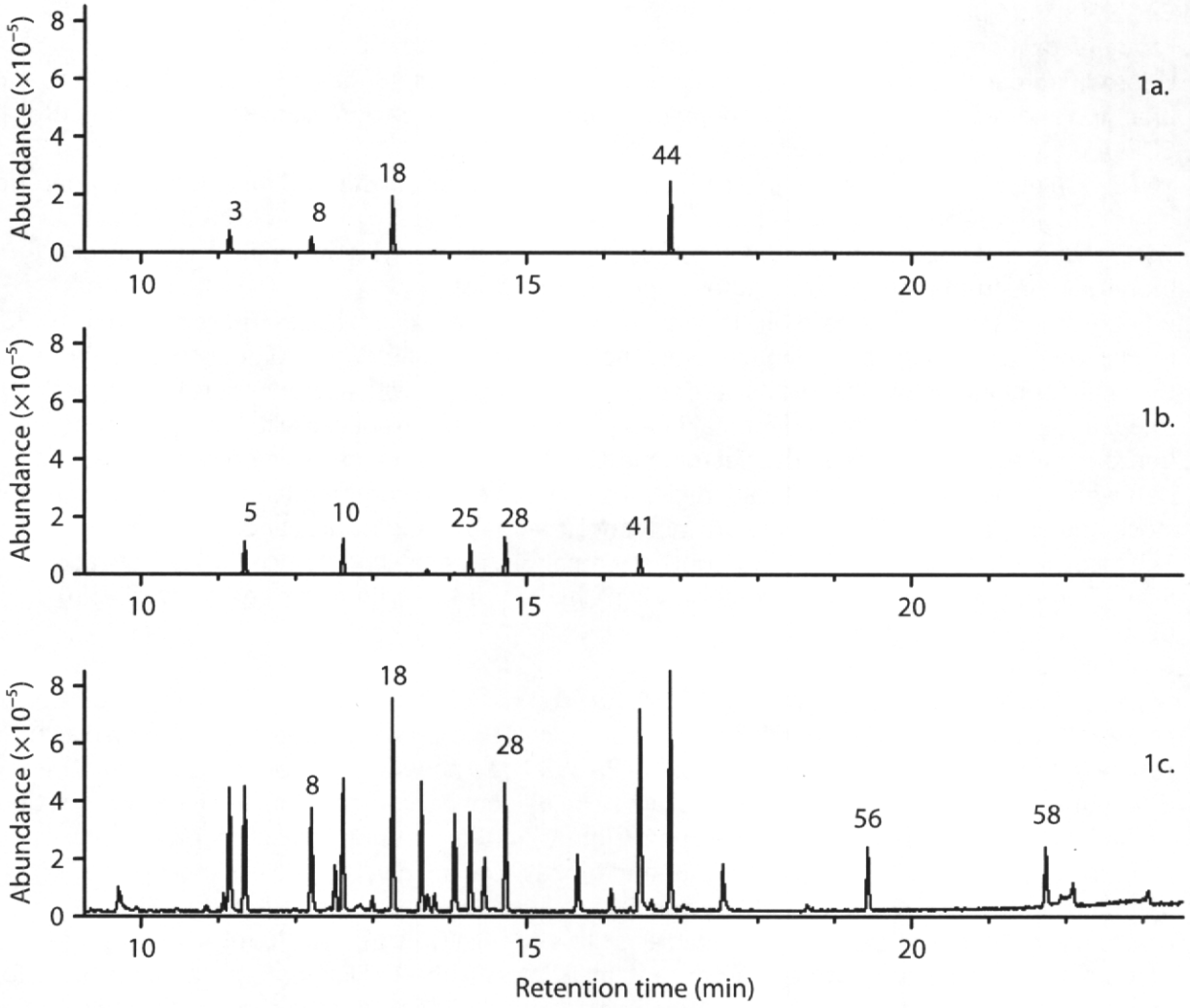

Figure 1a. Extracted ion chromatogram for *m/z* 156 (155.70 to 156.70).
Figure 1b. Extracted ion chromatogram for *m/z* 170 (169.70 to 170.70).
Figure 1c. Total ion chromatogram (TIC).

GC Peak Identification: See Table 10 for identification of numbered GC peaks. (But note that retention times in Table 10 do not correspond to those in Figure 1 because a different DB-5 column was used.)
GC-MS Conditions: See p. 9106-1 for GC-MS conditions.

APPENDIX

A. REAGENTS and SOLUTIONS:

1. For derivatization, pentafluoropropionic anhydride (PFPA) may be substituted for chlorodifluoroacetic anhydride (CDFAA). Spectra, retention times, suggested quantification ions, and precision and accuracy data for PFPA derivatives are given in the Backup Data Report [1]. Spectra for CDFAA derivatives are also given in the Backup Data Report [1].
   NOTE: 100 µL of pentafluoropropionic anhydride (PFPA) may be substituted for chlorodifluoroacetic anhydride, but the samples must be heated to 90 °C for 20-30 minutes in step 11c.
2. The instrumental internal standard, 4,4′-dibromooctafluorobiphenyl is optional. It is useful for monitoring instrument tuning and autosampler performance.
3. Primary amines form Schiff bases and enamines with ketones and aldehydes. These may in turn form derivatives with the acylating reagents. The use of acetone must be avoided strictly prior to the analytes being derivatized. Glassware and equipment rinsed with acetone must be thoroughly dried. Toluene should be avoided for making up standard solutions because it usually contains benzaldehyde, an oxidation product of toluene. Condensation products have been observed between primary amines and benzaldehyde. The only solvents recommended for the preparation of stock solutions and dilutions thereof are methanol (preferably) and isopropanol.
4. The reconstitution solvent should not contain methanol or other alcohol since the derivatized alcohol groups in ephedrine type compounds are hydrolyzed over time. Toluene containing 10 percent acetone is recommended.

B. EQUIPMENT:

1. Wipe media: Besides cotton gauze, 4"×4" (10 cm x 10 cm) 4-ply MIRASORB® (Johnson and Johnson), and 4"×4" (10 cm x 10 cm) AlphaWipe® (TX® 1004, Texwipe Corp.) were acceptable wipe media and can be used in the absence of cotton gauze. MIRASORB®, a non-woven cotton/polyester blend, is discontinued but counterparts exist that claim to be of identical construction and fiber composition. AlphaWipe® is a hydrophilic, highly adsorbent, tightly knitted continuous filament polyester wipe. Precision and accuracy data for MIRASORB® and AlphaWipe® are given in the Backup Data Report [1].
2. Shipping containers: The 50-mL polypropylene centrifuge tubes with caps are preferred for one or two gauze wipes and are not as breakable as glass 40-mL VOA vials. The 40-mL VOA vials are acceptable for single gauze wipes. Larger containers (glass with a PTFE lined cap) should be used for combining more than two gauze wipes into a single sample. The size of the container for two or more wipes should be approximately 25 mL per gauze wipe (e.g. a minimum size of 100-mL for up to four gauze wipe samples). There needs to be enough extra headspace in the shipping container to allow the desorption solution to cover the gauze wipes and to percolate freely through the wipe sample(s) during mixing.
3. Each regulatory agency having legal jurisdiction over the contaminated site may require different but specific off-site preparation and on-site sampling procedures. It is important to consult local regulatory agencies or departments of health having legal jurisdiction over contaminated sites to determine specific sampling, quality control, analyses, and reporting requirements.

C. SAMPLING:

1. Follow specific requirements of surface area to be wiped (usually 100 cm^2 or 1000 cm^2) and action threshold (or maximum allowable residual level) set by the state or specified by the client. Uptake rates depend upon the wipe sampling method used, so the specific wipe technique used must be specified, and any deviations from the required wipe sampling requirements noted.
   NOTE: To ensure that samples have not been tampered with, the use of custody seals and a chain-of-custody form is strongly recommended.
2. Prepare a rigid template from disposable cardstock or a sheet of PTFE having either a 10 cm × 10 cm or 32 cm × 32 cm square-cut hole. The template must be able to retain its shape during wiping to ensure that the areas wiped were either 100 cm^2 or 1000 cm^2. Secure the template(s) to the area(s) to be wiped (e.g. with tape along outside edge of template). If a single-use disposable template is not used, clean the template between samples to avoid cross-contamination, and provide the

laboratory with a blank wipe of the cleaned template between samples to determine that no cross-contamination has occurred.

3. A template might not always be applicable, as in curved or odd-shaped areas such as around burners on stove tops or a fan blade. In such cases sample an area as close to either 100 cm^2 or 1000 cm^2 as feasible and provide the measurement to the regulatory agency and to the analytical laboratory for proper reporting. Tape can be used to delineate the sampling area.
4. It is recommended to provide extra wipe media from the same lot for required media blanks, field equipment blanks, samples, and quality-control samples.
5. Gauze in sterile packaging is recommended to minimize the chance for cross-contamination, which can more easily occur with open bulk packaged cotton gauze.
6. To prevent contamination in the field, another alternative is to pre-wet and insert the gauze wipes into the sample containers off-site. This avoids any possibility of the bottle of methanol or isopropanol becoming contaminated on-site with methamphetamine (or other analytes). If the wipes were prepared off-site, then remove pre-wetted gauze wipe from sample container, opening only one sample container at a time. In either case, squeeze out and discard any excess solvent from the gauze wipe. Use fresh latex or nitrile gloves for each separate sample and blank. Do not use vinyl gloves due to the potential for leaching of phthalate plasticizers and contamination of the samples.
7. Wipe techniques
   a. Concentric Squares Wiping Technique (particularly suitable for smooth and non-porous surfaces): Fold the pre-wetted gauze in half and then fold in half again. Using firm pressure wipe the area within the template. Start at one of the inside corners of the template and wipe in concentric squares, progressing toward the center. End with a scooping motion. Without allowing the gauze to touch any other surface, reverse the last fold so that the exposed side of the gauze is facing inward and using a fresh surface of the gauze, wipe the same area in the same manner as before. Roll or fold the gauze again and insert into the shipping container.
      Note: Wiping in concentric squares is described by OSHA [21]. It is especially suitable for large (e.g. 1000 cm^2) areas.
   b. Side-to-side Wiping (or Blotting) Technique (particularly suitable for rough, porous, and/or soiled surfaces): Fold the pre-wetted gauze in half and then fold in half again. Using firm pressure wipe or blot the area within the template with at least five overlapping side-to-side horizontal passes (see NOTE) beginning at the top and progressing to the bottom in a "Z" pattern. End with a scooping motion. If blotting, blot at least five times on each horizontal pass (see NOTE). Without allowing the gauze to touch any other surface, reverse the last fold so that the exposed side of the gauze is facing inward. Using a fresh surface of the gauze, wipe or blot the area again with at least five overlapping top-to-bottom vertical passes beginning at the left side and progressing to the right in an "N" pattern. If blotting, blot at least five times on each vertical pass. Roll or fold the gauze again and insert into the shipping container. Blotting is suggested in areas so soiled or rough that the threads of the gauze media are continually snagged.
      NOTE: On areas larger than 100 cm^2, more than five passes and blots will be needed.
   c. Repeat or Serial Wiping: If isopropanol is used for wiping, a serial or repeat wipe sample of the same area with a fresh gauze wipe will improve sampling efficiency. (See recoveries for second wipe in Tables 11a and 11b.) For serial wiping, repeat the wiping procedure described above (APPENDIX steps 7a or 7b) with a fresh gauze wipe. Place the second gauze wipe into the same shipping container as the first gauze. The 50-mL polypropylene centrifuge tubes are large enough to contain up to two gauze wipes.
      NOTE: If the area to be wiped remains substantially wet from the first gauze, the second gauze wipe might be used in the dry state to soak up the residual solvent from the first gauze wipe.
8. Composite sampling: Composite samples are allowed by some regulatory agencies. Their use for quantitative purposes may be subject to the permission and guidance of regulatory agencies. Refer to guidelines of regulatory agency for directions on composite sampling. A basic default guideline for composite sampling is as follows: Do not mix inconsistent samples; that is, areas wiped must

be equal in area, sampled areas must have the same high or low probability of contamination, and sampled areas must relate to a specific target appliance or site and not to several appliances or incongruous sites combined.

NOTE: Composite samples cannot meet specific action-threshold requirements for discrete sampling locations. Nor do composite samples consisting of four wipes, for example, improve the sensitivity by decreasing the LOD four fold; instead it raises the LOD by a factor related to the extra volume of desorption solution that is required to desorb a larger number of wipes. The following example illustrates these two points. Assume that the action level was 0.1 µg/100 cm^2. If the analysis gave an LOD of 0.06 µg/sample for a single wipe or discrete sample covering an area of 100 cm^2, then the LOD for the analysis could be expressed as 0.06 µg/100 cm^2, which is low enough to be able to determine whether any discrete sample is at or exceeds the action level. Now if a composite of four wipes was taken, each with an area of 100 cm^2 for a total area wiped of 400 cm^2, the LOD for that composite sample is not 0.06 µg/400 cm^2 nor is it 0.015 µg/100 cm^2; it is actually several times larger than 0.06 µg/400 cm^2. First of all it increases relative to the ratio of the volume of desorption solution used to desorb the sample compared to that used for the calibration standards. Secondly it has nothing to do with the area that was wiped, because the LOD for the calibration curve is determined in terms of µg per sample, independent of the area. To explain the first point, assume approximately 90 mL was used (for ease in calculation) to desorb the four wipes and 30 mL (the normal amount for a single wipe) was used to desorb each calibration standard. The calculation of the LOD for the four composited samples would be µg/sample × (desorption volume for 4 wipes)/(desorption volume for the calibration standards), or 0.06 µg/sample × (90 mL/30 mL), or 0.18 µg/sample for the composited sample. Since the area wiped for the composite sample was 400 cm^2, the LOD for that sample could be expressed as 0.18 µg/400 cm^2. Regarding the second point, this value, 0.18 µg/400 cm^2, cannot be construed or mathematically reduced to 0.045 µg/100 cm^2 because it cannot be known whether three of the four wipes were blank and the fourth wipe just under the value of 0.18 µg. Hence, the effective LOD per individual wipe has to be regarded not only as 0.18 µg/400 cm^2 but also as 0.18 µg/100 cm^2 because any value determined for entire 400 cm^2 might have come from just one of those 100 cm^2 areas. Thus, for composite samples, the LOD must be expressed in terms of the entire area wiped and not extrapolated to some portion thereof. In this example, an LOD of 0.18 µg/100 cm^2 is above the action threshold of 0.1 µg/100 cm^2, meaning that this composite sample cannot satisfy the requirement that residual levels be below 0.1 µg/100 cm^2. It remains for the regulatory agency and not the laboratory to determine how to apply results for composite samples to the established action levels. The same consideration that is given above for the LOD applies to results that are greater than the LOD. To avoid confusion in reporting concentrations for composite samples, it is recommended that the sample concentration (in µg/sample, whatever the sample size) and the total area wiped (in cm^2) be reported separately. For example, a result of 0.4 µg/sample for a sample consisting of four separate wipes of 100 cm^2 each (for a total area wiped of 400 cm^2), is to be reported as 0.4 µg/400 cm^2 and not averaged to 0.1 µg/100 cm^2. This manner of reporting may be required by some regulatory agencies.

9. For quality assurance purposes, regulatory agencies may require duplicate samples to be taken in the field. If such is the case, an area contiguous with and adjacent to the first area, if possible, should be wiped as described under SAMPLING. Do not re-wipe the previously wiped area. This sample is a blind sample and should not be identifiable by the analytical laboratory as a duplicate of any other sample. These are distinct from the laboratory duplicates of a single sample described in step 14 of the method. Field duplicates are useful for evaluating the consistency of sampling technique, assuming uniformity of contamination on adjacent sampling sites. Laboratory duplicates are useful for evaluating consistency of sample preparation and instrumental analysis.

D. DESORPTION FROM MEDIA:

1. An internal standard spiking solution volume of 60 µL was selected for ease in scaling from 60 µL per 30 mL to 80 µL per 40 mL of desorption solution. In either case the rate of 2 µL internal standard spiking solution per mL desorption solution was used. However, any convenient volume of internal standard spiking solution (e.g. 50 µL) that can be delivered reproducibly is acceptable. Whatever volume is chosen, there must be no variation in the volume of the internal standard spiking solution used in preparing each of the calibration standards. If spiking Strategy A is used (see APPENDIX D3), it is critical to know the exact volume of internal standard spiking solution that is applied to each sample (V_1), the media blanks (V_5), and the calibration standards (V_2), since these volumes are used for internal standard spiking solution volume corrections in step 19.
2. It is not necessary to know the exact volume of desorption solution added to each sample or the volume of residual wetting alcohol because differences in the volumes are normalized through the use of internal standards added prior to desorption.
3. Alternate strategy for spiking internal standards (spiking strategy B below): By using the exact same volume of internal standard spiking solution in all samples, blanks, QC samples, and calibration standards, regardless of the volume of desorption solution added or residual wetting alcohol, the volume corrections in step 19, (V_1/V_2 and V_5/V_2) drop out of the equation. However, the internal standard GC peak areas must still be measurable in samples where larger volumes of desorption solution are used (such as for composite samples). Because of the increased dilution of the internal standard in larger samples, this approach should be limited to desorption solution volumes of about 120 mL or less.

   NOTE: There are two separate strategies for handling larger samples requiring larger volumes of desorption solvent. These are outlined below as strategies A and B.

Number of Wipes	Size of Shipping Container (mL)	Volume of Internal Standard Spiking Solution (µL)		Volume of Desorption Solution (mL) (Strategies A and B)
		Strategy A	Strategy B	
1	40-50	60	60	30
2	50	80	60	40
4 (e.g., Composite)	100-120	160	60	80
		Apply volume correction factors at step 19.	Do not apply volume correction factors at step 19.	

   With either strategy, if two gauze wipes were included in the samples, then use 40 mL of desorption solution. If four gauze wipes were included in the samples, then use 80 mL of desorption solution.

   a. In strategy A, the volume of internal standard spiking solution is kept at a constant ratio of 2 µL per mL of desorption solution added. This enables larger samples to be desorbed without diminishing the area of the GC peak for the internal standard. However, a volume correction factor (V_1/V_2) is needed in the final calculations in step 19. Therefore, the exact volume of internal standard added to each of the samples relative to that added to the calibration standards must be known.
   b. In strategy B, the volume of internal standard spiking solution is kept constant for all samples and calibration standards, but need not be exactly 60 µL. This enables the final calculations to be made in step 19 without a volume correction factor. However, the area of the GC peak for the

internal standard will vary with sample desorption volume and the internal standard must be concentrated enough to be measurable where larger volumes of desorption solution are used.

E. DRYING COLUMN PREPARATION

Using 1 cm i.d. × 12-15 cm long polypropylene columns having a fritted polyethylene disc or equivalent (see EQUIPMENT), add 1 gram (~0.8 cc) of anhydrous potassium carbonate (the bed dimension will be about 1.0 cm dia. × 1 cm long). Add 1 gram (~0.8 cc) anhydrous sodium sulfate on top of the potassium carbonate. Remove any particles clinging electrostatically to the outside surfaces.

NOTE: Particles of the drying salts must not get into the collection tube, either through the frits or glass wool plugs, or from particles clinging electrostatically to the outside of the columns. Salts appear to inhibit derivatization efficiency.

F. DERIVATIZATION:

If isopropanol was used as the wetting solvent for the wipes, some of it will be co-extracted into the methylene chloride. In the presence of trace isopropanol, the crystal violet will go through a series of color changes as the extracts are evaporated to dryness. However, if methanol was used as the wetting solvent, the color of the crystal violet will remain blue to blue-violet at all stages of drying. Yet even with methanol, the same color changes can be afforded by adding 0.1 mL of isopropanol to the extracts prior to evaporation. Recoveries of analyte will not be affected in the absence of isopropanol, however, as long as the residues are dry before proceeding to step 11b.

With the presence of a small amount of added or co-extracted isopropanol, as each sample concentrates, the color of the solution will go from a blue or violet color rapidly through green to a yellow color as the residue approaches dryness, which is indicative of increasing hydrogen ion concentration in the residual alcohol. Upon continued blowing with nitrogen, the color of the residue turns back to a green or blue hue just at the point of dryness, which is indicative of the loss of excess hydrogen chloride and/or alcohol. At this stage the samples are dry and may be removed. Continued blowing beyond this point may turn the dried residue to a deep blue-violet or violet color. Losses of analyte have not been experienced even after blowing for five additional minutes beyond the violet stage as long as the hydrochloric acid had been added. Color changes will not be as dramatic or will not develop if too much crystal violet is used.

As the samples become concentrated, the tubes may be raised up in the water bath so that only the very bottoms of the tubes touch the surface of the water. This makes it easier to observe the color changes. The tubes may be raised out of the water bath, but blow-down times are lengthened.

Prolonged heating at high temperatures during derivatization with the acidic conditions of the acid anhydride derivatizing agents promotes mutual isomerization between the ephedrine diastereomers (ephedrine and pseudoephedrine). Dehydration of the ephedrine compounds (ephedrine, norephedrine, and pseudoephedrine) also occurs to some extent to yield β-amino-β-methyl styrenes. Heating during derivatization for longer than one hour is especially not recommended. Thirty minutes is sufficient.

NOTE: The color of the solution will gradually fade from purple to deep blue within about 20-30 minutes. This is due to the known tendency of phenolphthalein to fade at high pH. It has also been observed that in certain bulk samples, unknown constituents will cause the color of phenolphthalein to fade rapidly so that a purple color cannot be obtained at a pH >9, leaving only the blue color of the bromothymol blue. A quick check with pH paper can confirm that the pH is 9 or greater.

G. MEASUREMENT:

Recoveries for the laboratory control matrix spike samples (QC and QD) must meet the guidelines of the specific regulatory agency involved, if applicable (80-120% is a reasonable target in the absence of specific guidance).

NOTE: The QC samples (QC and QD) in this method may be referred to in some guidance documents as matrix spike and matrix spike duplicate samples (MS/MSD), but serve the same purpose. Analyze and report field-equipment blanks as samples. Do not subtract their values from any other sample.

Recoveries of Continuing Calibration Verification (CCV) standards must meet guidelines of regulatory agency (80-120% is a reasonable target in the absence of specific guidance). The CCV standards may be referred to in some guidance documents as "QC samples," but such "QCs" are equivalent to liquid standards (not matrix spiked samples) and serve the same purpose of the CCVs in this method.

With the GC/MS it is possible to achieve the lower limit of 0.05 µg or less per sample for methamphetamine in either the scan mode or SIM mode. The scan mode is essential where the identification of unknowns is an analytical objective. If lower limits of detection are desired or difficult to obtain in the scan mode, or for routine target compound only analyses, the instrument may be operated in the SIM mode.

H. MAKING DILUTIONS:

If the samples exceed the upper calibration range for the analysis, one of the following procedures may be used to estimate the high level concentrations.

1. Dilution Procedure A (dilution of the derivatized sample by reconstitution solvent):
   This option may be used only if the analytes in the sample were completely derivatized (see NOTE below). If derivatization was complete, transfer an aliquot of the sample from the GC vial (e.g. 0.2 mL for a 1:5 dilution) to a clean GC vial and dilute with reconstitution solvent (e.g. 0.8 mL for a 1:5 dilution), cap vial, mix, and reanalyze. However, dilution also dilutes the internal standard, and this procedure is useful only if the GC peak area for the internal standard is sufficiently measurable and the calibration curve is reasonably linear. Dilutions probably should not exceed a factor of 10. If this approach is used it is not necessary to enter a dilution factor in step 19 (V_3/V_4) since both internal standard and analyte are diluted equally. The accuracy of this dilution procedure depends upon the linearity of the calibration curve in the extrapolated region beyond the upper end of the calibration curve.
   NOTE: Determination of Incomplete Derivatization: Incomplete derivatization can be caused by water, glycols, a large excess of analyte, or other contaminants that interfere with or compete for the derivatization reagent. If any one of the following symptoms appears, use Dilution Procedure B described below.
   a. An "oily" film (i.e., apparently viscous liquid) or unusual residue (e.g. grit) remains after being blown-down under nitrogen after derivatization (step 11d). This may be due to the presence of water, glycols, detergents, salts, or other contaminants. Incomplete derivatization has been observed with such residues.
   b. A very large (off scale) GC peak for any one of the derivatives (e.g. pseudoephedrine, a precursor for methamphetamine) indicates the possibility of incomplete derivatization for other analytes (e.g. methamphetamine) due to competition for the derivatization reagent.
   c. A smaller than usual GC peak area for the internal standard (<50% of the average) in undiluted samples suggests that something was competing for or inhibiting the derivatizing reagent. Such inhibition or competition for the internal standard will be experienced by the target analyte as well.
   d. Incomplete derivatization can be confirmed by the obvious presence of a GC peak for an underivatized target analyte. Underivatized analytes are not always detectable. Ephedrines usually do not show up on DB-5 capillary columns in this method, but GC peaks for underivatized secondary amines (e.g. methamphetamine) and for high levels of underivatized primary amines (e.g. amphetamine) can be detected, usually as irregularly shaped GC peaks, depending upon GC column conditions.

e. The problem of incomplete derivatization can be minimized by the use of an isotopic (e.g. deuterated) analog for each of the target analytes as the internal standard for that compound. This allows quantification in spite of incomplete derivatization.

2. Dilution Procedure B (dilution of a smaller aliquot of the original desorbate): If the sample was not completely derivatized or if large dilutions are needed (e.g. greater than about 1:5), the following procedure can be used. See NOTE in part 1 above. The procedure may also be used if derivatization was determined to be complete.
   a. Dilute an aliquot of the original aqueous acid desorbate of the wipe sample to 10 mL with desorption solution from a simulated sample blank, and re-extract. Add both the aliquot to be diluted and the diluting solution from the simulated blank directly to a clean 25-mL glass centrifuge tube (step 7f) and proceed to step 8. For example, to make a 1:10 dilution, transfer 1 mL of original desorbate to the 25-mL tube and dilute with 9 mL from a simulated sample blank.
   b. The simulated sample blank should be prepared identically to the sample being diluted, using the same volumes of internal standard spiking solution and desorption solution that were used with the sample in the original desorption. For example, if the original sample was desorbed with 40 mL desorption solution with 80 µL of added internal standard spiking solution, then prepare the simulated blank in the same way. The volume of wetting alcohol is estimated (e.g. about 3 mL per 3"×3" (7.5 cm x 7.5 cm) 12-ply cotton gauze wipe). Include a dilution factor (V_3/V_4) in the calculations in step 19 (e.g. V_3/V_4 = 10 mL divided by the volume in mL of original desorbate diluted to 10 mL with solution from the simulated blank). The dilution factor in the above example is 10 mL/ 1 mL or 10.
   c. Correct for differences in internal standard spiking solution volumes in step 19 (if applicable) using for V_1 the volume of internal standard spiking solution which was added to the original undiluted sample.
      NOTE: This dilution procedure gives quantitative results only if the residual volume of methanol (or isopropanol) used for wetting the sample wipes was exactly the same as the volume used in preparing the calibration standards (normally about 3 mL, see Table 7). Deviations of a few milliliters in residual wetting alcohol will not affect the results for undiluted samples, but will amount to an error of a few percent in the final results of samples that are diluted.
   d. The potential error due to differences in residual wetting solvent can be estimated for specific volumes of desorption solution and wetting alcohol. Assume the sample wipes and calibration standards are both desorbed in 30 mL of desorption solution and 3 mL of alcohol is added to the calibration standards. The potential error in volume (and final results) in the samples is approximately ±3 % (inversely proportional) per mL difference in the residual alcohol in the samples (i.e., ±1 mL difference in 33 mL). For 40 mL of desorption solution and 4 mL of alcohol added to the calibration standards, the error is ±2 % for every mL difference (i.e., ±1 mL difference in 44 mL). However, since the volume of residual wetting alcohol is not known and cannot be determined once the sample wipe has been desorbed, the actual error cannot be determined. However, the maximum possible error can be calculated. Since the maximum amount of alcohol that a recommended wipe can hold is about 6 mL when saturated (dripping wet), there can only be a deviation of plus or minus 3 mL from the 3 mL alcohol added to the calibration standards. Therefore, the maximum error in a result due to differences in the volume of residual alcohol in a cotton gauze sample compared to the standards can only be three times the error for a 1 mL difference in volume. Since the error for ±1 mL is ±3.03%, the maximum error for ±3 mL is three times larger, or ±9.1%. In practice, the error will be less than this because it is unlikely that the gauze samples will be completely dry or completely saturated after squeezing out the excess alcohol and wiping a surface. The practical amount of alcohol that remains in the wipes when the excess is squeezed out is between 1 and 2 mL. This translates into an error that is between +3% and +6% in the final results for diluted samples. Undiluted samples will not be affected. This error is within the overall accuracy for the method for methamphetamine.

3. Dilution Procedure C (dilution of desorbates from dried samples):
   Dilution errors for over-range samples may be corrected by knowing the exact amount of residual alcohol in the samples. The volume (or weight) of residual solvent in each gauze wipe might be determined by the difference between a wet weight and dry weight. Better yet, the error might be eliminated for diluted samples by adding, after the samples are dried (without taking any weight), the same known volume of wetting alcohol that is added to the calibration standards (i.e., 3 mL). Thereafter, if any samples need dilution, there will be no dilution errors due to differences in residual alcohol, because all samples and standards will have the same volume of alcohol and total volume of desorption solution.

   However, air drying of the samples is not recommended because of the possible loss of methamphetamine due to its volatility when it is not in the salt form, which form cannot be assured in field samples. Also, manipulating the samples for weighing and drying might introduce contamination. Drying is not recommended as a procedure for analytes having a vapor pressure high enough to be lost in the process, or that tend to form azeotropes with alcohols; this is especially important when the critical action levels for remedial cleanup are at the lower end of the method calibration range. Drying is not an option if the samples have already been desorbed.