CONFIRMATION OF FENTANYL BY GAS CHROMATOGRAPHY - MASS SPECTROMETRY

4.1 POLICY

This test method may be used to confirm the presence of fentanyl in biological samples. Quantitative results obtained through the use of this method will only be reported within the validated dynamic range. Reporting of results following the application of this method will be contingent upon a thorough review and acceptance of quality control data and the qualification of individual results under the criteria for acceptance.

Any adjustments or deviations from the procedures below must be approved by either the State Toxicologist, a Manager, or a Supervisor, and appropriately documented in the batch file.

4.2 PURPOSE

The purpose of this standard operating procedure (SOP) is to provide technical direction for the identification and quantitation of fentanyl present in biological specimens. This procedure will serve as the laboratory document describing sample preparation, instrumental analysis, data analysis, criteria for acceptance and reporting of the specified compounds.

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4.3 PRINCIPLE

The targeted compound and internal standard are isolated from whole blood, serum, plasma, urine or other submitted biological samples by the use of solid phase extraction (SPE). Following SPE, the specimens, now termed extracts, are injected into a gas chromatograph (GC) where they are separated between a gaseous mobile and liquid stationary phase. Each compound exits the GC at a reproducible time which is termed its retention time.

The GC is coupled to a mass spectrometer (MS) detector equipped with an electron ionization source. As each compound is ionized in the source, selected-ion-monitoring is used to measure the mass-to-charge ratios of each compound and its related fragments. Multiple-point, internal standard calibration is used to generate a calibration curve. The concentration of any fentanyl identified in a sample is determined from its calibration curve.

4.4 SPECIMENS

2.4.1 The specimen volume is 1mL.

2.4.2 Specimens include whole blood, serum, plasma, urine, and tissue homogenate.

2.4.3 Dilutions of specimens may be analyzed at the Forensic Scientist's discretion; however, this should be done in addition to testing the standard specimen volume, unless sample quantity dictates otherwise.

2.4.4 Analysis of larger specimen volumes must be approved and documented.

4.5 REAGENTS, MATERIALS AND EQUIPMENT

4.5.1 REAGENTS

4.5.1.1 Acetic acid (Glacial)

4.5.1.2 0.1M Acetic acid

Add 5.72 mL glacial acetic acid to 800 mL DI H_2O. Dilute to 1 L with DI H_2O and mix. Store the acetic acid in a glass bottle for up to 6 months.

4.5.1.3 Ammonium hydroxide (concentrated)

4.5.1.4 Certified blank blood

4.5.1.5 Deionized water (DI H_2O)

4.5.1.6 Elution solvent

To 20 mL isopropanol, add 2 mL concentrated ammonium hydroxide and mix. Add 78 mL methylene chloride and mix. Store in glass bottle at room temperature and use on date of preparation only. Adjustments to final volume are permitted as long as the proportions of the elution solvent are maintained.

4.5.1.7 Ethyl acetate

4.5.1.8 Isopropanol (IPA)

4.5.1.9 Methanol

4.5.1.10 Methylene chloride (dichloromethane, CH_2Cl_2)

4.5.1.11 0.1M Phosphate buffer (pH6):

Dissolve 1.7 g Na_2HPO_4 and 12.14 g NaH_2PO_4 in 800 mL DI H_2O. Dilute to 1 L with DI H_2O and mix. Check the pH and, if necessary, adjust to 6 ±0.5. Store the buffer in a glass bottle at room temperature for up to one year.

4.5.1.12 Sodium phosphate, dibasic anhydrous (Na_2HPO_4)

4.5.1.13 Sodium phosphate, monobasic monohydrate ($NaH_2PO_4 \bullet H_2O$)

4.5.2 MATERIALS

4.5.2.1 Autosampler vials, inserts and caps

4.5.2.2 Disposable 16 x 100mm tubes

4.5.2.3 Disposable screw-cap tubes or centrifuge tubes with closures

4.5.2.4 Disposable pipette tips

4.5.2.5 Disposable safety closures for 16 x 100mm tubes

4.5.2.6 Extraction column: United Chemical Technologies' Clean Screen SPE cartridge (CSDAU206, 200mg/6mL), or equivalent

4.5.2.7 GC column (Agilent HP-5MS; 30 m x 0.250 mm i.d. x 0.250 μm film thickness, or equivalent)

4.5.2.8 Laboratory glassware (graduated cylinders, flasks)

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4.5.2.9 Volumetric glassware (flasks)

4.5.3 EQUIPMENT

4.5.3.1 Agilent GC (6890 or equivalent)

4.5.3.2 Agilent MS (5973 or equivalent)

4.5.3.3 Calibrated, adjustable air-displacement pipettes

4.5.3.4 Centrifuge

4.5.3.5 Evaporator (Caliper LS, formerly Zymark, TurboVap)

4.5.3.6 pH Meter and/or indicating pH paper

4.5.3.7 Vortex mixer

4.5.3.8 Vacuum manifold

4.6 STANDARDS, CALIBRATORS AND CONTROLS

4.6.1 STANDARDS

4.6.1.1 Reference materials (referred to interchangeably in this method as stock standards) are used for the preparation of working standards which in turn are used to produce calibrators, positive controls and the working internal standard.

4.6.1.2 Stock standards and stock internal standards are purchased from an approved reference material supplier and include the following:

a. Fentanyl: 1.0 mg/mL
b. Fentanyl-d_5: 0.1 mg/mL

4.6.1.3 Working standard (10 ng/µL)

a. Using a calibrated pipette, measure 100 µl of fentanyl stock standard into a 10 mL class-A volumetric flask.
b. Add methanol to the flask to the designated volume.
c. The final concentration of the working standard is 10 ng/µl. The working standard is stored in the freezer in an amber bottle and expires one year from the date of preparation.

4.6.1.4 Working internal standard (0.1 ng/µL)

a. Using a calibrated pipette, measure 25 µl of fentanyl-d_5 stock internal standard into a 25 mL class-A volumetric flask.
b. Add methanol to the flask to the designated volume.
c. The final concentration of the working internal standard is 0.1 ng/µl. The working internal standard is stored in the freezer in an amber bottle and expires one year from the date of preparation.

4.6.2 CALIBRATORS

4.6.2.1 Calibrators are prepared in certified blank blood at the time of analysis using the working standard. The preparation of the calibrators is detailed in 4.7 SAMPLE PREPARATION. If necessary,

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calibrators may be prepared in alternate matrices provided that the matrix has been previously determined to not contain any of the compounds tested for by this procedure.

4.6.3 CONTROLS

4.6.3.1 Negative Control

a. At least one negative whole blood control is tested with every batch. The negative control is prepared using certified blank blood.
b. When testing different sample types, wherever possible, include a negative control prepared from that matrix. (For example, when analyzing whole blood and urine samples the batch shall include at least one negative whole blood control and at least one negative urine control.)

4.6.3.2 Positive Controls

a. Two positive whole blood controls are tested with every batch. The positive controls are prepared using certified blank blood to which the designated volume of control working standard has been added.
b. Control stock standards are obtained from an approved reference material supplier.
c. The control stock standards must be either a different lot number or from a different supplier to those used in producing the working standards.
d. The control working standard (10 ng/μL) is prepared as described in 4.6.1.3.
e. The preparation of the positive whole blood controls is detailed in 4.7 SAMPLE PREPARATION. Alternatively, quality control personnel may provide in-house positive controls.
f. When testing different sample types, wherever possible, include at least one positive control prepared from that matrix.

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4.7 SAMPLE PREPARATION

4.7.1 Label a clean 16 x 100mm tube for each member of the test batch. (i.e. Calibrator, control, case sample)

4.7.2 Place 4 mL of DI H_2O into each tube.

4.7.3 Add 1 mL of certified blank whole blood into each of the six calibrator tubes, the two positive control tubes and the negative control tube(s).

4.7.4 Prepare a 1:10 dilution of the working standard. (1 ng/μL)

a. Using a calibrated pipette, combine 0.1 mL of the working standard with 0.9 mL of methanol in a labeled tube.
b. Cap and vortex mix. This dilution shall be disposed of after calibrator preparation.

4.7.5 Prepare a 1:100 dilution of the working standard. (0.1 ng/μL)

a. Using a calibrated pipette, combine 0.1 mL of the 1:10 dilution with 0.9 mL of methanol in a labeled tube.

b. Cap and vortex mix. This dilution shall be disposed of after calibrator preparation.

4.7.6 Using the working standard dilutions, spike the calibrators according to the following table.

Calibrator Description	Volume (µL) Added	Working Standard
Calibrator 1 (2.5 ng/mL)	25	0.1 ng/µl
Calibrator 2 (5.0 ng/mL)	50	0.1 ng/µl
Calibrator 3 (10 ng/mL)	100	0.1 ng/µl
Calibrator 4 (25 ng/mL)	25	1 ng/µl
Calibrator 5 (35 ng/mL)	35	1 ng/µl
Calibrator 6 (50 ng/mL)	50	1 ng/µl

4.7.7 Prepare a 1:10 dilution of the control working standard. (1 ng/µL)

a. Using a calibrated pipette, combine 0.1 mL of the control working standard with 0.9 mL of methanol in a labeled tube.
b. Cap and vortex mix. This dilution shall be disposed of after control preparation.

4.7.8 Prepare a 1:100 dilution of the control working standard. (0.1 ng/µL)

a. Using a calibrated pipette, combine 0.1 mL of the 1:10 dilution with 0.9 mL of methanol in a labeled tube.
b. Cap and vortex mix. This dilution shall be disposed of after control preparation.

4.7.9 Using the control working standard and the prepared dilution, spike the positive controls according to the following table.

Control Description	Volume (µL) Added	Control Working Standard
Control 1 (4.0 ng/mL)	40	0.1 ng/µl
Control 2 (20 ng/mL)	20	1 ng/µl

4.7.10 If in-house positive controls are being used, transfer 1 mL of each into their labeled tubes.

4.7.11 Sample 1 mL of each case sample into its respective tube.

4.7.12 Add 2 mL 0.1M phosphate buffer (pH6) to each tube and briefly vortex mix.

4.7.13 Add 50 µL of the working internal standard solution to each tube. Final concentration of the internal standard is 5.0 ng/mL.

4.7.14 Cap the tubes and briefly vortex mix. Centrifuge the tubes for 10 minutes at 3500 rpm.

4.7.15 Place new, labeled SPE columns into the vacuum manifold.

4.7.16 Condition the SPE columns by passing each of the following solvents completely through under force of gravity.

a. 3 mL methanol
b. 3 mL DI H_2O

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c. 1 mL 0.1M phosphate buffer (pH6)

Do not let columns dry out between each conditioning step.

4.7.17 Transfer the contents of each tube to its respective SPE column and allow them to flow through under force of gravity. (Moderate, positive pressure or vacuum may be applied if the flow is insufficient.)

4.7.18 Wash the SPE columns by passing each of the following solvents completely through under force of gravity. (Moderate, positive pressure or vacuum may be applied if the flow is insufficient.)

a. 3 mL DI H2O
b. 1.5 mL 0.1M acetic acid
c. 3 mL methanol

4.7.19 Dry the columns for 10 minutes under vacuum.

4.7.20 Place clean, labeled screw-cap tubes or centrifuge tubes in the collection rack underneath their corresponding SPE columns.

4.7.21 Pass 3 mL of elution solvent through each SPE column and collect the extracts.

4.7.22 Transfer the tubes to the evaporator and evaporate the extracts to dryness at 50°C.

4.7.23 Reconstitute the extracts by the addition of 50 µL ethyl acetate to each tube. Briefly vortex mix the tubes. If necessary, centrifuge the tubes for 2 minutes at 2000 rpm to collect the extracts at the bottom of the tubes.

4.7.24 Transfer the extracts to labeled glass autosampler vials and cap.

4.8 INSTRUMENTAL PARAMETERS

The instrumental parameters can be found in Appendix A. Prepare a sequence table by first setting the data path in ChemStation to the date of the test. After entering all vial locations, sample descriptions, comments and/or lot numbers in the sequence table ensure that the method listing in the table is FENTSIMSPE.M for each line.

4.9 DATA ANALYSIS

4.9.1 Analysis of the batch data is conducted using the instrumental data analysis software in ChemStation.

4.9.2 Quantitative calculations are generated by internal standard, multi-point, linear regression with a 1/a (inverse of concentration) weighting factor. The calibration curves are updated using the calibrator results for the batch; no historical calibration curves are permitted.

4.9.3 Printed reports for each vial in the batch are generated for review along with the updated calibration curves.

4.9.4 Technical review of the batch is conducted according to the criteria listed below.

4.10 CRITERIA FOR BATCH ACCEPTANCE

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If the analysis of the batch meets the criteria listed below, the results for the specimens are accepted.

4.10.1 Calibrators and calibration curves

4.10.1.1 Chromatographic peaks for fentanyl and internal standard shall appear symmetrical (i.e. no co-elution, split peaks, or shoulders).

4.10.1.2 Retention times shall be within ±2% and ion ratios shall be within ±20% of those in calibrator 4. These are inclusive ranges.

4.10.1.3 Quantitative results for fentanyl in each calibrator shall be within ±20% of their target values with the exception of calibrator 1 which shall be within ±25% of its target. These are inclusive ranges. Result comparisons will use values truncated after the first decimal place in units of ng/mL.

4.10.1.4 The calibration curve for fentanyl shall have a correlation coefficient ≥0.99.

4.10.2 Controls

4.10.2.1 The negative control(s) shall not identify fentanyl above its limit of detection. Identification is based on a) acceptable retention time matching, b) distinct peaks present for all selected ions, and c) acceptable ion ratios.

4.10.2.2 Positive controls

a. Chromatographic peaks for fentanyl and internal standard shall appear symmetrical.
b. Retention times shall be within ±2% and ion ratios shall be within ±20% of those in calibrator 4 for fentanyl in the positive control. These are inclusive ranges.
c. Quantitative results for fentanyl in each control shall be within ±20% of their target values. These are inclusive ranges. Result comparisons will use values truncated after the first decimal place in units of ng/mL.
d. At least one positive control must meet these criteria for fentanyl for the batch to be accepted.

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4.11 CRITERIA FOR CASE SAMPLE ACCEPTANCE

If the criteria for batch acceptance have been satisfied, the results of individual case samples are deemed suitable for reporting if the following criteria are met.

4.11.1 Any chromatographic peak for fentanyl shall appear symmetrical.

4.11.2 The retention time for fentanyl is ±2% and the ion ratios are within ±20% of those in calibrator 4. These are inclusive ranges.

4.11.3 The quantitative result for fentanyl must be within the dynamic range of the test method.

4.11.4 When dilutions of case samples are tested, the quantitative result(s) before multiplication shall be within the dynamic range of the test method.

4.12 REPORTING

4.12.1 Results are truncated after the first decimal place and reported in units of nanograms per milliliter (ng/mL).

4.12.2 Results are truncated to no more than two significant figures for reporting.

a. Example 1: fentanyl is measured as 3.75 ng/mL.

b. The result is truncated to 3.7 ng/mL (two significant figures) and reported.

c. Example 2: fentanyl is measured as 12.31 ng/mL

d. The result is truncated to 12.3 ng/mL, but reported as 12 ng/mL (two significant figures).

e. Example 3: fentanyl is measured as 10.76 ng/mL

f. The result is truncated to 10.7 ng/mL (three significant figures), but reported as 10 ng/mL (one significant figure).

4.12.3 When multiple dilutions are analyzed, the smallest dilution within the dynamic range is reported.

4.13 METHOD PERFORMANCE

4.13.1 Limit of detection: 1 ng/mL

4.13.2 Lower limit of quantification: 2.5 ng/mL

4.13.3 Dynamic range: 2.5 ng/mL to 50 ng/mL

4.13.4 Upper limit of quantitation: 50 ng/mL

4.14 TRACEABILITY

4.14.1 Traceability of the reference materials to SI units is provided through the certificate of analysis provided by the approved reference material supplier.

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APPENDIX A
INSTRUMENTAL PARAMETERS

GAS CHROMATOGRAPH

Split/Splitless Inlet	
Mode	Splitless
Temperature	260° C
Split Ratio	N/A
Gas Type	Helium
Gas Saver	Off
Gas Saver Flow	N/A
Gas Saver Time	N/A
Autosampler	
Injection Volume	2.0 µL
Solvent Wash A	3 (Ethyl acetate)
Solvent Wash B	3 (Ethyl acetate)
Sample Pumps	2

Oven/Column	
Carrier Gas Mode	Constant Flow
Carrier Gas Flow	1.2 mL/min
Initial Temperature	140° C
Initial Time	0.50 min
Ramp Rate	20° C/min
Final Temperature	290° C
Final Time	3.0 min
Transfer Line Temp	280 ° C

MASS SPECTROMETER

Solvent Delay	8.00 min	MS Quad Temperature	150° C
EM Offset	+200V	MS Source Temperature	230° C
Resolution	Low	Dwell Time	50 msec
Signals	Ions	Ion Ratios	
Fentanyl	245, 189, 146	189/245, 146/245	
Fentanyl-d_5	250, 194	250/194	

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LIST OF CHANGES

Revision Date	Description	Page Number
09/01/11	Method approved by Washington State Toxicologist. See DRA dated 8/23/11. Method released for use in evidentiary testing on 09/01/11.	All
10/10/11	Preparation of working internal standard corrected for concentration & volume (4.6.1.4) and final concentration corrected in sample preparation (4.7.13).	3 & 5

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