Analysis of Samples Obtained from a Potential Methamphetamine Lab.

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Abstract

Drug tablets and an unknown liquid with white powder were found at a scene that is suspected to be a methamphetamine lab. A method was developed to analyze these samples for pseudoephedrine via LC-MS and GC-MS. Data at this time seem to indicate that most of these samples do not contain pseudoephedrine. There is still some method optimization that is needed in order to determine the presence of pseudoephedrine in the unknown samples with confidence.

Introduction

On Thursday, January 15, 2009, a 911 call was received from the vicinity of Butler University. The Indianapolis Metropolitan Police Department referred the matter to the Meth Suppression Section of the Indiana State Police because there were many indications of a methamphetamine lab at the scene. The police identified two individuals who were seen fleeing the scene. During a search of the crime scene evidence collected included fire debris, pills, pens, documents, explosive powders, and exploded plastic fragments. The evidence was submitted to Butler University for forensic testing. Acting as a cohesive crime lab, four units—arson analysis, document analysis, drug analysis, and explosive analysis—were employed to examine the evidence.

According to the U.S. Drug Enforcement Administration (DEA), Indiana had the second highest rate of methamphetamine incidents in 2006, 2007, and 2008 (1). Methamphetamines are a popular drug due to readily availability of manufacturing methods on the internet (2-4). The structure of methamphetamine is displayed in Figure 1.

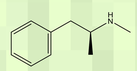

Figure 1. Methamphetamine

Currently, the two most popular methods of manufacturing methamphetamine involve the use of pseudoephedrine (or its stereoisomer, ephedrine) as starting materials. These compounds are displayed in Figure 2. The first method reduces *l*-ephedrine or *d*-pseudophedrine over red phosphorous and hydroiodic acid (5-6), the second method reduces these compounds using sodium or lithium metal in condensed liquid ammonia (6). Forensic chemists are able to determine the chosen method of synthesis by analyzing the trace compounds in the sample (4). These trace compounds constitute unreacted precursors, intermediates, or unintended by-products and are often indicative of the synthesis method used to manufacture the illicit drug.

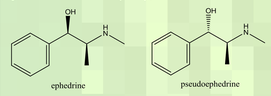

Figure 2. Ephedrine and pseudoephedrine.

LC-ESI-MS was chosen as the primary means of drug analysis for our samples because it is one of the more common instruments for analytical analysis of amphetamines (7-9). GC-MS was chosen as a confirmatory method of analysis because of its ease of use and quick analysis.

As part of the drug unit, tablets and clear liquids suspected to be methamphetamine precursors were examined. According to the U.S. Drug Enforcement Administration, two indicators of a clandestine laboratory are a large amount of cold tablets containing ephedrine as an active ingredient and jars containing clear liquid with a white or red colored solid on the bottom. The samples recovered are to be identified to determine if the crime scene was a methamphetamine clandestine laboratory.

Experimental

Evidence obtained from the scene of the crime for analysis include: an unopened blister pack of white pills containing 120 mg pseudoephedrine hydrochloride per pill, a second unopened blister pack of white pills containing 1.34 mg clemastine fumarate per pill, unknown white pills with the inscription “RX724”, unknown white pills with the inscription “44-526”, and a small bottle with an unknown organic liquid and an insoluble white powder. A pill casing fragment with the partial inscription “RX72” was found mixed in the mysterious white powder.

Solution and sample preparation: Ephedrine standards for analysis by LC-MS were prepared by dissolving ephedrine in the mobile phase solution (80:20, acetonitrile:water). These solutions were sonicated to ensure complete dissolution. Solutions as low as 200 ppb ephedrine were detectable with our method. All tablet samples were prepared by grinding the tablets into a powder form, and dissolving a small amount (~ 12 mg) in the LC mobile phase. The samples were then sonicated to ensure complete dissolution. The solution was then filtered through a nylon membrane filter (with a 0.2 µm pore size) to remove any undissolved tablet particles. The unknown liquid evidence sample was prepared by removing the solvent via rotary evaporation. This is necessary so that the solvent will not interfere with the mobile phase. The resulting residue was dissolved in the mobile phase solution, and then filtered through a nylon membrane filter (with a 0.2 µm pore size).

Instrumental Specifications

LC-MS/MS

A Varian LC-ESI-MS/MS was used for the analysis of ephedrine in the presented evidence. The pumps were programmed to deliver 20 % water and 80 % acetonitrile until 6.75 minutes into analysis, where the pumps would deliver only acetonitrile to flush the column. A Varian 5 µm Polaris C18-A column (model no. A2000050X020) with dimensions of 50 × 2.0 mm and a silica reverse phase (Polaris 180 Å pore size) stationary phase was used for separation.

Samples were injected with a ProStar 410 autosampler, with sample injection volumes of 100 µL. A Varian 310 Quadrupole Mass Spectrometer was equipped to the LC. The ESI configuation was adopted from Chi-Chi Chou’s method of amphetamine analysis (12). The concentration of ephedrine was observed in single ion monitoring (SIM) mode at 167.0 amu in positive ion mode.

GC-MS

The Varian CP-3800 GC was equipped with an AT-5ms capillary column (30 m × 0.32 mm × 1.00 µm film thickness) with a stationary phase consisting of 5 % phenyl and 95 % dimethylpolysiloxane (Alltech Associates, Inc.). The oven temperature was programmed with an initial temperature of 50 °C held for 1 min, followed by an increase of 20 °C/min to 260 °C, and then held for the remainder of the analysis. The injector temperature was held constant at 260 °C. Helium was used as a carrier gas at a constant column flow rate of 1.0 mL/min. The GC was also equipped with a Saturn 2000 MS/MS ion-trap mass spectrometer with a mass range of 35-550 (*m/z*).

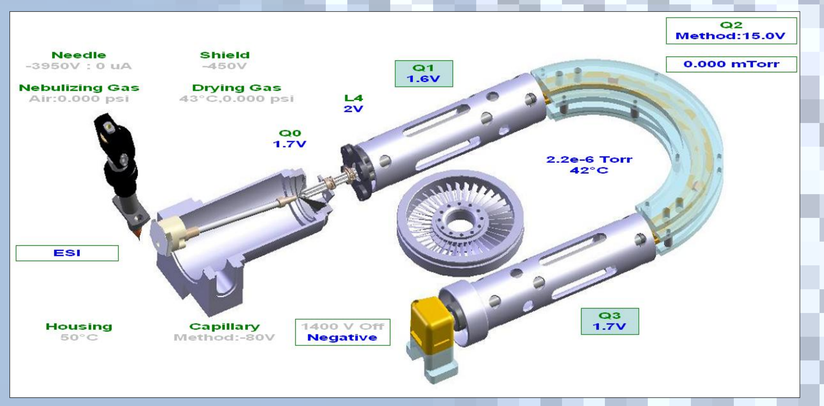

Figure 3. Diagram of the ESI-MS/MS utilized in the LC-MS

LC-MS Methodology

In the LC portion of the instrument, a column is used to separate the various compounds in the sample by polarity. As the analyte elutes off the column, the solution is ionized by a charge potential as it is ejected from a needle. This is called electrospray ionization (ESI). This produces heavily charged droplets that burst apart due to electrostatic forces. This effectively vaporizes the solvent and the analyte, ionizing them in the process. The charged analyte moves through the first quadruple, essentially selecting ions with a certain charge-to-mass ratio. This is done to filter out any extraneous and unwanted compounds. This ESI-MS/MS is diagramed in Figure 3.

In SIM (single ion monitoring) mode, these filtered ions are sent directly to the detector. If in MS/MS mode, the filtered ion travels through a second ionizer, where it is fragmented into several other ions that are characteristic of that ion. One of these particular ions is allowed to pass through the third quadrupole (while simultaneously filtering out the other ions). This ion is then sent to the detector. SIM mode is more sensitive, but MS/MS mode is much more selective. All analyses were performed in SIM mode.

Results and Discussion

LC-MS Analysis

A calibration curve was generated for 200, 500, and 1000 ppb ephedrine standards in 80:20 acetonitrile:water, shown in Figure 4. These calibration standards were run in quadruplicate for qualitative purposes. The minimum detection limit was calculated to be 63 ppb.

There were several problems encountered during LC-MS analysis which led to odd peak formation and a large amount of noise. Higher concentrated samples tended to yield chromatographic peaks with shoulders and trailing. This could be a factor of column overloading, where the stationary phase becomes temporarily ineffective due to a nearly total occupancy of the stationary phase by the eluting compounds. This, in turn, can lead to erratic peak shapes and irreproducible results.

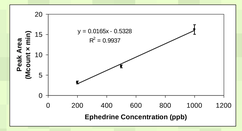

Figure 4. The calibration of the three ephedrine standards for the LC-MS.

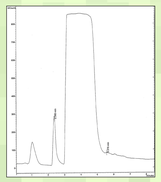

Figure 5. LC-MS chromatogram of tablet with known amount of pseudoephedrine

Mock samples made from a pill with a known amount of pseudoephedrine (240 mg) indicated that ephedrine was able to be detected in drug tablets using this method of analysis. The LC-MS chromatogram of this sample is displayed in Figure 5. The immense size of the 167 amu peak in the 3.0 to 5.0 min retention time range is a good indication of the presence of pseudoephedrine in the sample. It should be noted that this peak tops-out nearing the Gcount range. This is probably due to column overloading and the upper limit of the mass detector’s capabilities.

The two unknown pill samples (RX724 and 44-526) were prepared and analyzed by LC-MS. There were no distinguishable peaks in either of the chromatograms. This indicates that there probably is no pseudoephedrine present in either of these two samples. The unknown liquid sample also does not appear to contain pseudoephedrine. This chromatogram is displayed in Figure 6. The conclusions for this sample are similar to the RX724 and 44-526 tablet samples.

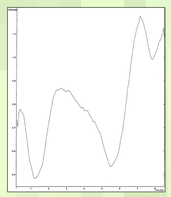

Figure 6. LC-MS chromatogram of the unknown liquid.

GC-MS Analysis

An ephedrine standard was made in an 80:20, acetonitrile:water solution and analyzed via GC-MS. The GC chromatogram obtained is shown in Figure 7. The peak for this compound is very broad, with a retention time range of about 9.0 to 12.0 min. The corresponding mass spectrum of ephedrine is displayed in Figure 8. The 58 m/z base peak in Figure 8 was used as the basis for determination of ephedrine in the GC-MS data in addition to the retention time range.

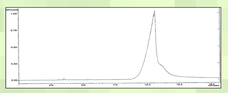

Figure 7. GC chromatogram for ephedrine standard.

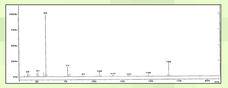

Figure 8. Generated mass spectrum of ephedrine.

Shown in Figure 9 are the GC chromatograms obtained for the RX724 and 44-526 tablet samples. There is one peak consistent in both tablets that fall within the ephedrine retention time range. This peak lies at 9.7 min and does not contain a 58 m/z peak. It appears that there is no pseudoephedrine in either of these samples using this method. This also seems to be the case for the unknown liquid, whose GC chromatogram is displayed in Figure 10. There are more peaks that fall in the 9.0 to 12.0 time range, but none of them display a significant 58 m/z mass peak.

Because it appears that the unknown liquid and powder mixture was generated from the RX724 tablets, a comparison of these two GC chromatograms has shown that there are seven peaks consistent between these two samples. The uncorrelated peaks in the unknown liquid may indicate other dissolved solids and/or the composition of the solvent.

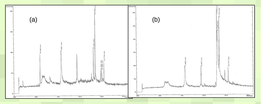

Figure 9. GC chromatograms of RX724 (a) and 44-526 (b) tablets.

The white powder mixed with the unknown liquid was isolated and attempted to be dissolved in a variety of different solvents, including water, acetonitrile, dichloromethane, ethanol, chloroform, and diethyl ether. None of these solvents (or combinations thereof) seemed to dissolve this solid. This indicates that the mysterious white powder probably contains some other insoluble powder in addition to the RX724 tablets.

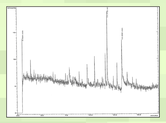

Figure 10. GC chromatogram of the unknown liquid.

Conclusions

Although it appears that no pseudoephedrine was detected in the RX724 tablets, the 44-526 tablets, the unknown liquid, or the mysterious powder, this does not mean that pseudoephedrine is not present. The RX724 and 44-526 tablets may contain other common methamphetamine precursors, as may the liquid and powder. The liquid and powder samples may also be the remains of an ephedrine extraction. The ephedrine that may have once been a part of the powder could have been isolated before police arrived on the scene.

The problems that arose during the LC-MS method development adds some uncertainty to the data generated from that instrument. Also, problems associated with ephedrine peak broadening (and possible rearrangements) as well as the solubility issues with the white powder add uncertainty to the data generated using the GC-MS method. The most significant loss of uncertainty probably results from the sole focus on ephedrine and pseudoephedrine. Although it is the most popular synthesis starting material, analysis for only pseudoephedrine is not comprehensive enough to determine if a methamphetamine lab was present or not at the crime scene. All of these factors should be considered for future work in determining the existence of a methamphetamine lab.

Future Work

Better parameters could be generated for the LC-MS to reduce noise and simplify peak shape. Autointegration parameters could also be adjusted to apply to our analyses.

The GC-MS could be used in SIM mode to observe the 58 m/z base peak of ephedrine. This would greatly simplify the detection and analysis of ephedrine using GC-MS.

A better sample preparation method for the unknown liquid and powder is necessary in order to confidently determine the presence of pseudoephedrine. Also, analysis of the solvent itself may give insight into the purpose of the liquid-powder mixture as a possible indicator of a clandestine lab.

Acknowledgements

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