APPLICATION NOTE

Gas Chromatography/ Mass Spectrometry

Authors:

Ethan McBride

Guido Verbeck

University of North Texas
Denton, TX

Zachary Lawton

PerkinElmer Inc.
Shelton, CT

Rapid In-Field Screening for Fentanyl Analogs Using Coiled Microextraction and Portable GC/MS

Introduction

In recent years there has been an increase in fatalities related to the use and consumption of opioids, a class of synthetically manufactured pain-relieving drugs similar to naturally derived opiates like morphine, opium, codeine, and heroin. When properly administered with the correct dosages, opioids serve as fast-acting solutions to severe pain management and have earned a place on the World Health Organization's List of Essential Medicines.[1] Unfortunately, the high-risk factor for physical dependence and the accompanying euphoric sensations that both opioid and opiate type drugs possess has led to significant misuse and abuse on a global scale. In 2017, the United Nations World Drug Report stated that worldwide a considerable proportion of fatalities, as well as 70 percent of diseases acquired through drug use, were attributed to opioids.[2] The severity of this issue has become particularly evident in the United States, where the misuse of pharmaceutical opioids, coupled with an increase in heroin and fentanyl use has resulted in the death rate tripling from 16,849 to 52,404 annually from 1999 to 2015.[2]

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While the misuse of prescription opioids and opiates plays a significant factor in the on-going epidemic, the opioid market is becoming more diversified with an increase of new drugs referred to as new psychoactive substances (NPS). NPS are produced in clandestine laboratories across the world and have been found in counterfeit medicines made to took like pharmaceutical products while containing fentanyl analogs, as well as non-opioid substances.[2] Counterfeit drugs and heroin seized after fatal overdoses have been found to include fentanyl analogs such as acetyl fentanyl, 3-methylfentanyl and the highly potent opioid carfentanil, a veterinary painkiller used for large animals that is ~10,000 times as strong as morphine.[3] The variations in potency and quantity of active components in counterfeit pills and powders is a threat to users, as well as the first responders that are exposed to the drugs at clandestine laboratories and intercepted through drug trafficking efforts. The severity of the opioid epidemic prompts the need for an analytical solution capable of safely screening confiscated drugs of abuse and clandestine laboratories for the presence of fentanyl analogs.

Gas Chromatography-Mass Spectrometry (GC/MS) has been the "gold standard" for the identification of controlled substances for decades, as it allows for the detection of a broad range of analytes in diverse sample mixtures. Typically samples prepared for GC/MS are collected on-site and transported to a forensic laboratory for analysis, but this process can take months due to current case backlogs and lengthy analysis times (15 – 60 minutes) associated with traditional benchtop units.[4,5] An alternative approach to reducing the time between collection and analysis is to bring the laboratory to the scene by employing portable GC/MS technology with rapid sampling techniques to acquire actionable results.

This application demonstrates the use of the novel Custodion® Coiled Microextraction (CME) syringes and the Torion® T-9 Portable GC/MS as a fast and easy to use screening tool for drugs of abuse and new psychoactive substances (NPS) in the field. Here in we report, the use of the Torion T-9 Portable GC/MS to screen for three opioids (fentanyl, acetyl fentanyl, and carfentanil) commonly found in clandestine laboratories, as well as cutting agents in counterfeit medications and heroin. Data acquired was matched to Wiley Designer Drug Library through Chromion Software resulting in ~8 minutes from sample collection to identification.

Custodion® Coiled Microextraction

Coiled Microextraction (CME) is a novel sampling technique created by PerkinElmer Inc. that combines liquid sample collection and preparation into a single device for sampling explosives and drugs of abuse in the field. The coiled wire within the Custodion-CME syringe consists of an inertium treated wire that is finely coiled to trap liquid samples. The hardened plastic design of the Custodion handle with the simplicity of a retractable ball-point pen enables users to deploy the CME wire with the ease of a single button press. The modest design and flexible blunt tip allow users equipped with personal protective equipment (PPE) to freely collect samples with one hand while avoiding the safety concerns of a traditional sharp syringe.

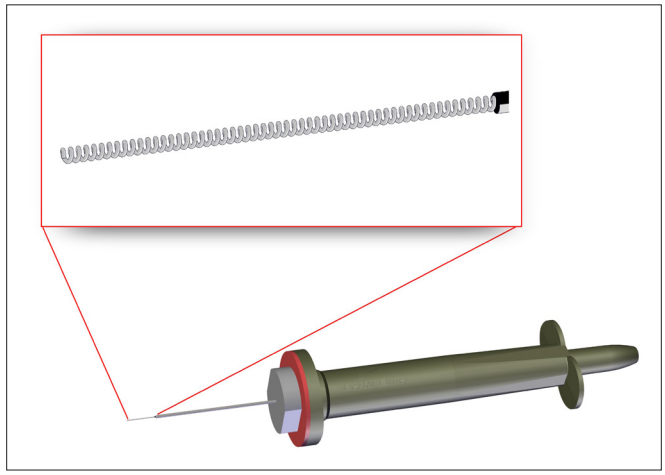

Figure 1. Custodion® Coiled Microextraction (CME) syringe with an extended coiled wire.

Torion T-9 Portable GC/MS

Built for portability and rapid analysis the Torion® T-9 Portable GC/MS provides the equivalent chromatographic performance to a benchtop system in a fraction of the time. Torion technology integrates a low thermal mass (LTM) capillary gas chromatograph with a miniaturized toroidal ion trap mass spectrometer to provide a fast, reliable and easy-to-operate GC/MS while minimizing power consumption to operate in the field. At a total weight of 32 pounds (14.5 kg) and a suite of versatile sample collection devices, the Torion T-9 is deployed on-site to quickly screen environmental volatiles and semi-volatiles (VOCs/SVOCs), drugs of abuse, explosives, chemical threats and hazardous substances.

Experimental

Sample Preparation

Analytical grade standards of fentanyl, acetyl fentanyl, carfentanil, and heroin were obtained from Cerilliant Corp. (Round Rock, TX, USA) at 1.0 mg/mL concentrations. Mock clandestine laboratory samples of fentanyl, acetyl fentanyl and carfentanil were synthesized at University of North Texas (Denton, TX, USA).

Sample collection and injection was accomplished by a Custodion-CME syringe. For analytical standards, a gas-tight syringe was used to apply 5 µL of solution directly to the coiled wire and left to dry 3-5 minutes to ensure repeatability. For on-site screening of laboratory synthesized materials, residual products from glassware were diluted in a suitable solvent (methanol or acetonitrile). Once fully dissolved, the tip of the coiled wire was extended, and submerged in the solution for 10 seconds as shown in Figure 2. The coiled wire was removed from the solution and left to dry 3-5 minutes to minimize the excess solvent entering the system, before direct injection into GC/MS for analysis.

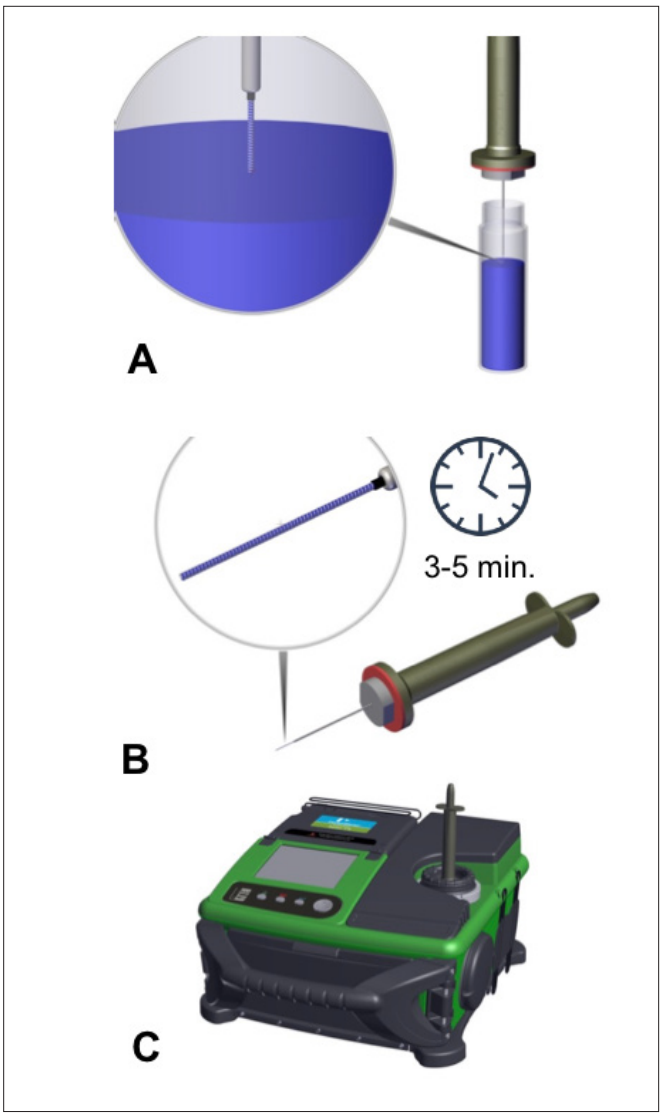

Figure 2. Representation of the sample collection and injection process using CME.

Table 1. GC/MS Method Parameters.

Sampling	Coiled Microextraction (CME)
Injection Type	Splitless
GC Injector Temp.	270 °C
GC Column	MXT-5, 5 m x 0.1 mm, 0.4 μm d_f
GC Column Temp.	50-300 °C at 2 °C/s, hold for 60 s
GC Carrier Gas	Helium, 0.2 mL/min.
Transfer Line Temp.	250 °C
Ionization Source	In-trap Electron Impact (EI)
Mass Analyzer	Toroidal Ion Trap
Mass Range	41 - 500 Da
Detector	Electron Multiplier
Resolution	< 0.5 m/z at 300 amu, nominal unit mass at 500 amu

Results and Discussion

Figure 3 shows the GC/MS analysis of carfentanil in methanol. All compounds were detected and positively identified by the Torion T-9. For identifying fentanyl analogs, an onboard deconvolution algorithm was able to positively identify and match MS data to the Wiley Designer Drug 2017 Library.

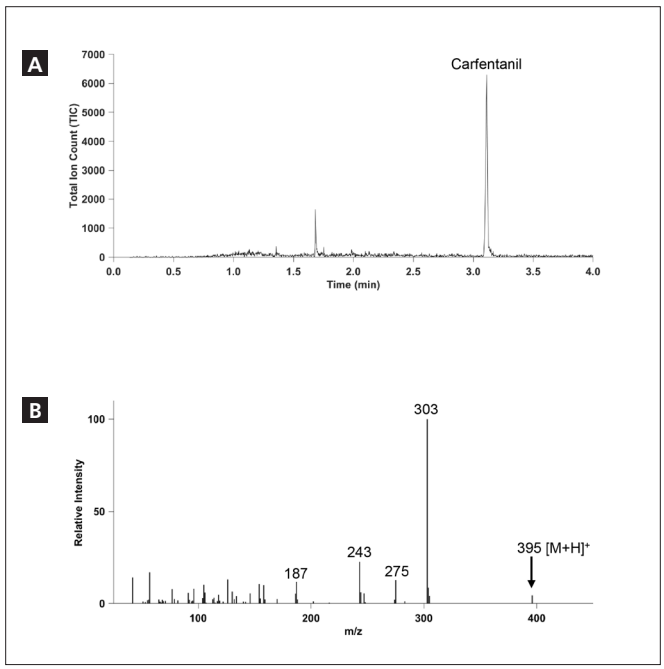

Figure 3. CME-GC/MS analysis of 100 mg/mL solution of carfentanil in methanol. (A) TIC of carfentanil. (B) Positive ion mass spectrum of carfentanil, showing the pseudomolecular ion at *m/z* 395.

The Torion T-9 CME-GC/MS method successfully collected, analyzed and identified the compounds of interest in relevant forensics scenarios involving adulterated heroin and synthesized fentanyl analogs. Figure 4 shows the CME-GC/MS analysis of a heroin solution containing 5% fentanyl diluted in methanol to demonstrate the capability of screening adulterated solutions. Figure 5A shows the CME-GC/MS analysis of residual products collected from glassware used in the synthesis of fentanyl analogs prepared at University of North Texas. Post-processing and MS matching resulted in the identification of fentanyl collected directly from laboratory glassware. Figure 5B shows the MS data compared to a NIST reference to highlight the differences between the toroidal ion trap and quadrupole mass analyzers. The differences in peak intensities and the presence of the pseudo-molecular ion [Fentanyl+H]$^+$ at *m/z* 337 is due to collision-induced dissociations that occur in ion trap mass analyzers.

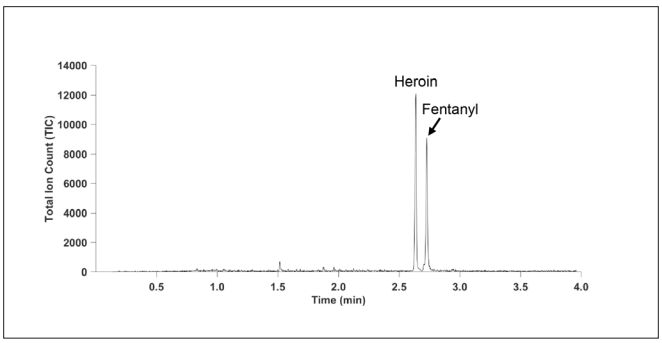

Figure 4. CME-GC/MS analysis of a heroin solution containing 5% fentanyl in acetonitrile.

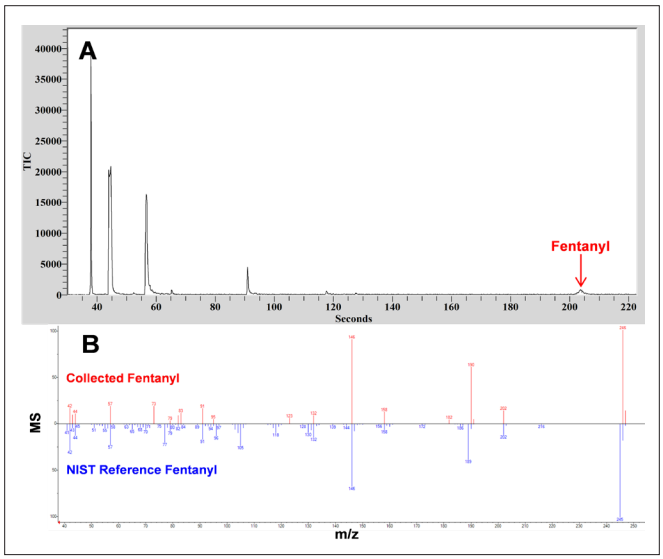

Figure 5. CME-GC/MS analysis of glassware used to synthesize fentanyl diluted in acetonitrile. (A) TIC of fentanyl and additional products from the fentanyl synthesis. (B) MS comparison between fentanyl collected with Torion T-9 (Blue) and NIST reference spectra (Red).

Conclusions

Fentanyl, acetyl fentanyl, carfentanil, and heroin were collected and identified using Custodion Coiled Microextraction (CME) syringes with the Torion T-9 Portable GC/MS in relevant drug screening scenarios. The CME-GC/MS technique coupled with Wiley Designer Drug Library provided rapid identification of drugs of abuse and new psychoactive substances (NPS) in less than eight minutes, with a simplified approach to minimize user interaction from potentially harmful evidence and allow in-field screening.

References

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PerkinElmer, Inc.
940 Winter Street
Waltham, MA 02451 USA
P: (800) 762-4000 or
(+1) 203-925-4602
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