

Gas Chromatography / Mass Spectrometry

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Rapid Identification of Illicit Drug Substances Using Thermal Desorption Coupled with a Portable Toroidal Trap GC/MS System

and miniaturization of GC/MS instrumentation are making this technique available for in-field investigators and researchers, which offers a simple, prompt, and onsite identification of a drug substance. This study describes the injection, separation, and identification of 16 drugs compounds in less than 10 minutes using portable gas chromatograph-toroidal ion trap mass spectrometry (PerkinElmer, Torion® T-9 Portable GC/MS) combined with a coiled-wire-filament (CWF) sampling injector to provide an effective tool for onsite analysis of illicit drugs substances.

Introduction

The misuse of drug substances creates the need for advancements in the ability to rapidly determine the type of chemical compound present. Gas chromatography-mass spectrometry (GC/MS) has regularly been used by scientists to detect the presence of pain medication in the laboratory. Fortunately, novel innovation

Torion T-9 GC/MS Technology

The original system and its applicability for field-based analysis are described previously in the open literature^{1,2}. However, a number of recent improvements have been realized by replacing the conventional capillary column with a low thermal mass (LTM) column bundle using direct-contact electrical resistive heating. This column provides identical heat distribution, but virtually eliminates cooler spots at the ends of traditional column technology, thus improving the chromatographic separation required for high boiling point compounds.

The mass spectrometer uses a toroidal ion trap configuration, which is well suited for miniaturization compared to other designs. The novel configuration allows for large trapping volumes resulting in high ion counts, low noise levels and good spectral quality. The ion trap mass analyzer is heated to ~175 °C and operates under vacuum, which results in the electrodes staying clean for long periods, reducing the need for frequent maintenance.

The instrument also uses retention time indices and an on-board spectral library to identify compounds of interest. Its performance is enhanced by deconvolution algorithms to ensure reliable identification of even co-eluting compounds in complex mixtures. When used in conjunction with an extensive NIST database and custom built target compound libraries, unknown peaks can be positively identified using known standards by non-experienced personnel in the field. For a detailed description of the Torion T-9 GC/MS technology and its application capability please refer to the following citations^{3,4}.

Sample Preparation Module

The capability and flexibility of this GC/MS technology can be further improved by the use of a compact, battery-operated, rugged sampling accessory (SPS-3, PerkinElmer Inc., Shelton, CT) for use in the field⁵. The choice of rapid sampling modules include:

- Heated headspace (HS) for volatiles in solid and liquid samples
- Purge and trap (P&T) for volatiles in liquid (aqueous) samples
- Thermal desorption (TD) for volatiles using a conventional TD tube
- Internal standard addition module

All of these modules require the use of the needle trap (NT) to transfer the analytes to the GC/MS. In addition to the SPS-3™ sampling module, the needle trap can be used independently to sample gases without the sampling module, while solid phase micro-extraction (SPME) can be utilized for gas and liquid samples and a coiled wire filament (CWF) can be used for semi volatiles dissolved in solvent samples. For this particular study, CWF without the SPS-3 was the sampling device of choice.

Let us now take a more detailed look at a method for the separation and identification of 16 painkilling drugs of abuse using this technology.

Sample Preparation and Analysis

Methanol solutions (1.0 mg/mL) of standard drug samples (methamphetamine, tapentadiol, methadone, cannabidiol, hydrocodone, morphine, hydromorphone, codeine, diazepam,

oxycodone, cannabinal, oxymorphone, fentanyl, clonazepam, alprazolam, and buprenorphine) were purchased (Cerilliant®, Round Rock, Texas) for the investigation. A single mixture of all 16 drugs was prepared (60 µg/mL). Prior to injection, and to eliminate backflash of the methanol within the injector of the gas chromatography toroidal mass spectrometer (GC-TMS), the sample was first added to a novel deactivated stainless steel CWF with subsequent evaporation of methanol at room temperature and pressure under a fan (1 – 5 min). Upon introduction of the CWF into the injector of the GC-TMS, the compounds were thermally desorbed.

The sample was applied to the CWF by the following two methods:

- Direct application of a measured volume using a 10 µL syringe
- Dipping the coil

Direct application employing a syringe allowed for known and variable (0.5 – 10 µL) sample volumes to be applied consistently to the CWF. Larger volumes (5 – 10 µL) required extended drying time (3 – 5 min). Dipping resulted in approximately 0.5 µL of sample coating the coil. Drying time was consistently 1 min. Once dry, the CWF containing the sample was ready for further analysis. The CWF was introduced into the injection port of the GC-TMS and the coil exposed for 20 s. The gas chromatographic separation conditions and mass spectrometer parameters are shown in Tables 1 and 2, respectively.

A custom user-defined compound library was created with individual drug standards to determine drug retention times and mass fragmentation patterns. The library was subsequently used to identify the mixture of 16 target analytes employing an on-board deconvolution algorithm for the drugs that co-eluted.

Table 1. The chromatographic separation conditions for a suite of illicit drugs.

Gas Chromatographic Separation Conditions	
Sample Delivery	Coiled Wire Filament Injection
Injection Type	Splitless
Split Injection Times	
50:1 Split On	20 s
50:1 Split Off	60 s
Injector Temperature	275 °C
Column Technology (Restek®, State College, PA)	MXT® -5: low-polarity phase diphenyl dimethyl polysiloxane; 5 m x 0.1 mm x 4 µm
Initial Temperature/ Hold Time	40 °C for 20 s
Temperature Ramp Rate	1.25 °C/sec
Final Temperature/Hold Time	300 °C for 147 s
Total Analysis Time	375 s

Table 2. Mass Spectrometer Parameters.

Mass Spectrometer Operating Conditions	
Mass Spectrometer	Toroidal Ion Trap
Ionization Source	Electron Impact
MS Operating Temperature	160 °C
Mass Range	45-500 amu
Resolution	< 0.5 m/z at 300 amu
MS Scan Rate	10-15 scans/sec
Detector	Electron Multiplier

Results and Discussion

Figure 1 shows a chromatogram of all 16 drugs when direct application of 5 μL of a drug mixture (60- $\mu\text{g}/\text{mL}$ of each drug) was applied to the CWF prior to injection. Twelve of the 16 drugs have unique retention times and ten can be separated with baseline resolution.

Although, two pairs of drugs (hydrocodone/morphine and cannabino/hydromorphone) co-elute as seen in Figure 2, their mass spectra are significantly different, which can then be deconvoluted and identified employing the on-board algorithm, as exemplified in Figure 3. Under ideal conditions, the whole identification and confirmation process requires approximately 8 – 10 min.

Although all 16 drugs were simultaneously identified with a direct application of 5 μL (~300 ng/drug) to the CWF, as seen in Figure 1, this was not possible upon dipping the coil. Figure 4 shows a

chromatogram of all 16 drugs when dipping the CWF into a drug mixture (60 $\mu\text{g}/\text{mL}$ of each drug).

After separation and deconvolution, only 10 – 12 of the 16 drugs could be identified. With this lower amount of sample (~30 ng/drug), signal intensity for fentanyl (~7000), and many other compounds, is approximately 1/10th the signal intensity in Figure 1 (70,000). In fact, the later eluting compounds (i.e., clonazepam, alprazolam, and buprenorphine) cannot be seen nor identified. Additionally, at least one of the lower intensity compounds (i.e., morphine, hydromorphone, and/or oxycodone) are unidentified after separation and deconvolution. On the other hand, the dipping technique is much simpler and requires less time, but also requires approximately 10 \times the concentration of drugs for an equivalent signal. As previously mentioned, it is estimated that ~0.5 μL of the sample is collected on the CWF during dipping.

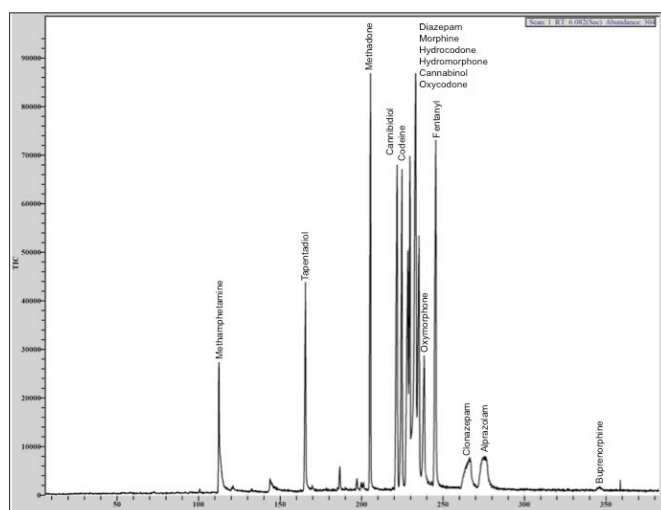


Figure 1. A chromatogram of all 16 drugs investigated in this study.

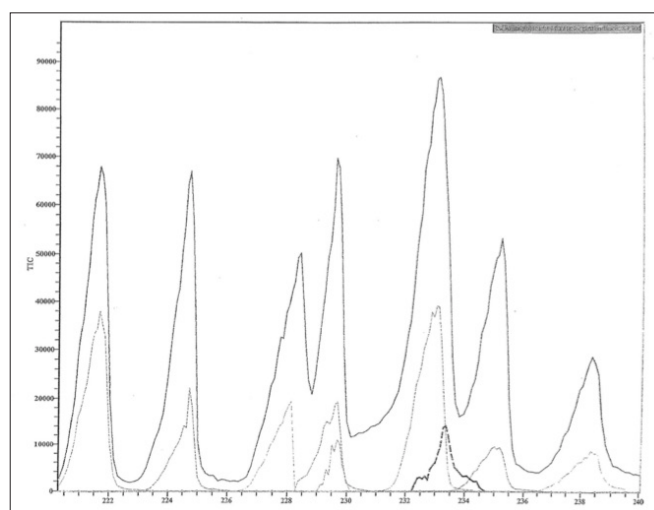


Figure 3. Deconvolution and identification of the two pairs of drugs shown in Figure 2 can be achieved using the Torion's on-board algorithms.

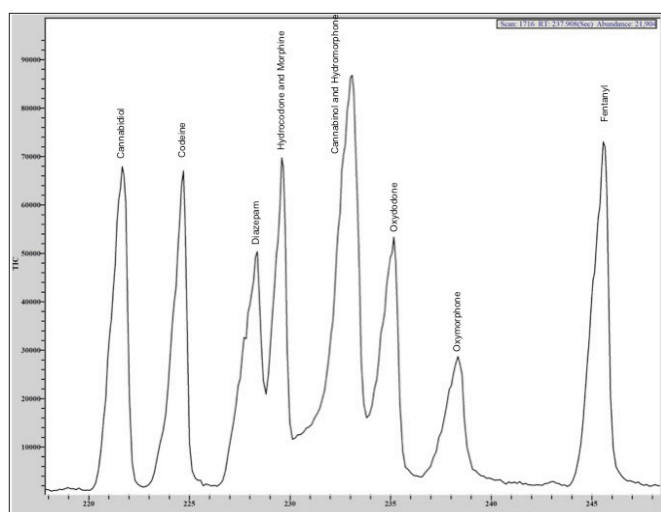


Figure 2. Chromatogram showing the co-elution of hydrocodone/morphine and cannabino/hydromorphone.

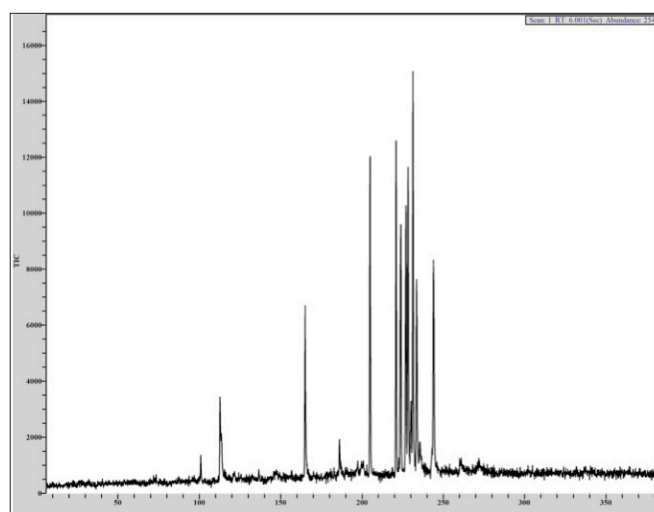


Figure 4. Chromatogram of all 16 drugs when dipping the CWF into a drug mixture (60 $\mu\text{g}/\text{mL}$ of each drug).

Conclusion

This study has shown that the separation and identification of 16 common drug substances is possible in the field using a combination of a novel coiled wire filament sampling device coupled with a portable gas chromatograph-toroidal ion trap mass spectrometer in under 10 min.

References

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5. SPS-3 Sample Preparation Module for Torion T-9, [http://www.perkinelmer.com/lab-solutions/resources/docs/PRD_Sample_Prep_Station\(013095_01\).pdf](http://www.perkinelmer.com/lab-solutions/resources/docs/PRD_Sample_Prep_Station(013095_01).pdf)

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