# Assessment of a Combined Portable Raman Spectroscopy and Mass Spectrometry Approach for the Analysis of Seized Drugs

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## ABSTRACT

Growing backlogs and lengthy turnaround times for seized drug analysis are causing significant strain on the judicial system. One potential solution is to improve the quality of field screening through on-site detection methods using field-portable instrumentation to reduce the amount of evidence submissions to forensic laboratories. This study investigates a combined field-portable Raman spectroscopy and mass spectrometry approach for the analysis of seized drug mixtures.

## INTRODUCTION

The illicit drug market poses a dynamic challenge for law enforcement officers and laboratory analysts due to the prevalence of seized drug mixtures. In the United States, methamphetamine and cocaine comprised 43% of identified controlled substances in 2022[1], with adulterants such as levamisole, phenacetin, procaine, and caffeine being among the most common cutting agents detected[2]. Given the continued increase in evidence submissions, there is growing interest in the implementation of field-portable instrumentation as a potential solution to alleviate casework backlogs. However, the incorporation of field-portable instrumentation into routine on-site detection requires extensive empirical data to establish the capabilities, limitations, and performance characteristics of each instrument. Portable Raman spectroscopy and mass spectrometry instrumentation are commercially available but are more commonly utilized for the analysis of explosive materials[3].

In this study, two handheld Raman spectrometers and one portable linear ion trap (LIT) mass spectrometer were used to analyze mixtures of controlled substances and common cutting agents in varying ratios. The strengths, limitations, and correct identification rate were assessed for each method both individually and then through a combined approach to help inform policy decisions regarding the appropriate implementation of field-portable instrumentation for the analysis of seized drug mixtures.

## MATERIALS & METHODS

*Instrumentation*

**Table 1.** Evaluated field-portable Raman spectrometers.

| Name | Manufacturer | Laser Wavelength | Scan Range | Dimensions |
|---|---|---|---|---|
| HandyRam | Field Forensics | 785 nm | 400 – 2300 $cm^{-1}$ | 9.1 x 7.1 x 3.8 cm, 0.34 kg |
| ResQ-CQL | Rigaku | 1064 nm | 200 – 2500 $cm^{-1}$ | 18.5 x 15 x 7.9 cm, 1.4 kg |

**Table 2.** Evaluated transportable mass spectrometer.

| Name | Manufacturer | Ionization Source | Dimensions |
|---|---|---|---|
| Continuity | BaySpec | TD-APCI | 38.1 x 38.1 x 39.4 cm, 20 kg |

## RESULTS & DISCUSSION

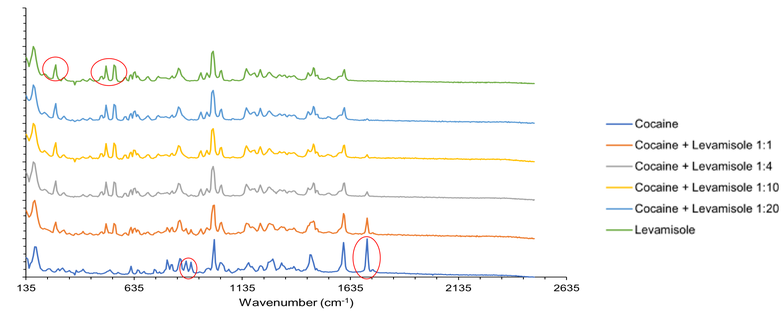


**Figure 1.** Raman spectra collected with the ResQ-CQL for pure cocaine, pure levamisole, and the cocaine + levamisole mixtures. Intensity is normalized for visualization purposes. A gradual decrease in the cocaine contribution can be seen as the mixture becomes more dilute.

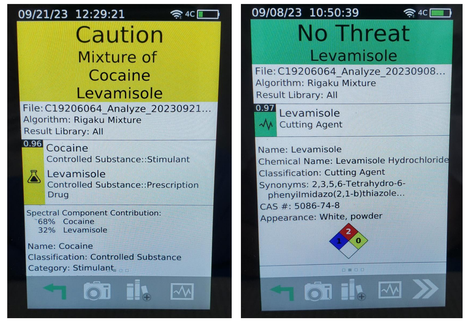


**Figure 2.** Example of the color-coded results from the ResQ-CQL internal library identification system when detecting a potentially harmful substance (left) and a non-threat (right).

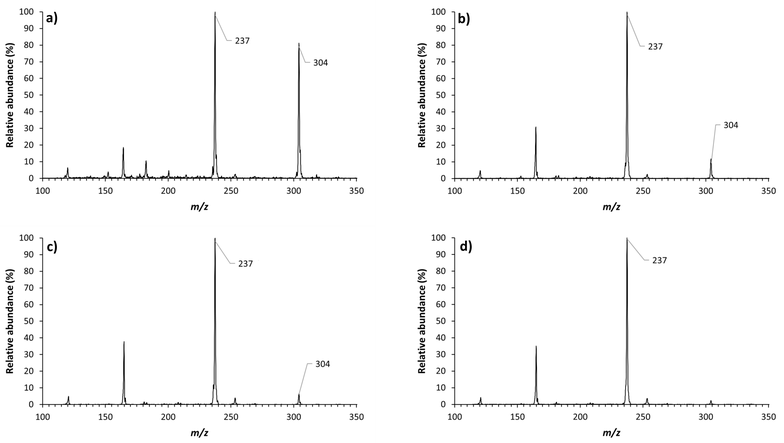


**Figure 3.** Full scan mass spectra of the cocaine + procaine mixture at ratios of a) 1:1, b) 1:4, c) 1:10, and d) 1:20.

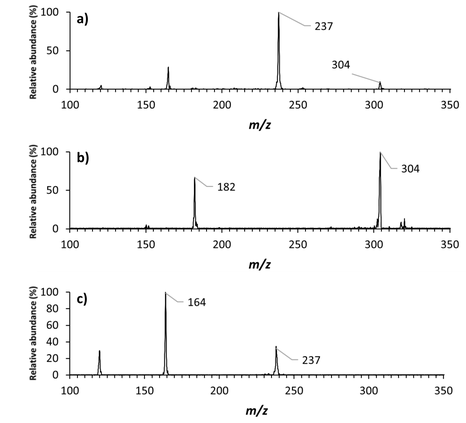


**Figure 4.** Full scan mass spectrum of the cocaine + procaine mixture (a) with the MS/MS spectra of cocaine (b) and procaine (c).

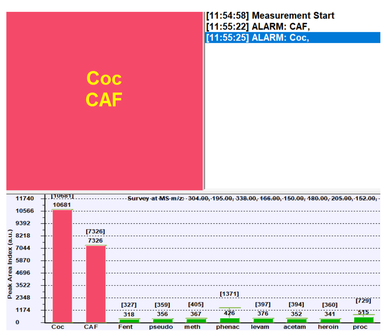


**Figure 5.** Example of the alarm system detecting a mixture of caffeine and cocaine on the Continuity instrument. The mass spectra are searched against the user-defined library.

| | 1:1 | 1:4 | 1:10 | 1:20 | 1:1 | 1:4 | 1:10 | 1:20 |
|---|---|---|---|---|---|---|---|---|
| Cocaine + Caffeine | 85 | 0 | 0 | 0 | 100 | 100 | 100 | 33 |
| Cocaine + Levamisole | 100 | 14 | 14 | 0 | 100 | 100 | 100 | 0 |
| Cocaine + Phenacetin | 43 | 0 | 0 | 0 | 100 | 67 | 100 | 67 |
| Cocaine + Procaine | 0 | 0 | 0 | 0 | 100 | 100 | 100 | 0 |
| Methamphetamine + Caffeine | 85 | 14 | 0 | 0 | 100 | 100 | 100 | 100 |
| Methamphetamine + Levamisole | 100 | 0 | 29 | 14 | 100 | 100 | 67 | 33 |
| Methamphetamine + Phenacetin | 0 | 0 | 0 | 0 | 100 | 100 | 67 | 0 |
| Methamphetamine + Procaine | 0 | 0 | 0 | 0 | 100 | 100 | 100 | 0 |

**Figure 6.** Correct identification rate (%) of the controlled substance with the ResQ-CQL internal library (left), the BaySpec Continuity auto-MS/MS (right).

## MATERIALS & METHODS

*Samples*

**Table 3.** Simulant seized drug mixtures analyzed.

| Controlled Substance (CS) | Cutting Agent (CA) | Ratio of CS:CA |
|---|---|---|
| Cocaine | Caffeine | 1:1, 1:4, 1:10, 1:20 |
| Cocaine | Levamisole | 1:1, 1:4, 1:10, 1:20 |
| Cocaine | Phenacetin | 1:1, 1:4, 1:10, 1:20 |
| Cocaine | Procaine | 1:1, 1:4, 1:10, 1:20 |
| Methamphetamine | Caffeine | 1:1, 1:4, 1:10, 1:20 |
| Methamphetamine | Levamisole | 1:1, 1:4, 1:10, 1:20 |
| Methamphetamine | Phenacetin | 1:1, 1:4, 1:10, 1:20 |
| Methamphetamine | Procaine | 1:1, 1:4, 1:10, 1:20 |

*Data Analysis*

Raw data was processed and visualized using Microsoft Excel and SpectraGryph optical spectroscopy software.

## CONCLUSIONS

- The portable Raman spectrometers were able to identify the drug of interest at the 1:1 ratio, but only the cutting agent at the 1:4, 1:10, and 1:20 ratios.
- The transportable mass spectrometer was able to identify the drug of interest in the 1:1, 1:4, and 1:10 ratios, but had several missed identifications at the 1:20 ratio, although this was with a 1:10 dilution before analysis.
- Combining the two methods resulted in at least a 67% identification rate for the 1:1, 1:4, and 1:10 ratios.
- Methamphetamine and caffeine were identified with a 100% correct identification rate.
- Though the Raman spectrometers struggled to identify the drug of interest at higher ratios, they can perform the analysis through a clear container.
- Authentic casework samples analyzed using this combined method showed similar identification rates.

## REFERENCES

[1] U.S. Drug Enforcement Administration. 2022 NFLIS-Drug Annual Report. 2023.
[2] T.R. Fiorentin, A.J. Krotulski, D.M. Martin, T. Browne, J. Triplett J, T. Conti, et al. Detection of Cutting Agents in Drug-Positive Seized Exhibits within the United States. *Journal of Forensic Sciences*. 64;3 (2019):888-896.
[3] D.S. Moore, R.J. Scharff, Portable Raman explosives detection. *Analytical and Bioanalytical Chemistry*. 393;6-7 (2009): 1571-1578.

## ACKNOWLEDGEMENTS

The authors would like to thank the Department of Forensic Science at Sam Houston State University for providing the resources necessary to conduct this research and the Montgomery County Fire Marshal's Office for access to the ResQ-CQL.

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