

HANDHELD RAMAN ANALYSIS IN THE FIELD FOR IMPROVED EFFICIENCY IN THE LAB

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Introduction

Crime labs are facing increasing pressure to analyze seized drugs in the needed time window. This pressure comes from several sources, including shrinking budgets needed to balance state and local financial constraints, and an explosion in the number of new and emerging synthetic drugs encountered. Technologies that can help to improve the efficiency of analyzing cases may help alleviate some of the pressure, and allow lab scientists to spend more time on more difficult cases.

Aim

This poster addresses handheld Raman spectroscopy and how its use as a field-based presumptive analysis technique for narcotics identification can increase efficiency of lab operations.

Two studies were conducted, the first with mixtures of laboratory standards of common seized drugs, and the second with actual seized drugs from three U.S. crime labs.

Raman Spectroscopy

- A form of vibrational spectroscopy, like FTIR spectroscopy
- Can scan liquids and solids through clear plastic and glass
- Automated algorithms with on-board libraries can identify mixtures of chemicals
- Thousands of rugged, handheld Raman in use today by military, first responders, pharmaceutical manufacturers.

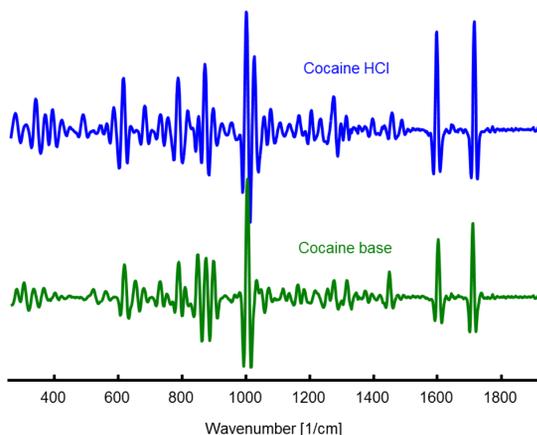


FIGURE 1. Raman spectra of cocaine hydrochloride and freebase powder standards. Spectra have been processed with a second derivative filter to eliminate broad spectral features such as fluorescence.

TruNarc



FIGURE 2. Thermo Scientific TruNarc analyzer

- ✓ Non-destructive, non-contact testing preserves evidence and increases officer safety
- ✓ Identifies dozens of different narcotics in a single test
- ✓ Provides clear, definitive results, requiring no user interpretation
- ✓ Automated data storage and report generation to support prosecution

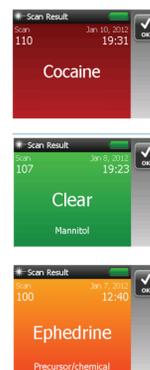


FIGURE 3 - TruNarc attributes

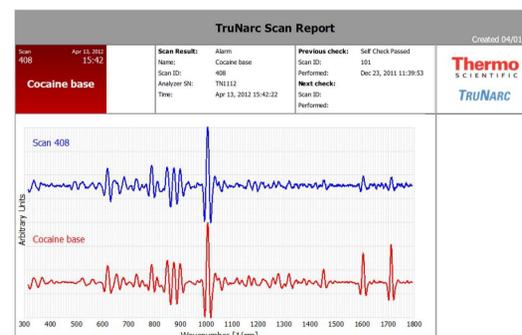


FIGURE 4 - TruNarc Admin PDF scan report



FIGURE 5. Scanning a seized drug sample contained in a plastic bag.

Methods

Sample Preparation

Powdered drug standards were purchased from Lipomed Inc. (Cambridge, MA) and mixed with cutting agents purchased from Sigma Aldrich (St. Louis, MS). The resulting mixtures were stored in 4-mil polyethylene bags, glass vials, or wax paper bags.

Seized drugs contained in plastic evidence bags were used without preparation, except in the case of heroin described next. Participating labs were: Minnesota Bureau of Criminal Apprehension, Phoenix Police Department Laboratory Services Bureau and Los Angeles Police Department Scientific Investigation Division.

Any sample containing heroin was prepared using the Thermo Scientific TruNarc Type H kit (Thermo Fisher Scientific, Tewksbury, MA). The Type H kit consists of a 4 mL vial containing approximately 1 mL ethanol, and test stick. The test stick is first used to scoop a small (approx. 10 mg) amount of powdered sample into the vial. After several seconds of gentle agitation, the stick is removed, and is waved in air to allow the ethanol to evaporate from the stick's roughened metal wafer. The stick is then positioned against the Raman analyzer and scanned.

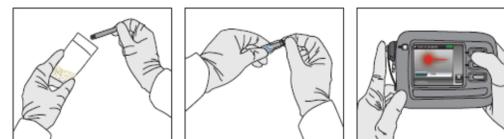


FIGURE 6. Type-H kit use

Data Collection

All samples were scanned with the Thermo Scientific TruNarc analyzer (Thermo Fisher Scientific, Tewksbury, MA). Analyzer specifications:

- 1.25 pounds, 6.4 x 4.1 x 2.0 inches
- 8 hour battery life
- Library size (version 1.3): 79 drugs of abuse, 52 chemicals/precursors, 66 cutting agents/inactive ingredients
- TruNarc Admin scan database & report generation

A total of 7 units and 5 operators were used in the lab mixture study, and 3 units and 3 operators were used in the seized drug study.

Data Analysis

The analyzer results displayed on the screen were recorded and compared to each sample's known identity. The scan time, defined as the time between pressing the scan button and result display, was recorded for each scan in the lab standard mixture experiment.

Results – Lab Mixtures

Seven different mixture samples were prepared using concentrations of the controlled substance typical of street samples in the U.S. and common cutting agents. Each sample was scanned at least once on the different units by different operators. In the case of cocaine HCl and methamphetamine HCl, the samples were contained in plastic bags, glass vials and wax paper bags.

Table 1 contains the summary results. Average scan times ranged from 15 seconds for the Heroin HCl and lactose sample measured using the type H kit, to 53 seconds for the MDMA and lactose sample. In general the scan times are variable because the analyzer automatically continues to collect data until the required signal-to-noise is the Raman spectrum is reached. This automated procedure alleviates the need for the operator to set up instrument acquisition parameters.

The detection rate (true positive rate) ranged from 87% to 100%. In all cases where the drug was not detected, the cutting agent was correctly identified.

Importantly for evidence collection, the false alarm rate (false positive rate) was 0% in all cases.

Sample	N	Avg Scan Time [s]	Detection Rate	False Alarm Rate
Cocaine HCl (40%) Tetramisole	45	31.1	97.7%	0%
Cocaine base (40%) Sodium bicarbonate	15	31.1	100%	0%
Methamphetamine HCl (40%) Dimethyl sulfone	45	22.3	86.7%	0%
Heroin base (20%) Caffeine	23	26.8*	91.0%	0%
Heroin HCl (20%) Lactose	30	15.3*	100%	0%
MDMA (20%) Lactose	30	52.9	100%	0%
MDPV (80%) Caffeine	15	49.0	100%	0%

TABLE 1. Results of the lab mixture study. Weight percentages of the drug are noted in parentheses. * Scan times for heroin samples do not include sample prep time, which was measured to be 43 seconds on average.

Results – Seized Drugs

Table 2 displays the summary results.

For cocaine, 51 of 55 samples correctly alarmed for cocaine, 1 gave an inconclusive result, and 4 correctly identified the cutting agent. For the inconclusive result, the cocaine contained a cutting agent that is not part of the analyzer library. For the results in which the cutting agent was identified, one sample was 90% lidocaine and the other two were 75%. Some cutting agents have strong Raman signals which can dominate the measured spectrum, resulting in a higher limit of detection. For example, in another study we found the limit of cocaine detection in lactose to be 5%, but 40% in benzocaine. This is still well below the average purity level of 55% typically seen in street samples according to the National Forensic Laboratory Information System.

For heroin, all samples were correctly identified. The heroin samples were either powdered heroin HCl or "black tar" heroin. It is important to note that if these samples were scanned without the type H preparation kit, all would have resulted in inconclusive results, due to the overwhelming amount of fluorescence contained in street samples of heroin in the U.S.

For methamphetamine, 54 of 56 samples correctly alarmed for methamphetamine, 1 gave an inconclusive result, and 1 correctly identified the cutting agent. For the inconclusive result, the sample was a yellow liquid contained in a glass vial, with a small crystal substance at the bottom of the vial. Detailed analysis of the spectrum reveals that methamphetamine is present but has a slightly different spectrum when dissolve in water than when scanned as a solid, which prevented identification by the analyzer. For the clear result, the methamphetamine sample was found to have been mixed with a crushed alprazolam tablet, and the analyzer correctly identified lactose, the major ingredient of the tablet.

Seized Drug	N	Detection Rate	False Alarm Rate
Cocaine	55	92.7%	0%
Heroin	26	100%	0%
Methamphetamine	56	96.4%	0%

TABLE 2. Results of the seized drugs study

Conclusions

- Harnessing the power of Raman spectroscopy, the TruNarc analyzer and its fine-tuned algorithm provide excellent selectivity, resulting in a very low false positive rate.
- The TruNarc analyzer has a high detection rate for commonly seen drugs of abuse, including cocaine, methamphetamine and heroin.
- In addition, the analyzer's on-board library allows identification of many pharmaceuticals (ex: oxycodone, clonazepam, methadone), and emerging synthetic drugs (18 substituted cathinones, 22 synthetic cannabinoids).
- TruNarc's intuitive, three button interface and color-coded result screens allow for use by non-technical law enforcement officers.
- TruNarc's scan time averages less than 1 minute, and combined with the ability to scan through plastic bags, could allow for rapid testing of routine, multiple sample submissions in the crime lab.

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