White
Paper: 201b

Improvements in Field Narcotics Identification Using Raman Spectroscopy

A Comparison of Raman Field Test Results and Laboratory Test Results

Overview

This white paper investigates the use of a hand-held, field-based Raman instrument to identify street samples of cocaine, heroin, and methamphetamine. The results of this study are evaluated against laboratory results for the same drug samples. The two data sets are compared and discussed, and concluding remarks are made regarding the potential for augmenting confirmatory laboratory testing with field testing at the point of seizure.

Introduction

Raman spectroscopy has been a widely recognized scientific technique used in laboratories and research applications for more than 40 years. In the last 10 years, advances in technology have led to instruments that were increasingly portable, and, eventually, handheld. These handheld systems, combined with advances in software "search" algorithms, have provided users in the field with the ability to quickly identify or authenticate chemicals at the point of need, including those in pharmaceutical operations and safety and security industries.

In particular, the use of Raman spectroscopy has grown exponentially by first responders for identification of explosives and potentially hazardous chemicals. Smaller, more rugged handheld equipment allows these first responders to use this lab-proven technique in the field, helping them resolve incidents more quickly and safely.

Handheld Raman systems are now in use for field-based narcotics identification by law enforcement officers. As a well established forensic laboratory technique, Raman spectroscopy is recommended by the Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG). SWGDRUG lists Raman spectroscopy as "category A": an analytical technique with the highest potential discriminating power for the analysis of controlled substances.

Currently, field analysis for narcotics involves colorimetric wet chemistry tests for presumptive testing, which are subsequently followed up by laboratory-based confirmatory test(s). Forensic labs tasked with providing confirmatory test results frequently use gas chromatography-mass spectrometry (GC/MS), as well as FTIR and microcrystalline analysis. GC/MS and FTIR are also SWGDRUG category A analytical techniques, providing reliable, definitive results. Raman spectroscopy has the advantage of non-contact, non-destructive testing through glass and plastic, helping speed analysis and enabling operators to scan more samples in less time.

This study compares results obtained from analyzing samples of three common street drugs (cocaine, heroin, and methamphetamine) using Raman spectroscopy versus laboratory test results.

The samples were street samples cut with a variety of unknown substances. The laboratory testing used various techniques including GC/MS, FTIR, microcrystalline and colorimetric analyses. The Raman spectra were collected and analyzed using a Thermo Scientific TruNarc analyzer, then compared with laboratory analysis results. The results indicate that the TruNarc™ analyzer is not only capable, but accurate and reliable when compared to laboratory testing for the identification of narcotics.

Methods

The handheld Raman system used in this study was the Thermo Scientific TruNarc analyzer. The TruNarc analyzer utilizes a 785-nm Class IIIB laser at 250mW. It is a small, field-based instrument with an integrated battery and an external microUSB port for data transfer and battery charging. The instrument was used in a point-and-shoot™ manner, namely, an operator presses a sample of interest to the nose cone and then presses a key to initiate laser interrogation of the sample. One of the analyzer's distinct advantages is its ability to measure solid and liquid samples through clear containers, such as plastic bags, wax paper, and glass vials, typically in less than one (1) minute. This non-contact, non-destructive analysis helps minimize operator exposure to the material of interest and maintains evidence integrity.

Drug samples were taken from active casework being conducted by several municipal and state forensics laboratories. Cocaine, heroin and methamphetamine samples were analyzed and the results provided by the Los Angeles Police Department Scientific Investigation Division and the Phoenix Police Department Laboratory Services Bureau. Additional methamphetamine samples were analyzed and results provided by the Minnesota Department of Public Safety in St. Paul, MN. The cocaine and methamphetamine samples were scanned with the TruNarc analyzer while enclosed in plastic bags or food storage wrap. In some cases, the samples were further contained in a transparent sealed evidence bag. The heroin samples were scanned using the TruNarc analyzer and a Type-H Test Kit. All samples were scanned with the TruNarc analyzer by trained forensic scientists. To compare against laboratory results, samples were analyzed by the forensic laboratories according to their standard procedures for identification of seized drugs.

Results

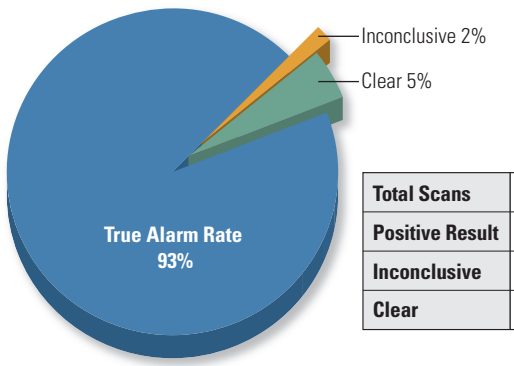
Cocaine Test Results:

A total of fifty-five (55) cocaine samples, consisting of cocaine hydrochloride (HCl) and cocaine free base, were analyzed. Each sample was tested by the TruNarc analyzer in point-and-shoot mode and by state forensic lab personnel using various laboratory techniques as described above. Table 1 compares results from the TruNarc Raman analyzer and the laboratory analysis results.

A review of the TruNarc analyzer results indicates 93 percent (93%) true alarm rate and a zero percent (0%) false alarm rate, also called true-positive and false-positive detection rate.

For the inconclusive result, the cocaine contained an inorganic mineral cutting agent that is not part of the TruNarc library. In the case of the clear results, one sample was 90 percent (90%) lidocaine and 10 percent (10%) cocaine, and the other two were 75 percent (75%) benzocaine and 25 percent (25%) cocaine. In all cases, the clear result correctly identified the cutting agent.

Lidocaine and benzocaine have strong Raman signals, which can provide a challenge to identification and may have contributed to the clear results. Internal testing has found that most cutting agents yield a limit of detection for cocaine in the 5–20 percent (5–20%) range. For example, only 5 percent (5%) cocaine is needed for identification when cut with lactose. Benzocaine is a challenging agent and requires a concentration of 40 percent (40%) cocaine in order to make a reliable identification. This is still well below the average purity level of 55% typically seen in street samples according to the National Forensic Laboratory Information System (NFLIS).



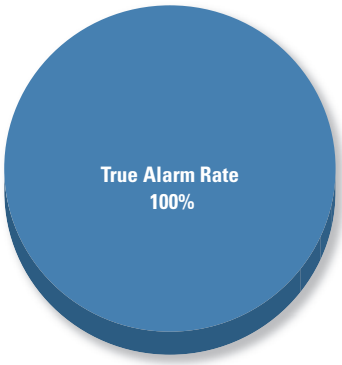
Total Scans	55
Positive Result	51
Inconclusive	1
Clear	3

Table 1. Cocaine Test Results

Heroin Test Results:
For the heroin study, twenty-six (26) samples were analyzed. Each sample was tested with the TruNarc analyzer using a Type-H Test Kit and by state lab personnel using a variety of laboratory techniques.

While most street narcotics can be analyzed directly through sealed packaging, heroin presents a challenge due to fluorescence which can mask the Raman signal of some narcotics, particularly plant-based narcotics such as heroin. To overcome this problem, yet retain the advantages of a handheld Raman spectrometer, the heroin test kit consists of a test stick and vial of ethanol that is used to dissolve a small amount of heroin. The test stick contains a roughened metal wafer onto which dissolved material will accumulate. When scanned using the TruNarc analyzer, the test stick quenches fluorescence and enhances Raman signal. This method has been shown to reduce the amount of fluorescence relative to the Raman signal of interest so that heroin can be identified in virtually all cases. Heroin base, hydrochloride salt, and "black tar" heroin all have been identified with the TruNarc analyzer and Type-H Test Kits.

Table 2 compares the results from the TruNarc analyzer to the laboratory results. The TruNarc analysis demonstrated a 100 percent (100%) true-alarm rate and a zero percent (0%) false alarm rate as compared to the laboratory results.

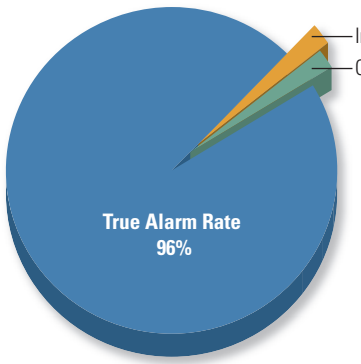


Total Scans	26
Positive Result	26
Inconclusive	0
Clear	0

Table 2. Heroin Test Results

Methamphetamine Test Results:
There were fifty-six (56) methamphetamine samples analyzed. Analogous to the cocaine, each sample was tested using the TruNarc analyzer in point-and-shoot mode and by state lab personnel using a variety of lab techniques as described above. Table 3 compares results that yielded a 96 percent (96%) true-alarm rate and a zero percent (0%) false alarm rate as compared to the laboratory results.

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. A future software release will allow the identification of methamphetamine dissolved in water, as is already possible with cocaine HCl dissolved in water and/or ethanol. For the clear result, the methamphetamine sample was mixed with a crushed alprazolam tablet, and the analyzer correctly identified lactose, the major ingredient of the tablet.

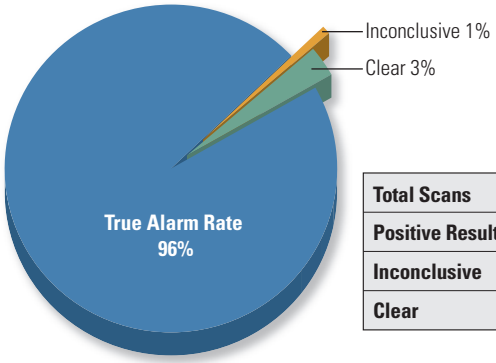


Total Scans	56
Positive Result	54
Inconclusive	1
Clear	1

Table 3. Methamphetamine Test Results

Conclusion

Overall, 131 of the 137 street samples measured with the Thermo Scientific TruNarc analyzer agreed with the laboratory results for three of the most commonly encountered controlled substances. This equates to a 96 percent (96%) true alarm rate and a zero percent (0%) false alarm rate. Measurements were made by the TruNarc analyzer through plastic bags with roughly one minute measurement times for cocaine and methamphetamine. The heroin samples took an additional 45 seconds to prepare the test stick, and then analysis time was less than one minute. The four clear results correctly identified the major ingredient of the sample, potentially providing actionable information to the law enforcement officer. The two inconclusive results would correctly lead to the user to perform additional testing to identify the samples.



Total Scans	137
Positive Result	131
Inconclusive	2
Clear	4

Table 4. Total Test Results

The TruNarc analyzer enables drug identification in the field in an easy-to-use, reliable manner. Raman spectroscopy is already a recommended method in the forensic laboratory for confirmatory analysis, and with handheld, easy-to-use, and reliable instruments, it may be possible in the future to consider confirmatory testing in the field.

For more information about the TruNarc analyzer, please contact:

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In addition to U.S. offices, Thermo Fisher Scientific maintains a network of representative organizations throughout the world.

References

- Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG) Recommendations Edition 6.0, 2011-07-07, downloaded 12/19/2011 from http://www.swgdrug.org/approved.htm.
- National Forensic Laboratory Information System (NFLIS) 2010 Annual Report, downloaded 12/19/2011 from http://www.deadiversion.usdoj.gov/nflis/index.html#reports.

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