Application Note

Handheld Chemical Identification

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Trusted Answers

Cocaine Detection with Agilent Resolve—a Handheld SORS System

Safe and rapid identification of physically and chemically concealed drugs

Authors

Ricardo Nobara and
Ana Blanco
Agilent Technologies, Inc.

Abstract

The Agilent Resolve Raman tactical analyzer identifies samples concealed behind barriers or within materials using Agilent proprietary spatially offset Raman spectroscopy (SORS) technology.

This application note details how the Resolve Raman system can easily identify cocaine in many situations, including mixtures used to camouflage and conceal the drug. With no need to open the containers before analysis, fast scan times of approximately 40 seconds can be achieved using the Resolve, enabling the safe and rapid identification of cocaine directly on location.

Introduction

In 2022, cocaine production reached a record high of 2,757 tons, marking a 20% increase from 2021. During the same period, global coca bush cultivation—the primary source of cocaine—expanded by 12%, reaching 355,000 hectares.[1] According to the World Drug Report, published by the United Nations Office on Drugs and Crime (UNODC) in June 2024, "A prolonged surge in cocaine supply and demand is bringing violence to countries along the supply chain and increased health harms at destination, most notably in Western and Central Europe."[2]

Traffickers of illicit drugs such as cocaine use various methods to evade detection by law enforcement agencies. One particularly challenging method involves chemically concealing or masking the drug within commercial shipments. Cocaine that has been incorporated into materials such as plastics or beverages must undergo processing to extract the drug from its chemically concealed state.[3]

Raman spectroscopy is a laser-based technique that illuminates a sample and analyzes the scattered light to identify the compounds present. The technique has been used extensively for the identification of illegal drugs and adulterants, including cocaine. Raman is a rapid and nondestructive way to perform sample characterization, with no need for chemical reagents. SORS is a variant of Raman that uses multiple measurements to allow samples to be identified inside sealed, thick, colored, and opaque containers or drugs concealed within materials or products.[4] SORS improves the speed, efficiency, and safety of Raman drug-identification methods.

The Agilent Resolve Tactical Handheld Raman Analyzer is a powerful tool that combines the capability of SORS with the portability of a handheld device (Figure 1). In addition to its unique ability to identify materials concealed behind barriers such as colored and opaque plastics, dark glass, paper, and fabric, Agilent's proprietary SORS optical setup allows Resolve to produce high quality data and reliable results. Resolve onboard libraries, which are available in three packages, are preloaded on the system and contain reference spectra for approximately 15,000 items. A large selection of spectra for controlled substances can be found in the Agilent Narcotics and New Psychoactive Substances library.

Figure 1. The Agilent Resolve Tactical Analyzer is a versatile through-barrier identification system that can be deployed on location to identify a broad range of materials including drugs, explosives, hazardous toxic materials, etc. Authorities use the portable system to identify a wide range of narcotics and psychoactive substances, as well as other items included in the onboard libraries, in a variety of concealed and obfuscated forms.

Cocaine detection

Pure forms of cocaine

Cocaine is a natural stimulant drug extracted from coca leaves. It has a high potential for addiction and comes in various forms that vary in color, purity, purpose, and effect.[5] The hydrochloride salt form of cocaine is usually snorted, while the free-base and crack forms are smokable.

To ensure that cocaine identification is successful in a range of situations, the Resolve Raman Narcotics and New Psychoactive Substances library contains spectra from several forms of pure cocaine. Spectra for some of the cocaine entries in the library are shown in Figure 2. Figure 3 shows an example of the results screen following the analysis of cocaine using the Resolve. The sample scan (green spectrum) was identified as cocaine with a 99% match quality score compared to the onboard library scan for cocaine (black spectrum).

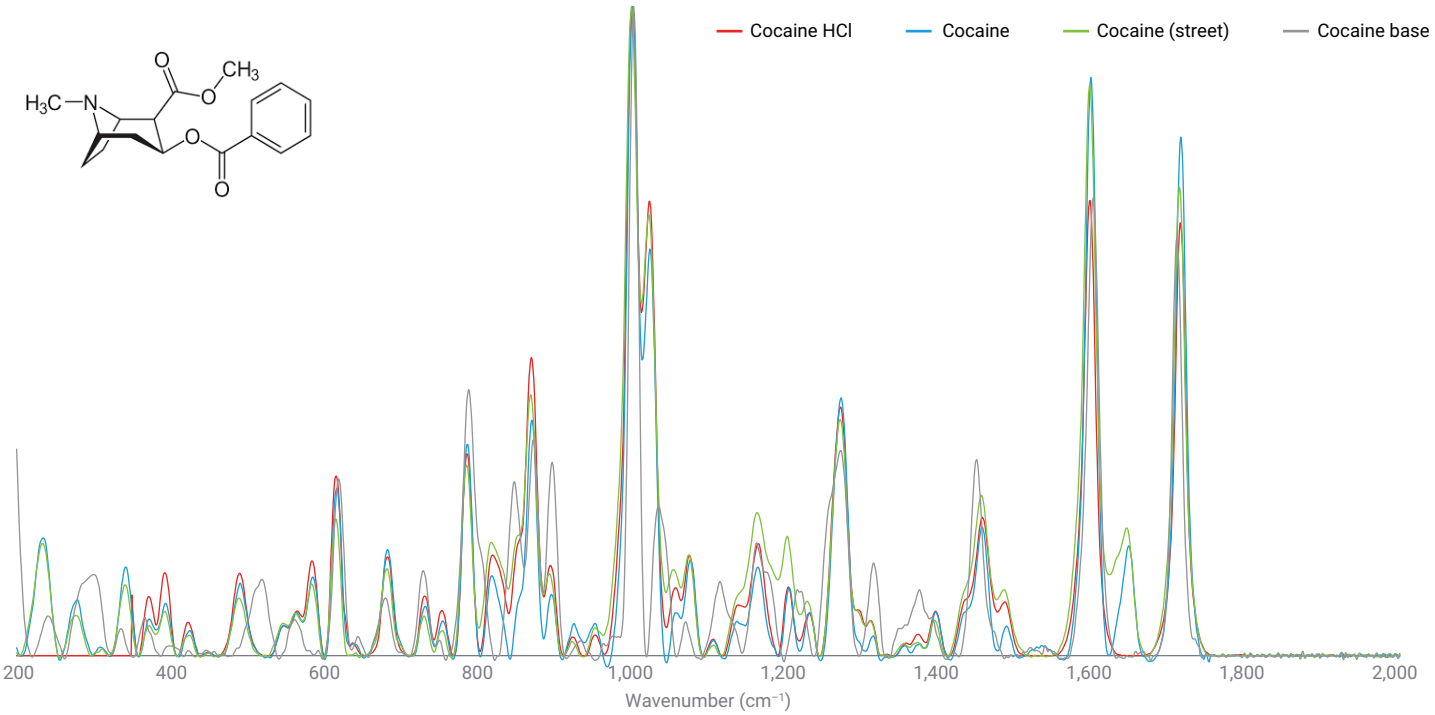


Figure 2. Structure of cocaine (top left) and some spectral entries in the Agilent Resolve Narcotics and New Psychoactive Substances library.

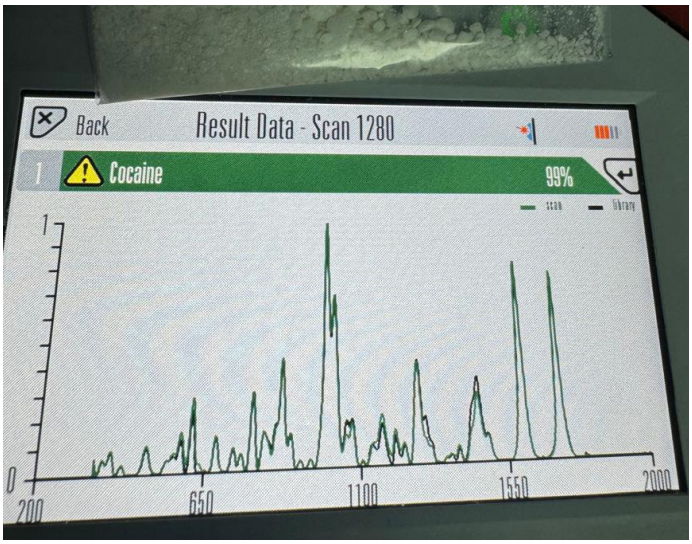


Figure 3. High quality Raman spectrum (green) of a cocaine sample and match to the onboard library (black) with 99% match quality.

Mixtures containing cocaine

Raman spectroscopy can help identify cocaine and other narcotics, not only as pure powders but also when mixed in with other substances. Figure 4 shows how the Raman signature of cocaine can be successfully identified in a mixture containing 17% cocaine and 83% lactose.

Figure 4. Analysis of a 17% cocaine/lactose mixture using an Agilent Resolve analyzer.

Concealed cocaine

Narcotics and other illegal substances are often concealed within bottles and containers or disguised as legal substances such as toys, foods, and other common objects to avoid detection by the authorities.

Physical concealment and camouflage

Resolve's through-barrier SORS measurement capability, together with its high data quality and extensive libraries, can enhance the detection of hidden or masked controlled substances. SORS offers additional advantages for narcotic identification through barriers including operator safety and the preservation of evidence. Removing the need to open packages and sample the unknown substance means that operators reduce the risk of accidental exposure to potentially lethal narcotics.

As shown in Figure 5, common forms of concealed cocaine, such as paper wrappers or plastic-wrapped bullets used in body concealment, can be analyzed without the need to destroy the wrapping, preserving the evidence as found. Cocaine can still be identified using SORS, even when more unusual physical concealment methods, such as green plastic electric cord (Figure 5), are used. A recent study has shown the handheld SORS technology to offer a rapid and accurate technique for locating drugs concealed inside some vegetable and fruit products.[4]

A

B

C

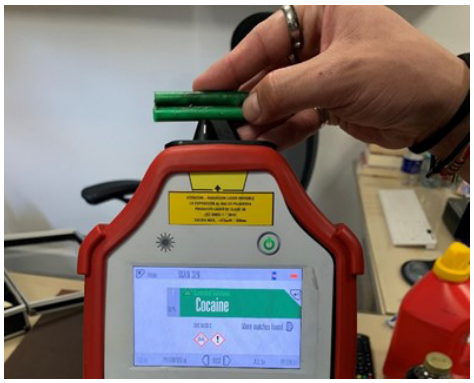


Figure 5. Analysis of cocaine in a paper wrapper (A), in plastic bullet form with multiple layers of red plastic (B) and concealed inside plastic electrical cord cable (C).

The intuitive onboard Agilent Resolve software simplifies the selection of the SORS "Through-barrier" scan mode, as shown in Figure 6. Simply select the appropriate container type for the sample of interest:

- "Thick, Colored or Opaque" for a SORS scan through a tough barrier such as thick clear or colored plastics or glass
- "Glass, Clear Bag or None" mode is used for the traditional "point and shoot" scan when there is no barrier or a simple barrier, such as thin clear plastic or glass (see Figure 7)
- "Vial" mode is used for the measurement of a sample in a vial using the Resolve fitted with a detachable vial holder accessory

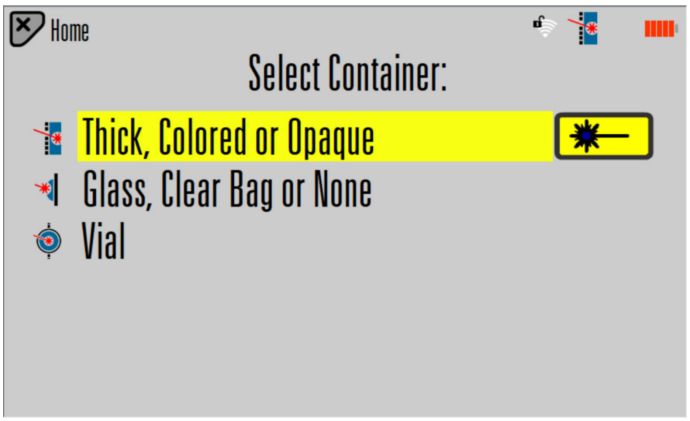


Figure 6. Different measurement modes available in the Agilent Resolve software.

Further examples of successful identification of seized cocaine samples, where the drug had been disguised or camouflaged as other products to pass undetected through customs and border security, are shown in Figure 7. Thanks to the Resolve's high sensitivity, low probability of burning dark-colored samples (in contrast to conventional Raman), and excellent efficiency for detecting mixtures, the analyzer was used to scan nine samples using the direct measurement mode "Glass, Clear Bag or None". Details of the samples, labeled A to I, are as follows:

A. This sample had a similar appearance to a sour tamarind-flavored candy, in the shape of a pill
B. Sample of cajeta (caramelized goat's milk)
C. Buddha statue filled with red waxy material, which contained a cocaine mixture
D. Yarn impregnated with cocaine and dried
E. Wood powder or sawdust
F. Candle wax-like material
G. A commercial product containing a liquefied fruit, used to make household drinks
H. A sample that looked like cornmeal
I. A commercial product from a car-repair shop containing a substance similar to car oil

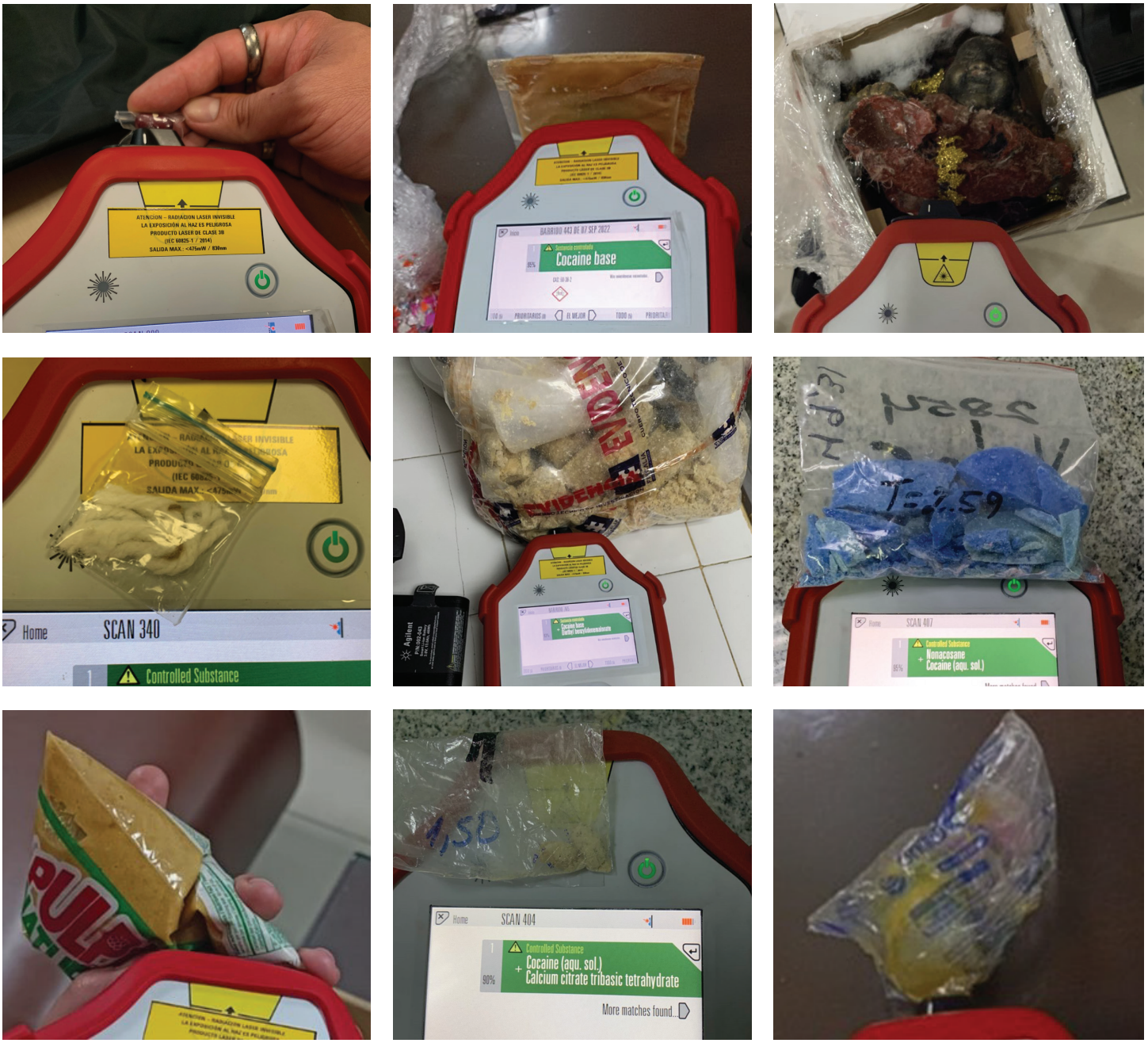


Figure 7. Examples of cocaine concealed in a range of different forms. All the items were found to contain cocaine when analyzed using an Agilent Resolve in "Glass, Clear Bag or None" measurement mode.

Chemical concealment

A commonly used method of chemical concealment is dissolution, usually in alcohol. Liquid cocaine is more difficult to detect than powdered cocaine because the diluent masks its odor and visual appearance. Producers of illegal substances often understand which techniques may be used to identify drugs, so use concealment methods to obscure detection. However, thanks to its special optical design, high sensitivity, and unmatched analytical capabilities, Resolve can detect chemically concealed samples.

Figure 8 shows the analysis of two different liquid black cocaine samples using Resolve in SORS mode. One sample was a thick, dark-brown wet substance resembling honey or molasses (Figure 8C) and the second sample resembled a coffee or cola drink (Figure 8B). Black cocaine is the result of mixing cocaine hydrochloride or cocaine base with masking substances, such as charcoal, printing toner, or cobalt salts, among other materials, to avoid detection by common methods. The dark color and added substances camouflage the appearance of cocaine and interfere with color-based tests and sniffer dogs trained to detect drugs. As shown in Figure 8, Resolve was able to correctly identify cocaine in the two samples, despite their dark appearance.

SORS has previously been used to identify dissolved cocaine inside a transparent glass bottle containing an alcoholic beverage (rum).[6] As shown in Figure 8A, Resolve successfully identified cocaine that had been dissolved in a bottle of aguardiente, a sugar cane distilled alcoholic spirit.

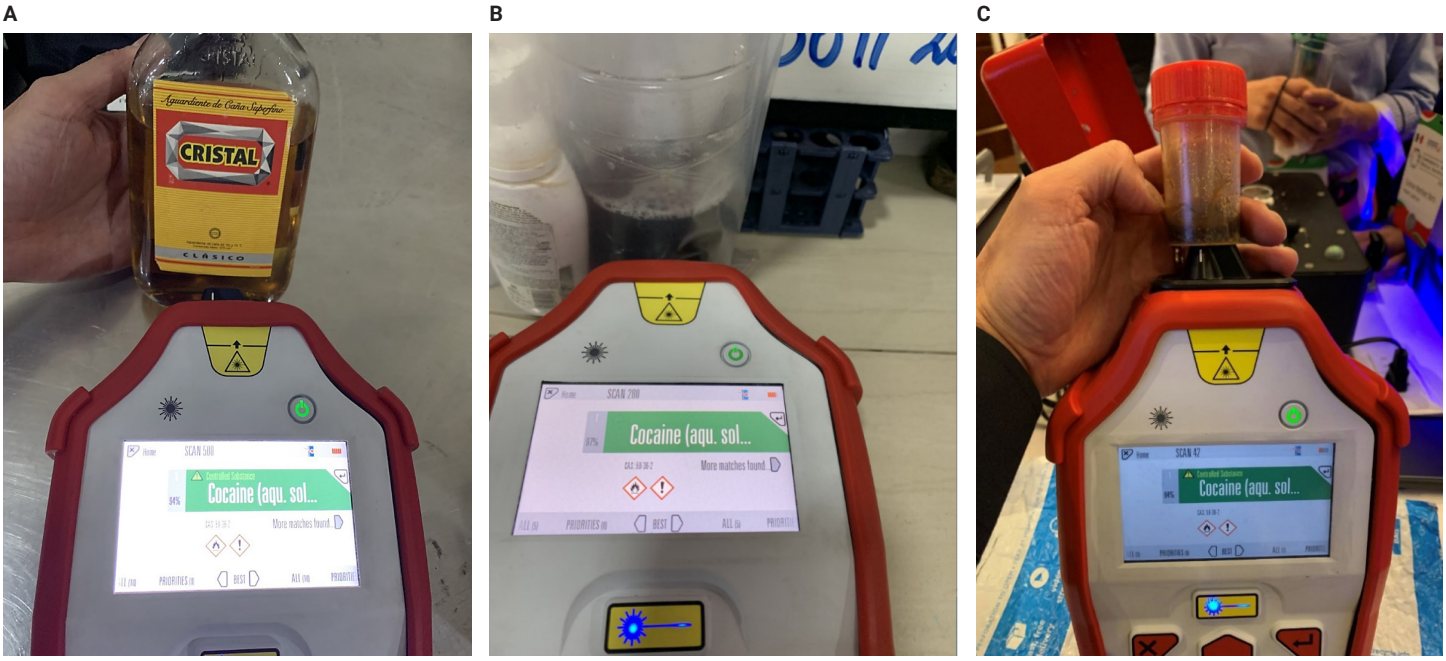


Figure 8. Analysis of cocaine dissolved in an alcoholic drink (A) and two liquid black cocaine samples (B and C) with the Agilent Resolve Tactical Analyzer using SORS technology ("Thick, Colored or Opaque" mode).

A more advanced method of chemical concealment involves adding cocaine to monomers used in the production of polymers, effectively hiding the drug within the structure of a normal-looking polymer material, such as polypropylene.[7] An example of this type of concealed sample can be seen in Figure 9A, where Resolve has identified a mixture of the polymer polymethyl methacrylate and cocaine in a transparent green plastic that otherwise looked normal. Cocaine was also identified in the rougher raw white polymer shown in Figure 9B.

Low concentrations of concealed cocaine

As producers seek more advanced methods for smuggling drugs, they have used camouflage methods such as mixing cocaine with a large amount of a common merchandise material such as charcoal.[8] In this type of scenario, the concentration of cocaine in the bulk matrix is very low compared to the examples shown in the previous sections. This low concentration makes it difficult for the authorities to detect the drug.

A **B**

Figure 9. Analysis of polymers co-manufactured with cocaine, showing the identification of cocaine by the Agilent Resolve analyzer.

As a bulk technique, the Raman identification of materials of interest that are present at very low levels can be challenging. This limitation can be overcome, to some extent, by combining Raman spectroscopy with a metallic surface—a technique known as surface-enhanced Raman spectroscopy (SERS). To adsorb the drug sample onto the metallic surface and enhance the Raman signal of the drug, SERS requires consumables and careful sample preparation, as illustrated in Figure 10. SERS analysis is more challenging than standard Raman analysis, but it has the potential to increase the sensitivity of a Raman spectrometer, enabling the low-level detection of narcotics.[9]

A

B

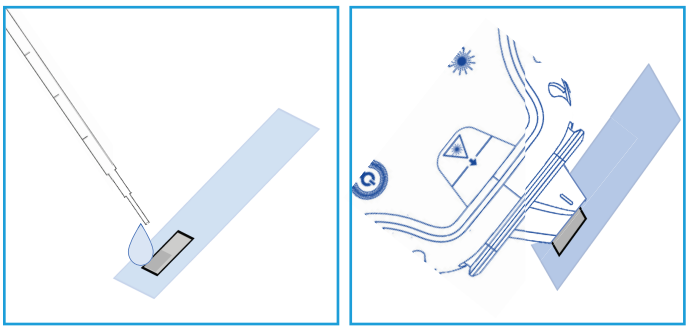
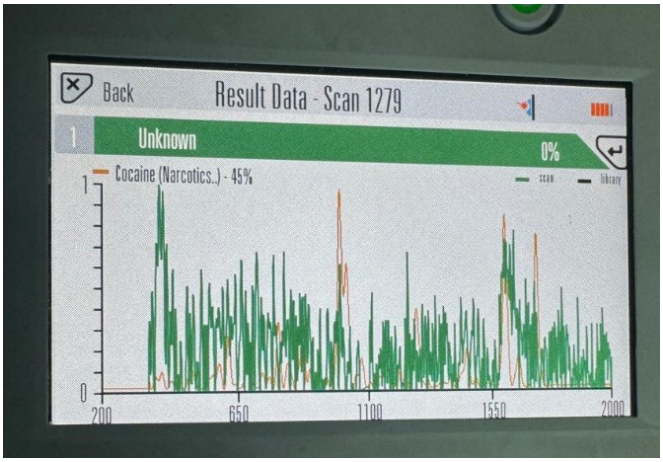


Figure 10. (A) Nikalyte gold SERS substrates used to enhance the sensitivity of the Agilent Resolve handheld Raman analyzer. Photo courtesy of Nikalyte Ltd, https://www.nikalyte.com/sers-substrates. (B) Illustration of loading a sample onto a SERS substrate and alignment of the loaded nanoparticle pad with the nose cone of the Agilent Resolve handheld Raman analyzer.[10]

Investigators have identified cocaine impregnated in wood pellets.[11] Figure 11 shows the analysis of similar wood pellets, mixed with burnt coffee and cocaine (5 to 0.5% concentration w/w) using the Resolve in SORS mode. This measurement would not be possible by conventional Raman spectroscopy as the sample would deflagrate immediately, and the arising smoke would impede the collection of Raman spectra. The Resolve analyzer with its SORS optical design enabled the direct measurement of the sample (Figure 11A), although the spectrum was noisy, with only a 45% match to the library scan of cocaine when overplotted (orange line). It is worth noting that the analysis did not damage the pellets despite their dark appearance.

A



B

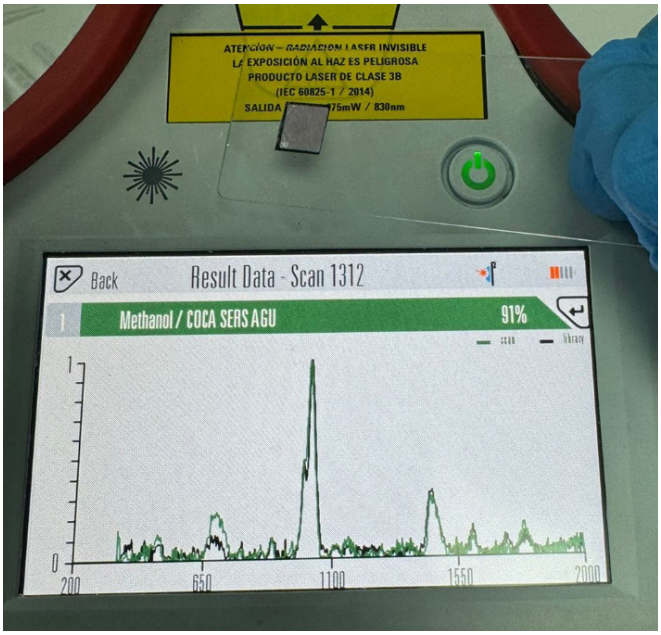


Figure 11. (A) Raman analysis of a cocaine-laced wood pellet using an Agilent Resolve in SORS mode, showing a low (45%) quality manual overplot of the cocaine library entry in orange over the sample scan, in green. (B) Cocaine detection using a SERS substrate with a 91% match to the "COCA SERS AGU" entry in the Resolve User Library.

To improve the spectral match quality result, a pure cocaine HCl standard in water was prepared for analysis. A drop was added to a SERS substrate and analyzed using the Resolve. The spectrum (Coca SERS agu) was immediately added to the Resolve User Library. A cocaine-impregnated wood pellet was then soaked in methanol. A drop was spotted on a SERS substrate and a new scan was performed using the Resolve analyzer. As shown in Figure 11B, there was a positive match (91% match score) between the sample scan and the new SERS cocaine library entry.

Other materials related to cocaine trafficking

Another method drug traffickers use to avoid detection and legal repercussions is to transport drug precursors across borders, then complete drug manufacturing in illicit labs in the destination country. This raises different challenges for the classification and detection of these types of substances and materials. Chemicals such as sulfuric acid, potassium permanganate, ethyl ether, methyl ethyl ketone (MEK), acetone, and toluene are commonly used in the production of cocaine. These materials are included in anti-drug trafficking conventions, such as the United Nations 1988 Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, which lists sulfuric acid, acetone, and certain other solvents in Table II, and potassium permanganate in Table I.[12]

Raman spectroscopy can also be used to identify most materials used during the manufacture of narcotics and drug precursors. Figure 12 shows the Raman library entries for the aforementioned chemicals.

Pink cocaine

Pink cocaine is a synthetic drug that produces similar effects to cocaine, but it is not actually cocaine. It is a mixture of several different substances, dyed to achieve a characteristic pink appearance. Originally composed of 2C-B, a psychedelic phenylethylamine, it now rarely contains 2C-B. Currently, pink cocaine typically comprises a mixture of substances, with the composition varying from batch to batch. The identity of substances in a batch remains unknown until a sample is tested.[13] Some identified combinations of pink powders include:

- Ketamine and MDMA
- Methamphetamine, ketamine, and MDMA
- Cocaine and fentanyl
- Fentanyl and xylazine

The variability and unpredictability of the pink cocaine mixtures makes them highly dangerous for consumption and can often lead to hospitalization and risk of death.[14] The types of aforementioned narcotics can be identified with Raman spectroscopy and are included in the Resolve library, Figure 13.

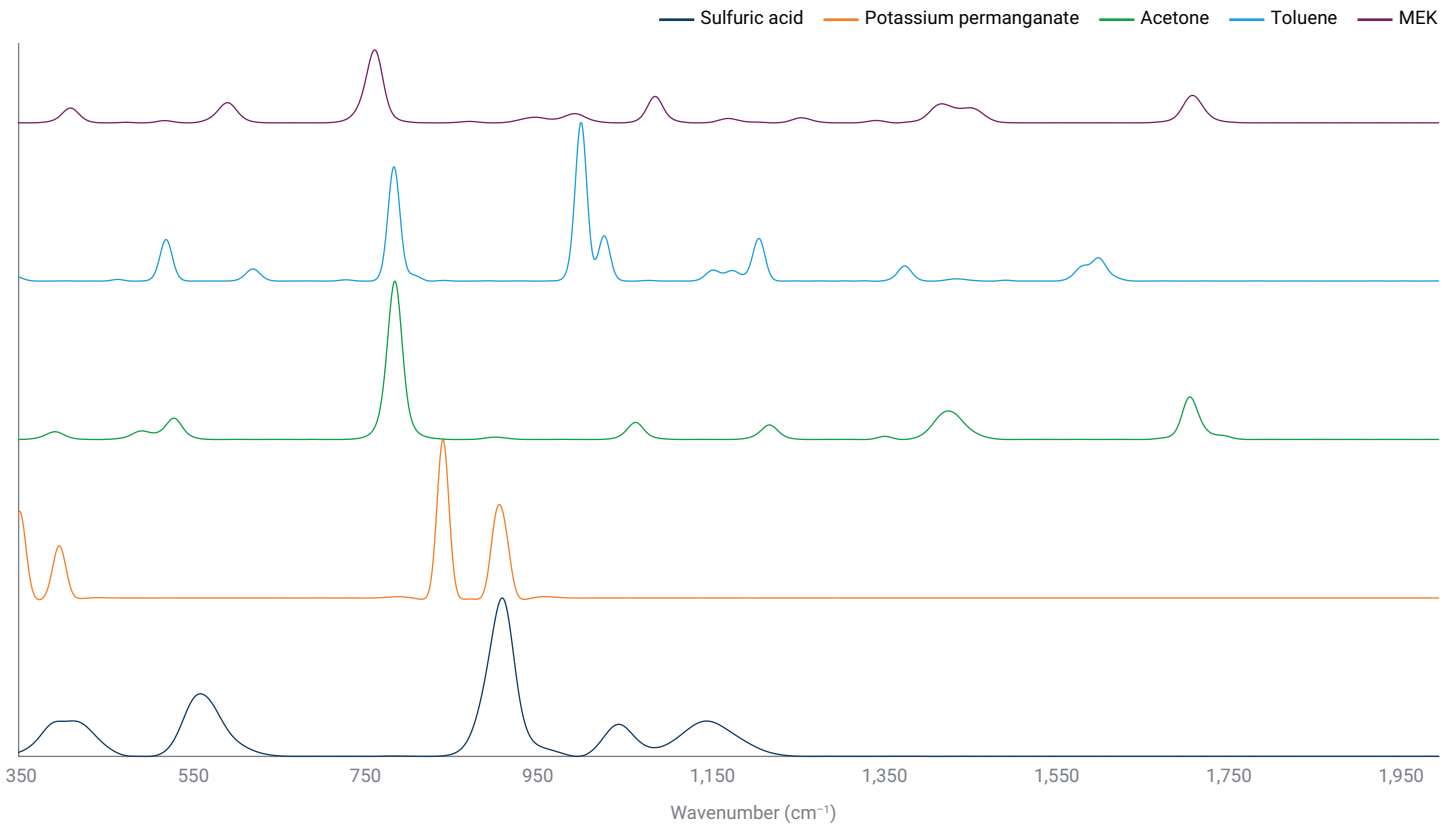


Figure 12. Agilent Resolve library entries for some of the materials used in cocaine production.

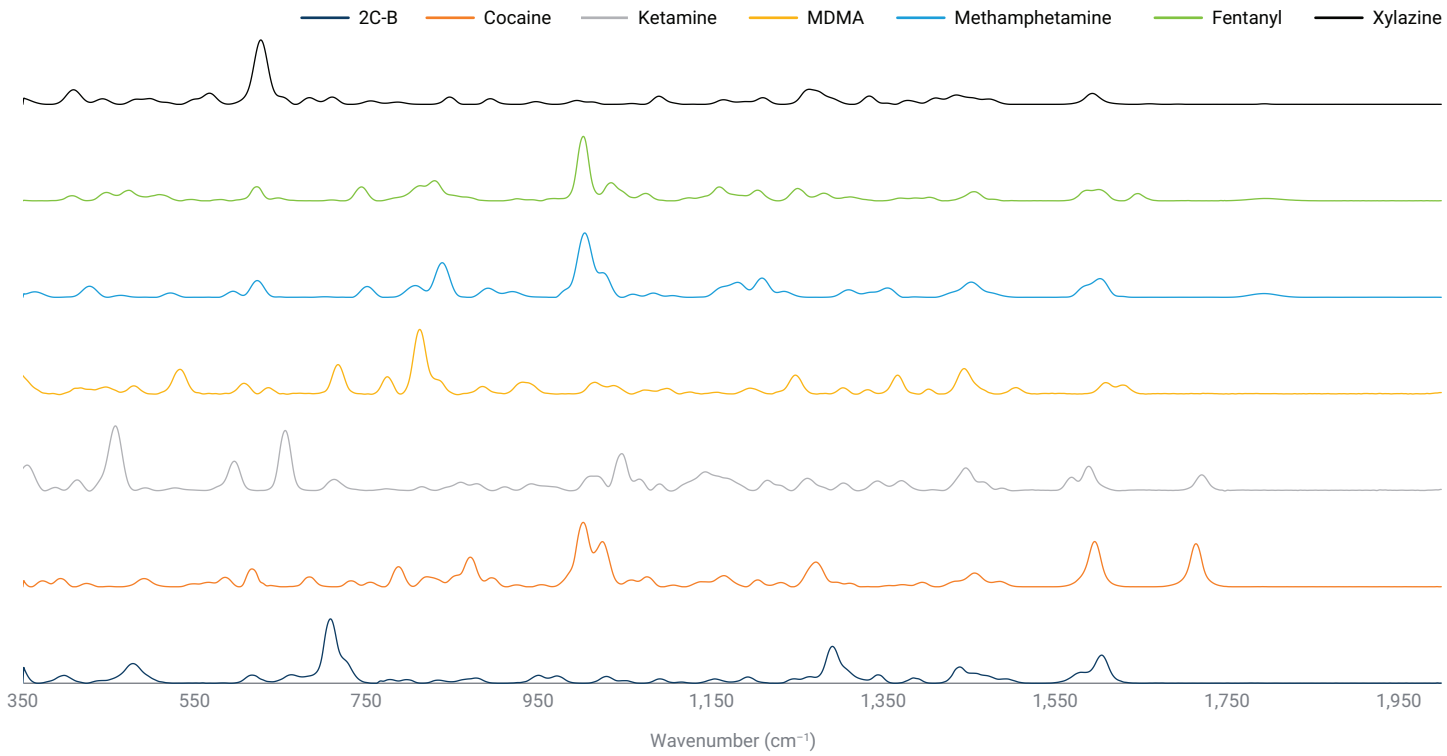


Figure 13. Agilent Resolve library entries for some of the materials identified in pink cocaine.

Conclusion

Cocaine remains a high-production, high-value, and highly sought-after drug – factors that continue to drive significant illegal trade. Traffickers use increasingly complex and diverse concealment techniques to smuggle drugs across borders and evade detection by law enforcement agencies.

This study demonstrates the versatility of the Agilent Resolve handheld spectrometer with offset Raman spectroscopy (SORS) technology for the identification of cocaine, which had been concealed or masked using a variety methods.

Some of the physical methods included mixing the drug with other substances, wrapping powders in paper or plastic, or inside plastic electrical cord cable, and disguising it as a commonly used object or product. The through-barrier SORS scanning mode allowed Resolve to analyze these samples directly, without the need to remove them from their original containment, preserving valuable evidence. The chemically concealed methods included adding the drug to alcohol and disguising the liquids as beverages, adding cocaine to plastics, and mixing cocaine with a large amount of a common merchandise material such as charcoal.

The Resolve handheld analyzer enabled:

- Generation of high quality data for improved detection of target compounds in powders and liquids, including cocaine, chemicals that are commonly used in the production of cocaine, and "pink cocaine"
- Access to the Agilent Narcotics and New Psychoactive Substances library, an extensive spectral library containing a large selection of spectra for controlled substances
- The direct analysis of unknown samples in less than one minute through barrier materials, ensuring the safety of the operator
- Identification of up to three components in mixtures
- Clear visual display of on-screen alerts and spectral identification information on samples
- Access to saved onboard metadata to facilitate decision-making
- The adsorption of a drug sample onto the metallic surface to enhance the Raman signal using SERS to detect a low concentration of cocaine

Overall, the Resolve handheld analyzer with SORS technology enhances the ability of law enforcement agencies to safely and quickly detect and intercept illicit drugs while preserving the integrity of evidence.

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