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Thermo Scientific® TruNarc™ Technical Evaluation Report

Project Information

Title: Thermo Scientific® TruNarc™ Technical Evaluation

Evaluation Type: Handheld Narcotics Identification Raman System

Stakeholder: Thermo Fisher Scientific®

Start Date: 04/30/2012 End Date: 08/09/2012

Kit Model Number(s): TruNarc™

Serial Number: TN1081 Manufactured: December 2011

Serial Number: TN1119 Manufactured: December 2011

Stakeholder Information

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Evaluation Summary

The National Forensic Science Technology Center (NFSTC) conducted an assessment of the Thermo Scientific® TruNarc™ analyzer, a handheld narcotics identification system. This portable hand-held Raman device is currently used by law enforcement, border patrol officers, and customs officers to rapidly identify unknown light-colored solids, liquids, gels, pastes, and pharmaceutical preparations encountered in field environments. The TruNarc™ is specifically designed to analyze and identify drugs of abuse, precursors, and common diluents.

The test plan for this evaluation was developed in conjunction with Thermo Scientific®. The objective is to assess the operational performance of the TruNarc™ for the identification of reference quality controlled substances, precursors, diluents, mixtures, and street samples including pharmaceutical preparations. The experimental process includes four sections:

- Identification of the most commonly encountered, single component, reference quality narcotics, bath salt precursors, and compounds producing false positives in colorimetric drug testing kits;
- Analysis of mixtures at two different concentrations;
- Identification of street samples with supporting laboratory reports; and
- Use of the TruNarc™ by individuals with different levels of experience with analytical equipment including laymen, law enforcement officers, and experienced forensic chemists.

The National Forensic Laboratory Information System (NFLIS) 2010 annual report and the NFLIS Special Report : Synthetic Cannabinoids and Bath Salts were referenced to determine the most commonly seen narcotics in the U.S., the most frequently encountered bath salts, and the average drug to diluent ratios for cocaine, methamphetamine, and heroin. No data was available on the average percentage of MDMA and cathinone samples. For both of these substances, fifty percent is used as the initial mixture. Both NFLIS reports can be found at www.deadiversion.usdoj.gov/nflis/index.html.

Overall, the TruNarc™ device performed well during this evaluation. It proved to be both accurate and reproducible for most single component common drugs of abuse. The TruNarc™ devices were accurate in the analysis of two-component mixtures in that either the controlled substance or the diluent was reported. However, reporting a diluent instead of the controlled substance when both are present may be misleading to the user. This is addressed further in the Discussion and Findings. Results from TruNarc™ operation by law enforcement and non-scientists highlighted the importance of training TruNarc™ customers on the proper operation of the device, and the significance of presenting a suitable sample to the laser to produce reliable results. Possible software modifications were suggested during the evaluation and are delineated in the Findings section of this report.

Product Specifications

The TruNarc™ weighs approximately 505 grams (1.11 lbs) and measures approximately 6.4 x 4.1 x 2.0 in. (16.26 x 10.41 x 5.1 cm). It has a 3.7V battery that lasts up to 10 hours and is rechargeable using a USB cable, a DC wall adapter with a package of plug adapters or an optional car charger. The unit comes in a rugged Pelican case, has an optional belt carrier to increase its portability, and operates in temperatures ranging from -14°F to 122°F (-10°C to +50°C). The Admin software for spectral review and reporting (.csv, .spc, .pdf, and Reachback .scz) is included on a CD for easy loading and is available in English or Chinese.

The carrying case includes a spare nose cone, AC adapter cable, USB cable, the TruNarc™ User Guide, the TruNarc™ Analyzer Quick Start Guide, and a CD-ROM with the TruNarc™ Admin software. There is an option for

purchasing the Thermo Scientific® heroin-testing Type-H Kit that contains ethanol filled vials and individually packaged heroin testing sticks.

The TruNarc™ is based on Raman spectroscopy, which measures the inelastic scattering of monochromatic light from an infrared laser source. The TruNarc™ has a class IIIB laser with an excitation wavelength of 785 nm, up to 250 mW output. When the sample of interest is bombarded with the laser energy, the molecular bonds within the compound scatter it. Some of the scattered light is collected by optics, and separated by wavelength by a dispersive spectrometer. A charge-coupled detector then measures the intensity of light at each wavelength and converts it to a spectrum, characteristic of a chemical compound. The spectrum from the sample is searched against entries in the libraries in the instrument memory via a search algorithm that uses a process of elimination to categorize results.

To facilitate data interpretation, scan results are displayed on colored backgrounds that designate a specifically defined category. The categories, as defined by the manufacturer, are: alarm, clear, acetaminophen, precursor chemical, and inconclusive. The chart below delineates each category with its corresponding color.

Category	Background Color	Display
Alarm result	Dark red	Alarm Substance identified
Clear result	Green	Detected a potential cutting agent
Acetaminophen (paracetamol) **Acetylsalicylic acid** **Warning**	Orange	Cannot rule out presence of narcotic: amounts may be too small for the analyzer to detect.
Precursor/chemical result **Warning**	Orange	Precursor/Chemical: used in the manufacture of illegal drugs
Inconclusive result	Gray	Neither a controlled substance nor cutting agent was identified.
Polystyrene warning result	Orange	Check that self test standard cap is not closed over laser.

References

"2010 Annual Report", National Forensic Laboratory Information System; U.S. Department of Justice, Drug Enforcement Administration, September, 2011.

"Special Report: Synthetic Cannabinoids and Synthetic Cathinones Reported in NFLIS, 2009-2010", National Forensic Laboratory Information System; U.S. Department of Justice, Drug Enforcement Administration, September, 2011.

Thermo Scientific® TruNarc™ User Guide, Part Number 110-00056-01.

Photos

TruNarc™ (powered on)

Result: Cocaine HCl (Controlled substances display a red background)

TruNarc™ in Pelican® carrying case with chargers, batteries and manual

Level of Operator Knowledge (Set per Manufacturer)

☒ Non-Scientist ☐ Technician ☐Scientist

Chemicals and Reagents

Substances by Manufacturer

Sigma
Cocaine HCl
Hydrocodone bitartrate salt
d- Amphetamine sulfate
Alprazolam
Oxycodone HCl
MDMA HCl
Clonazepam
Methylone HCl
Quinine
Lidocaine
Guaifenesin
Ketamine HCl
Diphenhydramine HCl
Caffeine
Safrole
Lactose monohydrate

Lipomed
Heroin HCl

Secondary Standards
Cocaine Base – NFSTC Heroin -DEA

Thermo Scientific®
Type-H Kit

Gayford Chemical
Dimethyl Sulfone

National Measurement Institute
Mephedrone HCl

Fisher
Sodium Bicarbonate
Acetone
MEK
Acetic Anhydride

Fluka
Levamisol

Acros
Inositol

Aldrich
Ephedrine HCl

Cayman Chemical

4' methylmethcathinone HCl (mephedrone HCl or 4-MMC)

Methylenedioxy pyrovalerone HCl (MDPV HCl)

Equipment

TruNarc™ Devices (2) – Serial Numbers: TN1081 and TN1119

Mettler-Toledo AB104-S analytical balance

TruNarc™ Vials

Type-H Kit

Zip bags

Weigh paper

Spatulas

Samples

1. **Identification of Single Component Samples**
    a. Controlled Substances (Standards):
        i. Cocaine HCl and Cocaine Base
        ii. Methamphetamine HCl
        iii. Heroin HCl
        iv. Oxycodone
        v. Morphine Sulfate
        vi. D-Amphetamine Sulfate
        vii. MDMA
        viii. Clonazepam
    b. Synthetic Cathinones (Bath Salts)
        i. 4' methylmethcathinone HCl (mephedrone HCl or 4-MMC)
        ii. Methylenedioxy pyrovalerone HCl (MDPV HCl)
        iii. Methylone HCl
    c. Precursor Chemicals:
        i. Acetone
        ii. Methyl ethyl ketone
        iii. Acetic anhydride
        iv. Ephedrine HCl
        v. Safrole
    d. Substances Producing False Positives in Presumptive Field Kits
        i. Guaifenesin
        ii. Ketamine

iii. Diphenhydramine
iv. Lidocaine
v. Quinine

e. Compounds Not Currently in the TruNarc™ Library:

i. DOB (±)-2,4-dimethoxy-4-bromoamphetamine
ii. Butylone HCl
iii. 5-Methoxy DALT

2. Mixture Identification:

a. Mixtures at Most Common Drug/Diluents Ratio w/w:

i. Cocaine HCl + Inositol 50/50 w/w
ii. Cocaine HCl + Levamisole HCl 50/50 w/w
iii. Cocaine base (secondary standard) + Sodium bicarbonate 55/45 w/w
iv. Methamphetamine HCl + Dimethyl sulfone w/w 70/30
v. Heroin HCl + Caffeine 30/70 w/w
vi. MDMA HCl+ lactose 50/50 w/w
vii. Mephedrone HCl + Caffeine 50/50 w/w

b. Mixtures Identification, Part II:

i. Cocaine HCl + Inositol 30/70 w/w
ii. Cocaine base (secondary standard)+ Sodium bicarbonate 30/70 w/w
iii. Heroin HCl + Caffeine 10/90 w/w
iv. MDMA HCl + Lactose 20/80 w/w
v. Mephedrone HCl + Caffeine 30/70 w/w

3. Street Sample Identification

Adjudicated case samples with laboratory identifications were interrogated on the Thermo Scientific® TruNarc™. The samples included: common pharmaceuticals, commonly encountered narcotics, and bath salts.

4. Multiple Users

a. The following individuals received brief training and were then given 10 samples to analyze in triplicate and record the results. A questionnaire was given to each participant for feedback.

i. NFSTC staff chemists (2)
ii. Non-scientists (2):
    1. NFSTC staff
    2. External college student
iii. Law Enforcement Officers (Narcotics Detectives) (2)

Synopsis of Experiments

Most powdered samples were interrogated in zip bags containing 20-40mg. Due to the limited quantities available: MDMA HCl, clonazepam, some bath salts, and mephedrone/caffeine mixtures had 6.8-15mg in the zip bag. Liquid samples were interrogated in vials. Methoxy DALT, MDPV, Butylone HCl, and DOB were analyzed in the manufacturer's vial. Butylone and DOB were in amber vials.

All samples were analyzed in triplicate. The samples were shaken between each interrogation. The manufacturer's procedure for sample analysis provided in the TruNarc™ User's Guide was followed throughout the evaluation. TruNarc™ data are viewed by syncing data files to a computer equipped with the TruNarc™ Admin software.

Self Test Method

This was performed by interrogating a polystyrene clip attached to the instrument laser to confirm proper operation of the instrument.

1. Perform the self test three times a day:
    a. In the morning before testing began
    b. Mid-day
    c. At the end of each day
2. Record results

Single Component Sample Analysis

1. Measure out each compound reference standard and place in an individual plastic zip bag or vial
2. Interrogate sample
3. Record results

Heroin Sample Analysis:

1. Obtain the Type-H Kits available from Thermo Scientific®
2. Prepare and analyze the sample per the procedure provided by the manufacturer
3. Record results

Mixtures

1. Weigh out the appropriate amounts of drug and diluents on an analytical balance, mix thoroughly, and place in a plastic zip baggie
2. Interrogate sample
3. Record results

Adjudicated Case Sample Analysis

1. Powder samples were scanned through zip-lock or heat-sealed bags
2. Pharmaceutical preparations, carisprodol and tramadol, were scanned whole. All others were cut in half or crushed to scan the interior of the tablet
3. Interrogate sample

4. Record results

Multiple User Sample Analysis

1. Analyze a subset of samples (from the list above) on one of the TruNarc™ devices
2. Record results and complete the survey

Results

Table 1A. Most Frequently Encountered Controlled Substances						
	TN1081 Results			TN1119 Results		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Cocaine HCL	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen
Cocaine Base	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen
Methamphetamine	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen
Heroin	Heroin Red Screen	Heroin Red Screen	Inconclusive Gray Screen	Heroin Red Screen	Heroin Red Screen	Heroin Red Screen
Oxycodone HCl	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen
Morphine Sulfate	Morphine Red Screen	Morphine Red Screen	Morphine Red Screen	Morphine Red Screen	Morphine Red Screen	Morphine Red Screen
D-Amphetamine Sulfate	Amphetamine Red Screen	Amphetamine Red Screen	Amphetamine Red Screen	Amphetamine Red Screen	Amphetamine Red Screen	Amphetamine Red Screen
MDMA	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen
Clonazepam	Clonazepam Red Screen	Clonazepam Red Screen	Clonazepam Red Screen	Clonazepam Red Screen	Clonazepam Red Screen	Clonazepam Red Screen

Table 1B. Synthetic Cathinones (Bath Salts)						
	TN1081 Results			TN1119 Results		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Mephedrone HCl	Mephedrone Red Screen	Mephedrone Red Screen	Mephedrone Red Screen	Mephedrone Red Screen	Mephedrone Red Screen	Mephedrone Red Screen
MDPV HCl	MDPV Red Screen	MDPV Red Screen	MDPV Red Screen	MDPV Red Screen	MDPV Red Screen	MDPV Red Screen

Table 1B. Synthetic Cathinones (Bath Salts)						
	TN1081 Results			TN1119 Results		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Methylone HCl	Methylone Red Screen	Methylone Red Screen	Methylone Red Screen	Methylone Red Screen	Inconclusive Gray Screen	Methylone Red Screen

Table 1C. Precursor Chemicals						
	TN1081 Results			TN1119 Results		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Acetone	Acetone Orange Screen	Acetone Orange Screen	Acetone Orange Screen	Acetone Orange Screen	Acetone Orange Screen	Acetone Orange Screen
MEK	MEK Orange Screen	MEK Orange Screen	MEK Orange Screen	MEK Orange Screen	MEK Orange Screen	MEK Orange Screen
Acetic Anhydride	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen
Ephedrine HCl	Ephedrine Orange Screen	Ephedrine Orange Screen	Ephedrine Orange Screen	Ephedrine Orange Screen	Ephedrine Orange Screen	Ephedrine Orange Screen
Safrole	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen

Table 1D. Compounds that Give a False Positive in Field Presumptive Kits						
	TN1081 Results			TN1119 Results		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Guaifenesin*	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen
Ketamine	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen
Diphenhydramine	Benadryl** Green Screen	Benadryl** Green Screen	Benadryl** Green Screen	Benadryl** Green Screen	Benadryl** Green Screen	Benadryl** Green Screen
Lidocaine	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen	Inconclusive Gray Screen
Quinine	Quinine Green Screen	Quinine Green Screen	Quinine Green Screen	Quinine Green Screen	Quinine Green Screen	Quinine Green Screen

*Compound not currently in library. **Trade name for diphenhydramine

Table 1E. Compounds Currently Not in TruNarc™ Library						
	TN1081 Results			TN1119 Results		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
DOB	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen
Butylone HCl	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen
5-Methoxy DALT	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen

Table 2A. Mixtures at a Higher Drug to Diluent Ratio						
	TN1081 Results			TN1119 Results		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Cocaine HCl Inositol 50/50 w/w	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen
Cocaine HCl Levamisole 50/50 w/w	Cocaine HCl Red Screen	Levamisole Green Screen	Cocaine HCl Red Screen	Levamisole Green Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen
Cocaine Base Sodium Bicarbonate 50/50 w/w	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen
Methamphetamine Dimethyl Sulfone 70/30 w/w	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen
Heroin HCl Caffeine 30/70 w/w	Heroin Red Screen	Heroin Red Screen	Heroin Red Screen	Heroin Red Screen	Heroin Red Screen	Heroin Red Screen
MDMA Lactose 50/50 w/w	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen
Mephedrone HCl Caffeine 50/50 w/w	Mephedrone Red Screen	Mephedrone Red Screen	Mephedrone Red Screen	Mephedrone Red Screen	Mephedrone Red Screen	Mephedrone Red Screen

Table 2B. Mixtures at Lower Drug to Diluent Ratio						
	TN1081 Results			TN1119 Results		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Cocaine HCl Inositol 30/70 w/w	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Inositol Green Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen
Cocaine Base Sodium Bicarbonate 30/70 w/w	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen

Table 2B. Mixtures at Lower Drug to Diluent Ratio						
	TN1081 Results			TN1119 Results		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Heroin HCl Caffeine 10/90 w/w	Heroin Red Screen	Inconclusive Gray Screen	Heroin Red Screen	Heroin Red Screen	Heroin Red Screen	Heroin Red Screen
MDMA Lactose 20/80 w/w	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen	Lactose Green Screen
Mephedrone HCl Caffeine 30/70 w/w	Mephedrone Red Screen	Caffeine Green Screen	Mephedrone Red Screen	Mephedrone Red Screen	Mephedrone Red Screen	Mephedrone Red Screen

Table 3A. TruNarc™ Street Sample Results						
	TN1081 Street Samples			TN1191 Street Samples		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
D,L Amphetamine and Dimethyl Sulfone	Dimethyl Sulfone Green Screen	Dimethyl Sulfone Green Screen	Dimethyl Sulfone Green Screen	Dimethyl Sulfone Green Screen	Dimethyl Sulfone Green Screen	Dimethyl Sulfone Green Screen
Cocaine HCL	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen
Cocaine Base	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen
Heroin HCL	Heroin Red Screen	Heroin Red Screen	Heroin Red Screen	Heroin Red Screen	Heroin Red Screen	Heroin Red Screen
Methamphetamine HCL	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen
Carisoprodol (350mg tablet)	Carisoprodol Red Screen	Carisoprodol Red Screen	Carisoprodol Red Screen	Carisoprodol Red Screen	Carisoprodol Red Screen	Carisoprodol Red Screen
Alprazolam (2.0 mg tablet)	Lactose Green Screen	Lactose Green Screen	Lactose Green Screen	Lactose Green Screen	Lactose Green Screen	Lactose Green Screen
Diazepam (10 mg tablet)	Diazapam Red Screen	Diazapam Red Screen	Diazapam Red Screen	Diazapam Red Screen	Diazapam Red Screen	Diazapam Red Screen
Diazepam (5 mg tablet)	Diazapam Red Screen	Diazapam Red Screen	Cellulose Green Screen	Diazapam Red Screen	Diazapam Red Screen	Diazapam Red Screen
Oxycodone (20mg tablet)	Low Density Polyethylene/ Lactose Green Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen
Oxycodone HCL (30mg tablet)	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen
Oxycodone HCL (5mg tablet)	Lactose/ Cellulose Green Screen	Lactose/ Cellulose Green Screen	Lactose/ Cellulose Green Screen	Lactose/ Cellulose Green Screen	Lactose/ Cellulose Green Screen	Lactose/ Cellulose Green Screen

Table 3A. TruNarc™ Street Sample Results						
	TN1081 Street Samples			TN1191 Street Samples		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
MDMA	MDMA Red Screen	MDMA Red Screen	Baking Soda Green Screen	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen
Cocaine	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base/ Pseudo-ephedrine Red Screen
Hydrocodone/APAP (10mg/650 mg tablet)	Acetaminophen (Paracetamol) Orange Screen	Acetaminophen (Paracetamol) Orange Screen	Acetaminophen (Paracetamol) Orange Screen	Acetaminophen (Paracetamol) Orange Screen	Acetaminophen (Paracetamol) Orange Screen	Acetaminophen (Paracetamol) Orange Screen
Cocaine	Cocaine Base/ Methylethyl-cathinone Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base/ Methylethyl-cathinone Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen
Cocaine	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen
Cocaine	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen
Hydromorphone (8mg tablet)	Lactose Green Screen	Lactose Green Screen	Lactose Green Screen	Lactose Green Screen	Lactose Green Screen	Lactose Green Screen
Methamphetamine	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen
Methamphetamine	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen
Cocaine	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen	Cocaine Base Red Screen
MDMA/Meth.	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen
Hydrocodone/ Ibuprofen (7.5/200 mg tablet)	Ibuprofen Green Screen	Ibuprofen Green Screen	Ibuprofen Green Screen	Ibuprofen Green Screen	Ibuprofen Green Screen	Ibuprofen Green Screen
Tramadol (50 mg tablet)	Tramadol Red Screen	Tramadol Red Screen	Tramadol Red Screen	Tramadol Red Screen	Tramadol Red Screen	Tramadol Red Screen

Table 4Ai. TruNarc™ Results Run By Scientists						
	TN1081 Results - Scientist 1			TN1119 Results - Scientist 2		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Lidocaine	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen
Oxycodone HCl	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen
Methamphetamine	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen
Guaifensesin	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen
Cocaine HCl Inositol 50/50 w/w	Cocaine HCl Red Screen	Inositol Green Screen	Inositol Green Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Inositol Green Screen
MDMA Lactose 20/80 w/w	Lactose Green Screen	Inconclusive Gray Screen	Lactose Green Screen	Lactose Green Screen	MDMA Red Screen	MDMA Red Screen
Ketamine HCl	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen
Safrole	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen
Acetic Anhydride	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen

Table 4Aii. TruNarc™ Results Run By Non-Scientists						
	TN1081 Results - Non-Scientist 1			TN1119 Results – Non-Scientist 2		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Lidocaine	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen
Oxycodone HCl	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen
Methamphetamine	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen
Guaifensesin	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen
Cocaine HCl Inositol 50/50 w/w	Cocaine HCl Red Screen	Inositol Green Screen	Inositol Green Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Inositol Green Screen
MDMA Lactose 20/80 w/w	MDMA Red Screen	MDMA Red Screen	Lactose Green Screen	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen

Table 4Aii. TruNarc™ Results Run By Non-Scientists						
	TN1081 Results - Non-Scientist 1			TN1119 Results – Non-Scientist 2		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Ketamine HCl	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen
Safrole	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen
Acetic Anhydride	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen

Table 4Aiii. TruNarc™ Results Run By LEOs						
	TN1081 Results - LEO 1			TN1119 Results - LEO 2		
Sample	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 1**	**Trial 2**	**Trial 3**
Lidocaine	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen	Lidocaine Green Screen
Oxycodone HCl	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen	Oxycodone Red Screen
Methamphetamine	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen	Meth-amphetamine Red Screen
Guaifensesin	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen	Inconclusive Gray Screen
Cocaine HCl Inositol 50/50 w/w	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen	Cocaine HCl Red Screen
MDMA Lactose 20/80 w/w	MDMA Red Screen	MDMA Red Screen	Lactose Green Screen	MDMA Red Screen	MDMA Red Screen	MDMA Red Screen
Ketamine HCl	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen	Ketamine Red Screen
Safrole	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen	Sassafras Oil Orange Screen
Acetic Anhydride	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen	Acetic Anhydride Orange Screen

User Feedback

Specifically, what do you like about the device?

- LEO 1: Convenient size.
  The ability to test without removing substance from packaging.
  More reliable than standard presumptive test.
  Easy to operate and collection of stored data.
- LEO 2: Easy to handle.
  User friendly.
- NS 1: Small and easy to handle-portable.
- NS 2: Very easy to use.
- Sci 1: The device is small, easily portable and the user interface is intuitive.
- Sci 2: The size is great. The user interface is simple. I like the categories of results and that it still identifies “clear” substances.

What improvements or changes would you suggest?

- LEO 1: Through laboratory testing I would not change a thing. Field testing would be necessary to give an absolute opinion.
- LEO 2: User identifier feature.

Please give your opinion of the ease of use for this device:

- LEO 1: Very easy to use, understand and to operate.
- LEO 2: Very easy.
- NS 1: Very simple to use; color indicators were obvious and easy to read.
- NS 2: It was very easy.
- Sci 1: Great user interface and simple to use.
- Sci 2: It is very easy to use and interpret results.

As a member of law enforcement, do you think this device would be useful to you? How specifically?

- LEO 1: Absolutely. Simplifies testing process. Presumptive testing is sometimes difficult in the field due to some uncontrollable factors. This device makes the process much easier.
- LEO 2: The device is very useful to LEO. Quick results.

Discussion

Identification of Single Component Samples

Controlled Reference Samples

Commonly encountered (including both cocaine HCl and cocaine base) controlled substances reported nationally by forensic laboratories and suggested by Thermo Scientific® were analyzed. All of the compounds are entries in the TruNarc™ library, so positive results were expected. Both TruNarc™ devices proved to be accurate and reproducible. One heroin trial was inconclusive. Given that the heroin standard was a pure white powder, Type-H Kits were not used. The heroin samples were interrogated by the point-and-shoot method.

Synthetic Cathinones

Three commonly encountered synthetic cathinones or "bath salts": mephedrone HCl, methylone HCl, and MDPV HCl, were tested on each TruNarc™. These synthetic cathinones have recently been scheduled by the Drug Enforcement Administration (DEA). All three produced consistently accurate and reproducible outcomes.

Precursor Chemicals

Five common precursor chemicals required for methamphetamine, heroin, and MDMA production were tested. The TruNarc™ instruments were 100 percent accurate and the results reproducible with the five-sample set of precursor chemicals.

Substances Producing False Positives in Presumptive Field Kits

These compounds were chosen because they are relatively common and produce false positives in a presumptive field kit. The trials for all five compounds were accurate and reproducible on both TruNarc™ devices. The inconclusive results for guaifenesin were expected since this substance is not in the TruNarc™ library. Guaifenesin is an over-the-counter expectorant that produces a purple color (positive for opiates) in a Marquis presumptive field kit. It would be beneficial to add guaifenesin to the TruNarc™ library.

Diphenhydramine was reported as Benadryl®, which is a brand name. There are many over-the-counter medications containing diphenhydramine. It may be less ambiguous for the drug result to read diphenhydramine with brands listed parenthetically. This holds true for any brand names in the library. TruNarc™ training should include an explanation of brand name versus drug name. This is a distinction that is typically unclear to non-scientists, including law enforcement officers.

One lidocaine trial displayed the inconclusive screen on device TN1119.

Compounds Not Currently in the TruNarc™ Library

As expected, since these compounds are not in the TruNarc™ library, all the results displayed as inconclusive, thereby producing a low false positive rate.

Mixtures at a Higher Drug to Diluent Ratio

With the exception of two trials, results for the mixtures at a higher drug to diluent ratio all reported the compound of interest as opposed to the diluents. In two trials of the 50/50 w/w cocaine HCl and levamisole, the levamisole was detected instead of the cocaine.

The heroin used to prepare this mixture set and the lower concentration heroin/caffeine samples was a secondary standard obtained from the DEA. This sample is beige in color and better represents street heroin. The Thermo Scientific® Type-H Kit was used in the analysis of all the mixture samples. Use of the kit enabled the successful detection of heroin in all the trials.

Mixtures at a Lower Drug to Diluent Ratio

Not surprisingly, this group of samples displayed a couple of positive results for the diluents rather than for the target compounds. For these samples, because the laser is interacting more frequently with the diluents rather than the compound of interest, the result is a positive identification of the diluent rather than the identification of the lower concentration narcotic. In this test, and as recommended by Thermo Scientific® to their users in their training material, several scans of each sample were performed shaking the bag between scans and targeting a different area of the sample, to account for low concentration and non-homogeneous samples.

The Thermo Scientific® Type-H Kit was again used in the analysis of the heroin and caffeine mixtures. Five out of the six trials effectively displayed a red alarm heroin screen. One trial produced an inconclusive result. The ethanol in this Type-H Kit had evaporated. HPLC grade ethanol was substituted for the kit ethanol, and the inconclusive result occurred.

Adjudicated Street Samples

Twenty-five street samples were scanned on both TruNarc™ devices. The samples were obtained from law enforcement with accompanying laboratory reports. The samples included unknown powders and a variety of pharmaceutical preparations. The results appear in Table 3A. Salt forms are only listed if contained in the laboratory report.

The TruNarc™ performed accurately and reproducibly in most cases. It should be noted that the D, L form of amphetamine is not in the TruNarc™ library, which may partially account for only dimethyl sulfone being reported. Also, the dimethyl sulfone was in much higher concentration.

Pharmaceuticals were analyzed from highest concentration to lowest, stopping at the highest dosage that gave binders or fillers as results. Alprazolam at 2 milligrams resulted in lactose in all scans on both devices. Diazepam was reported accurately in all scans at 10 milligrams and 5 out of 6 scans at 5 milligrams.

The orange warning screen for acetaminophen and aspirin is a valuable feature for flagging preparations that may contain an opiate at a low concentration. Ibuprofen should also produce an orange warning screen, since it too is in preparations with low dose opiates as exemplified by the 7.5mg hydrocodone/200mg ibuprofen tablet.

Samples Run by Experienced Forensic Scientists

A subset of previously analyzed samples was interrogated by experienced forensic scientists, each scientist using one of the devices. With the exception of one, all the results were accurate. Trial 2 of the 20/80 MDMA and lactose mixture displayed an inconclusive result. Comments from the scientist appear previously in this report.

Samples Run by Non-Scientists and Samples Run by Law Enforcement Officers (LEOs)

Two non-scientists, a NFSTC staff member and a college student, along with two narcotics officers were asked to run the same samples as the forensic scientists. Each non-scientist and narcotics officer operated one of the TruNarc™ devices. None of these operators had previous experience with the TruNarc™. Each was provided training on instrument operation and sample analysis using the device.

These two groups of operators experienced a common problem with sampling to a much greater extent than the other users in this evaluation. Some powdered samples are significantly impacted by static electricity in the zip bag. The powder disperses extensively and is difficult to gather for effective analysis. A significant number of unexpected inconclusive results were obtained the first time these operators ran the samples. After reviewing the data, the users were called back to re-analyze the samples in question. Re-training took place with an emphasis

on sampling. Detection of the target drug was very successful during re-analysis. Those results are included in this document.

When testing a mixture, if an alarm item is found, it is reported accurately. If the outcome is a diluent, the operator is trained to scan a different zone of the sample, which may yield an alarm. This is due to the fact that the laser is interacting more frequently with the diluents rather than the compound of interest, resulting in a positive result for a diluent rather than for the lower concentrations of the alarm substance.

In part, because of this situation, users were required to run evaluation samples in triplicate, to account for non-homogeneous samples, if an alarm was given, this was recorded. In the Thermo Scientific® training, users are recommended to scan a sample more than once if they receive a clear screen.

Findings

Strengths

- The Type-H Kit improves the challenge of heroin analysis.
- The TruNarc™ exhibited more success in detecting the active component of pharmaceutical preparations or flagging preparations that require further analysis.
- The TruNarc™ is compact and weighs a little more than a pound (~1.11 lb).
- Raman spectroscopy is non-destructive, unless using a Type-H Kit.
- Little to no sample preparation is required.
- The device is operated in a point-and-shoot mode.
- A small amount of sample is required and analysis can be performed through a container in most cases.
- The instrument was accurate and reproducible for most samples included in this evaluation.
- The User Manual is extremely thorough, and the Quick Reference Guide is easy to follow.
- The unit is easy to operate with a menu-driven user interface.
- The results screen provides a scan identification number and date and time stamp for data tracking.
- The results screen categorizes the compound.
- The library contains many compounds, common diluents, and precursors to controlled substances.
- Data is downloaded into the computer software for review.
- Data can be printed into a.pdf report with a user customized with a logo.
- The online software is equipped with an online training course on instrument operation.
- Case information can be added to the scan results within the user software.
- The user can review identification results in a list by scan identification number on the instrument.
- Data formats for GRAMS/OMNIC software (.spc), comma-separated values (.csv), Reachback (.scz), and report files (.pdf) allow users to access files with other programs or send them to a Reachback representative for assistance.
- The TruNarc™ may be charged using a USB cord, a wall charger, or an optional car charger.
- The only consumables for the unit are vials and the Type-H Kit.

Issues Encountered

- On device TN1081 the software did not always recognize the device when plugged in for downloading data. Multiple restarts of the software or rebooting the TruNarc™ were required when transferring data from TN1081. This issue was not experienced with TN1119.
- On occasion, TN1081 was recognized by the software, and a message of "no scans to sync" was received. The software and device were re-booted to resolve the issue. This issue was not encounter in TN1119.
- The spectral comparisons on the report do not visibly match well. This may make data review and court presentation difficult. Thermo Scientific® is currently addressing this issue.
- The ethanol in multiple vials included in the Type-H Kit had evaporated. Improved packaging to prevent this is necessary. Thermo Scientific® is working toward an answer to this problem.

Suggestions

- Provide the ability to view spectral results and comparisons on the device.
- Add the option to enter a unique identifier (case number, laboratory number) before running a sample. Tracking data by the scan number did not always work well in a controlled environment and would be cumbersome in the field.
- It is unclear if the TruNarc™ data can be shared on multiple computers pointed to a common data folder. If this is not currently an option, implementation would be useful.
- Include a correlation/confidence score with library matches.
- Add the feature to sort data by clicking at the top of a column ("Time" or "Result Type").

Training Recommendations

- Effective presentation of a sample to the laser must be emphasized in training. Operators lacking in experience with analytical devices do not necessarily grasp the correlation between effective sampling and adherence to a specified procedure to dependable results.
- Samples should be run in triplicate, shaking the sample between each interrogation, in order to ensure a homogenous mixture is presented to the laser. This is essential in the analysis of mixture given that only one component is typically reported by the TruNarc™, and it may not be a compound of interest.
- Provide easy to understand explanations to operators about all aspects of the TruNarc™ analysis process that they may be expected to explain in court.
- The libraries are limited compared to other hand-held Raman devices. That this is by design should be communicated to the users along with any resultant limitations.

Health and Safety Issues

- The unit has a Nominal Ocular Hazard Distance of 14 inches (the distance at which the radiation has decreased to 2 mW/cm^2). Exposure to the beam and reflections from the beam should be avoided within this range, or goggles with an optical density greater than 3 should be worn.

- Raman should not be used to sample dark-colored materials, which is explained during TruNarc™ training. Small samples should be isolated for testing. A user should also take care with dark colored gloves, as they may heat up if holding the sample to the aperture.
- The ethanol vials used for heroin testing contain ethanol, a flammable liquid, which should be treated with appropriate caution.

Acknowledgements

NFSTC wishes to thank the **Cayman Chemical Company** for their collaborative contribution of standards used to facilitate this evaluation.