PRELIMINARY VALIDATION OF COMMERCIALLY AVAILABLE FIELD TEST KITS FOR DRUGS OF ABUSE

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ABSTRACT

A **validation study of commercially available field test kits for drugs of abuse** was conducted. The purpose of the study was to provide objective information about commercially available kits for inclusion in the National Forensic Science Technology Center's (NFSTC) **Field Investigation Drug Officer Program (FIDO)**.

The **test kits** included in the validation study are those manufactured by:

- ODV, Inc. (NarcoPouch®)
- NIK® Public Safety (NIK® System of Narcotic Identification)
- Sirchie® Finger Print Laboratories, Inc. (NARK II)

This preliminary study evaluated the **sensitivity**, **reproducibility**, and **specificity** of the kits, which are designed for the presumptive identification of:

- Cocaine salt
- Cocaine base
- Methamphetamine
- Heroin

The **tested substances** included:

- Pure drug standards
- Pure cutting agents
- Known mixtures of drug standards and cutting agents
- Street samples

The study confirmed that field test kits can provide sensitive, accurate, and reproducible results, when used within the confines of a Field Investigation Drug Officer (FIDO) program.

INTRODUCTION

The concept for the development of a best practices guide for a Field Investigation Drug Officer (FIDO) program was presented to the American Academy of Forensic Sciences by the NFSTC in 2005.

The FIDO program is comprised of documents that articulate:

- Program administration
- Guidelines for quality assurance
- Legal issues
- Materials for the development of training and certification programs
  - Lesson plans
  - Class outlines
  - Recertification lesson plans
  - Class lecture content and slideshows
  - Practical exercises
  - Written examinations and practical assessments
  - Forms
  - References

Program Benefits

Benefits of the effective implementation of a FIDO program include:

- Immediate investigative information
- Facilitation of case adjudication in the preliminary phase
- Reduction of laboratory case backlog
- Increased potential for a guilty plea at arraignment when field test results are positive

Cases with a negative or ambiguous result or any case in which the defendant chooses to proceed to trial are submitted to the laboratory for complete analysis.

Substance Selection

According to the National Forensic Laboratory Information System (NFLIS), the most commonly encountered controlled substances reported by forensic laboratories are **Cannabis, cocaine, methamphetamine**, and **heroin**.

These drugs are addressed in the FIDO program and are the focus of this preliminary study (with the exception of Cannabis).

Test Kit Selection

The use of color test kits is the most common method for the presumptive identification of drugs in the field because they are quick, easy to use, and cost effective, thus they are an ideal method for use in a FIDO program.

For consideration in the FIDO program, color test kits must provide:

- Clear, unambiguous color to indicate a positive or negative result
- Sufficient specificity to minimize false positive or false negative interpretation
- Adequate sensitivity to allow the detection of drugs at concentrations commonly encountered in street samples
- Accurate results for drugs mixed with a variety of adulterants
- Reproducible results

A validation study was designed and conducted to address the above criteria for kits manufactured by ODV, Inc., NIK® Public Safety, and Sirchie® Finger Print Laboratories, Inc.

MATERIALS AND METHODS

Equipment

- Analytical balance[a]
- Spatulas
- Weigh paper
- Munsell Book of Color (Volumes 1 and 2)

Test Kits

- Scott (modified)
- Marquis
- Mecke's (modified)
- Sodium Nitroprusside

Drugs

- Cocaine hydrochloride[b]
- Cocaine base[f]
- Methamphetamine[b]
- Heroin[b]

Cutting Agents

- Acetaminophen[b]
- Aspirin[b]
- Baking Soda[c]
- Benzocaine[b]
- Boric Acid[a]
- Caffeine[b]
- Chlorpheniramine[b]
- Dextromethorphan[b]
- Dimethylsulfone[d]
- Diphenhydramine[e]
- Ephedrine[b]
- Lidocaine[b]
- Inositol[a]
- Mannitol[b]
- Niacinamide[b]
- Procaine[b]
- Quinine[b]

Procedure

1. Three (3) milligram portions of each sample were weighed.
   - Sensitivity: samples tested in duplicate
   - Specificity: samples tested in duplicate
   - Reproducibility: Ten (10) replicates
   - Street sample verification: Single test of each
2. One three (3) milligram portion was placed in each test pouch.
3. Each test was performed following the manufacturer's instructions.
   The test(s) performed on each drug included:
   - Cocaine HCl and Cocaine base – Scott (modified) test
   - Methamphetamine – Marquis and Sodium Nitroprusside
   - Heroin – Marquis and Mecke's (modified)
4. After sixty (60) seconds, the hue, value, and chroma of the final color for each sample were recorded, referencing *The Munsell Book of Color*.

RESULTS

Fig. 1: Scott (modified)

Fig. 2: Marquis

Fig. 3: Marquis

Fig. 4: Mecke's (modified)

Fig. 5: Sodium Nitroprusside

Table 1: Estimated Limits of Detection Expressed as Percent Drug Purity

Drug	Test	Cut	Limit of Detection		
			ODV	NIK	NARK II
Cocaine Hydrochloride	Scott (modified)	Caffeine	20 - 40%	10 - 30%	10 - 30%
		Mannitol	30 - 60%	10 - 30%	10 - 30%
		Benzocaine	30 - 60%	10 - 30%	10 - 30%
		Boric Acid	30 - 60%	30 - 60%	>30%
Cocaine Base	Scott (modified)	Caffeine	10 - 30%	10%	10 - 30%
		Mannitol	10 - 30%	30 - 60%	10 - 30%
		Benzocaine	30 - 60%	30 - 60%	10 - 30%
Methamphetamine	Marquis	Caffeine	2150%	2150%	2150%
		DMS	2150%	2150%	2150%
		Niacinamide	2150%	2150%	2150%
	Sodium Nitroprusside	Caffeine	2150%	2150%	2150%
		DMS	2150%	2150%	2150%
		Niacinamide	2150%	2150%	2150%
Heroin	Marquis	Caffeine	2150%	2150%	2150%
		Quinine	2150%	10 - 30%	10 - 30%
	Mecke's (modified)	Caffeine	2150%	2150%	2150%
		Quinine	2150%	10 - 30%	10 - 30%
		Procaine	2150%	30 - 60%	30 - 60%
		Quinine	2150%	10 - 30%	10 - 30%

Table 2: Reproducibility (Eight Repeats at 45% Drug Purity Mixed with Caffeine)

Drug	Test	ODV	NIK	NARK II
Cocaine Hydrochloride	Scott (modified)	All positive	All positive	All positive
Cocaine Base	Scott (modified)	All positive	All positive	All positive
Methamphetamine	Marquis	All positive	All positive	All positive
	Sodium Nitroprusside	All positive	All positive	All positive
Heroin	Marquis	All positive	All positive	All positive
	Mecke's (modified)	All positive	All positive	All positive

Table 3: Test Kit Specificity Using Common Diluents

Substance	Scott (modified)			Marquis			Sodium Nitroprusside			Mecke's (modified)		
	ODV	NIK	NARK II	ODV	NIK	NARK II	ODV	NIK	NARK II	ODV	NIK	NARK II
Acetaminophen	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aspirin	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Baking Soda	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Benzocaine	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Boric Acid	NR	NR	pale blue*	NR	NR	NR	NR	NR	NR	NR	NR	NR
Caffeine	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Chlorpheniramine	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dextromethorphan	NR	NR	NR	green/black	green/black	green/brown	red	red	red	yellow	yellow	yellow
Dimethylsulfone	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Diphenhydramine	NR	blue*	blue*	yellow*	yellow*	yellow*	NR	NR	NR	yellow	yellow	yellow
Ephedrine	NR	NR	NR	NR	NR	NR	red	red	red	NR	NR	NR
Inositol	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Lidocaine base	blue flash	blue*	blue*	NR	NR	NR	NR	NR	NR	NR	NR	NR
Mannitol	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Niacinamide	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Procaine	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Quinine	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table 4: Verification of Validation Using Street Samples

Suspected Drug	Test	Sample Number	ODV	NIK	NARK II
Cocaine Salt	Scott (modified)	42	Blue	Blue	Blue
		45	Blue	Blue	Blue
		47	Blue	Blue	Blue
		49	Blue	Blue	Blue
		50	Blue	Blue	Blue
Cocaine Base	Scott (modified)	1	Blue	Blue	Blue
		6	Blue	Blue	Blue
		7	NR	NR	NR
		10	Blue	Blue	Blue
		11	Blue	Blue	Blue
		13	Blue	Blue	Blue
		40	Blue	Blue	Blue
		41	Blue	Blue	Blue
		43	Blue	Blue	Blue
		44	Blue	Blue	Blue
		48	Blue	Blue	Blue
Methamphetamine	Marquis	1	Orange-Brown	Orange-Brown	Orange-Brown
		2	Orange-Brown	Orange-Brown	Orange-Brown
		3	Orange-Brown	Orange-Brown	Orange-Brown
	Sodium Nitroprusside	1	Blue-Purple	Blue-Purple	Blue-Purple
		2	Blue-Purple	Blue-Purple	Blue-Purple
		3	Blue-Purple	Blue-Purple	Blue-Purple
Heroin	Marquis	31	Purple	Purple	Purple
		32	Purple	Purple	Purple
		33	Purple	Purple	Purple
		34	Purple	Purple	Purple
		35	Purple	Purple	Purple
		36	Purple	Purple	Purple
		38	Purple	Purple	Purple
		39	Purple	Purple	Purple
		46	Purple	Purple	Purple
		477	Purple	Purple	Purple
		478	Purple-Brown	Purple-Brown	Purple-Brown
	Mecke's (modified)	31	Green	Green	Green
		32	Green	Green	Green
		33	Green	Green	Green
		34	Green	Green	Green
		35	Green	Green	Green
		36	Green	Green	Green
		38	Green	Green	Green
		39	Green	Green	Green
		46	Green	Green	Green
		47	Green	Green	Green
		42	Yellow	Yellow	Yellow

*Laboratory analysis revealed sample to be negative for cocaine
Weak but
Brown, Pinkyline, Lactose sample charred, color ambiguous

DISCUSSION

This preliminary study provides validation data for three commercially available kits used to test controlled substances in the field. **The sensitivity, reproducibility, and specificity information confirms that these field test kits are valuable tools for the preliminary identification of controlled substances, as prescribed by the FIDO program.**

Sensitivity

- Methamphetamine exhibited a consistent detection limit at ≤10% in both Marquis and Sodium Nitroprusside kits from all three manufacturers. The limit of detection did not vary with sample composition.
- The detection limit of heroin was consistent for both of ODV's Marquis and Mecke's kits at a level of ≤10%. More variability and higher detection limits were observed when using NIK and NARKII kits on the samples containing procaine and quinine.
- Generally, the Scott test showed higher detection limits for cocaine hydrochloride with significant variability. Overall, it was noted that the ODV Scott test kits appeared to have lower sensitivity.
- **These measures of sensitivity demonstrate that presumptive testing may not be suitable for all drug samples. This emphasizes that those samples producing negative or ambiguous results must undergo laboratory testing procedures, as stated in the FIDO program guidelines.**

Reproducibility

- All reproducibility studies were conducted on mixtures containing 45% drug purity. This level of purity was selected because it represents a mid-level concentration that is above the estimated limit of detection.
- All drugs tested in all kits exhibited reproducible positive results at the chosen concentration.

Specificity

- The majority of the diluents tested exhibited no reaction with the test kit reagents.
- Color changes were noted in tests conducted on boric acid, diphenhydramine, lidocaine, and dextromethorphan.
- Lidocaine and boric acid produced a blue color similar to that produced by cocaine in the Scott test. Drugs sharing common chemical properties may yield similar results in a presumptive field kit.
- **Within a FIDO program, all questionable results or in the event that a defendant pleads not guilty at pre-trial, the case is submitted to the laboratory for a complete analysis.**

Verification

- An ambiguous result was obtained for a heroin street sample known also to contain procaine and lactose. The sample charred more rapidly in the test kit than would normally be expected. **In a field testing program, such a sample should subsequently undergo full laboratory analysis.**
- A negative result was obtained for one street sample suspected to contain cocaine. This sample was later confirmed by laboratory analysis to be negative for the presence of cocaine or any other controlled substance.
- All other tested street samples produced positive results, in agreement with laboratory findings.
- **These verification results demonstrate that field test kits are an applicable and appropriate technique for the preliminary field identification of cocaine, methamphetamine, and heroin.**

General Observations and Recommendations

- Using Scott test kits to distinguish between cocaine salt and cocaine base is ambiguous; it is the opinion of the authors that this does not fall within the purview of a presumptive field test.
- A small number of kits used in the study presented manufacturing quality control issues, including vials reversed in holder, missing vials, and empty vials. **Before use, the field test kit should be examined carefully.**
- Manufacturer's instructions should be followed for loading kits, testing, and safety precautions.
- Kits should not be used beyond their expiration date.

Future Studies

- Narrow the estimated detection limit ranges.
- Provide inter-day reproducibility data for each drug.
- Extend the specificity study to test common diluents at amounts larger than three (3) milligrams.
- Extend the specificity study to include additional drugs with a similar chemical structure to cocaine
- Investigate kit performance under various environmental conditions.
- Extend the validation study to include Cannabis samples.

CONCLUSIONS

This preliminary validation study of commercially available field test kits for drugs of abuse:

- Presents data in support of the use of commercially available drug test kits in a field based drug testing program.
- Supports the effectiveness of field based drug testing programs in decreasing drug case backlogs and expediting case adjudication without compromising quality.
- Emphasizes the FIDO program guidelines requiring that all samples producing negative or ambiguous field test results undergo complete laboratory analysis.
- Presents results intended to assist administrators of law enforcement agencies in the selection of field test kits most suited to their needs.
- **Provides preliminary verification to the criminal justice system that this methodology is both adequate and scientifically acceptable for use in a field testing program.**

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MATERIAL SOURCES

[a]Fisher Scientific
Pittsburgh, PA

[b]Sigma-Aldrich Chemical Company
St. Louis, MO

[c]Arm & Hammer
Princeton, NJ

[d]Gaylord Chemical Corporation
Bogalusa, LA

[e]ICN Biomedicals, Inc.
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