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Product Evaluation of M.M.C. International B.V. Screening Tests for Narcotics

Project Information

Title: Product Evaluation of M.M.C. International B.V. Screening Tests for Narcotics

Evaluation Type: Colorimetric test kits

Stakeholder: SOHO Network Solutions, Inc.

Start Date: 06/10/10 End Date: 9/27/10

Kit Model Number(s): N/A

Lot Number(s): Crack / Cocaine: 362

Crystal Meth / XTC: 299, 324

Heroin: 2009/307, 337

Manufacturer Information

Manufacturer: M.M.C. International B.V.

Phone Number: +31-76-5711140

Internet address: www.mmcinter.com

www.narcotictests.com

Stakeholder Information

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Evaluation Summary

The National Forensic Science Technology Center evaluated three types of Narcotic Screening Tests manufactured by M.M.C. International B.V. Each test is designed to presumptively identify specific target drugs; the crack / cocaine tests target cocaine base and hydrochloride (HCl); the crystal meth / XTC tests target methamphetamine and MDMA (XTC or 3,4-methylenedioxymethamphetamine); and the heroin tests target heroin (diacetylmorphine). The evaluation included assessment of conformity, reproducibility, limit of detection, specificity, mixture sensitivity and ruggedness and was performed in duplicate by independent evaluators. The

objective of this evaluation was to provide impartial data to members of the forensic community interested in new colorimetric tools for their laboratory or field-testing protocols.

The single-use test ampoules are packaged in boxes of 10, approximately 5.7 to 6.1 cm long (test dependent), and include a plastic cap for each ampoule, a package of 10 disposable spatulas and a set of written and photographic instructions. Each ampoule (test) contains a proprietary reagent-granulate (liquid and crystals), and is printed with the name of the test, the target drug and a band of color to indicate a positive result. Samples are added by breaking off the tip of the ampoule at the fracture line and using a supplied disposable spatula, or other appropriate device, to insert sample material into the bottom portion of the ampoule. Alternatively, the sample can be added to the cap, which is then placed on top of the opened ampoule. The ampoule is tapped to distribute the sample over the reagent-granulate. When positive, the reagent-granulate within the vial will change to the appropriate color within one to two minutes. According to product information, neutralization occurs within the ampoule, allowing for safe disposal of the tests after use.

Three test types, labeled “Cocaine / Crack Test”, “Heroin Test” and “Crystal Meth / XTC Test”, were assessed. The evaluation samples included the appropriate target drug for each test, common diluents and other drugs similar in structure or function. The evaluation procedure was designed to follow the written instructions provided in each box of tests. Results of each trial were recorded in a table as positive, negative, or inconclusive. To minimize subjectivity in color description, each result was compared with the Munsell Book of Color, and the hue, value and chroma identifiers on the back of each chip were recorded. (See “Table 1” for those values considered within the positive range for each test.)

Product Specifications

Photos

Left: Unreacted test
Right: Cocaine HCl

Left: Unreacted test
Right: Heroin HCl

Left: Unreacted test
Right: Methamphetamine HCl

Left: Unreacted test
Right: MDMA HCl

Product Uses

The M.M.C. Narcotics Tests can be used to presumptively identify illicit drugs in a laboratory or field environment.

Instrument Setup Comments

Not applicable

Level of Operator Knowledge (Set per Manufacturer)

__X__ Non-Scientist ____ Technician ____ Scientist

Procedure

The following method was used for performance checking and sampling:

1) If attached, remove the plastic cap from the ampoule and place nearby.
2) Gently knock the bottom of the unopened ampoule against a hard surface so the reagent-granulate within falls to the lower portion of the ampoule.
3) Snap the smaller, top portion of the ampoule off at the fracture line using the thumb and index finger of one hand or by inserting the top of the ampoule into the Snapit™ ampoule opener.
4) Using a disposable spatula, weigh paper, pipette, or other appropriate device, add a small amount of sample to the ampoule and start the timer.
5) Place the cap over the ampoule.
6) Tap the ampoule lightly to distribute the sample.
7) After approximately one minute, compare the color of the granules within the ampoule to the color of the band printed on the outside of the ampoule. (*Note: Wait no longer than two minutes.*)
8) Compare the reagent-granulate color produced to the color chips in the Munsell Book of Color.
9) Record identifiers for color chips matching granular contents of the ampoule as well as interpretation:
    a. "+" (positive);
    b. "-" (negative); or
    c. "INC" (inconclusive).
10) Properly dispose of the ampoule.

Each test kit type was evaluated in duplicate for the following: conformity, reproducibility, limit of detection, specificity, mixture sensitivity, ruggedness and ease of use, including training requirements.

A. Conformity – The following reference samples were added to the test in approximately 2-mg amounts (see also "Specificity") to determine the kit's ability to react positively to the target drug:
    1. Cocaine / Crack Test: cocaine HCl, cocaine base*, methamphetamine and heroin;
    **The "crack" (cocaine base) was obtained from the U.S. Drug Enforcement Administration (DEA) and its identity was verified using Fourier transform infrared spectroscopy (FTIR).*
    2. Heroin Test: heroin, cocaine HCl, cocaine base, methamphetamine;
    3. Crystal Meth / XTC Test: methamphetamine HCl*, MDMA , MDA (3,4-methylenedioxyamphetamine), MDEA (3,4-methylenedioxyethylamphetamine) and PMA (p-methoxyamphetamine).
    **Methamphetamine HCl used in place of methamphetamine base ("crystal meth").*

B. Reproducibility – All samples were tested by two evaluators at two* different times. Results were compared.
**Some samples were tested three times to confirm data.*

C. Limit of Detection – Decreasing amounts of the drug of interest (0.5 to 0.1 mg) were added to the ampoules in 0.1-mg increments, to determine if the limit of detection is as listed by the manufacturer (<0.3 mg).
   1. Cocaine / Crack Test: cocaine HCl and cocaine base;
   2. Heroin Test: heroin;
   3. Crystal Meth / XTC Test: methamphetamine HCl and MDMA.

D. Specificity – Approximately 2-mg samples of the following compounds were evaluated for false positive results (see also "Conformity"):
   1. Cocaine / Crack Test: ketamine, procaine, lidocaine, tetracaine, benzocaine, baking soda, diltiazem, levamisol HCl, caffeine, mannitol, inositol, acetaminophen and acetylsalicylic acid (aspirin);
   2. Heroin Test: morphine, oxycodone, hydrocodone, quinine, procaine, guaifenesin, caffeine and acetaminophen;
   3. Crystal Meth / XTC Test: amphetamine, pseudoephedrine, benzphetamine, caffeine, dimethyl sulfone (DMS), dextromethorphan (DXM), ketamine, cocaine HCl, cocaine base and heroin.

E. Mixture sensitivity – A series of mixtures was created to determine the ability of the test to detect the compound of interest in samples of decreasing concentration. Mixtures were prepared of target drugs and diluents in the following ratios: 50:50, 40:60, 30:70, 20:80, 10:90 and 5:95. The following mixtures were analyzed:
   1. Cocaine / Crack Test: cocaine HCl mixed with caffeine; cocaine base mixed with caffeine;
   2. Heroin Test: heroin mixed with quinine;
   3. Crystal Meth / XTC Test: methamphetamine HCl mixed with DMS and MDMA mixed with caffeine.

F. Ruggedness – The manufacturer recommends that the kits be stored below 35°C (cocaine test) or 25°C (heroin and meth / XTC tests) and be protected from light. To evaluate the ruggedness of the test with typical user treatment, a number of kits were subjected to one of the following environmental insults for a period of two weeks:
   1. Freezing;
   2. Refrigeration;
   3. Heat (dry): laboratory oven;
   4. Heat (humid): trunk of car, ~27 to ~57°C.

   Temperatures were recorded upon entry and removal*. A sample of approximately 2 mg (cocaine HCl, cocaine base, heroin, methamphetamine HCl and MDMA) was added to each appropriate test to evaluate efficacy.
   **Upon final removal, the screen of the thermometer was not readable. It is possible that the temperature exceeded the threshold of the thermometer (158°F or ~70°C) and was thus immeasurable.*

G. Ease of use was evaluated throughout the trials.

Results of Evaluation (For Data, See Appendix, Tables A-1, A-2 and A-3)

- Results were initially recorded as color chip identifiers from the Munsell Book of Color (for example, 2.5B 7/6).
- A result was defined as a "positive" or "+" if:
  - It fell within a reasonable range of color in comparison to the band on the outside of the ampoule; OR
  - It fell within a reasonable range of color of the target drug color result (see Table 1); and
  - The reagent-granulate was large enough to compare to a color chip; and
  - The color result did not fade before one minute.

Table 1: Results Within the Positive Range

	Test Kit Stripe	Positive Color	Positive Result (results in these ranges)
Crack / Cocaine	Blue: 2.5PB 4/6 (purple-blue)	Blue to blue-green	2.5B, 10B, 7.5BG, 10BG, 2.5PB
Heroin	Black: N1.5/ (neutrals)	Dark blue-green, green, blue, or black	2.5B, 5B, 7.5B, 10G, 2.5GB, 5GB, 7.5BG, 10BG, 7.5GY, N1.5
Crystal Meth / XTC	Meth: Orange: 2.5YR 5/12 (yellow-red) Black: N0.5/ (neutrals)	Orange or orange to brown (meth) Dark purple-brown or black	Meth: 2.5YR, 3.75YR, 5YR, 6.25YR, 7.5YR, 8.75YR XTC: 2.5P, 5P, 7.5P, 10P, 2.5R, 5YR, 7.5YR, 2.5RP (2/2), 7.5RP (2/2), 10RP, N0.5, N1.25, N1.5, N1.75

- Results were considered "negative" or "-" if:
  - No observable color change was produced; or
  - The test color was outside the range or color progression for a positive result as defined above; or
  - The reagent-granulate was too small to compare to a color; or
  - The color faded before the analysis time was over.
- A result was considered "inconclusive" or "INC" if:
  - The test color was sufficiently close to the defined range or color progression for a positive result to make misinterpretation possible; or

- The color result was within the defined range or color progression for a positive result but insufficient in intensity and/or volume to consider positive.

Findings

Strengths

- The tests are very simple to use and require minimal training.
- Initial positive color changes were immediate.
- Limit of detection was found to closely match the value found in the product insert of <0.3 mg. The kits were reproducibly sensitive to the following levels:
  - Crack / Cocaine: approximately 0.5 mg* for cocaine HCl and cocaine base;
    **Samples as low as 0.1 mg were detected, but not reproducibly.*
  - Heroin: approximately 0.1 mg; and
  - Crystal Meth / XTC: approximately 0.1 mg for both methamphetamine and MDMA (XTC).
    Note: The limit of the analytical balance used to measure the limit of detection samples is 0.1 mg. Balance uncertainty and loss in transfer should be considered.
- The Crack / Cocaine, Crystal Meth / XTC, and Heroin kits correctly identified their compounds of interest, with sensitivity in mixtures reproducible at the following ratios (target compound to diluent):
  - Crack / Cocaine: approximately 30:70 for cocaine HCl to caffeine and 10:90 for cocaine base to caffeine*;
    **Samples with lower ratios were detected, but not reproducibly.*
  - Heroin: approximately 30:70 for heroin to quinine; and
  - Crystal Meth / XTC: approximately 5:95 for both methamphetamine HCl to DMS and MDMA to caffeine.
- Given the presumptive nature of colorimetric tests, the kits performed with acceptable specificity with the following "false" positives observed in at least one trial from the sample set (see Tables A-1 through A-3 in the Appendix for more information):
  - Crack / Cocaine: lidocaine, tetracaine, diltiazem and levamisol HCl;
  - Heroin: morphine and hydrocodone;
    Note: Oxycodone and guaifenesin also had strong reactions but color inconsistent with that of the target drug(s).
  - Crystal Meth / XTC:
    - Methamphetamine: amphetamine, benzphetamine;
    - XTC: dextromethorphan, MDA and MDEA;

    Note: Heroin also had a strong reaction but a color progression inconsistent with that of the target drug(s).
- The tests were rugged, producing positive results with the appropriate target drug(s) after two weeks of exposure to hot / dry, hot / humid, cold and freezing storage conditions.
- The analysis procedure takes approximately one to two minutes to complete.
- Each package of test kits comes packaged with an instructional insert in six languages, as well as a set of disposable spatulas for sampling purposes.
- The kits are small, lightweight and portable and come in a secondary container to ensure safe transport and disposal.
- Test kits were reproducible from one replicate (and assessor) to the next in amounts above the limit of detection and limit in mixture sensitivity.

- The tests contain a reagent-granulate that is advertised not to require neutralization. The tests' small volumes make them safer than conventional colorimetric tests in this regard.
- Lot information is printed on the exterior of boxes of 10 tests.
- Ampoule breakers and kit carrying cases are available.

Areas for Improvement

- Lot numbers should be printed on the ampoule for traceability and quality control measures.
- The color band printed on the outside of each ampoule should be closer to actual positive results and/or a color range should be printed on the ampoule.
- The instructions should be clarified as to what portion of the ampoule should be considered for results. Often, the dominating color was more visible in the concentrated liquid / granulate, and not on the reagent-granulate, as listed in the instructions in the product insert*.
  **This may be a translation issue.*
- An analysis scheme consisting of a combination of different screening test kits may help users to eliminate false positives.
- Though small and lightweight, the kits are glass and housed in a non-rugged box. Large carrying cases for multiple kits are available for purchase, but a smaller, rigid, plastic kit fitted for ampoules would retain the portability of the kits while increasing the ruggedness. Packaging the test in a material other than glass ampoules would also increase the ruggedness and decrease the safety hazards presented by broken glass.
- The reagent-granulate volume to ampoule volume ratio was small. Increasing the volume of reagent-granulate in comparison to the ampoule volume may help concentrate the color and make the test easier to interpret.

Limitations

- Colorimetric testing is presumptive in nature and cannot identify a substance to the exclusion of all others.
- The kits are identified by either one or two controlled substances (such as Crystal Meth / XTC). The kits may be better described by a family of drugs, such as "phenethylamines" or "amphetamine-like" drugs.
- Proper training must be conducted in order to correctly* identify and interpret a positive result.
  **Even with proper training, interpretation is subjective.*
- These tests are limited by a user's experience and ability to determine color.
- Colorimetric testing is appropriate for solid or liquid samples only and should not be used on paraphernalia. The sample should be conserved for confirmatory tests as necessary.
- The color often continued to change throughout the testing time frame, giving an immediate color and darkening over time or changing color (such as guaifenesin in the heroin test).
- Multiple colors were present in a number of tests.
- The curvature of the glass ampoule slightly interfered with color interpretation.
- Initial color of the unknown sample may interfere with test interpretation. For example, blue powder could interfere with the positive blue color of the crack / cocaine test.

Training Requirements

- Minimal training is necessary to perform the testing.
- Training to interpret the results of testing should include the expected color changes, "false" positives and/or negatives, and proper safety.

Health and Safety Issues

- The glass top of the ampoule must be broken off. In many instances, this left jagged edges which did not allow for the cap to fit well. In other instances, the top was crushed between the fingers of the evaluator. Care should be taken to avoid injury.
- The Snapit™ ampoule opener was effective at removing the top of the ampoule, but got jammed multiple times when attempting to eject the broken glass top. In some instances, it was necessary to use a foreign implement to eject the glass.
- All recommended personal protective equipment (PPE) should be worn when using these kits for the following reasons:
    - Breaking of the ampoule results in broken glass;
    - Material(s) in question may be health hazard(s);
    - Ampoules contain chemical reagents.
- In the event of an exposure, safety information (for example, Material Safety Data Sheets (MSDSs) or National Fire Protection Association (NFPA) guides) regarding the basic chemical information should be included (for example, strong acid, toxic) for reference.

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APPENDIX

Data

For all table data:

- "+" indicates a positive result;
- "-" indicates a negative result;
- "INC" indicates an inconclusive result;
- (1) or (2) indicates replicate associated with the comment;
- "CR" indicates the granulate / crystal portion of the reagent;
- "→" indicates a progressive color change from the one color to the other.

Table A-1: Crack / Cocaine Tests

	Sample	+/-/ INC	+/-/ INC	Comments
Conformity				
1	Cocaine HCl	+	+	
2	Cocaine base	+	+	
3	Methamphetamine HCl	-	-	
4	Heroin HCl	-	-	
Limit of Detection				
5	Cocaine HCl 0.5 mg	+	+	
6	Cocaine HCl 0.4 mg	+	+	
7	Cocaine HCl 0.3 mg	+	-	
8	Cocaine HCl 0.2 mg	+	+	(1) Fade < 20 sec. (2) faint, faded
9	Cocaine HCl 0.1 mg	INC	+	(1) Very light
10	Cocaine base 0.5 mg	+	+	(1) Few CR
11	Cocaine base 0.4 mg	+	INC	(2) 1 CR
12	Cocaine base 0.3 mg	-	+	(1) 1 CR, faded
13	Cocaine base 0.2 mg	-	-	
14	Cocaine base 0.1 mg	+	+	
Specificity				
15	Ketamine	-	-	
16	Procaine	-	-	
17	Lidocaine	INC	+	(1) 1 CR
		INC		TRIAL 3 faint, out of range
18	Tetracaine	-	+	(2) Liquid turned color of band on ampoule

	Sample	+/-/ INC	+/-/ INC	Comments
		+		TRIAL 3
19	Benzocaine	-	-	
20	Baking soda	-	-	
21	Diltiazem	+	INC	(2) 1 CR, weak, faded
		+		TRIAL 3
22	Levamisol HCl	INC	+	(1) CR faint, (out of range), fading
		+		TRIAL 3: top ampoule smashed
23	Caffeine	-	-	
24	Mannitol	-	-	
25	Inositol	-	-	
26	Acetaminophen	-	-	
27	Acetylsalicylic acid	-	-	
Mixture Sensitivity				
28	Cocaine HCl: Caffeine (50:50)	+	+	
29	Cocaine HCl: Caffeine (40:60)	+	+	(1) Few CR on bottom, faint (2) Few granules; weak change
30	Cocaine HCl: Caffeine (30:70)	+	+	(1) Scattered
31	Cocaine HCl: Caffeine (20:80)	+	-	(1) Faint smear
32	Cocaine HCl: Caffeine (10:90)	+	INC	(2) Faint, 1 CR
33	Cocaine HCl: Caffeine (5:95)	-	-	
34	Cocaine base: Caffeine (50:50)	+	+	
35	Cocaine base: Caffeine (40:60)	+	+	
36	Cocaine base: Caffeine (30:70)	+	+	(1) First color, top, second, bottom
37	Cocaine base: Caffeine (20:80)	+	+	
38	Cocaine base: Caffeine (10:90)	+	+	(1) 2 CR (2) Weak
39	Cocaine base: Caffeine (5:95)	INC	INC	(1) Faded (2) 1 CR, too small to compare
Ruggedness				
Humid heat (Car trunk ~27 to ~57°C)				
40	Cocaine HCl	+	+	(1) Faint (2) Instant
41	Cocaine base	+	+	(1) ~5 CR scattered

	Sample	+/-/ INC	+/-/ INC	Comments
Dry Heat (Oven ~45°C)				
42	Cocaine HCl	+	+	(2) Vial top smashed
43	Cocaine base	+	+	(2) Liquid: Blue-green
Refrigeration (~2 to ~5°C)				
44	Cocaine HCl	+	+	
45	Cocaine base	+	+	
Freezer (~-23 to ~-21°C)				
46	Cocaine HCl	+	+	(1) Instant (2) CR turned color only
47	Cocaine base	+	+	

Table A-2: Heroin Tests

	Sample	+/-/ INC	+/-/ INC	Comments
1	Heroin HCl	+	+	(2) Instant multi-green; blue-green and green
2	Cocaine HCl	-	-	
3	Cocaine base	-	-	(2) Orange-brown CR & liquid
4	Methamphetamine HCl	-	-	
Limit of Detection				
5	Heroin 0.5 mg	+	+	
6	Heroin 0.4 mg	+	+	
7	Heroin 0.3 mg	+	+	
8	Heroin 0.2 mg	+	+	(1) Faint
9	Heroin 0.1 mg	+	+	(2) Green-yellow smear
Specificity				
10	Morphine	+	+	
11	Oxycodone	INC	-	(1) Orange→yellow→black (2) Instant orange
12	Hydrocodone	+	+	
13	Quinine	-	-	
14	Procaine	-	-	
15	Guaifenesin	INC	INC	(1) Purple and green (10G) to dark red-purple

	Sample	+/-/ INC	+/-/ INC	Comments
				(2) Purple and dark green (5B) to dark red-purple
16	Caffeine	-	-	
17	Acetaminophen	-	-	(1, 2) Peach→pink→purple
Mixture Sensitivity				
18	Heroin HCl: Quinine (50:50)	+	+	
19	Heroin HCl: Quinine (40:60)	+	+	(1) Faint
20	Heroin HCl: Quinine (30:70)	+	+	
21	Heroin HCl: Quinine (20:80)	+	INC	(2) Liquid: olive yellow (-green)
22	Heroin HCl: Quinine (10:90)	INC	+	(1) Light green-yellow
23	Heroin HCl: Quinine (5:95)	INC	INC	(1) Light green-yellow (2) Light green-yellow
Ruggedness				
Humid heat (Car trunk ~27 to ~57°C)				
27	Heroin HCl	+	+	
Dry Heat (Oven ~45°C)				
28	Heroin HCl	+	+	
Refrigeration (~2 to ~5°C)				
29	Heroin HCl	+	+	
Freezer (~-23 to ~-21°C)				
30	Heroin HCl	+	+	

Table A-3: Crystal Meth / XTC Tests

Trial	Sample	+/-/ INC	+/-/ INC	Comments
Conformity				
1	Methamphetamine HCl	+	+	
2	MDMA	+	+	
3	MDA	+	+	
4	MDEA	+	+	
5	PMA	-	-	

Trial	Sample	+/-/ INC	+/-/ INC	Comments
Limit of Detection				
6	Methamphetamine HCl 0.5 mg	+	+	(1) Color not fading, strong color present
7	Methamphetamine HCl 0.4 mg	+	+	(1) Color weaker, faded quickly
8	Methamphetamine HCl 0.3 mg	INC	+	(1) Color very weak, quick fade (few sec) (2) Some crystals darker on side
9	Methamphetamine HCl 0.2 mg	+	+	
10	Methamphetamine HCl 0.1 mg	+	INC	(1) Definite color change (2) More concentrated on side
11	MDMA 0.5 mg	+	+	
12	MDMA 0.4 mg	+	+	
13	MDMA 0.3 mg	+	+	
14	MDMA 0.2 mg	+	+	
15	MDMA 0.1 mg	+	+	
Specificity				
16	Amphetamine	+	+	(1) Orange→brown
17	Pseudoephedrine	-	-	
18	Benzphetamine	+	+	
19	Caffeine	-	-	
20	Dimethylsulfone (DMS)	-	-	
21	Dextromethorphan	+	+	(2) Blue-green→black
22	Ketamine	-	-	
23	Cocaine HCl	-	-	
24	Cocaine base	-	-	
25	Heroin	INC	INC	(1,2) Pink→purple; close to range
26	Benzylpiperazine (BZP)	-	-	(1,2) Foamed
Mixture Sensitivity				
27	Meth. HCl: DMS (50:50)	+	+	
28	Meth. HCl: DMS (40:60)	+	+	
29	Meth. HCl: DMS (30:70)	+	+	
30	Meth. HCl: DMS (20:80)	+	+	
31	Meth. HCl: DMS (10:90)	+	+	
32	Meth. HCl: DMS (5:95)	+	+	

Trial	Sample	+/-/ INC	+/-/ INC	Comments
33	MDMA: Caffeine (50:50)	+	+	
34	MDMA: Caffeine (40:60)	+	+	
35	MDMA: Caffeine (30:70)	+	+	
36	MDMA: Caffeine (20:80)	+	+	
37	MDMA: Caffeine (10:90)	+	+	
38	MDMA: Caffeine (5:95)	+	+	
Ruggedness				
Humid Heat (Car trunk ~27 to ~57°C)				
39	Methamphetamine HCl	+	+	(2) Cap wouldn't fit on top; tube possibly swelled
40	MDMA	+	+	
Dry Heat (Oven ~45°C)				
41	Methamphetamine HCl	+	+	
42	MDMA	+	+	
Refrigeration (~2 to ~5°C)				
43	Methamphetamine HCl	+	+	
44	MDMA	+	+	
Freezer (~-23 to ~-21°C)				
45	Methamphetamine HCl	+	+	
46	MDMA	+	+	