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The Use of Chemical Spot Tests Kits for the Presumptive Identification of Narcotics and Drugs of Abuse

It is well known that chemical spot tests contribute to and are used for the identification of various substances [*1–5*]. From this information, chemical spot test kits have been commercially developed which are used by many law enforcement agencies for the identification of narcotics and drugs of abuse. There are basically two types of problems associated with the use of these kits, one which is inherent in the color reaction and the other which lies with color interpretation.

First, colors produced, although usually quite specific, are assigned a broad "spectral" range. For example, colors within the spectral range from purplish blue to purplish red may be considered positive to untrained observers with no color cards available for comparison, when the actual positive color should be violet.

Second, the color-producing chemical reactions are usually not specific. While it is true that a particular reagent gives the designated color reaction with the specific, regulated drug, other regulated and nonregulated drugs or substances can give the same or similar colors with that particular reagent. These substances are then considered to be interferences which produce false positives. For example, Clarke [*6*], Thienes and Haley [*7*], and others [*1,5,8–13*] list numerous substances which produce colors with the Marquis reagent. Included in these groups are aromatic compounds with free *para* positions or *para*-hydroxy groups that yield colored quinoidal compounds [*1*]. Salicylates interfere with the Dille-Koppanyi test for barbiturates [*12*]. Nakamura and Thornton [*14,15*] and Goddard [*16*] report that olivetol, mace, nutmeg, currants, terpenes, and phenolics give colors with the Duquenois-Levine test for marijuana or hashish.

As a consequence, several brief reports have recently appeared concerning the observance of false positives in the use of the chemical spot test kits [*17–19*]. Thus, positive and false positive tests can be obtained, the latter serving only to confuse results and making definitive test interpretations essentially impossible.

There are, of course, a great many chemical reagents which may be used as a spot test for a particular drug. For instance, more than fifty reagents have been suggested for the qualitative and quantitative color reactions with the opium alkaloids, most of which are summarized in Refs *20* and *21*. Other reagents have been listed for morphine derivatives [*22*]. Nevertheless, the majority of chemical field test kits use the Marquis reagent as the primary test for the opium alkaloids. Some kits include concentrated nitric acid as

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a secondary test. In general, however, most of the kits use chemical reagent formulations which are essentially the same for various classes of drugs.

This paper presents investigations on the reactions of selected pure drugs and possible interferences with typical chemical reagents usually found in narcotic chemical spot test kits. The colors produced by these reactions have been assigned numbers and descriptions corresponding to colors in the Inter-Society Color Council-National Bureau of Standards (ISCC-NBS) Centroid Color Charts. These charts are referred to as Standard Reference Material (SRM) 2106 [*23*] and are described in NBS Publication 533 [*24*]. This color assignment decreases the ambiguities associated with color interpretations.

Two additional reagents, Mandelin and concentrated nitric acid, have been included in this study. The suggested total of seven reagents provides a reasonable, multireagent testing scheme which would decrease the number of false positives and thus increase specificity. In addition, information on reagent stabilities, pure drug detection limits, temperature effects, and typical street drug-reagent color production are presented.

Experimental[2]

Reagents

Typical kit test reagents were prepared with reagent grade chemicals and solvents according to the following formulations [*1,25,26*].

A.1 Cobalt(II) Thiocyanate—Dissolve 2.0 g of cobalt(II) thiocyanate in 100 ml of distilled water.

A.2 Dille-Koppanyi Reagent, Modified

Solution 1—Dissolve 0.1 g of cobalt(II) acetate dihydrate in 100 ml of methanol. Add 0.2 ml glacial acetic acid and mix.

Solution 2—Add 5 ml of isopropylamine to 95 ml of methanol.

Use of Reagent A.2—Add 2 volumes of Solution 1 to the drug followed by 1 volume of Solution 2.

A.3 Duquenois-Levine Reagent

Solution 1—Add 2.5 ml of acetaldehyde and 2.0 g vanillin to 100 ml of 95 percent ethanol.

Solution 2—Hydrochloric acid.

Solution 3—Chloroform.

Use of Reagent A.3—Add 1 volume of Solutions 1 and 2 to the drug in order. Determine the color produced. Add 3 volumes of chloroform and note if the color produced is extracted from the mixture of 1 and 2.

A.4 Ferric Chloride—Dissolve 2.0 g anhydrous ferric chloride in 100 ml of distilled water.

A.5 Froehde Reagent—Dissolve 0.5 g of molybdic acid or sodium molybdate in 100 ml hot concentrated sulfuric acid.

A.6 Mandelin Reagent—Dissolve 1.0 g of ammonium vanadate in 100 ml of concentrated sulfuric acid.

[2] In order to adequately describe materials and experimental procedures, it was occasionally necessary to identify commercial products by manufacturer's name or label. In no instances does such identification imply endorsement by the National Bureau of Standards, nor does it imply that the particular product or equipment is necessarily the best available for that purpose.

A.7 Marquis Reagent—Carefully add 10 ml of 40 percent formaldehyde [volume:volume (v:v) formaldehyde:water] to 100 ml of concentrated sulfuric acid.

A.8 Mecke Reagent—Dissolve 1.0 g of selenious acid in 100 ml concentrated sulfuric acid.

A.9 Nitric Acid—Concentrated.

A.10 para-*Dimethylaminobenzaldehyde* (p-*DMAB*)—Add 2.0 g of *p*-DMAB to 50 ml of 95 percent ethanol and 50 ml of concentrated hydrochloric acid.

A.11 Zwikker Reagent
Solution 1—Dissolve 0.5 g of copper(II) sulfate pentahydrate in 100 ml of distilled water.
Solution 2—Add 5 ml of pyridine to 95 ml of chloroform.
Use of Reagent A.11—Add 1 volume of Solution 1 to the drug followed by addition of 1 volume of Solution 2.

Drugs and Diluents

The drugs and other materials were used as obtained from the manufacturers.

Benzphetamine—Upjohn Co., No. X5815.
Brompheniramine—Robins Research, No. CN41255.
Chlorpromazine·HCl—Smith, Kline and French, No. 2601A.
Cocaine·HCl—Mallinckrodt, No. E232019.
Codeine Sulfate—Mallinckrodt, No. E277088.
d-*amphetamine*—Applied Science, No. 389.
d-*methamphetamine·HCl*—Applied Science, No. 413.
dl-*methamphetamine·HCl*—Sigma Chemical Co., No. 20c-0040.
Darvon®—E. I. Lilly, No. 0QS77 and Byron Chemical Co., No. 101/I.
Demerol®*·HCl*—Sterling Winthrop Research, Inc., No. 320-BF.
Doxepin·HCl—Pfizer, No. 13506-02021.
Heroin·HCl—Drug Enforcement Administration (DEA), No. A99A.
Lysergic Acid Diethylamide (*LSD*)*·Tartrate*—Sandoz Pharmaceuticals, No. 160015.
l-*isomethadon·HCl*—Mallinckrodt, No. E176328.
Marezine (*Cyclizine·HCl*)—Burroughs Wellcome and Co., No. 50595.
Marijuana—DEA, No. A143A.
MDA·SO$_4$—Smith, Kline and French, No. X-19-LDS.
Mescaline Sulfate—DEA, No. A162c and Sigma Chemical Co., No. 78B-1620.
Methadon·HCl—Mallinckrodt, No. E223128.
Methapyriline·HCl—E. I. Lilly, No. X03064.
Methaqualone—W. H. Rorer, Inc., No. 69C11A.
Methprylon—Hoffman-LaRoche, Inc., No. 041054.
Morphine Alkaloid—Mallinckrodt, No. E294032.
Opium—Penick (DEA), No. 310NKN-1.
Oxycodone·HCl—Endo Labs., Inc., No. 70-027.
Pentobarbital—Ganes, No. 3-RR-101.
Phencyclidene—DEA, No. A226A.
Phenobarbital—Ganes, No. 3-RR-127 and Merck and Co., Inc., No. 227365.
Procaine·HCl—Sterling Winthrop Research, Inc., No. 135 HN.
Ritalin®—CIBA, No. 77386.
Secobarbital—Ganes, No. 127-RR-111.

2,5-Dimethoxy-4-methylamphetamine (STP)·HCl—DEA, No. A261c.
Tri-methoxyamphetamine (TMA)·HCl—DEA, No. A282A.

Other diluents and possible interferences were either reagent grade chemicals or commercial spices, teas, tobacco, coffee, etc.

Typical street drugs were obtained from the Drug Enforcement Administration (DEA) or prepared by mixing the pure drug with appropriate diluents in a shaker.

Methodology

Color Development

Twenty-five to 100 μg of the pure drug powder, diluent, or street sample, were placed in a spot test plate. One drop (~0.1 ml) of the appropriate reagent was added to the side of the depression before making contact with the test material. Comparison of the transitory and final colors were made using the ISCC-NBS Centroid Color Charts.

Experimental Detection Limits

Preliminary experimental detection limits (ExDL), were determined for selected drugs. A solution of the drug to be tested (approximately 1 μg/10 μl) was prepared in an appropriate solvent. Five samples of different volumes (1–10 μl) were transferred by micropipet (±1 percent accuracy) to a porcelain test plate and the solvent was evaporated. The smallest volume and, thus, drug quantity which produced five positive tests was considered to be the preliminary ExDL.

The experimental detection limits for LSD tartrate and heroin were determined in a more stringent, statistical manner. Initially, the preliminary ExDLs were determined. Seven drug solutions were then prepared containing concentrations which bracketed that used for the determination of the preliminary ExDL. Six of the solutions were of such concentrations that the drug quantity obtained upon evaporation of 5-μl samples would be below the preliminary ExDL value, while one was above this value. Twenty 5-μl samples of each of these solutions and that used for the preliminary ExDL (eight solutions, 160 total samples) were transferred to the spot test plate according to 160 computer-generated random numbers. The particular test reagent was then added and positive or negative tests were recorded for that particular random number, and then correlated with actual drug quantity from a master sheet. Sample transfer and testing were done by different people to eliminate bias.

The percent positives, $\%T_p$, were determined for each sample according to Eq 1.

$$\%T_P = \frac{\Sigma T_{Pi}}{\Sigma T}(100) \tag{1}$$

where ΣT_{Pi} is the number of positive tests for the i^{th} drug quantity and ΣT is the number of tests for that drug quantity. In this case, ΣT equalled 20. The $\%T_p$'s were then plotted versus drug quantity. The smallest drug amount producing twenty positive tests was determined graphically and designated as the ExDL.

Reagent Stability

The reagents were placed in two sets of glass vials, nitrogen was passed briefly over the reagent, and the vials were sealed. The vials were placed in a water bath at 40°C. At the end of two weeks, one set of vials was removed and the reagents were tested on drug quantities which were one order of magnitude greater than the ExDL (see color development). This procedure was repeated at the end of ten weeks on the second set of vials.

Temperature Effect Studies

Typical spot test reagents including Marquis, Mecke, Froehde, Mandelin, Dille-Koppanyi, Duquenois-Levine, *p*-dimethylaminobenzaldehyde, concentrated nitric acid, cobalt thiocyanate, and drugs and accessories were placed in a cold room at 3°C overnight. Chemical spot tests were then made at this temperature and the colors and qualitative rates of reaction were noted.

Results and Discussion

Color Production

The interpretation of color is subjective. Few kits have color cards which can be compared to the color produced by the reactions of the spot test reagents with individual drugs. Table 1 lists transitory and final colors produced by the addition of typical chemical spot test reagents (those marked by an asterisk) and others to selected drugs. All colors produced are in the general color spectral ranges reported by other investigators [*2,3,5–18, 20–22*].

The colors, which depend on lightness, saturation, and hue, are identified in the Centroid Color Charts by number, description, and a color chip. Color lightness, illustrated by the vertical columns in the Centroid Color Charts, increases vertically, bottom to top. In this case, it is a relative measure of decreasing drug concentration. Color saturation, illustrated by the rows of color chips, increases horizontally, left to right. The color hue is approximately the same for each individual chart, but changes from one chart to the next. Table 2 summarizes chemical spot test results on typical diluents and possible interferences.

Correct color assignment by color chip comparison allows some differentiation between a positive and a false positive for potential interferences. For example, using Tables 1 and 3 and color comparison alone, it is possible to differentiate between aspirin or Excedrin® and heroin or morphine. The first two give red colors with the Marquis reagent while the last two give reddish purples. Similarly, codeine gives a violet color with the Marquis reagent. Darvon® (blackish purple), a previously reported interference [*17*] for the Marquis test, may be distinguished with difficulty from heroin (very deep reddish purple) and morphine (very dark reddish purple) by color alone. In this same manner, Demerol® gives a different color with the Marquis reagent than the amphetamines. Again, the color differentiation is small, brown versus reddish brown.

It is also possible to distinguish mace, nutmeg, and tea from marijuana using the Duquenois-Levine test by (1) color extraction into chloroform (teas do not), (2) color remaining in the aqueous HCl-vanillin layer (mace and nutmeg are purple, while marijuana is blue), and (3) rate of color extraction (mace and nutmeg show very slow color extraction, while marijuana usually exhibits rapid $CHCl_3$ color extraction). It is recognized that with repeated extractions, total color transfer into the $CHCl_3$ layer from the aqueous phase will eventually occur [*14,15*]. However, under normal test conditions, this does not take place and a blue color remains in the aqueous phase with marijuana.

It is evident, however, from the similarities in colors produced by various substances with the same reagent, that many false positives are possible for an observer with no color chip as a guide. In fact, numerous noncontrolled substances give the same color as the controlled drug with the same reagent.

Reagent A.1 [$Co(SCN)_2$] listed in Table 3, the usual kit reagent for cocaine, gives many false positives. Substances such as quinine, Ritalin®, methapyriline, Darvon®, etc,

TABLE 1—*ISCC-NBS assignments of colors produced by the reactions of chemical reagents with various drugs.*

Compound	Reagent	Color[a] Developed—ISCC-NBS Centroid Color Charts
Benzphetamine	A.1	168. brill. g B → 169. s. g B
	A.6	98. brill. g Y → 119. l. Y G
	A.7[b]	50. s. O → 48. v. O → 51. deep O → 40. s. r Br → 41. deep r Br
	A.8	101. l. g Y
Brompheniramine	A.1	168. brill. g B + 177. brill. B
	A.6	50. brill. O
Chlorpromazine·HCl	A.1	168. brill. g B
	A.5	3. deep Pink → 12. s. Red → 13. deep Red → 14. v. deep Red → 21. blackish R
	A.6	3. deep Pink → 13. deep Red → 107. m. Ol + 13. deep Red
	A.7	2. s. Pink → 3. deep Pink → 255. s. p R → 256. deep p R → 260. v. d. p R
	A.8	13. deep Red → 14. v. deep Red[c] → 21. blackish R[c] → 111. d. gy. Ol + 108. d. Ol
	A.9	13. deep R → 101 l. g Y[c]
Cocaine·HCl	A.1[b]	169. s. g B and/or 178. s. B
	A.6	50. s. O → 48. v. O → 51. deep O
Codeine Sulfate	A.5	94. l. Ol Br → 137. d. y G → 125. m. Ol G → 147. v. d. G
	A.6	94. l. Ol Br → 95. m. Ol Br → 107. m. Ol
	A.7[b]	17. v. d. R → 212. d. V
	A.8	174. d. g B → 161. deep b G → 175. v. d. g B
	A.9	34. v. r O → 51. deep O → 101. l. g Y[c]
d-Amphetamine	A.6	100. deep g Y → 106. l. Ol → 125. m. Ol G → 164. m. b G
	A.7[b]	48. v. O → 34. v. r O → 40. s. r Br → 44. d. r Br
d-methamphetamine·HCl	A.6	120. m. Y G → 136. m. y G
	A.7[b]	48. v. O → 34. v. r O → 40. s. r Br → 41. deep r Br → 44. d. r Br
Darvon®	A.1	171. v. l. g B → 168. brill. g B → 169. s. g B
	A.5	39. gy. r O → 43. m. r Br → 110. gy. Ol → 111. d. gy. Ol → 230. blackish P
	A.6	47. d. gy. r Br → 44. d. r Br
	A.7	242. d. r P → 243. v. d. r P → 230. blackish P[c]
	A.8	74. s. y Br → 54. br O → 55. s. Br → 43. m. r Br → 41. deep r Br
Demerol®·HCl	A.1	169. s. g B
	A.7	50. s. O → 51. deep O[d] → 55. s. Br → 56. deep Br[d]
Doxepin·HCl	A.1	169. s. g B
	A.5	40. s. r Br → 14. v. dcep Red → 41. deep r Br[c]
	A.6	17. v. d. Red → 21. blackish R
	A.7	14. v. deep Red → 17. v. d. Red → 21. blackish R
	A.8	21. blackish R
	A.9	38. d. r O → 40. s. r Br → 84. s. Y

(*Continued*)

TABLE 1—Continued.

Compound	Reagent	Color[a] Developed—ISCC-NBS Centroid Color Charts
Heroin·HCl	A.1	169. s. g B
	A.5	256. deep p R → 257. v. deep p R → 256. deep p R[e]
	A.6	42. l. r Br → 43. m. r Br
	A.7[b]	11. v. R → 13. deep R → 256. deep p R → 239. v. deep r P
	A.8	107. m. Ol → 126. d. Ol G → 142. deep G → 161. deep b G
	A.9[b]	89. p. Y
LSD tartrate	A.5	119. l. Y G → 120. m. Y G → 126. d. Ol G → 138. v. d. y G[e]
	A.7	55. s. Br → 61. gy. Br → 62. d. gy. Br → 65. br. Black → 234. d. p Gy → 235. p Black
	A.8	166. v. d. b G → 152. blackish G
	A.9	54. br O[e]
	A.10[b]	218. s. P → 219. deep P
l-isomethadon·HCl	A.6	16. d. R → 260. v. d. p R → 243. v. d. r P
	A.8	89. p. Y → 7. p. Pk[f]
Marezine (cyclizine·HCl)	A.1	171. v. l. g B
	A.5	101. l. g Y
	A.7	101. l. g Y → 98. brill. g Y
	A.8	101. l. g Y → 98. brill. g Y
Marijuana	A.3[b]	206. brill. V → 207. s. V → 197. deep p B[g] 186. gy B[h] 221. v. l. P → 222. l. P → 220. v. deep P[d,i,j]
MDA·SO_4 (3,4-methylene-dioxy-amphetamine)	A.5	107. m. Ol → 41. deep r Br → 114. Ol Black → 157. g Black[c]
	A.6	14. v. deep Red → 235. p Black[c]
	A.7[b]	267. Black
	A.8	107. m. Ol → 108. d. Ol → 161. deep b G → 166. v. d. b G → 175. v. d. g B → 183. d. Blue[e]
	A.9	101. l. g Y
Mescaline Sulfate	A.5	83. brill. Y → 84. s. Y
	A.6	120. m. Y G → 95. m. Ol Br → 65. br. Black
	A.7[b]	34. v. r O → 36. deep r O
	A.8	69. deep O Y → 74. s. y Br → 107. m. Ol → 114. Ol Black
	A.9[b]	17. v. d. R → 41. deep r Br
Methadon·HCl	A.1[b]	211. m. V → 208. deep V → 165. d. b G → 166. v. d. b G → 175. v. d. g B → 179. deep B → 183. d. B
	A.6	31. p. y Pk → 28. l. y Pk
Methapyrilene·HCl	A.1	169. s. g B
	A.5	51. d. O → 40. s. r Br → 65. br Black[c]
	A.6	40. s. r Br → 41. deep r Br → 44. d. r Br → 17. v. d. Red → 243. v. d. r P + 260 v. d. p R

	A.7	43. m. r Br → 16. d. Red → 259. d. p R → 260. v. d. p R[k]
	A.8	256. deep p R → 260. v. d. p R → 225. v. d. P → 230. blackish P
	A.9	2. s. Pink → 3. deep Pink → 26. s. y Pink → 44. d. r Br[d]
Methaqualone	A.6	38. d. R O → 35. s. R O[e]
Methprylon	A.6	184. v. p. B
Morphine	A.4	36. deep r O → 48. v. O → 67. brill. O Y
	A.5	256. deep p R → 257. v. deep p R → 260. v. d. p R[d]
	A.6	38. d. r O → 43. m. r Br → 47. d. gy. r Br
	A.7[b]	243. v. d. r P
	A.8	174. d. g B → 161. deep b G → 166. v. d. b G
	A.9[b]	36. r O → 48. v. O → 67. brill. O Y[d]
Opium	A.1	146. d. G
	A.5	16. d. R → 44. d. r Br → 96. d. Ol. Br
	A.6	94. l. Ol Br
	A.7[b]	43. m. r Br → 41. deep r Br → 44. d. r Br
	A.8	128. d. gy. Ol Br → 111. d. gy. Ol → 114. Ol Black[d]
	A.9[b]	34. v. r O → 51. deep O → 101. l. g Y[c]
Oxycodone·HCl	A.5	84. s. Y
	A.6	68. s. O Y
	A.7[b]	83. brill. Y → 85. deep Y → 95. m. Ol Br → 96. d. Ol Br → 225. v. d. P → 201. d. p B
	A.8	83. brill. Y → 84. s. Y → 94. l. Ol Br → 95. m. Ol Br → 107. m. Ol
	A.9[b]	86. l. Y
Pentobarbital	A.2[b]	222. l. P → 223. m. P → 218. s. P[d]
	A.7	73. p. O Y → 87. m. Y → 76. l. y Br → 78. d. y Br[d]
	A.11	221. v. l. P → 222. l. P[j]
Phencyclidine	A.1	168. brill. g B
	A.5	7. p. Pink
	A.7	7. p. Pink
	A.8	7. p. Pink
Phenobarbital	A.2[b]	222. l. P → 223. m. P → 218. s. P[d]
	A.7	73. p. O Y → 87. m. Y → 76. l. y Br → 78. d. y Br[d]
	A.11	221. v. l. P → 222. l. P[j]
Procaine·HCl	A.1[b]	169. s. g B + 178. s. B
	A.6	26. s. y Pink → 50. s. O → 51. deep O
Ritalin®	A.1	168. brill. g B
	A.6	68. s. O Y
	A.7	73. p. O Y → 71. m. O Y[l]

(*Continued*)

TABLE 1—Continued.

Compound	Reagent	Color[a] Developed—ISCC-NBS Centroid Color Charts
Secobarbital	A.2[b]	222. l. P → 223. m. P → 218. s. P[d]
	A.7	73. p. O Y → 87. m. Y → 76. l. y Br → 78. d. y Br[d]
	A.11	221. v. l. P → 222. l. P[j]
STP·HCl (2, 5-dimethoxy-4-methylamphetamine)	A.5	116. brill. Y G → 117. s. Y G
	A.6	116. brill. Y G → 117. s. Y G
	A.7	101. l. g Y
	A.8	117. s. Y G → 118. deep Y G
	A.9	125. m. Ol G → 89. p. Y[e]
TMA·HCl (trimethoxy-amphetamine)	A.5	174. d. g B → 183. d. Blue
	A.6	117. s. Y G → 94. l. Ol Br
	A.7[b]	35. s. R O → 36. deep r O
	A.8	125. m. Ol G → 95. m. Ol Br → 96. d. Ol Br → 75. deep y Br[e,d]
	A.9	17. v. d. Red → 14. v. deep Red[e]

[a] Color abbreviations used:

B = blue	gy. = grayish	pk = pinkish
b = bluish	l. = light	R = red
Br = brown	m. = moderate	r = reddish
br = brownish	O = orange	s. = strong
brill. = brilliant	Ol = olive	v. = very or vivid
d. = dark	p. = pale	
G = green	P = purple	V = violet
g = greenish	p = purplish	Y = yellow
Gy = gray	Pk = pink	y = yellowish

[b] Usual kit reagents for tests of particular drug.
[c] Fast.
[d] Intensity proportional to concentration.
[e] Color fades.
[f] Poor color test.
[g] Aqueous phase before extraction.
[h] Aqueous phase after extraction.
[i] Chloroform phase after extraction.
[j] Color extraction is rapid.
[k] Precipitate.
[l] Slow.

TABLE 2—*Summary of chemical spot test results on possible interferences*[a].

Material	Reagent										
	A.1	A.2	A.3	A.4	A.5	A.6	A.7	A.8	A.9	A.10	A.11
Aspirin	–	–	–	–	+	+	+	?	–	–	–
Baking Soda	–	–	–	+	–	–	–	–	–	–	+
Catnip	–	–	–	–	–	–	–	–	–	–	–
Contac®	–	+	–	–	–	+	–	–	–	–	–
Dristan®	–	–	–	–	+	+	+	+	–	–	–
Excedrin®	–	–	–	+	+	+	+	+	+	–	+
d-Galactose	–	–	–	–	–	–	–	–	–	–	–
Glucose	–	–	–	–	–	–	–	–	–	–	–
Mace	–	–	+	–	+	+	+	+	+	–	–
Mannitol	–	–	–	–	–	–	–	–	–	–	–
Nutmeg	–	–	+	–	–	–	–	+	–	–	–
Oregano, Leaf	–	–	–	–	–	–	–	–	–	–	–
Quinine	+	–	–	–	–	–	–	–	–	–	–
Quinine Sulfate	+	–	–	–	–	–	–	–	–	–	–
Rosemary	–	–	–	–	–	–	–	–	–	–	–
Salt, Iodized	–	–	–	–	–	+	–	–	–	–	–
Sugar	–	–	–	–	–	–	+	?	–	–	–
Tea, Cut Green	–	+	–	–	–	–	–	–	–	–	+
Tea, Orange Pekoe, Pekoe, Black	–	–	–	–	–	–	–	–	–	–	–
Thyme	–	–	–	–	–	–	–	–	–	–	–
Tobacco, Amphora	–	–	–	–	–	–	–	–	–	–	+

[a] Typical strong acid-organic produced colors not included here.

all noncontrolled or over-the-counter materials, give the same or similar color as cocaine. All compounds tested existing as the HCl salt and even HCl itself give a positive test with the cobalt reagent.

It is also well known that any ergot alkaloid such as ergotamine or ergonovine will give a positive test with the LSD test reagent, *p*-dimethylaminobenzaldehyde. One kit reagent for LSD was found to be a typical Zak reagent which is used for the quantitative determination of cholesterol and other steroids [*27*]. Thus, it is quite possible to obtain false positives with this reagent if certain steroids are present.

Street Sample Testing

Additional problems in color interpretation arise if samples of street drugs are analyzed using typical reagents. Table 4 summarizes the colors produced when simulated street samples (5 percent drug) were tested. The heroin and cocaine were actual street samples obtained from DEA.

As can be seen, only diluted cocaine gives the same color as the pure drug. In these cases, a positive test is defined as being in the color vicinity of those produced by the pure drugs, that is, being adjacent to or in the same column (proportional to concentration) as the color in the Centroid Color Charts. Codeine, heroin, and secobarbital would be considered positive. The remaining street samples give colors which are listed as transitory colors in Table 1 and can be considered positive under these conditions. Running a similar sample with the suspected street sample and having color interpretation by a trained investigator would certainly aid in decreasing false positives, but it must be recognized that false positives cannot be totally eliminated due to the many families of drugs and substances which give similar colors with chemical spot test reagents.

TABLE 3—*Partial list of common adulterants and drugs which give positive spot tests with a single reagent.*

Compound	Reagent	Color[a]
Brompheniramine[b]	A.1	168. brill. g B + 177. brill. B
Chlorpromazine·HCl[b]	A.1	168. brill. g B
Cocaine·HCl	A.1[c]	169. s. g B + 178. s. B
Darvon®[b]	A.1	169. s. g B
Demerol®·HCl[b]	A.1	169. s. g B
Doxepin·HCl[b]	A.1	169. s. g B
Heroin·HCl	A.1	169. s. g B
Librium[b]	A.1	181. l. B
Marezine[b]	A.1	171. v. l. g B
Methadon·HCl	A.1[c]	183. d. B
Methapyrilene·HCl[b]	A.1	169. s. g B
Phencyclidine[b]	A.1	168. brill. g B
Procaine·HCl	A.1[c]	169. s. g B + 178. s. B
Quinine[b,d]	A.1	178. s. B
Ritalin®[b]	A.1	168. brill. g B
Contac®	A.2	31. p. y Pk
Pentobarbital	A.2[c]	218. s. P
Phenobarbital	A.2[c]	218. s. P
Secobarbital	A.2[c]	218. s. P
Tea, Green	A.2	29. m. Y. Pk
Mace[b,e,f]	A.3	237. s. r P[g]
	A.3	237. s. r P[h]
	A.3	221. v. l. P[i] (extraction slow)
Marijuana	A.3[c]	197. deep p B[g]
	A.3[c]	186. gy. B[h]
	A.3[c]	220. v. deep P[i] (extraction rapid)
Nutmeg[b,e,f]	A.3	244. p. r P[g]
	A.3	244. p. r P[h]
	A.3	226. v. p. P[i] (extraction slow)
Tea[e], Orange Pekoe,	A.3	243. v. d. r P[g]
Pekoe, Black	A.3	Not extracted into $CHCl_3$
Tea[e], Green	A.3	243. v. d. r P
	A.3	Not extracted into $CHCl_3$
Aspirin[b]	A.6	113. Ol Gy
Brompheniramine[b]	A.6	50. brill. O
Chlorpromazine·HCl[b]	A.6	107. m. Ol + 13. deep Red
Cocaine	A.6	51. deep O
Codeine·SO_4	A.6	107. m. Ol
Contac®[b]	A.6	84. s. Y
d-Amphetamine	A.6	164. m. b G
d-methamphetamine·HCl	A.6	136. m. y G
Darvon®[b]	A.6	44. d. r Br
Doxepin·HCl[b]	A.6	21. blackish R
Dristan®[b]	A.6	127. gy Ol G
Excedrin®[b]	A.6	108. d. Ol
Heroin·HCl	A.6	43. m. r Br
l-isomethadon·HCl	A.6	243. v. d. r P
Mace[b]	A.6	46. gy. r Br
MDA·SO_4	A.6	235. p Black
Mescaline·SO_4	A.6	65. br. Black
Methadon·HCl[b]	A.6	28. l. y Pk
Methapyrilene·HCl[b]	A.6	243. v. d. r P + 260. v. d. p R
Methaqualone[b]	A.6	35. s. R O
Methprylon	A.6	184. v. p. B
Morphine	A.6	47. d. gy. r Br
Opium	A.6	94. l. Ol Br
Oxycodone	A.6	68. s. O Y
Procaine·HCl	A.6	51. deep O

(*Continued*)

TABLE 3—Continued.

Compound	Reagent	Color[a]
Ritalin®[b]	A.6	68. s. O Y
STP·HCl	A.6	117. s. Y G
TMA·HCl	A.6	94. l. Ol Br
Aspirin	A.7	12. s. R
Benzphetamine	A.7[c]	41. deep r Br
Chlorpromazine·HCl[b]	A.7	260. v. d. p R
Codeine·SO_4	A.7[c]	212. d. V
d-Amphetamine	A.7[c]	44. d. r Br
d-methamphetamine·HCl	A.7[c]	44. d. r Br
Darvon®[b]	A.7	230. blackish P
Demerol®·HCl[b]	A.7	56. deep Br
Doxepin·HCl[b]	A.7	21. blackish R
Dristan®[b]	A.7	241. m. r P
Excedrin®[b]	A.7	15. m. R
Heroin·HCl	A.7[c]	239. v. deep r P
LSD·Tartrate	A.7	235. p Black
Mace	A.7	244. p. r P
Marezine	A.7	98. brill. g Y
MDA·SO_4	A.7[c]	267. Black
Mescaline·SO_4	A.7[c]	36. deep r O
Methapyrilene·HCl[b]	A.7	260. v. d. p R
Morphine	A.7[c]	243. v. d. r P
Opium	A.7[c]	44. d. r Br
Oxycodone	A.7[c]	201. d. p B
Pentobarbital	A.7	78. d. y Br
Phencyclidine	A.7	7. p. Pink
Phenobarbital	A.7	78. d. y Br
Ritalin®[b]	A.7	71. m. O Y
Secobarbital	A.7	78. d. y Br
STP·HCl	A.7[c]	101. l. g Y
Sugar	A.7	46. gy. r Br
TMA·HCl	A.7[c]	36. deep r O
Chlorpromazine[b]	A.9	13. deep R → 101. l. g Y
Codeine·SO_4	A.9[c]	101. l. g Y
Doxepin·HCl[b]	A.9	84. s. Y
Excedrin®[b]	A.9	68. s. O Y
Heroin·HCl	A.9[c]	89. p. Y
LSD·Tartrate	A.9	54. br O
MDA·SO_4	A.9	101. l. g Y
Mace[b]	A.9	40. s. r Br
Mescaline·SO_4	A.9[c]	41. deep r Br
Methapyrilene·HCl[b]	A.9	44. d. r Br
Morphine	A.9[c]	67. brill. O Y
Opium	A.9[c]	101. l. g Y
Oxycodone·HCl	A.9[c]	86. l. Y
STP·HCl	A.9	89. p. Y
TMA·HCl	A.9	14. v. deep Red
LSD·Tartrate	A.10[c]	219. deep P

[a] See Table 1 for color abbreviations used.
[b] Interference or possible interference for single kit reagent.
[c] Usual kit test.
[d] Interference using flow chart, Fig. 1.
[e] Color and extraction rate differentiates between these and marijuana. Consider also initial physical appearance. Need experienced observer.
[f] Interference if Duquenois-Levine modification not used.
[g] Aqueous phase.
[h] Aqueous phase after $CHCl_3$ extraction.
[i] $CHCl_3$ phase; slow extraction compared to marijuana extraction.

TABLE 4—*Spot color tests of typical street drugs.*

Drug	Percent	Diluent	Reagent	Color[a]
Cocaine	5	lactose	A.1	169. s. g B
Cocaine[b]	16.7	lactose	A.1	169. s. g B
Cocaine	100[c]	...	A.1	169. s. g B + 178. s. B
Codeine	5	lactose	A.7	208. deep V
Codeine·SO_4	100[c]	...	A.7	212. d. V
Darvon®	5	lactose	A.7	242. d. r P
Darvon®	100[c]	...	A.7	230. blackish P
Dextroamphetamine	5	lactose	A.7	51. d. O
d-Amphetamine	100[c]	...	A.7	44. d. r Br
Heroin[b]	4.7	quinine, mannitol	A.7	240. l. r P
Heroin	100[c]	...	A.7	239. v. deep r P
Heroin[b]	4.7	quinine, mannitol	A.9	92. y White[d]
Heroin	100[c]	...	A.9	89. p. Y
Methapyrilene	5	lactose	A.7	40. s. r Br
Methapyrilene	100[c]	...	A.7	260. v. d. p R
Morphine	5	lactose	A.7	256. deep p R
Morphine	100[c]	...	A.7	243. v. d. r P
Morphine	5	lactose	A.9	36. r O
Morphine	100[c]	...	A.9	67. brill. O Y
Secobarbital	5	lactose	A.2	223. m. P
Secobarbital	100[c]	...	A.2	218. s. P

[a] See Table 1 for color abbreviations used.
[b] Actual street samples.
[c] Pure drugs, colors from Table 1.
[d] Color difficult to interpret.

The colors produced in these reactions are for colorless (white) or light colored (tan, etc) drugs that are not mixed with dyes or substances that mask the true color reaction. Obviously, color interpretation would be almost impossible if the latter were true, that is, if masking colors were produced. The investigator, however, would undoubtedly find deep masking color production suspicious in itself.

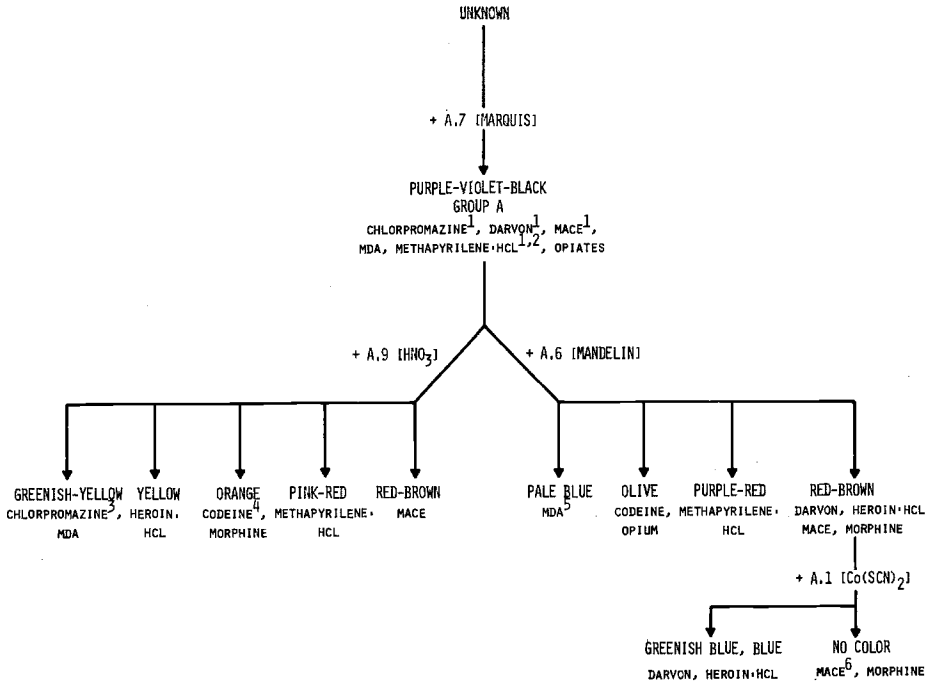
The final conclusion is that *positive* identification of a pure drug by the color produced with a single reagent is difficult and probably incorrect—even if the interpretation is by a trained investigator.

One must not overlook the information inherent in obtaining a negative test. If a negative test or no color is obtained with the Marquis reagent, it is reasonable to assume that no opiates, amphetamines, certain hallucinogens, etc are present. If these materials are present, they are in quantities below the experimental detection limits which are well below the usual, ingested drug quantities.

Multiple Reagent Testing

Increased selectivity can be accomplished by multiple reagent use. The drugs and interferences listed here can be identified by using the testing scheme illustrated in Figs. 1–4.

Initial testing of a suspected drug with Reagent A.7 (Marquis) gives six groupings of colors: Group A, purple-violet-black; Group B, orange-brown; Group C, pink-red; Group D, yellow-green; Group E, tan; and Group F, no color. Testing with three reagents, A.9, A.6, and A.1, identifies the compounds in Group A. Testing with A.9 and A.6 separates all the substances listed except Darvon® and mace. These latter two can be



THE NUMBERED FOOTNOTES ARE FOR FIGURES 1-4.

[1] POSSIBLE INTERFERENCE
[2] PURPLE BLACK PRECIPITATE
[3] DEEP RED → GREENISH YELLOW, VERY FAST
[4] GREEN → ORANGE, VERY FAST
[5] DEEP RED → PALE BLUE, VERY FAST
[6] DIFFERENTIATED BY REAGENT A.9
[7] DIFFERENTIATED BY COLOR FORMED
[8] TRUE INTERFERENCE, COLOR FORMED SLOWLY.
[9] P-DIMETHYLAMINOBENZALDEHYDE
[10] VERY WEAK COLOR

FIG. 1—*Partial flow chart for color development and presumptive identification of narcotics and drugs of abuse with designated reagents. Additional color reagents necessary for increased specificity are included. Group A: Purple-Violet-Black. (See footnotes in figure.)*

identified by their reactions with Reagent A.1, $Co(SCN)_2$. Heroin and morphine would seem to interfere; however, they are separated by the reaction with Reagent A.9.

Similarly, four reagents are used for differentiation within Group B; one for Groups C, D, and E; and three reagents for Group F. Seven reagents are used in this flow scheme. More elaborate flow schemes have been developed [*28*]; however, supplemental reagents are needed in addition to microcrystalline tests. Although supplemental reagents and microcrystalline tests would reduce the likelihood of obtaining false positives, two factors must be emphasized. First, the kit should have some degree of portability. The use of many additional reagents and other procedures such as microcrystalline tests decreases kit portability and simplicity. Second, the kits cannot and are not intended to identify drugs with 100 percent accuracy. Definitive drug identification should be made by trained laboratory personnel using other techniques such as thin-layer, liquid, and gas chromatography; microcrystalline tests; infrared, ultraviolet, visible, and mass spectroscopy; electron spin resonance (ESR); free radical assay techniques; etc.

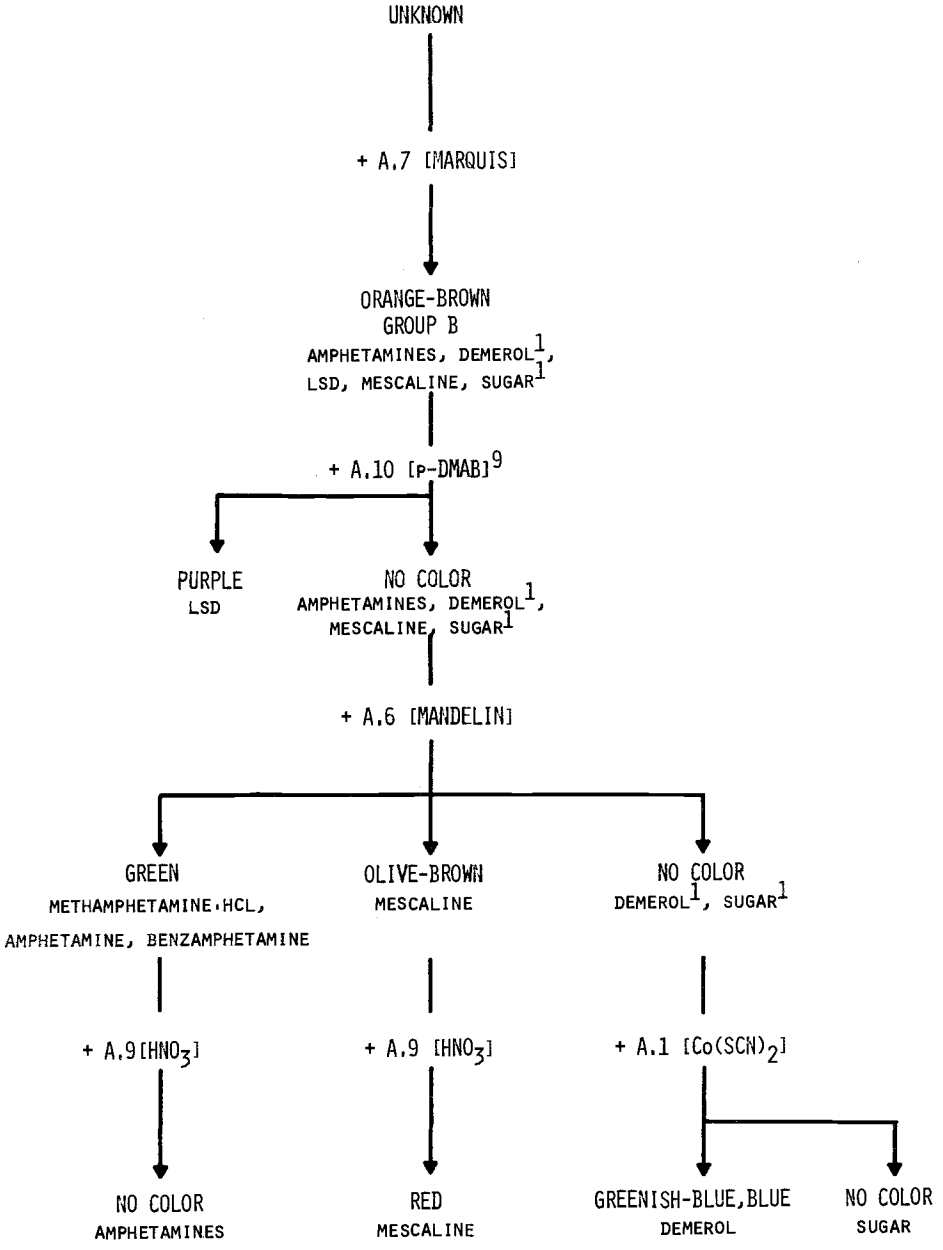


FIG. 2—*Partial flow chart for color development and presumptive identification of narcotics and drugs of abuse with designated reagents. Additional color reagents necessary for increased specificity are included. Group B: Orange-Brown. (See footnotes in Fig. 1.)*

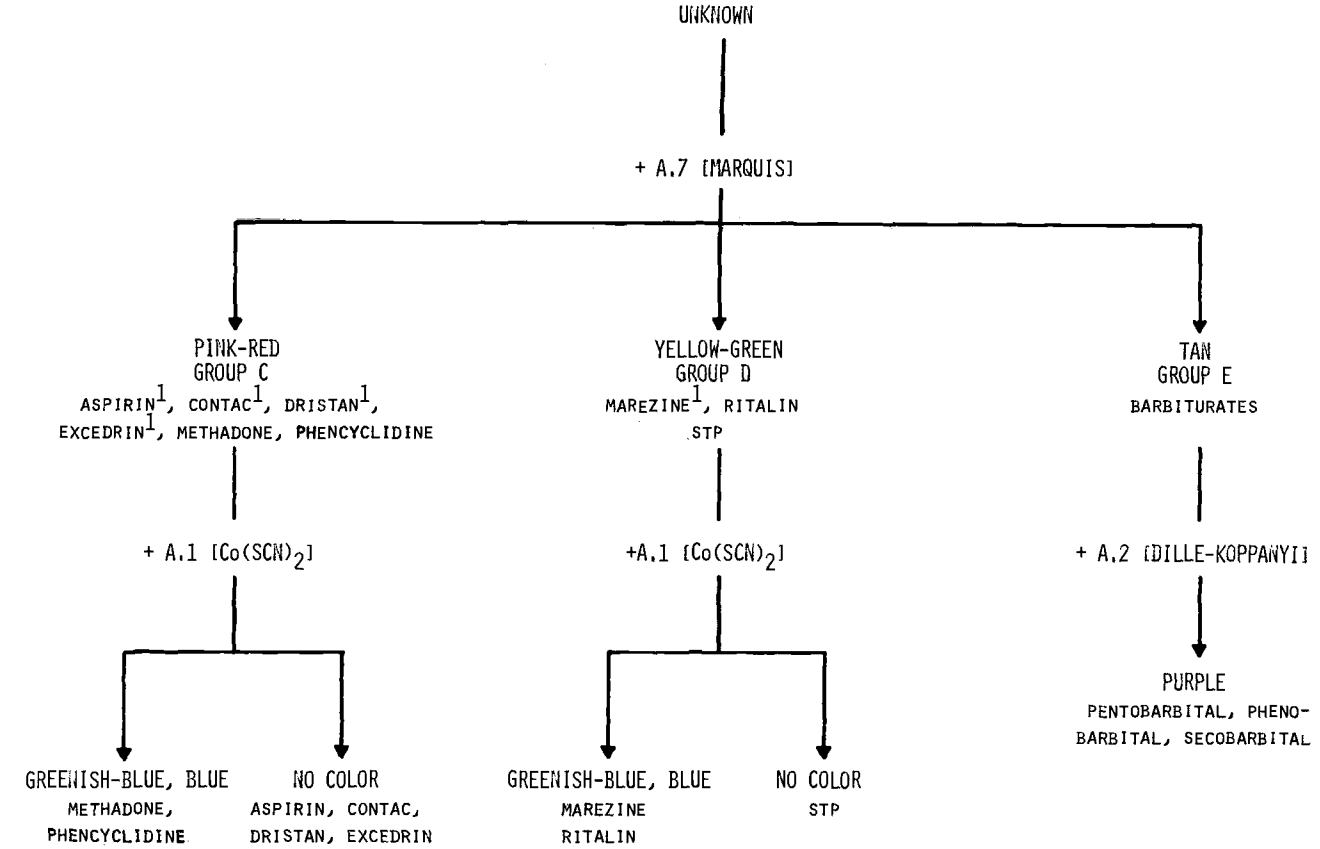


FIG. 3—*Partial flow chart for color development and presumptive identification of narcotics and drugs of abuse with designated reagents. Additional color reagents necessary for increased specificity are included. Group C: Pink-Red; Group D: Yellow-Green; Group E: Tan. (See footnotes in Fig. 1.)*

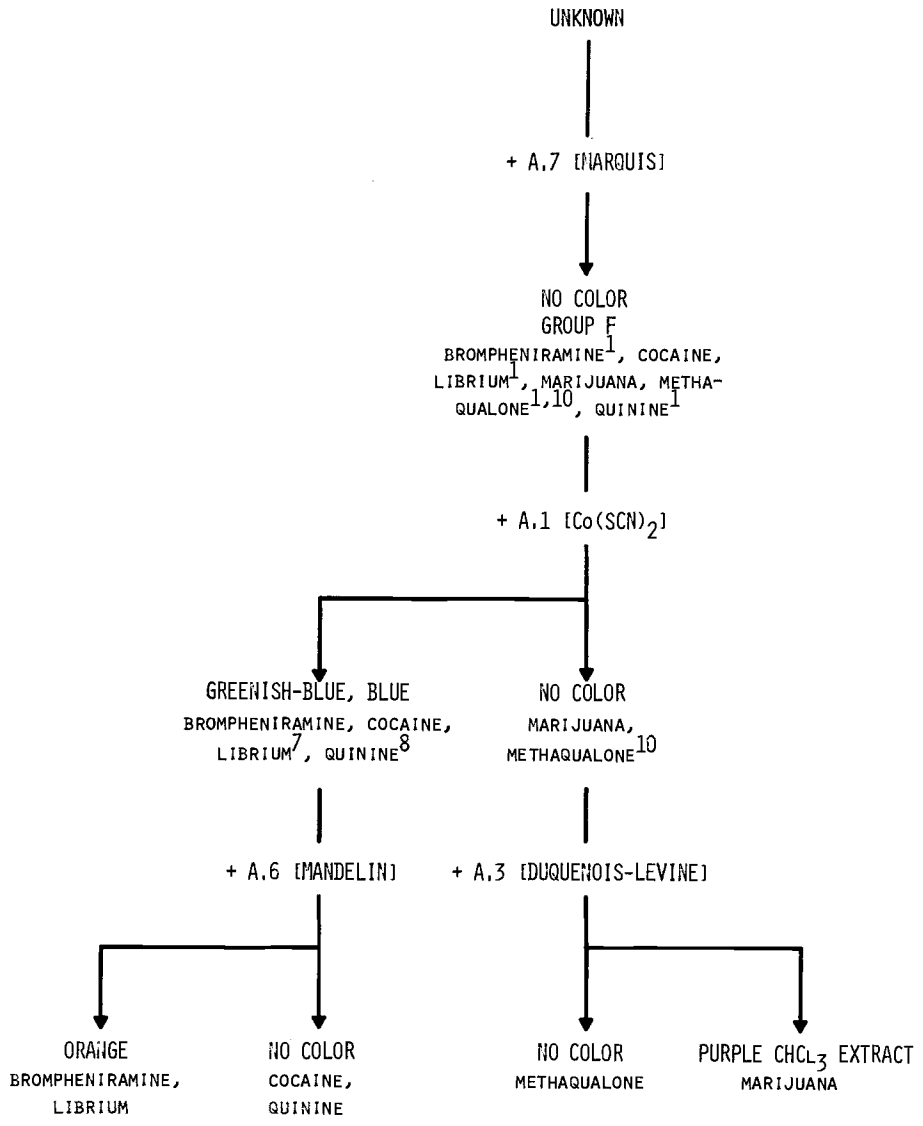


FIG. 4—*Partial flow chart for color development and presumptive identification of narcotics and drugs of abuse with designated reagents. Additional color reagents necessary for increased specificity are included. Group F: No Color. (See footnotes in Fig. 1.)*

Experimental Detection Limits

Experimental detection limits obtained for selected drugs are listed in Table 5. Those listed for LSD·tartrate (0.12 μg) and heroin (0.75 μg) are slightly higher than the experimental detection limits obtained in the more rigorous, statistical manner (0.04 μg and 0.20 μg, respectively) outlined in the **Experimental** section. As an example, the positive, negative, and percent positive tests for LSD are listed in Table 6 and plotted versus

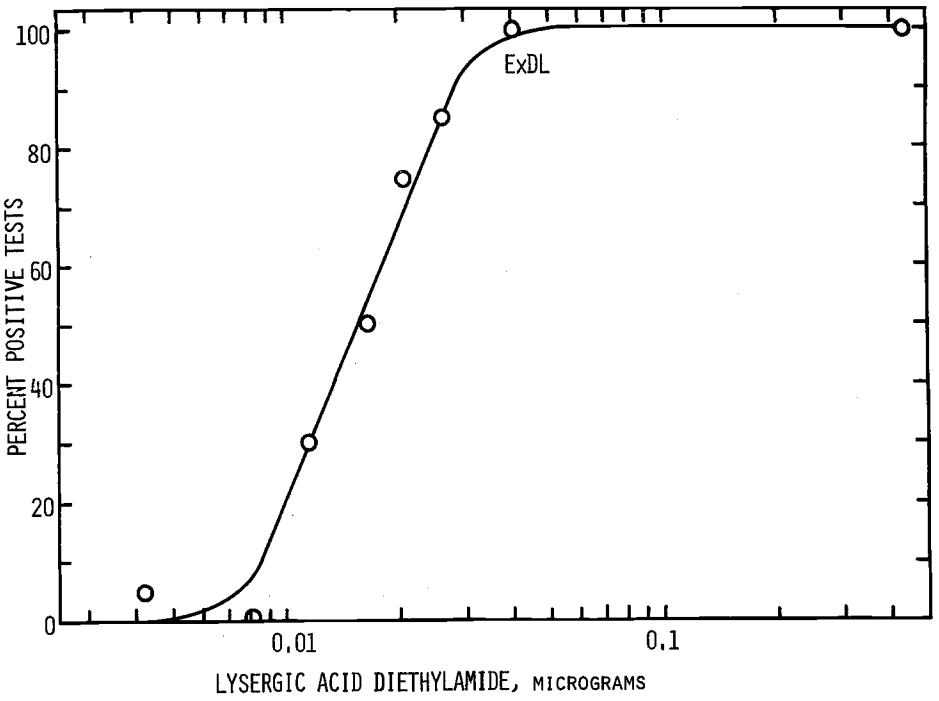


FIG. 5—*Plot of percent positive tests versus amount lysergic acid diethylamide using* para-*dimethylaminobenzaldehyde as the color-developing reagent. Twenty spot tests were performed at each drug quantity.*

micrograms LSD in Fig. 5. The one positive test for the lowest LSD quantity suggests possible limits of errors involved in this method for any particular test. Very low quantities of drugs and very weak color changes are involved in these tests. Some question as to the positiveness at these levels did exist. A few tests (eight of 160) were marked (+ ?) or (− ?); however, in Table 6 these results were included as + and −, respectively.

Typical drug doses also listed in Table 5 are orders of magnitude greater than the experimental detection limits. Thus, the likelihood of obtaining false negatives is relatively low unless masking agents, etc, previously mentioned, are present.

Reagent Stability

All reagents gave positive tests with selected drugs at the experimental detection limits, or at drug amounts one order of magnitude higher, after being immersed in water at 40°C in sealed capsules for two and ten weeks. Thus, the reagents may be considered stable under these conditions. Reagents in glass dropping bottles on laboratory benches under typical fluorescent lighting gave positive tests more than nine months after the initial preparation.

Temperature Effect

All reagents gave the respective colors with selected drugs when reacted at 3°C. Color production, however, for some of the reactions, was somewhat slower. In the slowest case, the color developed with Duquenois-Levine test was ~5 times slower (10 s rather than 2 s). Color extraction into the $CHCl_3$ layer occurred at the same rate. No tests were

TABLE 5—*Experimental detection limits of spot test reagents with selected drugs.*

Drug	Reagent	ExDL, μg	Estimated Amount in Street Sample, μg[a]
Cocaine·HCl	A.1[b]	5.3	2 000
Codeine·SO_4	A.7[b]	0.05	40 000
	A.6	0.25	
d-Amphetamine·HCl	A.7[b]	0.75	8 000
	A.6	0.50	
Heroin·HCl	A.7[b]	0.75	50 000
	A.6	2.0	
LSD·Tartrate	A.10[b]	0.12	200
	A.7	0.16	
Marijuana	A.3[b]	0.16[c]	5 000
Mescaline·SO_4	A.7[b]	0.05	10 000
	A.9	0.05	
Methadon·HCl	A.1[b]	1.5	5 000
	A.7	0.1	
d-methamphetamine·HCl	A.7[b]	0.32	8 000
	A.6	15.0	
Morphine	A.7[b]	0.20	7 000
	A.6	0.25	
Phenobarbital	A.2[b]	10.0	50 000

[a] Average values obtained from police and laboratory reports and Ref *29* and *30*.
[b] Reagent usually found in kit.
[c] Determined on benzene extract of marijuana containing 1.7 percent tetrahydrocannabinol.

TABLE 6—*Results of 160 random tests for lysergic acid diethylamide tartrate with* para-*dimethylaminobenzaldehyde.*

LSD Tartrate, μg	ΣP[a]	ΣN[b]	$(\Sigma T_P/\Sigma T)$ (100)
0.4100	20	...	100
0.0410	20	...	100
0.0312	17	3	85
0.0205	15	5	75
0.0164	10	10	50
0.0123	6	14	30
0.0082	0	20	0
0.0041	1	19	5

[a] Positive.
[b] Negative.

made at elevated temperatures except that several Marquis tests on amphetamines and heroin were made at 40°C and 60°C. These temperatures gave reactions resulting in very rapid color formation making transitory color identification impossible.

Summary

In summary, we have assigned numbers from the Centroid Color Charts to the colors produced by reactions of selected pure and street drug samples with typical narcotic identification kit reagents, resulting in decreased ambiguity in color interpretation. We have also included the colors produced with other chemical spot test reagents. Additional selectivity was obtained by a multiple reagent testing scheme. Experimental detection limits were obtained for selected drugs by a rigorous, statistically meaningful

method, and reagent stabilities and temperature effects on the colors produced and qualitative reaction rates were discussed. Most importantly, however, it must be emphasized that these kits are useful in obtaining preliminary and presumptive evidence only and should not be used as sole evidence for the identification of a narcotic or drug of abuse.

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