NAVEODFAC TECHNICAL REPORT TR-186

DEVELOPMENT OF A SIMPLE PORTABLE DETECTION KIT FOR SELECTED EXPLOSIVES

hy Robert II. Wyant Battelle Columbus Laboratories 500 King Avenue Columbus, Ohio 43201

> SEPTEMBER 1977 FINAL REPORT

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Prepared for NAVAL EXPLOSIVE ORDNANCE DISPOSAL FACILITY Indian Head, Maryland 20640

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| benzene, followed by naphthylamine in 10(| a solution of 0.35 grams of procaine and 0.35 grams N,N-dimethyl 0 milliliters of a 50/50 acetic acid/distilled water mixture |
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FOREWORD

Specific reagents have been identified which will form colored reaction products with TNT, RDX and Nitrate esters (PETN, EGDN). Leather was shown to be the only common material incompatible with the spray. A decrease in sensitivity was observed on dark-colored paper because the reaction product and the background were similar in color. The high sensitivity of these reagents (0.4 µg) and their low expected false alarm rate should provide an explosive detection capability suitable for letter and package bombs.

Future work will be conducted at Naval Explosive Ordnance
Disposal Facility. The spray's maximum sensitivities will be
determined under ideal conditions using white filter paper and
under real-world conditions using typical envelopes and flats
which have arrived at NAVEODFAC via the U.S. Mail. Common
materials which may give false alarms, and the feasibility of using
the two sets of sprays sequentially will also be investigated.
The result will be an inexpensive easy-to-use spray detection
kit with known real-world sensitivity.

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DR. LYLE MALOTKY
Project Officer
Naval Explosive Ordnance Disposal
Facility

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INTRODUCTION

Recently, the sending of explosive devices, even as letter bombs. package bombs, and luggage bombs through the mail, and the use of explosive devices against both the civilian and military population has increased in certain nations. While not yet a major problem in the United States, the possibility of it becoming a serious problem should not be overlooked. Not knowing whether a suspicious looking letter or package contains explosives and is likely to detonate, produces anxiety among people who must handle these packages, and those concerned with their safety. It is known that small quantities of explosives are sometimes deposited on the outer surface of letter bombs and packages during the preparation of the explosive device. Most explosives used in the preparation of such a device have sufficient vapor pressure at ambient conditions to diffuse traces of these explosives to the surface. These small quantities of explosives should be detectable under proper conditions. Currently there are no test kits available that are specifically designed to detect trace quantities of explosives. Hence this program was initiated to develop such a kit.

The proposed study is designed to develop a simple, portable kit which will permit a person to determine whether a suspicious looking letter or package contains explosives. The test kit should be simple, easy to operate, and give the results rapidly. It is preferable that the test reagent be colorless or at least very light in color. It is recognized that more than one consecutive reagent may be required in order to give a definite answer. Further, the test reagent should be nontoxic and should be safe if sprayed on humans. The test reagent spray should not deface the letters or packages in any way, should be specific for explosives, and give no false positive or negative detections. Finally, the test reagent should show good sensitivity since the quantities of explosive being detected are likely to be quite small. The capability to distinguish between explosives is highly desirable, but this does not appear feasible with a single reagent. However, it should be possible to do this with a series of several reagents. Specifically, this study is concerned with: (1) the study of the chemistry of the various classes of explosives likely to be found in letter bombs and package bombs, with special emphasis on their color forming reactions; (2) the study of the color forming reactions to determine which ones might be suitably specific and adaptable to a test kit; and (3) the design of the test kit.

In summary, the kit resulting from this project should:

(1) Have the ability to detect very low surface densities of dynamite, trinitrotoluene, RDX, and pentaerythritol tetranitrate.

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- (2) Be specific and give few false positive reactions and if possible the common inferences for the test should be known.
- (3) Use reactants which are not extremely toxic or highly corrosive.
- (4) Involve a maximum number of three or four spray reagents.
- (5) Have a shelf life of at least three months.

In addition, it would be highly desirable that the kit be able to differentiate among the various types of explosives and should be nonstaining and noncorrosive on the common surfaces on which it will be used. These surfaces include paper of all types, leather, and certain plastics which are used in the manufacture of luggage.

Those explosives that are currently of prime interest include the following.

- (1) Dynamite (NG and EGDN)
- (2) 2,4,6-Trinitrotoluene (TNT)
- (3) Cyclonite (RDX)
- (4) Pentaerythritol tetranitrate (PETN).

RESULTS

The properties of those reagents for the detection of TNT, the nitrate esters (NG, PETN and EGDN), and RDX that were selected for further consideration are presented in Tables A1, A2 and A3. As can be seen from the tables, a number of reagents, potentially useful to the 0.4 microgram level, have been identified for all three classes of explosives.

The toxicity data were all obtained from "The Toxic Substance List," 1974, ed., H. Christiansen, ed., U. S. Department of Health, Education and Welfare, HEW Pub. No. (NIOSH)74-134. It should be kept in mind that when the toxicity data are listed as unknown it merely means that the data are not presented in the compilation. Time did not permit a literature search to determine whether the data were available elsewhere.

The candidate reagents for the detection of TNT, nitrate esters and RDX were thoroughly evaluated and a number of potential reagents eliminated. Selected reagents were then given a second evaluation to determine whether the results previously obtained were reproducible. Following this step even more reagents were eliminated from consideration, leaving only three candidate reagents for the detection of TNT and six candidate reagents for the detection of the nitrate esters and RDX.

Storage tests were conducted on these reagents, and their ability to detect the explosives of interest on a variety of substrates was examined. The subject of possible interferences present in the various substrates is also addressed. Finally, a single reagent was selected for each of the three classes of explosives of interest.

2,4,6-Trinitrotoluene (TNT)

At the end of the broad reagent screening portion of this program a total of 45 candidate reagents for the detection of TNT remained. The first step in elimination of some of the reagents from further consideration was a thorough evaluation of all the candidates. This involved carrying out the color generation in solution and measuring the absorption maximum and the absorptivity. The result of this evaluation is presented in Table A4. On the basis of these experiments 11 of the reagents were selected for further evaluation. The thorough evaluation of these 11 reagents was then repeated to determine the reproducibility of the reagent systems. The comparison of the results of the two series of experiments are collected in Table A5.

Although the comparisons between the two series of experiments do not agree well in some instances, three candidate reagent systems were selected for further consideration. These reagent systems are:

- (1) 1,3-Diphenylacetone-Et, NOH
- (2) Cyclopentanone-Et, NOH
- (3) Nitromethane-ET4NOH

All of these reagents employ ethanol as the solvent. All three reagents were subsequently prepared and stored at room temperature for a period of five weeks, with the sensitivity of the reagent being checked weekly and any color change in the reagent noted. The results of these storage tests are shown in Table A6. Although all three reagents undergo a color change on storage, this does not appear to affect their ability to detect low levels of TNT. Ail reagents were capable of detecting 0.4 μ g of TNT at the end of five weeks of storage. The color of the reagents seemed to stablize after about two weeks; no further color changes were noted after this period. It is anticipated that these systems will be stable for an even longer period, but time did not permit further storage tests. Since the reagent based on 1,3-diphenylacetone underwent the least color change, this is the reagent of choice.

Since all three reagents had the same capability for the detection of TNT when freshly prepared, only one of the systems, cyclopentanone—ET,NOH, was examined for its ability to detect TNT in the various substrates. A total of 34 substrates was examined and these results are presented in Table A7. With the possible exception of leather, the reagent responded satisfactorily on all the substrates. On leather

it is impossible to detect small quantities of TNT, but this could possibly be due to the fact that the color of the leather (brown) obscured the positive response of the small amounts of explosive.

The reagent of choice for the detection of TNT is based on 1,3-diphenylacetone and tetraethylammonium hydroxide in methanol. The spray reagent is prepared by adding 5 grams 1,3-diphenylacetone and 5 milliliters 20 percent tetraethylammonium hydroxide in methanol to 100 milliliters ethanol. When the system described above is used as a spray reagent the presence of TNT produces a red or red-orange color. This reagent is sensitive to at least the 0.4 μ g level of TNT and may be useful at even lower levels. No tests were conducted at lower levels.

This reagent is reported to be specific for polynitro aromatic compounds. Thus it will detect compounds other than TNT, and these other polynitro aromatic compounds could be considered as interferences for this test. However, consultation with paper and packaging experts indicate that such compounds are not very likely to be encountered in the various substrates. No polynitro aromatics are used in the preparation of various types of paper, cardboard, or other substrates of interest, nor are they used as additives to these substrates. Thus a positive response to this reagent on various substrates probably indicates the presence of TNT.

Nitrate Esters

At the end of the broad reagent screening portion of this program almost 100 candidate reagents remained under consideration. A thorough evaluation of most of these reagents was the first step in reducing the number of potential reagents. This involved carrying out the color generation reactions in solution and measuring the absorption maximum and the molar absorptivity. The results of these experiments are collected in Table A8. No reagents involving azulene were examined. Based on the results of these experiments 36 of the candidate reagents were selected for further examination. These reagents were reexamined to determine the reproducibility of the reagent systems. The comparison of the results of the two experiments are collected in Table A9. It can be seen from this table that much better agreement between the two experiments was obtained than was obtained with the TNT reagents. On the basis of these results six reagents were selected for further examination. All gave molar absorptivities around 50,000 and yielded a red color. These reagents included the following.

- (1) p-Aminobenzoic acid N-Phenyl-1-naphthylamine
- (2) p-Aminoacetophenone N-Phenyl-1-naphthylamine

- (3) Diaminodiphenylsulfone N-Phenyl-1-naphthylamine
- (4) p-Aminobenzonitrile N-Phenyl-1-naphthylamine
- (5) Proceine
 N,N-Dimethyl-1-naphthylamine
- (6) Sulfanilamide N-Phenyl-1-naphthylamine

All the reagents are prepared in 50/50 acetic acid/water and are applied following a spray of zinc dust in benzene.

All six of the reagents described above were subsequently prepared and stored at room temperature for a period of five weeks, with the sensitivity of the reagent being checked weekly and any color change in the reagent noted. The results of this study are presented in Table AlO. All of the reagents developed some color on storage. However this color did not deter from the reagents' ability to detect low levels of the nitrate esters. All detected the nitrate ester at 0.4 μ g even after five weeks of storage. There is every reason to believe that this reagent is stable indefinitely since it is merely a solution of a primary aromatic amine and a coupling agent in aqueous acetic acid. These two components should not react with each other. As mentioned previously, all the reagents developed a slight amount of color but this color is probably due to the traces of nitrate ion present in the water supply. The reagent that developed the least color is based on procains and N,Ndimethyl-1-naphthylamine, and this is the reagent of choice for the nitrate ester detection.

Since all six reagents had the same sensitivity when freshly prepared, only the reagent consisting of procaine and N,N-dimethyl-1-naphthylamine was examined for its ability to detect PETN on the various substrates. A total of 34 various substrates were examined and the results of this experiment are presented in Table All. As can be seen from these results, the reagent has good sensitivity on almost all of the substrates. In the case of the one leather sample examined, no positive response was obtained. The leather turned very dark brown, possibly obscuring the positive response, and became very brittle. In the case of polyethylene and polyvinyl chloride the colors faded and with several of the dark brown substrates quantities less than 100 micrograms of PETN could not be readily detected. It was also noted that in one instance a weak positive response was given by the glue on one of the envelopes. In summary, this reagent appears to work well on most of the substrates.

The reagent of choice is prepared by dissolving 0.35 grams of proceine and 0.35 grams of N,N-dimethyl-1-naphthylamine in a 100 milliliter mixture of 50/50 acetic acid/distilled (or deionized) water. It should

be pointed out that the use of distilled water is very important in the preparation of this reagent. The use of ordinary tap water is likely to result in a highly colored reagent because of the presence of nitrite ion. This reagent is applied as a spray following a spray of a suspension of 10 grams of zinc dust in 100 milliliters of benzene. The presence of nitrate esters is indicated by the development of a red or red-violet color. This reagent is sensitive to at least the $0.4\,\mu\mathrm{g}$ level of the nitrate esters and may be useful at even lower levels. However no tests were conducted at lower levels.

This reagent is specific for nitrite ion or compounds that will liberate nitrate ion under the conditions of the test. Thus, RDX is also detected by this reagent. However in consultations with paper and packaging experts it has been determined that neither nitrite ion (nitrite salts) nor nitrite ion releasing compounds are a usual component or additive to the substrates of interest. Thus this reagent system should be specific for the nitrate esters and RDX.

RDX

At the end of the broad reagent screening portion of this program almost 80 potential RDX reagents were still under consideration. In order to eliminate a number of these reagents from further consideration the first step was the thorough evaluation of most of these reagents. This involved carrying out the color generation reaction in solution and measuring the absorption maximum and molar absorptivity of each reagent system. The results of these studies are presented in Table A12. It should be pointed out that no azulene-based reagents were examined. On the basis of these experiments 36 reagents were selected for further study. These are essentially the same reagents selected for the detection of the nitrate esters. These reagents were reexamined to determine the reproducibility of the two experiments. The results of this comparison is presented in Table Al3. As can be seen from this table, very good agreement was obtained in the two experiments. On the basis of these results six of the reagents were selected for continued study. The selected reagents are the same ones relected for the nitrate ester determination. All give red colors in the presence of RDX and exhibit molar absorptivities in the 50,000 range. All use 50/50 acetic acid/water as the solvent and are applied following the zinc dust spray. The reagents selected are listed below.

- (1) p-Aminobenzoic acid N-Phenyl-1-naphthylamine
- (2) p-Aminoacetophenone N-Phenyl-1-naphthylamina

- (3) Diaminodiphenylsulfone N-Phenyl-1-naphthylamine
- (4) p-Aminobenzonitrile N-Phenyl-l-naphthylamine
- (5) Procaine
 N,N-Dimethyl-1-naphthylamine
- (6) Sulfanilamide N-Phenyl-1-naphthylamine

All six of the above reagents were prepared and put on storage tests for five weeks at room temperature, with the sensitivity and any color change in the reagent being noted weekly. The results of these storage tests are presented in Table Al4. In storage, all the reagents developed a slight color but this did not interfere with the reagents' ability to detect RDX. All six reagents responded to RDX at the 0.4 μg level even after five weeks of storage. It is anticipated that these reagents are stable indefinitely and that the color will not change to any extent since most of the color was present initially and did not deepen in storage. That reagent with the least color was based on procaine-N,N-dimethyl-1-naphthylamine, and this is the reagent of choice.

The reagent consisting of Procaine and N,N-dimethyl-1-naphthylamine was selected as being representative of the six reagents, and its ability to detect RDX on various substrates was examined. A total of 34 substrates were examined and the results are collected in Table A15. The sensitivity of this reagent for RDX on the various substrates appears to be adequate for its intended purpose. With the exception of leather, the reagent detected RDX on all the substances. In the case of the one leather sample examined it turned very dark brown, possibly obscuring a positive response and became very brittle. Although in several instances the RDX detection limit was 40 micrograms, in most instances the detection level was 4.0 or 0.4 micrograms of RDX. In one instance the glue on one of the substrates did give a weak positive response. In summary, a reagent of this type does appear to be usable on a variety of substrates.

The reagent of choice for the detection of RDX is the same reagent chosen for nitrate ester detection, and is prepared by dissolving 0.35 grams of procaine and 0.35 grams of N,N-dimethyl-1-naphthylamine in 100 milliliters of a mixture 50/50 acetic acid/distilled (or deionized) water. It is important to use distilled water since the use of ordinary tap water is likely to result in a highly colored reagent because of the presence of nitrite ion in the water. This spray reagent is applied following a spray of a suspension of 10 grams zinc milliliters benzene. A positive response is evidenced by the development of a red or red-violet color. This reagent is sensitive to at least the $0.4~\mu g$ level of RDX and may be useful to even lower levels but we did no studies at lower levels.

This reagent is specific for nitrite ion or compounds that will liberate nitrite ion under the conditions of the test. Thus the nitrate esters will also respond to this reagent. However paper and packaging experts report that neither nitrite ion (nitrite salts) nor nitrite ion releasing compounds are a usual component or additive to the substrates of interest. Thus this reagent system should be specific for RDX and the nitrate esters.

APPENDIX A
PROPERTIES OF DETECTION REAGENTS AND REACTION PRODUCTS

TABLE A-1. SUMMARY OF PROPERTIES OF CANDIDATE REAGENTS FOR 2,4,6-TRINITROTOLUENE

| REAGENT | SOLVENT | COLOR RESPONSE | BACKGROUND COLOR | REACENT COLOR | SENSITIVITY, MICROGRAMS | REACENT AVAILABILITY | TOXICITY OF REACENT |
|--|----------------------|-------------------|---------------------|-----------------|----------------------------|-------------------------|--|
| 1,4-Diazabicyclo[2,2]octane | Chloroform | Red | Colorless | Colorless | 0.4 | Cowe. (2) | Unk. (b) |
| Bis (9-julolidyl)methane | Chloroform | Violet | Colorless | Colorless | 9.0 | Synthetic | Unk. |
| 1,5-Diazabicyclo[5.4.0]undec-5-ene Chloroform | Chloroform | Red | Colorless | Coloriess | 7.0 | Some. | U-sk. |
| 1,5-Diazabicyclo[4.3.0]non-5-ene | Chloroform | Red | Colorless | Coloriess | 4.0 | Some | Dak. |
| 1,8-Bis (dimethylamino) naphthalene Chloroform | Chloroform | Red | Colorless | Colorless | 4.0 | Comme. | Unk. |
| 2,3,5,6-Tetramethyl-p-phenylenediamine | Chloroform | Blue-violet | Colorless | Colorless | 0.4 | . | LDLo (c) v 20 mg/kg. |
| 4,4-Dimethoxy-2-butazone,Et ₄ NOH | Ethanol | Red | Colorless | Orange | 9.0 | Com. | Unk.; LDLo 102 mg/kg. |
| 1,3-Diphemylacetone, Et, NOH | Ethanol | Red-orange | Colorless | Orange | 7.0 | S. | Unk.; 1Dio 102 mg/kg. |
| Phenyl-2-propanone, Et 4 NOH | Ethanol | Red | Coloriess | Yellow | 4.0 | Comm. | Unk.; LDLo 102 mg/kg. |
| 5-Hexene-2-one, Et, NOH | Ethanol | Red-violet | Colorless | Orange, odorous | 4.0 | S. | Unk.; LDLo 102 mg/kg. |
| Acetophenone, Et, NOH | Ethanol | Red-violet | Colorless | Orange, odorous | 7.0 | S | 1.D50 ^(d) 3000 ng/kg; 1.Dl.o 102 ng/kg. |
| 3-Methyl-2-hexanone, Et, NOH | Ethanol | Red-violet | Colorless | Yellow | 4.0 | Comm. | 1.D50~ 2500 mg/kg.; 1.0%.0 102 mg/kg. |
| Fluorene, Et _k NOH | DMF-H ₂ 0 | Red | Colorless | Colorless | 4.0 | Corra. | TDLo (e) 15g/kg.; LDLo 102 mg/kg. |
| 1,3-Bis(dimethylamino)2-propanol | Chloroform | Violet | Colorless | Straw | 9.0 | S | LD50~ 1500 mg/kg. |
| Ethanolamine | Chloroform | Orange | Colorless | Colorless | 4.0 | Come. | LD50 2100 mg/kg. |
| N-Ethyldiethanolamine | Chloroform | Red | Colorless | Colorless | 9.0 | Corm. | LD50 ~ 1000 mg/kg. |
| Tetraethylamonium hydroxide | Dec | Brown | Colorless | Colorless | 9.0 | Cours. | LDLo 102 mg/kg. |
| Diethylamine | DMESO | Violet | Colorless | Colorless | 9.0 | 3 | LD50 540 mg/kg. |
| Propylenediamine | Def | Violet | Coloriess | Colorless | 4.0 | Com. | LD50 2230 mg/kg. |
| Piperazine | 350 | Violet | Colorless | Colorless | 9.0 | Ço B | 1.050 ~ 11 g/kg. |
| Potassium indroxide | Methyl Cellosolve | Red-violet | Colorless | Coloriess | 9.6 | Com. | LD50 365 mg/kg. |

TABLE A-1 (Continued)

| REACENT | SOLVENT | COLOR RESPONSE | BACKGROUND | REAGENT | SENSITIVITY | REAGENT AVAILABILITY | TOXICITY OF REACEST |
|---|---------------------|-------------------|----------------------|------------|-------------|-------------------------|-------------------------------------|
| SnC12-dimethylaminobenzaldehyde | IMBC1- Ethenol | Yellow | Lt. Yellow Colorless | Colorless | 4.0 | ě | 1.050 620 me/ke |
| SnCl ₂ -diphenylacrolein | INEX.1- Ethenol | Yellow | Lt. Yellow | Coloriess | 4.0 | | 1.050 v. 3500 m/kg. |
| SnCl ₂ -N)4-pyridyl)pyridinium chloride | IMBC1-IN MeOH | Red- orang¢ | Lt. Yellow | | 4.0 | S | Unk. |
| Cyclohexanone, Et.HOH | Ethanol | Red | Colorless | Lt. Yeilow | 9.0 | Com. | 1.959 1620 mg.; LDLo 102 mg/kg. |
| Cyclopentamone, Et 180H | Ethanol | Red | Coloriess | Lt. Orange | 9.0 | Comm. | LD50 2950 mg/kg. LDLo 102 mg/kg. |
| Propiophenone, It, NOE | Ethenol | sted | Colorless | Yellow | 0.4 | Comm. | 1D50 4490 mg/kg.; 1Dlo ' 102 ng/kg. |
| 3-Acetyl-l-propanol, Et, HOH | Ethenol | Red-violet | Coloriess | Lt. Orange | 9.0 | Cons. | Unk.; iDLo : 102 mg/kg. |
| Benzalactione, Et MUH | Ethano1 | Red-violet | Colorless | Lt. Orange | 7.0 | Come. | Unk.; 1DLo 102 mg/kg. |
| 1-Phenyl-2-butanone, Et ₄ NOS | Ethanol | Red-orange | Colorless | Lt. Orange | 4.0 | Com. | Juk.; LDLo 102 ng/kg. |
| Phenylzcetonitrile, Et NOH | Ethano1 | Red-orange | Coloriess | Coloriess | 4.0 | | LD50 270 mg/kg.; LDLo 102 mg/kg. |
| 3,4-Dimethoxyphenylacetomitrile, Et_MOH | Ethanol | Red | Coloriess | Colorless | 0.4 | Com. | ťak. |
| Mitromethane, Et MOH | Ethanol | Red-orange | Colorless | Colorless | 4.0 | Conm. | 1.050 940 mg/kg.; 1.51.0 102 mg/kg. |
| Phioroglucinol, Et 1008 | Ethanol | Orange | Coloriess | Colorless | 9.0 | Comm. | LDLo 1550 mg/kg.; LDLo 102 mg/kg. |
| Tetramethylammonium hydroxide | Ethyl cellosolve | Violet | Coloriess | Colorless | 0.4 | Comm. | LDLo ~ 102 ng/kg. |
| Diphenylamine, Kt. 108 | Acetone- | Violet | Coloriess | Colorless | 9.6 | 3 | LDLo ~ 200 mg/kg.; LDLo 102 mg/kg. |
| Ethy lenedisaine | DIESO | Violet | Coloriess | Coloriess | 9.0 | Common | 1350 ~ 150 mg/kg. |
| 4,4'-Nis (dimethylaminophenyl) methane | Chloroform | Red-orange | Coloriese | Coloriess | 4.0 | Come: | i.D50 681 mg/kg. |

TABLE A-1 (Continued)

| REACENT | SOLVENT | COLOR | RACKGROUND COLOR | REACENT COLOR | SENSITIVITY MICROGRAMS | REAGENT AVAILABILITY | TOXICITY OF REACENT |
|---|-------------------------------------|------------|---------------------|------------------|---------------------------|-------------------------|--------------------------------|
| p-Chlorophenylacetonitrile, Et NOH | Ethano! | Red | Colorless | Coloriess | 0.4 | Com. | Unk.; 1Dio 102 mg/kg. |
| o-Methoxyphenylacetonitrile, Et _é MOH | Behanel | Violet | Colorless | Colorless | 9.0 | S | Unk.; LDI.c 102 mg/kg. |
| p-Methoxyphenylacetonitrile, Et ann | Ethanol | Violet | Colorless | Colorless | 4.0 | Some. | Unk.; 1Dlo 102 mg/kg. |
| SnCl ₂ -2-bromo-4-dimethylamino- benzaldehyde | INBC1- Ethenol | Orange | Colorless | Colorless | 0.4 | Synthetic | LD50 ∿ 620 mg/kg. |
| SnCl, -2-phenoxy-4-dimethylamino- benzaldehyde | IMBC!- Ethanol | Orange | Colorless | Colorless | 0.4 | Synthetic | 1.D50 ~ 620 mg/kg. |
| SaCl, -4-diphenylaminobenzalde- hyde | IMBC1- Ethanol | Red-orange | Colorless | Straw | 0.4 | Synthetic | .D50 ∿ 620 mg/kg. |
| SnCl,-4-dimethylmminocinnam- aldehyde | IMBC1- Ethanol | Violet | Colorless | Tan | 4.0 | Synthetic | LD50 ~ 620 mg/kg. |
| SnCl,-2-Chloro-4-dimethylamino- behraldehyde | IMBC1- Ethanol | Orange | Colorless | Colorless | 9.0 | Synthetic | 1.050 ~ 620 mg/kg. |
| SaC1,-2-hydroxy-1-naphth- aldehyde | DERCI- Ethanol | Orange | Colorless | Straw | 0.4 | 3 | Unk. |
| SnCl, -2, 5-dimethoxy-4-dimethyl- amimobenzaldehyde | INECI- Ethanol | Orange | Colorless | Yellow | 0.4 | Synthetic | LD50 ~ 620 mg/kg. |
| SnCl2-methyl-4-dimethyl- aminobenzaldehyde | INECI- Ethenol | Orange | Colorless | Colorless | 0.4 | Syntheric | LD50 ~ 620 mg/kg. |
| Past Blue BB | Water | Orange | Tan | Straw | 9.0 | Som. | Unk. |
| Fast Blue R | Water | Violet | Tan | Lt. Green | 6.4 | 8 | Unk. |
| Varianise Biue B | Water | Violet | Yellow | Lt. Brown | 0.4 | S | Unk. |
| Sodium sulfite-Griess Reagent | H,O, 50/50 HOAC/H ₂ 0 | Orange | Coloriess | Colorless | 9.4 | Comm. | LD50 v 2g/kg.; LDfo 150 mg/kg. |

TABLE A.i (Continued)

| | | COLOR | BACKGROUND REAGENT | REAGENT | SERSITIVITY | PPA(:P)FT | TOTICITY OF |
|--|---------------------|---------------|--------------------|------------|-------------|--------------|-----------------------------------|
| REACENT | SOLVENT | RESPONSE | COLOR | COLOR | PICROCRAMS | AVAILABILITY | RACERT |
| 2,4-Pentamedione,Et, NOH | Ethenol | Violet | Coloriess | Colorless | 0.4 | Som. | LD50 1000 mc/kg.: LDLo 102 mc/kg. |
| p-Witrosodimethylaniline | Acetone, | | | | | | |
| | R 20 | Orange | Yellow | Green | 4.0 | Com. | LD50 65 mg/kg. |
| 1,3-Dicarbomethoxyacetone,Et_3H | Ethanol | Orange | Colorless | Colorless | 4.0 | Comm. | Unk.; LDLo 102 mg/kg. |
| Flavone, Et, NOH | Ethanol | Violet | Colorless | Straw | 4.0 | Com. | Unk.; LDLo 102 mg/kg. |
| Hitron | Chloroform | Violet | Lt. Yellow | Red | 9.0 | Co | Jak. |
| o-Maphthoflavone, Et MOH | Ethanol | Violet | Colorless | Colorless | 9.0 | Comm. | Unk.; LNto 102 mg/kg. |
| Khellen, Et ₄ NOR | Ethanol | Violet | Colorless | Colorless | 0.4 | Som. | Unk.; LDLo 102 mg/kg. |
| 2,6-Dimethyl-dipyrone, Et, NOH | Ethanol | Violet | Coloriess | Colorless | 9.0 | Comm. | |
| Testosterome, Et. NOR | Ethenol | Violet | Colorless | Colorless | 9.0 | Cours. | Unk.; UDLo 102 mg/kg. |
| Cholestan-3-one-Et, NOH | Ethanol | Violet | Colorless | Colorless | 9.0 | Com. | Unk.; LPLo 102 mg/kg. |
| Methyltestosterome, Et MOH | Ethanol | Violet | Colorless | Colorless | 9.0 | Gom. | Unk.: LDLo 102 mg/kg. |
| Progesterome, Et MOR | Etheno1 | Violet | Colorless | Colorless | 9.0 | Comm. | TDLo 120 mg/kg.: 1Dlo 102 mg/kg. |
| Pregnenolone, Et MOH | Ethanol | Violet | Colorless | Colorless | 0.4 | 3 | Unk.; LDLo 102 mg/kg. |
| I Cl.,-p-disethysainobenz- aldehyde | IMBC1-EtOH | Yellow | Grey | Colorless | 9 *0 | į | 100 620 /1- |
| TCl3 diphenylacrolein | IMBC1-Econ | Yellow | Grey | Colorless | 0.4 | 3 | 1050 1, 3500 100/100 |
| TiCl3-W(4-pyridyl)pyridimium chloride | 1388C1- 138 MeOH | Red-orange | Cream | Ten | 9.0 | 9 | Dok. |
| Ticl -p-disethylasisocismas- aldehyda | DESCI-ECOR | Violet | Grey | Yellow | 7.0 | 3 | Dak. |
| SuCl,-2,5-dimethoxytetrahydro- fufan-p-dimethylaminobuns- aldehyde | | Violet | Coloriess | Lt. Yellow | 4.0 | ġ | Unk.; 1.050 620 mg/kg. |

TABLE A-1 (Continued)

| | | | | • | | | |
|--|--------------------|-------------------|---------------------|---------------------|---------------------------|-------------------------|----------------------------------|
| REACERT | SOLVENT | COLOR RESPONSE | BACKGROUND COLOR | REAGENT | SENSITIVITY MICHOGRAMS | REACENT AVAILABILITY | TOXICITY OF REACENT |
| SaCl ₂ -Vanillin | IMBC1-EtOH | Yellow | Colorless Colorless | Colorless | 9.6 | 83 | LD50 1580 mg/kg. |
| T.ClMinhydrin-p-dimethylamino- benzaldehyde | DMC1- Pyridine- | | | | | | |
| | Ethanol | Orange | Coloriess | Colorless Colorless | 9.6 | Comm. | LDLo 250 mg/kg.; LD50 620 mg/kg. |

(a) Com. - Commercial.

(b) Unk. - Unknown.

LUID - Lethal Dose Low - the lowest dose of a substance other than LD50 introduced by any route other than inhalation over any given period of time and reported to have caused death in man or the lowest dose introduced in one or more divided portions and reported to have caused death in animals. છ

(d) LD50 - Lethal Dose - 50 percent kill.

TDLo - Toxic Dose Low - the lowest dose of a substance, as published or made available to publish, introduced by any route other than inhalation over any given period of time and reported to produce any toxic effect in man or to produce carcinogenic, teratogenic, maragenic or memplasti-genic effects in humans or animals. 3

TABLE A-2 SUMMARY OF PROPERTIES OF CANDIDATE REAGENTS FOR NITRATE ESTERS

| Regent | Solvent | Color Response | Background Color | Reagent Color | Sensitivity, Micrograms | Reagent Availability | Toxicity of Reagent |
|---|--------------------|--------------------|---------------------|------------------|----------------------------|-------------------------|--------------------------------|
| 2,6-Bis(dimethylamino)anthracene | Benzene | Red-Orange | Colorless | Yellow | 4.0 | Syntheric | ľnk. (ď) |
| 2,6-Bis (dimethylamino) antinracene | Chloroform | Violet | Yellow | Tellow | 7.0 | Synthetic | Unk. |
| | Benzene | Violet | Tellow | Tan | 4.0 | Synthetic | Dak. |
| Good) | Chlorofor n | Blue-Violet Yellow | Yellow | Tan | 9.6 | Synthetic | Unk. |
| 4,4",4" Methylidynetris (W.W-dimethylaniline) | Acetone | Violet | Colorless | Lt Violet | 9.6 | Synthetic | Bak. |
| 3,3,-Bis(p-dimethylaminophenyl) 2-methoxy-p-crisol | Acetone | Blue | Colorless | Lt Red-Violet | 0.4 | Synthetic | Unk. |
| ", "-Dipheny lbeng ldine | Acetone | Blue (NV) | Colorless | Colorless | 9.4 | (S) | Unk. |
| 1 811^(a)- Griess Reagent | Ecos-BOAC/H20 | Violet | Colorless | Coloriess | 9.0 | 3 | 1050" 2 g/Kg; 1.01.0 150 mg/Kg |
| DBO(b).Griess Reagent | Ecos-BOAC/H20 | Violet | Colorless | Colorless | 4.0 | 8 | LD50" 2 g/Kg; LDt.o 150 mg/Kg |
| 1M MaCM-Griess Resgent | H20-HOAC/H20 | Violet | Colorless | Colorless | 9.0 | . | LP50-2 g/Kg; LDLo 150 mg/Kg |
| 3,3-Bis(p-dimethylaminophenyl)- o-crasol | Acetone | Green | Colorless | Tan | 4.0 | Synthetic | Vak. |
| 4-Chloro-3, 3-bis (p-dimethylamino- phemyl)-o-cresol | Acetone | Green | Colorless | Straw | 4.0 | Synthetic | Verk. |
| 4,41-(2-Thenylidene)bis(N,H-dimethylanlline) | Acetone | Green | V Lt Green | Straw | 4.0 | Synthetic | Unk. |
| <pre>3,3-Bis(p-dimethylaminophenyl)- p-cresol</pre> | Acetone | Violet | V Lt OViclet Orange | Orange | 4.0 | Synchetic | Vak. |
| 0,3-Bis(p-dimethylamimophenyl)-6- methoxy-m-toluenesulfonic and sodium salt | Ethenoi | Green | Colorless | Colorless | 4.0 | Synthetic | Unit. |

TABLE A-2 (Continued)

| Reagent | Solvent | Color Response | Background Color | Reagent | Sensitivity, Micrograms | Reagent Availability | Toxicity of Reagent |
|--|----------------------------|-------------------|---------------------|-----------|----------------------------|-------------------------|----------------------------------|
| USH-p-Mitrosailine-W(1-naphthyl)- RtOH-BOAC/H20 ethylenedismine | Ecom-HOAC/H20 | Red-Violet | Colorless | Lt Yellow | 0.4 | | LD50 3249 mg/Kg; LDLo 150 mg/Kg |
| DEM-p-Chlorosailine-M(naphthyl)-ethylamediamine | EtoH-HOAC/H20 | Orange | Colorless | Colorless | 9.0 | Some. | LD50 300 mg/Kg; LDLo 150 mg/Kg |
| DMM-p-toliudene-W(l-naphthyl)- ethyletadiamine | EtOH-HOAC/H2O Blue-Violet | Blue-Violet | Colorless | Coloriess | 9** 0 | • | LD50 1285 mg/Kg; LDto 250 mg/Kg |
| DBM-Procaine-W(1-naphthy1)-ethylemediamine | EtOH-HOAC/H20 | Red-Violet | Colorless | Colorless | 9.4 | | 1D50 500 mg/Kg; 1Dio 15C mg/Kg |
| DBH-2-Haphthylamine-6,8-disulfonic Et(W-MOAC/H20 Blue-Violet acid M(1-naphthyl)ehtylenedizmine | ELOH-HOAC/H20 | Blue-Violet | Colorless | Colorless | 4.0 | | Unk. LDIo 150 mg/Kg |
| DEM-Sulfauille acid-M.M-dimethyl-naphthylamine | ktOH-HDAC/H20 Violet | Vi olet | Colorlese | Colorless | 4.0 | Comm. | LD50- Z g/Kg; LD50~1500 mg/Kg |
| DEM-p-Mitroeniline-H.M-dimethyl- l-naphthylamine | EtOE-BOAC/H20 Red Violet | Red Violet | Colorless | Lt Yellow | 7.0 | | LD50 3249 mg/Kz; LD50~1400 mg/Kg |
| BM-p-Chlorozafilae-f-H- disethyl-l-naphthylanise | BtOH-HOAC/H2O Violet | Violet | Colorless | Colorless | 9.0 | 3 | LD50 300 mg/Kg: LD50~1400 mg/Kg |
| 1885-proceine-N.M-dimethyl- l-naphthylmrine | EtOH-HOAC/H2O Red-Violet | Red-Violet | Colorless | Colorless | 7.0 | Comm. | LD50 500 mg/Kg; LD50-1400 mg/Kg |
| DMM-2-maphthylamine-6.9-disul- fonic scid-N.N-dimethyl-1- maphthylamine | EtOH-HOAC/H ₂ 0 | Blue-Violet | Colorless | Coloriess | 4.0 | S | Dak. |
| DMM-N.M.W. W-Tetramethyl-p- phenylemedianine | Acetic acid | Blue | Colorless | V Lt Blue | 9.4 | į | LD50-50 mg/Kg |
| Mar-Glyonal bis(N.M-diphenyl-hydrasons) | Acetic acid | Pink | Tan | Red | 4.0 | Synthetic | yak. |
| DBH-3-Machyl-2-benzothiazolinone- Picryl-bydrazone | Acetic acid | Orange | Colorless | Orange | 4.0 | Synthetic | Jak. |

TABLE A-2 (Continued)

| Resgent | Solvent | Color Response | Background Color | Reagent Color | Sensitivity, Micrograms | Reagent Availability | Toxicity of Reagent |
|---|----------------------------------|-------------------|---------------------|---------------------|----------------------------|-------------------------|------------------------------------|
| DEM-M.M.M. 11-Tetramethylbenzidine | Acetic acid | Orange | Colorless | Colorless | 0.4 | Comme | Unk. |
| DMM-H, W-Diphenyl-p-phenylenediamine | Acetic acid | Orange-Red | Colorless | V Lt Blue- Green | 0.4 | 3 | LD50 2370 mg/Kg |
| DEM-Indole | Water-HC1 | Violet | Colorless | Colorless | 9.0 | Co | LD50 1063 mg/Kg |
| DEE-Sulfamilic acid Phemol | HOAC/H20 1H Mach | Orange | Colorless | Colorless | 0.4 | Comm. | LD50-2g/Kg LD50 414 mg/Kg |
| DMM-1-Maphthylamine-7-selfonic scid M(1-Maphthyl)ethylenediamine | BOAC/H20 | Brown-Orange | Colorless | Colorless | 9.4 | Comm. | Unik. LDLo 150 mg/Kg |
| DWM-Sulfamilic acid H(l-Maphthyl)ethylenediamine | HOAC/H ₂ 0 | Red-Violet | Colorless | Colorless | 9.0 | Co. | LD50-2 R/RR LD50-150 mg/Kg |
| DEST-1-Assisopyrese | HOAC | Tellow | Colorless | Colorless | 9.0 | 3 | LD50 1070 mg/Kg |
| DMM-p-dataobeazoic acid H(1-Hapbthyl)ethylenediamine | BOAC/H ₂ 0 | Violet | Colorless | Colcriess | 4.0 | 3 | LD50 2000 mg/Kg LDLo 150 mg/Kg |
| DEE-4-Aminoscetophenone H-Phenyl-2-naphthylamine | BOAC/B ₂ 0 | Pink | Colorless | Colorless | 9.4 | 3 | LDLO 300 mg/Kg LDLo 80 mg/Kg |
| DME-o-Dismisidine n-Thenylenedismine | HOAC/H20 | Brown | Colorless | Colorless | 9.6 | 3 | LD50 1450 ng/Kg LDLo 50 mg/Kg |
| DEST-o-Tolidine | BOAC/H20 | Orange-Brown | Colorless | Colorless | 9.0 | Ç. | LD50 404 mg/Kg |
| DNM-p-Aminosalicyclic acid H(1-maphthyl)ethylemediame | BOAC/E ₂ 0 | Purple | Colorless | Colorless | 4. 0 | 89 | LDSO 4 g/Kg LDLo 350 mg/Kg |
| BEL-e-Phenylenedlanine | HOAC/IL O | Orange-Brown | Colorless | Colorless | 7.0 | S | LDLo 80 mg/kg |
| DEE-Indole | 0.3mH2504 | Violet | Colorless | Coloriess | 7.0 | 3 | LD50 1000 mg/Kg |
| DON-0-Dismissidine 2-Naphthol | HOAC/H ₂ O- IMMACH | Orange-Brown | Coloriess | Colorless | 9.0 | | LD50 1920 mg/Kg LD50 2480 mg/Kg |
| DEE-Dijulolidylmethane | BOAC | Mue | Lt Blue | Blue | 4.0 | Synthetic | Unk. |
| DMM-Sulfamilic acid n-Phemylamediamine | BOAL/N20 | Brown-Orange | Coloriess | Colorless | 4.0 | . | ID50'2 3/Eg IDIO 80 mg/Kg |
| MME-2-Ethony-3, 6-dismissecridise H(1-Heptchyl) ethylescdismise | BOAC/B20 | Purple | Colorless | Colorless | 4.0 | Come. | LDLo 100 mg/Kg LDLo 150 mg/Kg |

TABLE A-2 (Continued)

| Roogent | Solvent | Color Response | Background Color | Reagent Color | Sensitivity, Micrograms | Reagent Availability | Toxicity of Reagent |
|---|-----------------------|-----------------------|---------------------|------------------|----------------------------|-------------------------|--------------------------------------|
| DEE-p-Aminobenzoic acid M(1-Maphthyl)ethylenediamine | HOAC/B20 | Violet | Colorless | Colorless | 0.4 | Som. | LD50 2000 mg/Kg |
| UM-p-Thenylazoaniline N(1-Naphthyl) ethylenediamine | HOAC/H20 | Purple | Colorless | Colorless | 9.0 | • | LDLo 1600 mg/Kg LDLo 150 mg/Kg |
| DMM-Disminodyphenylsulfone H(1-Haphthyl)ethylenedismine | HO&C/H20 | Violet | Colorless | Colorless | 4.0 | S | LD50~100 mg/Kg LDto 150 mg/Kg |
| DMM-dackranilic acid H(l-Hepkibyl)ethylenediamine | HOAC/H20 | Blue | Colorless | Coloriese | 4.0 | S | TDLo 4000 mg/Kg (8) |
| NM-p-detackensonitrite N(1-Nephthyl)ethylenedianine | HOAC/H20 | Red-Violet | Colorless | Colorless | 4.0 | i 8 | UPK. LDLo 150 mg/Kg |
| UM-)-Animobenrotrifluoride H(1-Umpkihyl)ethylenetiznine | HOAC/H20 | Red-Violet | Colorless | Coloriess | 9.6 | į | Unk. LDLo 150 mg/Kg |
| DEF-4-miso-6-chloro-m-benzen- disulfousmide H(1-Haphthyl)- ethyl-ssedismine | HOAC/H20 | Blue-Violet Colorless | Colorless | Colorless | 4.0 | 93 | Unik. LDSO 3900 mg/Kg |
| DMS-Sulfanilanide 3(1-Hepthyl)ethylenedianiae | | Red-Viclet | Coloriess | Colorless | 7.0 | j | 1,050 3900 mg/Kg 1,01,0 150 mg/Kg |
| DMM-p-Aminobensoic acid M.M-Dimethyl-l-maphthylamine | BOAC/H20 | Red-Violet | Colorless | Coloriess | 7.0 | S | LD50 2000 mg/Kg LD50-1400 mg/Kg |
| DMF-4-tminoscetophenose N,M-bianthyl-1-naphthylamine | NOAC/H.20 | Red-Violet | Colorless | Colorless | 4.0 | 3 | LDLo 300 mg/Kg LD50~1400 mg/Kg |
| DMM-biantmodyphenylsulfone W.M-bimethyl-l-naphthylanine | BOAC/H ₂ 0 | Red-Violet | Colorless | Colorless | 4.0 | Comm. | LD50~100 mg/Kg LD50~1400 mg/Kg |
| DMF-p-Aminobenzonitrile M.M-Dimethyl-l-maphthiamine | BOAC/H20 | Red-Violet | Colorless | Colorless | 4.0 | | Unk. LD50-1400 =8/Kg |
| NM-3-datachenzotrifleoride N.H-Binethyl-1-naphthylanine | MOAC/B20 | Red-Vinlet | Colorless | Colorless | 7.0 | . | Unk. LD50-1400 mg/Kg |
| DNH-Sulfanilamide N.H-Dimethyl-l-nephthlamine | MOAC/B20 | Red-Violet | Coloriess | Colorless | 4.0 | ġ | LD50 3900 mg/Kg LD50~1400 mg/Kg |

TABLE A-2 (Continued)

| kesgeat | Solvent | Color Response | Background Color | Reagent Color | Sensitivity, Micrograms | Reagent Availability | Toxicity of Reagent |
|--|-----------------------|-------------------|---------------------|------------------|----------------------------|-------------------------|---------------------------------|
| DPB-p-Aminobensoic acid l-Ammo-7-maphibolenesulfonic acid | BOAC/B20 | Red-Violet | Colorless | Colorless | 7.0 | Comm. | LB50 2000 mg/Kg Unk. |
| DER-4-Aminoacetophenone 1-Amino-7-naphthalenesulfonic acid | HOAC/H20 | Red-Violet | Colorless | Colorless | 0.4 | Coom. | LDLo 300 mg/Kg Unk. |
| OMM-Diaminodiphenylsulfone I-Amino-7-naphthalenesulfonic acid | HOAC/H20 | Red-Violet | Colorless | Colorless | 0.4 | Comm. | LD50~100 mg/Kg Unk. |
| DZM-p-Aminobenionitrile l-Amino-7-maphthalenesulfonic acid | HOAC/H20 | Red-Violet | Colorless | Coloriess | 0.4 | Code. | Unk. Unk. |
| DGM-3-Aminobenzotrifluoride 1-Amino-7-Maphtholenesulfonic acid | BOAC/B20 | Red-Violet | Colorless | Colorless | 6.4 | Comm. | Unk. Unk. |
| DEN-Sulfanilamide l-Amino-7-maphthalenesulfonic acid | BOAC/H20 | Red-Violet | Colorless | Colorless | 9.0 | Comm. | LD50 3900 mg/Kg Unk. |
| DMM-p-Aminobenzoic acid M-Phenyl-l-naphthylamin; | HOAC/H ₂ 0 | Purple | Colorless | Colorless | 0.4 | Com. | LD50 2009 mg/Kg Unk. |
| DBH-4-Aminoscetopherione H-Phesyl-1-maphthylamine | HOAC/H ₂ 0 | Purple | Colorless | Colorless | 0.4 | Cours. | LDLo 300 mg/Kg Unk. |
| Offf-p-dataobenzointrile H-Phenyl-l-naphthylamine | BOAC/H20 | Purple | Colorless | Colorless | 0.4 | Comm. | Unk. |
| DBB-Sulfamilic acid B-Phenyl-l-maphthylamine | HOAC/H2C | Purple | Colorless | Colorless | 9.0 | Contin. | LD50-2 g/Kg Unk. |
| DM-Dismisodiphenylsulfone K-Phenyl-2-naphthylssine | BOAC/H20 | Violet | Colorless | Colorless | 9.6 | Comm. | LD50~100 mg/kg LDLo 80 mg/Kg |
| DBM-Sulfamilic acid 1,8-Naphthalenediamine | BDAC/H ₂ 0 | Blue | Tan | Brown | 4.0 | Comm. | LD50~2900 mg/Kg Unk. |
| Sulfanilsmide 1,8-Naphthalenedismine | BOAC/H ₂ 0 | Blue | Tan | Brown | 7.0 | Comm. | LD50 3900 mg/Kg Unk. |
| DBH-1-Amino-4-Chloro-3-toluenesul- fonic acid M(1-Haphthyl)ethylenediam | HOAC/H ₂ 0 | Purple | Colorless | Colorless | 0.4 | Com. | Unk. LDLo 150 mg/Kg |

TABLE A-2 (Continued)

| | | Color | Backeround | Reacent | Sonairiuitu | Doorgan | |
|--|-----------------------|----------------------------------|------------|-----------|-------------|--------------|-------------------------------------|
| Regent | Solveat | Response | Color | Color | Microgram | Availability | Toxicity of Reagent |
| DES-1-Amino-6-Chloro-3-toluenesulfonic acid 1,8-Haphthalenediamine | HOAC/R20 | Blue | Tan | Brown | 0.4 | Com. | Unk. Unk. |
| DBN-1-Amimo-4-Chloro-3-toluenesuifonic scid l-Amimo-7-saphthalenesulfonic acid | HOAC/H ₂ 0 | HOAC/H ₂ O Red-Violet | Colorless | Colorless | 7.0 | Comm. | tink. Gok. |
| DMF-1-Amimo-2,5-benzemedisulfonic acid 1,8-Naphthalemediamine | HOAC/H20 | Blue | Tan | Brown | 4.0 | Comm. | Unk. |
| DMM-1-Amino-2,5-dichloro-4-beazene- sulfonic acid 1-Amino-7-naphthalesesulfonic acid | HOAC/H ₂ 0 | Violet | Colorless | Colorless | 9.4 | Count. | Unk. |
| Zz-Sulfamilic acid H(1-Haphthyl)ethylenediamine | BOAC/R ₂ 3 | Violet | Colorless | Colorless | 7.0 | Comm. | LD50 2 g/Kg |
| Zn-Sulfamilamide H(l-Maphthyl)ethylenediamine | HOAC/H20 | Violet | Colorless | Colorless | 7.0 | Comm. | LD50 3900 mg/Kg LDLo 150 mg/Kg |
| Zn-Diamisodyphenylsulfone H(l-Maphthyl)erhylenediamine | HOAC | Violet | Colorless | Colorless | 0.4 | Comm. | 1.D50~100 mg/Kg 1.D1-0 150 cz/Kg |
| Za-p-Aminobenzonitrile M(1-Maphthyl)ethylenediamine | HOAC/H ₂ O | Violet | Colorless | Colorless | 0.4 | Comm. | Unk. LDLo 150 m3/Kg |
| Zn-p-Aminobenzoic acid H(l-Haphthyl)ethylenediamine | HOAC/N ₂ 0 | Violet | Colorless | Colorless | 9.4 | Country | CD50 2000 mg/Kg LDLo 150 mg/Kg |
| Zn-2-Haphthylamine-6,8-disulfonic acid H(1-Haphthyl)ethylenediamine | HOAC/H ₂ 0 | Violet | Colorless | Colorless | 0.4 | Comm. | Unk. LDLo 150 mg/Kg |
| Zn-4-Aminoacetophenone N(1-Maphthyl)ethylenediamine | HOAC/H20 | Violet | Coloriess | Colorless | 9.0 | Comm. | IDLO 300 mg/Kg IDLO 150 mg/Kg |
| Zn-l-Amino-7-naphtholenesulfonic acid M(l-Maphthyl)ethylenediamine | HOAC/H20 | Brown | Colorless | Colorless | 9.0 | Cours. | Unk, LDLo 150 mg/Kg |
| Zn-p-Aminosalicylic acid H(1-Maphthyl)ethylenediamine | ROAC/H20 | Violet | Colorless | Colorless | 9.4 | Comm. | LD50 4 g/Kg LDLo 150 mg/Kg |
| Zn-p-Amimobenzonitile M.M-Dimethyl-l-naphthylamine | HOAC/H20 | Violet | Colorless | Colorless | 7.0 | Col. | Unk. LD50~1400 mg/Kg |
| Zn-Di-o-amisidiae l-Amino-7-naphthalenesulfonic acid | HOAC/H20 | Orange | Colorless | Colorless | 7.0 | Cours. | ID50 1920 mg/Kg Unk. |

TABLE A-2 (Continued)

| Reagent | Solvent | Color Response | Background Color | Reagent | Sensitivity, Micrograms | Reagent Availability | Toxicity of Reagent |
|--|----------|-------------------|---------------------|-----------|----------------------------|-------------------------|-----------------------------------|
| In-p-Aminobernoic ació l-Amino-7-naptholenesulfonic acid | BOAC/H20 | Violet | Colorless | Colorless | 9.0 | Com. | LD50 2000 mg/Kg Unk. |
| <pre>Zn-Sulfamilic acid l-Amino-7-maphtholenesulfonic acid</pre> | HOAC/H20 | Red-Violet | Colorless | Colorless | 7.0 | i 8 | L950-2 g/Kg Unk. |
| Zn-Diaminodiphenylsulfone Arulene | HOAC/H20 | Violet | Lt Blue | Blue | 7.0 | i | LD50~100 mg/Eg fink, |
| Zn-4-Aminoacetophenone W-Phynel-2-naphthylamine | HOAC/H20 | Violet | Colorless | Colorless | 7.0 | . | LDLo 300 mg/Kg LDLo 80 mg/Kg |
| Zn-Sulfamilic acid Dimethylamiline | HOAC/H2G | Violet | Colorless | Colorless | 9.4 | • 8 | LD50~2 g/Kg LDLo 500 mg/Kg |
| Zn-p-Chloraniline W91Naphthyl)ethylenediamine | HOAC/H20 | Violet | Colorless | Colorless | 9.4 | | LD50 300 mg/Kg LDLo 150 mg/Kg |
| Zn-p-Toluidine W(1-Naphthyl)etheyienediamine | HOAC/H20 | Blue-Violet | Colorless | Colorless | 9.4 | • | LD50 1285 mg/Kg LDEo 150 mg/Kg |
| Zn-Procaine W(1-Kaphthyl)ethylenediamine | BOAC/H20 | Red-Violet | Colorless | Colorless | 9.4 | 8 | LD50 500 mg/Kg LDIo 150 mg/Kg |
| Zn-D1-o-anisidine W(1-Maphthyl)ethylenedizsine | HOAC/H20 | Brown | Colorless | Coloriess | 9.4 | . S | LD50 1920 mg/Kg LD50 150 mg/Kg |
| Zn-p-Aminobenzoic acid M(1-Naphthyl)ethylenediamine | HOAC/H20 | Violet | Colorless | Colorless | 7.0 | Som. | LD50 2000 mg/Kg LDLo 250 mg/Kg |
| Zn-4-Aminoacetophenone M(1-Naphthul)ethylencdismine | HOAC/H20 | Violet | Colorless | Colorless | 7.0 | | LD50 300 mg/Kg LDLo 150 mg/Kg |
| Zn-Proceine N.W-Direckyl-l-nephthylemine | HOAC/H20 | med-Wiolet | Colorless | Colorless | 7.0 | Come. | LD50 500 mg/Kg LD50-1400 mg/Kg |
| Zn-5-Chloro-2-Aminoanisole 1-Haphthylamine-7-sulfonic acid | HOAC/B20 | Violet | Colorless | Colorless | 7.0 | Comme. | Unk. Unk. |
| Zn-4-Aminoautophenone 1-Naphthwlamine-7-sulfonic acid | HOAC/H20 | Red-Violet | Colorless | Colorless | 7.0 | CO | 1.D50 300 mg/Kg Unk. |
| Zn-Dirminodiphenylsulfone l-Maphtylamine-7-sulfonic acid | HOAC/H20 | Violet | Colorless | Colorless | 0.4 | 8 | LD50~100 mg/Kg Unk. |

・ アイティー をする いち 一番だられば 人 むいみ 大きな かんいっこう かんしゅう

| Reagent | Solvent | Color Response | Background Color | Reagent | Sensitivity, Micrograms | Regeant Availability | Toxicity of Reagent |
|---|-----------------------|-------------------|---------------------|-----------|----------------------------|-------------------------|--------------------------------------|
| Zn-p-Aminobenzonitrile 1-Naphthylamine-7-sulfonic acid | HOAC/H20 | Pink | Colorless | Colorless | 0.4 | | Dak. Unk. |
| Zn-3-Aminobenzotrifiuoride 1-Naphthylamine-7-sulfonic acid | HOAC/H20 | Pink | Colorless | Colorless | 7.0 | • | Bak. Unk. |
| Zn-Sulfanilamide 1-Maphthylamine-7-sulfonic acid | HOAC/H ₂ 0 | Red-Violet | Colorless | Colorless | 9.6 | Com. | LD50 3900 mg/Kg Unk. |
| Zn-Procaine Azulene | ROAC/H ₂ 0 | Violet | Lt Blue | Blue | 7.0 | Com. | LD50 500 mg/Kg Unk. |
| Zn-p-Aminobenzoic acid M-Phenyl-Laaphthylamine | HOAC/H20 | Blue | Colorless | Colcriess | 7.0 | Co.■. | LD50 2000 mg/Kg Unk. |
| Zn-Diaminodiphenylsulfone W-Phenyl-l-naphthylamine | HOAC/H20 | Blue | Colorless | Colorless | 0.4 | | LD50'100 mg/Kg Unk. |
| Zn-p-Aminobenzonitrile W-Phenyl-l-naphthylamine | HOAC/H20 | Violet | Colorless | Colorless | 7.0 | Comme. | Unk. Unk. |
| Zn-Sulfantlamide K-Phenyl-l-naphthylamine | EOAC/B_0 | Violet | Colorless | Colorless | 7.0 | Comm. | LD50 3900 mg/Kg Unk. |
| Zu-W.W.W.W. H-Tetramethyl-p- phenylenediamine | BOAC | Blue | Colorless | Colorless | 0.4 | Comm. | LBLo 20 mg/Kg |
| 2n-Tetramethylbenzidine | BOAC | Yellow | Colorless | Colorless | 7.0 | Comm. | Unk. |
| Zn-Thio Michier's ketone | HOAC/H20 | Blue | Lt Green | Green | 7.0 | Som. | Unk. |
| Zn-Dijulolidylmethane | BOAC | Blue | Lt Blue | Lt Blue | 7.0 | Synthetic | Unk. |
| Zn-o-Tolidine | BOAC/H20 | Вгочп | Colorless | Colorless | 7.0 | Comp. | LD50 404 mg/Kg |
| Zn-Di-olanisidine 2-naphthol | HOAC/H20-0.1NNaOH | Orange | Coiorless | Colorless | 0.4 | 3 | 1.050 1920 mg/kg L.050 2420 mg/Kg |
| | | | | | | | |

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(a) DBW-1,5-Diazobicyclo [4.3.0] non-5-ene.
(b) DBW-1,5-Diazobicyclo [5.4.0] undu-5-enc
(c) Comm.-Commercial.
(d) Unk. - Ukinown.
(e) LDSO - Lethal dose - 50 percent kill.
(f) LDLo - The lowest Jose of a substance of

LD50 - Lethal dose - 50 percent kill.

LDLo - The lowest Jose of a substance other than LD50 introduced by any route other than inhalation over any given period of time and reported to have caused death in man or the lowest duse introduced in one or more portions and reported to have caused death in animals.

فالفائح مدائده والمجار والمساولة فالمتحاط المستحقيق ويتجميه وكافل فيتط فالطفية ويزاء وماطيفية والأ

TDLo- The lowest dose of a substance, as published or made available to publish, introduced by any route other than inhalation over any given period of time and reported to produce any toxic effect in man or to produce carcenogenic, teratogenic,

mutagenic or neoplustigenic effects in humans or animals.

TABLE A.3 SUGMARY OF PROPERTIES OF CAFDIDATE REAGENTS FOR RDX

| REAGENT | SOLVENT | COLOR | RACKGROUND COLOR | REAGENT COLOR | SENSITIVITY, MICROGRAMS | REACENT AVAILABILITY | TOXICITY OF REAGENT |
|--|-----------------------------------|-------------|---------------------|------------------|----------------------------|-------------------------|--------------------------------------|
| Zn-Sulfanilic acid/W(1-naphthyi)- Benzene-H ₂ 0, ethylenediamine ROAC | Benzene-H ₂ 0/ ROAC | Violet | Colorless | Colorless | 9.0 | Com. (2) | LD50 (b) 2g/kg/; LDLo (c) 150 mg/kg. |
| Zn-p-Chlorosniline/h(l-naphthyl)-ethylenediamine | Benzene-H ₂ O/ BOAC | Violet | Colorless | Colorless | 0.4 | Comm. | LD50 300 mg/kg.; LDLo 150 mg/kg. |
| <pre>2n-Procainc/M(1-naphthy1)- ethylenediamine</pre> | Benzene-H ₂ 0/ HOAC | Violet | Colorless | Coloríess | 0.4 | S | LD50 500 mg/kg.; LDLo 150 mg/kg. |
| <pre>Zn-2-Naohthylamine-6,8-disulfonic acid/N(1-naphthyl)ethylene- dismine</pre> | Benzene—H ₂ 0/ HOAC | Violet | Colorless | Colorless | 0.4 | . | Unk. (d); 1DIco 150 mg/kg. |
| Zn-Sulfanilic acid/azulene | Benzene-H ₂ O/HOAC | Violet | Lt. Blue | Blue | 7.0 | Com. | 1.D50 ~ 2g/kg.; Unk. |
| Zn-p-Mitroaniline/azuiene | Benzene-H ₂ 0/HOAC | Blue-violet | Lt. Blue | Blue | 7.0 | Com. | 1.050 3249 mg/kg.; Unk. |
| Zn-p-Chloroaniline/azulene | Benzeue-H20/HOAC | Violet | Lt. Blue | Blue | 7.0 | Comm. | LD50 300 mg/kg.; Unk. |
| 2n-p-Toluidine/azulene | Benzene-R ₂ 0/BOAC | Blue-green | Lt. Blue | Blue | 7.0 | Comm. | LD50 1255 mg/kg.; Unk. |
| Zn-p-Anisidine/azulene | Benzene-H,0/HOAC | Blue-green | Lt. Blue | Blue | 7.0 | Çom. | LD50 ~ 500 mg/kg.; önk. |
| Zn-M.M-dimethyl-p-phenylene- diamin&/arulene | Benzene-H ₂ 0/ HOAC | Blue-green | Lt. Blue | Blue | 0.4 | 8 | M.D ~ 250 mg/kg.; Unk. |
| Zn-Procaine/azulene | Lenzene-H, 3/HOAC | Red-violet | Lt. Blue | Blue | 7.0 | Corra. | LD50 500 mg/kg.; Unk. |
| Zn-Sulfamilic acid/N.N-dimethyl- l-naphthylamine | Benz∺ne-H ₂ 3/ HOAC | Violet | Colorless | Colorless | 0.4 | Som. | 1.050 v 2g/kg.; 1.050 v 1400 mg/kg. |
| Zn-p-Chloroamiline/N.M-dimethyl- l-naphthylandne | Benzene-H ₂ 6/ BOAC | Violet | Colorless | Colorless | 7.0 | Comm. | LD50 300 mg/kg.; LD50 ~ 1400 mg/kg. |
| 2n-Proceine/W.W-dimethyl-l- naphthylamine | Benzene-H ₂ O/ HOAC | Red-violet | Colorless | Colorless | 9.0 | Comm. | LD50 500 mg/kg.; LD50 ~ 1400 mg/kg. |

TABLE A.3 (Continued)

| REACENT | SOLVERT | COLOR RESPONSE | BACKGROUND COLOR | REACENT COLOR | SENSITIVITY, MICROGRAMS | REAGENT AVAILABILITY | TOXICITY OF |
|--|-----------------------------------|-------------------|---------------------|------------------|----------------------------|-------------------------|-----------------------------------|
| Zn-2-Naphthylamine-6, 3-disulfonic acid/W. N-dimethyl-l-naphthyl- amine | Benzene-H ₂ 0/ Hth | | | | | | ACAGERI I |
| Zn-M,M,M',M'-Tetramethyl-p- | All and a second | Blue-violet | Colorless | Colorless | 7.0 | Come. | Unk.; 1,050 ~ 1,400 mg/kg. |
| Fhenylenediamine | HOAC | Blue | Lt. Blue | Lt. Blue | 7 0 | į | |
| KOH-Sulfamilie acid/Wilcontermin | BOAC | Yellow | Colorless | Straw | 0.4 | . 3 | Louis v 20 mg/kg. |
| ethylenedianine | HOLE 20/ | Violet | Colories | 1000 | | | 447 |
| Za-p-aminoacetophenone/N(1- | Benzene-H,0/ | | 800110100 | SSATJOTON | 4.0 | Comm. | LD50 ~ 2g/kg.; LDLo 150 mg/kg. |
| referred tyles of the saffine | BOAC | Violet | Colorless | Colorless | 0.4 | Į | |
| 7-14-minoscetopaenone/arulene | Benzene-HOAC | Vivlet | Lt. Blue | Blue | 7 0 | i j | LDLo 300 mg/kg.; LDLo 150 mg/kg. |
| Light and the control of the control | Benzene-HOAC | Violet | Lt. Blue | Blue | 7:0 | | LDLo 300 mg/kg.; Unit. |
| benzeldebyde | BC1-Eron | 9 | , | | | į | LUNG to 100 mg/kg.; Unk. |
| TiCl3-p-dimethylaminobenzalde- | | orange | Grey | Colorless | 4.0 | Com. | LD50 620 mg/kg. |
| tryde 78-1-Mapleby Jawfna-7a.:16011 | RCI-EtOH | Orange | Grey | Colorless | 0.4 | Comm. | 1050 620 (1 |
| acid/N.F-Dimethyl-1-naph- | Benzene-H20/ | | | | | | |
| Zn-Sulfanilic acid/1-naphthyl- | Benzene-H_0/ | Red-orange | Colorless | Coloriess | 9.0 | 8 | Unk. ; LDS0 ~ 1400 mg/kg. |
| Amine-7-sulfonic acid | BOAC 2 | Violet | Colorless | Colorless | 0.4 | Į | |
| prominosenzoic acid/R(i- naphthyl)ethylenediamine | Benzene-H ₂ 0/ HOAC | Violer | | , | | i 3 | LUNU 1 28/kg.; Unk. |
| Z.r-4-Aminoscetophenome/H-Phenyl- ?-mspltbylamine | Benzene-H ₂ 0/ | | | Colorless | 9.4 | Come. | LD50 2000 mg/kg.; LDLo 150 mg/kg. |
| Za-Di-o-anisidine/a-phenylene- | Benzene-R,0/ | Violet | Colorless | Colorless | 4.0 | 83 | Wo 300 ng/kg.; w50 1450 ng/kg. |
| | BOAC | Orang 2 | Colorless | Colorless | 0.4 | Comme | THEO 1000 |

TABLE A-3 (Continued)

| REACENT | SOLVERT | COLOR | BACKGROUND COLOR | REAGURT COLOR | SENSITIVITY, MICROGRANS | REACENT AVAILARILITY | TOXICITY OF |
|--|--|--------|---------------------|------------------|----------------------------|-------------------------|---|
| Zn-Tolidine Zn-Aminosalicylic acid/W(1-naph- | Benzene-BOAC/H ₂ O Benzene-BOAC/ | Orange | Colorless | Colorless | 0.4 | Comm. | LD50 404 mg/kg. |
| tuyi,ethylenediamine | н ₂ 0 | Violet | Colorless | Colorless | 7 0 | į | |
| on-a-raenyl-chediamine Zn-Dinbenylamine | Benzene-BOAC/H ₂ 0 | Orange | Coloriess | Colorless | 0.4 | . 5 | 1050 4g/kg.; LDLo 150 mg/kg. |
| Zn-Sulfanilic acid/s-phenylene- | Benzene-H ₂ O-E ₂ SO ₄ Benzene-HOAC/ | Violet | Colorless | Colorless | 0.4 | | Lulo 80 mg/kg. Itlo v 200 mg/kg. |
| Zn-p-Aminobenzoic acid/N(1-naph- | H ₂ 0 Benzene-HOAC/ | Orange | Colorless | Colorless | 9.4 | Co∎. | LD50 \ 2g/kg.; LDLo 80 mg/kg. |
| Zn-4-Azinoacetophenone/N(1-naph- | H ₂ 0 Benzene-HOAC/ | Violet | Colorless | Coloriess | 9.0 | Comm. | LDSO 2000 mg/kg.; LDLo 15C mg/kg. |
| Zn-Diaminodiphenylsulfone/H(l- nachtivi)ethelened | H ₂ 0 Benzene-HOAC/ | Violet | Colorless | Colorless | 7.0 | .§ | LDIG 306 mg/kg.; LDLg 150 mg/kg. |
| Zq-p-Aminobenzonitrile/N(1-uaph- | H ₂ 0 Benzene-HUAC/ | Violet | Colorless | Colorless | 9.4 | S S | LD50 ~ 106 mg/kg.; LDto 156 mg/kg. |
| Zn-3-Aminobenzotrifluoridz/N(1- | H_2^0 Benzene-BOAC/ | Violet | Colorless | Colorless | 6.4 | Comm. | Unk.; LDLo 150 mg/kg. |
| Zn-Sulfamilamide/W(1-maphthyl)- | H ₂ 0 Benzene-HOAC/ | Violet | Colorless | Colorless | 6.4 | Com. | Unk.; LDLo 150 mg/kg. |
| Zn-Di-o-anisidine/K, M-dimethyl- | H ₂ 0 Benzene-HOAC/ | Violet | Coloriess | Coluriess | 7.0 | Come. | 1D50 3900 mg/kg.; LDLo 150 mg/kg. |
| Zn-4-Aminoecetophenone /N.H. | H ₂ 0 Benzene- HOAC/ | Orange | Colorless | Colorless | 9.0 | Comm. | LD50 1920 mg/kg.; LD50 v 1400 mg/kg. |
| Za-Diaminodiphenylsulfone/H.B- | H ₂ 0 Benzene-HOAC/ | Violet | Colorless | Coloriess | 7.0 | Come. | LDLo 306 mg/kg.; LD50 v 1400 mg/kg. |
| Zm-Anthranilic acid/E, W-Dimethyl- | H ₂ 0 Benzene-HOAC/ | Violet | Colorless | Colorless | 0.4 | • | LD50 ~ 150 mg/kg.; LD50 ~ 1409 mg/kg. |
| | ^H 2 ⁰ | Blue | Colorless | Colorless | 9.4 | | TDLo (e) 4066 mg/kg.; 1050 v. 1400 mg/kc. |

TABLE A.3 (Continued)

| REAGENT | SOLVERT | COLOR | BACKGROUND COLOR | REAGENT | SERSITIVITY, MICROGRAMS | REACENT AVAILABILITY | TOXICITY OF REACEST |
|---|--------------------------------------|-------------|---------------------|-----------|----------------------------|-------------------------|---------------------------|
| Zn-p-Aminobenzonitrile/W,W-Dime- thyl-l-naphtbylamine | Benzene-HOAC/ | Violet | Colorless | Colorless | 0.4 | 1 8 | Unk.; LD50 ~ 1400 mg/kg. |
| Zn-3-Aminobenzotrifluoride/N.K- Dimethyl-1-naphthylamine | Benzene-HOAC/ H ₂ 0 | Red-violet | Colorless | Colorless | 0.4 | 8 | Unk.; LD50 v 1400 mg/kg. |
| Zn-5-Chloro-2-caincani sole/N, W- Dimethyl-1-naphthylamine | Benzene-HOAC/ H20 | Violet | Colorless | Coloriess | 9.0 | So. | Unk.; LD50 ~ 1400 mg/kg. |
| Zn-Dl-o-anisidine/l-amino-?- naphthalinesulfonic acid | Benzene-BOAC/ H ₂ 0 | Orange | Colorless | Colorless | 7.0 | Comm. | LD50 1920 mg/kg.; Unk. |
| Zn-4-Aminoacetophenone/l-amino- 7-maphthalinesulfonic acid | Benzene-HOAC/ | Violet | Colorless | Colorless | 0.4 | 8 | LDLo 300 mg/kg.; Unk. |
| Zn-p-Aminobenzoic acid/l- amino- 7-maphthalenesulfonic acid | Benzene-BOAC/ H,0 | Red-violet | Colorless | Colorless | 0.4 | . | LD50 2000 mg/kg.; Unk. |
| Zn-Disminodiphenylaulfone/i- Benzer amino-7-naphthalenesulfonic acid H,0 | Benzene-HOAC/ id H ₂ 0 | Red-violet | Colorless | Colorless | 0.4 | S | 1D50 ~ 100 mg/kg.; Unk. |
| Zn-p-Amino-benzonitrite/l-amino- 7-naphthalene-sulfonic acid | Benzene-BOAC/ H,0 | Red-violet | Colorless | Colorless | 0.4 | 8 | Unk.; Unk. |
| Zn-Sulfanilamide//-amino-7- naphthalenesulfonic acid | Benzene-HOAC/ H ₂ 0 | Red-violet | Colorless | Colorless | 0.4 | Ço ss . | LD50 3900 mg/kg.; Unk. |
| Zn-Diaminodiphenylsulfone/N- phenyl-l-naphthylamine | Benzene-BOAC/ H ₂ 0 | Purple | Colorless | Colorless | 4.0 | Ço | 1.050 2100 mg/kg.; Unit. |
| 2n-p-Aminobenzonitrile/H- Phenyl-l-naphthylamine | Benzene-HOAC/ H ₂ 0 | Purple | Colorless | Colorless | 9.6 | S | Unk.; Unk. |
| Zn-Sulfanilamide/W-phenyl-i- naphthylamine | Benzene-HOAC/ | Blue-violet | Colorless | Colorless | 0.4 | 8 | 1.050 v 3900 mg/kg.; Unk. |
| Zn-Sulfamilic acid/l-emino-5- paphthalenesulfonic acid | Benzene-HOAC/ H ₂ 0 | Violet | Colorless | Colorless | 9.0 | S | LD50 ~ 2g/kg.; Unk. |

TABLE A.3 (Continued)

| REACENT | SOLVENT | COLOR RESPONSE | BACKGROUND COLOR | REAGENT COLOR | SENSITIVITY, MICROGRAMS | REAGENT AVAILABILITY | TOXICITY OF REAGENT |
|---|--|-------------------|---------------------|------------------|----------------------------|-------------------------|------------------------------------|
| Zn-Sulfanilamide/l-amino-5-naph- thalenesulforic acid | Benzene-HOAC H ₂ 0 | Violet | Colorless | Colorless | 0.4 | Come. | LD50 3900 mg/kg.; Unk. |
| Zn-Sulfanilamide/1,8-naphthalene-diamine | | Violet | Tan | Brown | 0.4 | Çom. | LD50 3900 mg/kg.; Unk. |
| <pre>Zn-l-Amino-4-chloro-3-toluene sulfonic acid/M(l-naphthyl)- ethylenediamine</pre> | Benzene-HOAC/ H,0 | Blue-violet | Coiorless | Colorless | 6.4 | Com. | Unk.; LDLo 150 mg/kg. |
| Zn-i-Amino-4-chloro-3-toluene- sulfonic acid/l-amino-7-naph- thelenesulfonic acid | Benzene-HOAC/ H,0 | Violet | Colorless | Colorless | 4.0 | 8 | Oak.; Oak. |
| Zn-l-Amino-2, 5-dichloro-4-ben- zene sulfonic acid/l-Amino-7- | Benzene-HOAC/ H ₂ 0 | Violet | Colorless | Colorless | 9.0 | So me | Unk.; Unk. |
| naphthalenesulfonic acid KOH-p-Chloroaniline /W(1-naph- thyi)ethylenediamine | H ₂ 0-H0AC/ H ₂ 0 | Orange | Colorless | Colorless | 0.4 | Com. | LD50 300 mg/kg.; LDLo 150 mg/kg. |
| <pre>XOH-Procaine/N(l-naphthyl) ethylenediamine</pre> | н, о-номс/ н, о | Violet | Coloriess | Colorless | 4.0 | € | LD50 500 mg/kg.; LDIo 150 mg/kg. |
| KOH-Sulfamilic acid/azulene | и, 0-ноа с/н, 0 | Pink | Blue | Blue | 0.4 | Com. | LD50 2g/kg.; Unk. |
| XOH-Procaine/azulene | H20-BOAC/H20 | Pink | Lt. Blue | Blue | 7.0 | Cotton. | LD50 500 mg/kg.; Unk. |
| KOH-Sulfamilic acid/N,H-Dimethyl- l-maphthylamine | H,0-HOAC/H,0 | Pínk | Colorless | Colorless | 9.6 | S | LD50 2g/kg.; LD50 ~ 1400 mg/kg. |
| KOM-p-Mitroaniline/K,W-Dimethyl- l-maphthylamine | H,0-HOAC/H,0 | Orange | Colorless | Colorless | 9.0 | 8 | LD50 3249 mg/kg.; LD50 ~ 1400 mg/k |
| KOH-Procaine/N,H-Dimethyl-l- naphthylamine | B,O-HCAC/H,0 | Pink | Colorless | Colorless | 9.0 | Comm. | LD50 500 mg/kg.; LD50 ~ 1400 mg/kg |
| KON-N.N.M', N'-Tetramethyl-p- phenylenediamine | BOAC | Blue | Colorless | Colorless | 7.0 | | LDLo ~ 20 mg/kg. |
| | | | | | | | |

TABLE A-3 (Continued)

| REAGENT | SOLVENT | COLOR RESPONSE | BACKCROUND COLOR | REACENT | SEMSITIVITY, | REACENT | TOXICITY OF |
|---|---|--------------------------|------------------------|------------------------|--------------|--------------|---|
| KOH-2-Maphthylamine-6,8-disulfonic acid/M(1-naphthyl)ethylene- | ic H,0-BOAC/ | | | | | AVAILABILITY | REACERT |
| KOR-p-Phenyla zoaniline/H(1-naph-thyl)ethylenedianina | H20 R20-BOAC | Violet | Colorless | Colorless | 9.0 | | 10to 150 me/ke. |
| KNE-4-Aminoacetophenone/H(1-naph- thyl)ethylenediamina | | Brown | Yellow | Red | 9.6 | Some | O. 1600 me/le 174 1600 |
| IOH-p-Mirrosniline/M-Phenyl-1- Daphthylamine | H ₂ 0-HOAC/ | Red-violet | Coloriess | Colorless | 9.4 | 8 | LDLo 300 mg/kg.; LDto 150 mm/t. |
| IOB-4-Aminoscetophenone/Azulene IOB-Disminodiphenylevifone/ Azulene | "2" H ₂ O-BOAC/H ₂ O H ₂ O-BOAC/ | Brown Orange | Lt. Yellow Lt. Blue | Yellow Blue | 0.4 | 8 8 | LD50 3429 mg/kg.; Unit. |
| NON-Dijulolidylmethane NON-m-Thenylenediamine | H2O-BOAC H2O-BOAC H2O-BOAC/H2O | Orange Blue Orange | | Blue Lt. Blue | 0.4 | Com. | LD50 ~ 100 mg/kg.; Unk. Unk. |
| WME-Sulfamilic acid/m-Phenylene- amine KOH-1-Amino-7-naphthalenesul- fonic acid/W(1-naphthy) | H ₂ O-BOAC/R ₂ O | Orange | Colorless | Colorless Colorless | 0.4 | Comm. | LDLo 80 mg/kg. LD50 2g/kg.; LDLo 80 mg/kg. |
| ethylenediamine 208-1-Amino-7-naphthalenemi- fonic acid/N.W-Dimethyl-1- namhthyl | H20-HOAC/ | Pink | Colorless (| Coloriess | 7.0 | J | Unk.; LDLo 150 ag/kg. |
| KOH-Sulfanilic acid/l-aming-7- Daphthalensulfonic acid | H_20-HQAC/ | Pink | Colorless C | Colorless | 4.0 | Comi. | Unk.; 1D50 ~ 1400 mg/kg. |
| | "2" H,0-H04C/ H,0 | Pink | | Colorless | 0.4 | i S | LD50 2g/kg.; Unk. |
| eny !- | | Pink Pink | Colorless | Colorless | 0.4 | S | LD50 2000 mg/kg.; LDLo 150 mg/kg. |

TABLE A.3 (Continued)

| REACENT | SOLVENT | COLOR | BACKGROUND COLOR | REAGENT COLOR | SENSITIVITY, MICROGRAMS | REAGENT AVAILABILITY | TOXICITY OF REAGENT |
|--|--|-------------|---------------------|------------------|----------------------------|-------------------------|---|
| KOH-Di-o-anisidine/w-Phenylene- dismine | H_O-HOAC/ H_O | Paroen a | Colorless | Colorina | | | |
| KOH-Sulfanilic acid/1-naphthol | B_O-BOAC/H_O | Violet | Colorina | Colorina | į , | | LUNCO 1920 mg/kg.; Lulio 80 mg/kg. |
| KOH-p-Aminobenzoic acid/8-amino- | L.O-BO&C/ | | 000110100 | SSAT TOTON | | | LD50 2g/kg.; LD50 2590 mg/kg. |
| 1-maphthol-3,6-disulfonic acid | H ₂ 0 | Violet | Colorless | Colorless | 7.0 | Som. | 1.D50 2000 mg/kg.: Unk. |
| KOH-Di-o-anisidine/2-nephthol | H2O-BOAC/H2O | Orange | Colorless | Colorless | 9.0 | Some. | 1050 1920 me/ke : 1050 2420 me/ke |
| <pre>KOM-D1-o-amisidine/H(1-maphthy1)- ethylemediamine</pre> | H20-HOAC/ | Orange | Colorina | 1010 | | | |
| KOH-p-Aminobenzoic acid/H(1- | 2 H,0-BOAC/ | | 99110700 | 882110100 | | | LD50 1920 mg/kg.; LDKo 150 mg/kg. |
| s naphthyl)ethylenedismine | H ₂ 0 | Red-violet | Coloriess | Colorless | 0.4 | Comm. | LD55 1920 mg/kg.: LDLo 150 mg/kg. |
| KOH-4-Aminoacet.phenome/H(1- maphthyl)ethylenediamine | H,0-HOAC/ H,0 | Red-violet | Coloriess | Colorless | 9.0 | S | 1.00 300 and the 1 100 at 100 |
| KOM-Disminodiphenylsulfone/ | H_C-BOAC/ | , | | | | į | 200 Mg/ Kg. 140/40 450 mg/ Kg. |
| H(1-departy) et dy lened 1001ne | H ₂ 0 | Pink | Colorless | Colorless | 7.0 | COMM. | LD50 ~ 100 mg/kg.; LDEo 150 mg/kg. |
| | H20-HUMC/ | Blue-violet | Colorless | Coloriess | 9.4 | | TDLo 4000 mg/kg.; LDLo 150 mg/kg. |
| | H ₂ 0-HOAC/ H ₂ 0 | Pink | Colorless | Colorless | 9.0 | | Unk.; LDLo 150 mg/kg. |
| MON-3-Anthobensotrifluorije/ W(1-naphthyl)ethylenediamine | H_0-BOAC/ H_20 | Orange | Colorless | Colorless | 4.0 | Corps. | Unk.; LDLo 150 mg/kg. |
| MM-Sulfanidanide/F(1-naphthyl)- ethylesedinaine | H_0-H0AC/ | Pink-violet | Coloriess | Colorless | 0.4 | 8 | LD50 3900 ag/kg.; tinis 150 mg/kg. |
| MM-p-Mathobensoic acid/H,W- Dimethyl-l-naphthylamine | H ₂ 0-HOAC/ | Pink-violet | Colorless | Colorless | 4.0 | . | LD50 2000 mg/kg.; LD50 ~ 1400 mg/kg. |

TABLE A-3 (Continued)

| REACEST | SOLVENT | COLUR RESPONSE | BACKGROUND COLOR | REAGENT | SENSITIVITY, MICROGRAMS | REACENT AVAILABILITY | TOXICITY OF REAGENT |
|---|--|-------------------|---------------------|-----------|----------------------------|-------------------------|--------------------------------------|
| KOH-4-Asinoscetophenone/N.W-Dise- thyl-1-naphthylasine | H ₂ 0-ROAC/ | Red-violet | Colorless | Colorless | 0.4 | Ç₀ . | LDEO 300 mg/kg.; LD50 ~ 1460 mg/kg. |
| KOM-Disminodiphenylsulfone/ M, M-Dimethyl-l-naphthylamine | 8-0-40AC/ 8-0-40AC/ | Red-violet | Colorless | Colcriess | 9.6 | Com. | LD50 ~ 100 mg/kg.; LD50 ~ 1400 mg/kg |
| KOM-p-Aminobenzonitrile; M.M- Dimethyl-l-maphthylamine | H ₂ 0-BOAC/ H ₂ 0 | Red-violet | Coloriess | Colorless | 9.0 | Comm. | Unk.; 1.050 ~ 1400 mg/kg. |
| NOM-Sulfamilamide/N.H-Dimethyl- l-naphthylamine | я_0-нолс/ н ₂ 0 | Pink | Colorless | Colorless | 0.4 | Cons. | LD50 3960 mg/kg.; LD50 v 1406 mg/kg. |
| EOH-p-Aminobenzoic acid/l-Amino- 7-maphthalenesulfonic acid | H,0-50AC/ | Red-violet | Colorless | Colorless | 9.0 | : | LD50 2000 mg/kg.; Unk. |
| KOH-4-Aminoacetophenome/l-Amino- 7-naphthalenesuifonic acid | R,0-HOAC/ H,0 | Red-violet | Colorless | Colorless | 0.4 | Comm. | LDIto 300 mg/kg.; Unk. |
| EOH-Diamino-diphenylsulfone/ l-Amino-7-naphthalenesulfonic acid | H ₂ 0-BO&C/ H ₂ 0 | Red-wiolet | Colorless | Colorless | 4.0 | Ş | 1D50 ~ 100 mg/kg.; Unk. |
| <pre>KDH-Anthramilic acid/l-Amino- /-maphthalenesulfonic acid</pre> | H20-HOAC/ R20 | Violet | Coloriess | Colorless | 0.4 | 3 | TDLo 400 me/ke.; Unk. |
| KOM-p-Aminobenzonitrile/l-Amino- 7-naphthalenesulfonic acid | R_0-HOAC/ R_0 | Red-violet | Coloriess | Coloriess | 0.4 | Cotte. | Unk.; Unk. |
| KOM-3-Aminobenzotrifluoride/ 1-Amino-7-uaphthalene sulfonic acid | H20-HOAC/ | Violet | Colorless | Colorless | 4.0 | Š | Unk.; Dak. |
| EOH-5-Chloro-2-asino-anisole/ l-Asino-7-naphthalene sulfonic acid | H O-BOAC/ H 20 | Violet | Colorless | Colorless | 4.0 | Š | Unk.; 'lak. |
| KOH-Sulfamilaminde/l-Amino-7- naphthalene sulfonic acid | #20-BOAC/ | Pink | Colorless | Colorless | 4.0 | Com. | LD50 3900 mg/kg.; Unk. |

TABLE A-3 (Continued)

| REACENT | SOLVERT | COLOR | BACKGROUND REACENT COLOR COLOR | REACENT | SENSITIVITY, REAGENT | SENSITIVITY, REACENT | TOXICITY OF |
|---|--|------------|-----------------------------------|-----------|----------------------|----------------------|------------------------|
| KOH-Di-o-znisidine/N-Phenyl-1- | H. O-HOAC/ | | | | Current | AVAILABILITY | REACENT |
| naphthylasine H20 KOM-p-Asisobenzoic acid/H-Phenyl- H-0-HOAC/ | H20-H0AC/ | Orange | Colorless Colorless | Colorless | 9.6 | Eo | ID50 1920 me/ke . Hat |
| 1-nephthylamine KOM-4-Amino-acetophenone/M- | H20 H.O-HOAC/ | Red-violet | Colorless Colorless | Colorless | 7.0 | Comm. | LD50 2000 mg/kg . Hub |
| Fuenyi-l-naphthylsmine KOM-Diamimo-diphenyisulfone/ | H20 H.O-HOAC/ | Red-violet | Colorless | Colorless | 0.4 | 8 | IDLo 300 mg/kg : Tub |
| F-resyl-i-naphthylamine KON-p-Aminobenzonitrile/H- | H ₂ 0 H ₂ 0-HOAC/ | Red-violet | Colorless | Colorless | 9.0 | Comm. | LD50 ~ 100 mg/kg.: Unk |
| rneny 1-1-naphthy Janine | # 20 | Red-violet | Colorless Colorless | Colorless | 0.4 | Comm. | Unk : The |

(a) Comm. - Commercial.

(b) LD5G = Lethal dome - 50 percent kill.

LMLO - Lethal Dose Low - the lowest dose of a substance other than LD50 introduced by any route than inhalation over any given period of time and reported to have caused death in man or the lowest single dose introduced in on or more divided portions and reported to have છ

(d) Unk. = Unknown.

(e) TDLO - Toxic Dose Low - the lowest dose of a substance, as published or made available to publish, introduced by any route other than inhalation over any given period of time and reported to produce any toxic effect in man or to produce carcinogenic, teratogenic, mutagenic or neoplastigenic effects in bumans or animals.

TABLE A-4 PROPERTIES OF THE THT DETECTION SYSTEMS

| Reagent | max max | Molar Absorbance | Solvent |
|---|--------------------|------------------|---------|
| 1,5-Diazabicyclo[5.4.0]undec-5-ene | 530 | 10,000 | DMSO |
| Nitron | 525-535 | 5,700 | DMSO |
| 1,5-Diazabicyclo[4.3.0]non-5-ene | 535-545 | 9,100 | DMSO |
| Bis (4-Dimethylaminophenyl)methane | 505-530 | 38 | DMSO |
| 2,3,5,6-Tetramethyl-p-phenylenediamine | 513-530 | 307 | DMSO |
| Di-(9-Julolidyl)methane | 510-528 | 76 | DMSO |
| 1,4-Diazabicyclo[2.2.2]octane | 520-530 | 4,500 | DMSO |
| 1,8-Bis(dimethylamino)naphthalane | 532 | 840 | DMSO |
| 3,4-Dimethoxyphenylacetonitrile-Et ₄ NOH | 503-513 458-465 | 5,910 6,140 | EtOH |
| Benzylacetone-Et ₄ NOH | 468 505 | 6,360 5,910 | EtOH |
| 3-Methy1-2-hexanone-Et ₄ NOH | 500-512 | 5,910 | EtOH |
| Pheny1-2-propanone-Et4NOH | 508 | 5,910 | EtOH |
| 4-Chlorophenylacetonitrile-Et ₄ NOH | 512 | 17,270 | EtOH |
| Phenylacetonitrile-Et ₄ NOH | 505-515 | 11,140 | EtOH |
| p-Methoxyphenylacetonitrile-Et ₄ NOH | 508-515 460 | 6,820 7,955 | EtOH |
| 1,3-Diphenylacetone-Et ₄ NOH | 500 | 32,270 | EtOH |
| 5-Hexene-2-one-Et ₄ NOH | 468 | 6,365 | EtOH |
| 1-Pheny1-2-butanone-Et ₄ NOH | 510 | 6,590 | EtOH |
| 4,4-Dimethoxy-2-butanone-Et ₄ NOH | 575-505 | 2,955 | EtOH |
| Propiophenone-Et ₄ NOH | 465 | 6,820 | EtOH |
| Cyclohexanone-Et ₄ NOH | 515 465 | 10,230 8,410 | Et OH |

TABLE A-4 (Continued

| Reagent | mαx γ | Molar Absorbance | Solvent |
|---|-------------------------|------------------|---------|
| 1,3-Dicarbomethoxyacetone-Et4NOH | 495-500 | 1,000 | EtOH |
| Cholestan-3-one-Et ₄ NOH | 505 | 4,775 | EtOH |
| Progesterone-Et ₄ NOH | 438 490 | 5,170 5,055 | EtOH |
| 17-Methylestosterone-Et ₄ NOH | 492-505 438 | 3,410 3,070 | EtOH |
| Pregnenlone-Et ₄ NOH | 495 - 505 435 | 3,600 3,410 | ELOH |
| Testosterone-Et ₄ NCH | 500-510 437 | 2,615 2,045 | EtOH |
| FiCl ₃ -Dipheny lacrolein | 460 ^(a) | 40 | EtOH |
| FiCl ₃ -Dimethylaminobenzaldehyde | 460 ^(a) | 60 | EtOH |
| FiCl ₃ -4-Dimethylaminocinnamaldehyde | 550 | 1,230 | EtOH |
| FiCl ₃ -N(4-Pyridyl)pyridinium chloride | 490 ^(b) | 1,250 | EtOH |
| SnCl ₂ -2-Hydroxy-1-naphthaldehyde | 460 ^(a) | 85 | EtOH |
| SnCl ₂ -2-Chloro-4-dimethylamino- benzaldehyde | 460 ^(a) | 75 | EtOH |
| SnCl ₂ -?-Methyl-4-dimethylamino- benzaldehyde | 460 ^(a) | 85 | EtOH |
| SnCl ₂ -Vanillin | 460 ^(a) | 75 | EtOH |
| SnCl ₂ -N(4-Pyridyl)pyridinium chloride | 490 ^(b) | 1,590 | EtOH |
| SnCl ₂ -2-Bromo-4-dimethylamino- benZaldehyde | 460 ^(a) | 45 | EtOH |
| SnCl2-Phenoxy-4-dimethylamino- benzaldehyde | 460 ^(a) . | 60 | EtOH |
| SnCl ₂ -4-Dimethylaminocinnamaldehyde | 520 | 45 | EtOH |
| SnCl ₂ -2,5-Dimethoxy-4-dimethylamino- benzaldehyde | 460 ^(a) | 60 | EtOH |
| SnCl ₂ -Diphenylacrolein | 460 ^(a) | 50 | EtOH |

TABLE A4 (Continued)

| | χ _ | M 1 . Al . 1 . | |
|--|-------------------------|----------------|-----------------|
| Reagent | m ⁱ n wex | Molar Absorba | Solvent |
| SnCl ₂ -4-Dimethylaminobenzaldehyde | 460 (a) | 160 | EtQH |
| SnCl ₂ -4-Diphenylaminobenzaldehyde | 460 ^(a) | 60 | EtOH |
| p-Nitrosodimethylaniline | 422 | 11,025 | EtOH |
| KOH-Methylcellosolve | 505-535 | 8,409 | Methylcellosolv |

⁽a) No absorption peak was evident in this spectra but since the solution was yellow the absorbance was taken at 460 mu, the middle of the yellow absorption band.

⁽b) No absorption peak was evident in this spectra but since the solution was orange the absorbance was taken at 490 mu, the middle of the orange absorption band.

TABLE A-5 EVALUATION OF TNT REAGENTS

| | 1ot Dotor | 1000 | חשים מייני | 1-045 |
|---|-----------|----------|------------|----------|
| Reagent | Amax (mu) | THEFTOIL | Amax (mu) | mination |
| 1,5-Diazabicyclo[5.4.0]undec-5-ene | 530 | 10,000 | 510-515 | 4,430 |
| 1,5-Diazabicyclo[4.3.0]non-5-ene | 535-545 | 9,100 | 505-515 | 3,520 |
| 4-Chlorophenylacetonitrile-Et $_4^{ m NOH}$ | 512 | 17,270 | 512 | 16,590 |
| Phenylacetonitrile-Et,NOH | 505-515 | 11,140 | 510-515 | 15,000 |
| 1,3-Diphenylacetone-Et $_4$ NOH | 200 | 32,270 | 503 | 22,272 |
| Cyclohexanone-Et ₄ NOH | 515 | 10,230 | 515 | 15,000 |
| Cyclopentanone-Et $_4^{ m NOH}$ | 511 | 10,445 | 512 | 22,272 |
| Nitromethane-Et $_4^{NOH}$ | 505 | 28,510 | 505 | 20,000 |
| Fluorene-Et,NOH | 200 | 11,500 | 520 | 6,705 |
| Ethylenediamine | 523-530 | 9,090 | 530 | 9,770 |
| KOH-Methylcellosolve | 505-535 | 8,409 | 505-510 | 5,227 |

TABLE A-6 STORAGE TESTS ON INT REAGENTS

| | | | 7 Day | 808 | 14 Davs | £n | 21 Days | | 28 Days | | 35 Days | 82 |
|------------------------------|-----------|----------|-----------------------|-------|---------------|-------------|-----------------------------|-----|-------------------|-------------|---------------|-------------|
| Rescent | Initial | Limit (b | Limit (b) Limit Color | Limit | Color | Limit µg | Color | | Limit Hg Color | Limit 48 | Color | Limit |
| 1,3-Dimethyl- Yellow acetone | Yellow | 0.4 | 0.4 Yellow | 0.4 | 0.4 Yel-org | 0.4 | 0,4 Yel-org | 7.0 | 0.4 Yel-org | 7.0 | 0.4 Yel-org | 7. 0 |
| Cyclo- pentanone(a) | Straw | 0.4 | Orange | 0.4 | 0.4 Org-brown | 7.0 | 0.4 Org-brown | 7.0 | 0.4 Org-brown | | 0.4 Org-brown | 7.0 |
| Mitro- | Colorless | 4.0 | Orange | 0.4 | 0.4 Org-brown | | 0.4 Org-brown 0.4 Org-brown | 4.0 | Org-brown | 9.4 | 0.4 Org-brown | 7.0 |

(a) All reagents consisted of 100 ml EtOH, 4 ml 20 % Me $_4$ NOH in MeOH and 5 g ketone or nitromethane.

(b) Using PEIN.

TABLE A-7 EVALUATION OF THI REAGENT ON VARIOUS SUBSTRATES (a)

| Cubattato | Color Com | Composition | Detection Limit, ug | Resarks |
|-----------------------|------------|-------------|------------------------|---------|
| | | | | |
| Рарети | | • | Č | |
| 20 1b bond | White | 100% cotton | 3 · | |
| 16 1b bond | Yellow | : | 9.0 | |
| Omion skin | White | 25% cotton | 7. 0 | |
| Plain, long grain | White | ; | 7.0 | |
| Index card | White | ; | 9. 0 | |
| File folder | Straw | ; | 7.0 | |
| File packet, glazed | Dk brown | ; | 4 | |
| File folder, glazed | Med brown | ę | 7.0 | |
| Blotter Daber | White | ; | 4.0 | |
| Xerox copy paper, | White | : | 7.0 | |
| coated | | | • | |
| Construction paper | White | ; | 7. 0 | |
| Notebook filler | White | • | 7. 0 | |
| Legal pad | Yellow | : | 7.0 | |
| Grocery bag | Brown | • | 7. 0 | |
| Wrapping paper | Brown | 1 | 7. 0 | |
| Envelopes | | | • | |
| Letterhead Bond | White | ; | 4.0 | |
| Adment 1 | White/blue | : | 9.6 | |
| Riefoes | White | : | 4.0 | |
| Class envelope | I.c brown | : | 7.0 | |
| Class carelone glazed | Yed brown | : | 7. 0 | |
| neilter abinning has | Med brown | ï | 4.0 | |
| Cturdite ahiming bag | Med brown | ; | 0.4 | |
| on outline satisfac | | | | |

TABLE A-7 (Continued)

| Remarks | | |
|---------------------------------|---|--|
| Detection Limit, Mg | 444 4.0 | 0.4 0.4 0.4 0.4 0.4 |
| Detection Composition Limit, Mg | 111 1 | Vinyl Polyethylene Calfskin Cotton Polyurethane |
| Color | White Gray Brown White | Gream Clear Tan Med-brown White |
| Substrate | Cardboard Posterboard Lightweight cardboard Medium weight box- board Corrugated, coated | Miscellaneous Accohyde Polyethylene sheet Wood Leather, vegetable tanned Cloth |

(a) Reagent consisted of 5 g cyclopentanone, 5 ml ${\rm Rt}_4{\rm NOH}$ in water and 100 ml ethanol.

TABLE A-8 EVALUATION OF NITRATE ESTER REAGENTS

| Reagent |) max | <u> </u> | Solvent |
|--|--------------------|----------|------------------------|
| p-Aminobenzoic acid N(1-Naphthyl)ethylenediamine | 555 | 36,666 | HOAC -H ₂ O |
| 4-Aminosalicylic acid N(1-Naphthyl)ethylenediamine | 550 | 27,333 | HOAC -H ₂ O |
| 4-Aminoacetophenone N-Phenyl-2-naphthylamine | 515-525 | 12,500 | HOAc -H ₂ O |
| o-Dianisidine m-Phenylenediamine | 455 | 25,500 | HOAC-H20 |
| 1-Aminopyrene | 435 (yel-green) | 5,417 | HOAc -H20 |
| Sulfanilic acid m-Phenylenediamine | 453 | 19,778 | HOAc -H20 |
| N, N-Diphenyl-p-phenylenediamine | 520 | 8,667 | HOAC-H ₂ O |
| Indole | 465 (yellow) | 1,000 | HOAC -H2O |
| p-Chloroaniline N,N-Dimethyl-1-naphthylamine | 550 | 14,333 | HOA6-H20 |
| 2-Naphthylamine-6,8-disulfonic acid N,N-Dimethyl-1-naphthylamine | 558 | 5,500 | HOAc-H2O |
| N,N,N',N'-Tetramethyl-p-phenylenediamine | 618 565 | 70,000 | HOA&- B 20 |
| o-Tolidine | 440 | 16,500 | HOAc-H ₂ O |
| Procaine N,N-Dimethyl-1-naphthylamine | 530-535 | 42,333 | H0A6-H20 |
| Sulfanilic acid N,N-Dimethyl-1-naphthylamine | 543 | 21,667 | H0A6-H20 |
| p-Nitroaniline N,N-Dimethyl-1-naphthylamine | 528 | 45,333 | HOAC -H ₂ O |

TABLE A-8 (Continued)

| Reagent | λ _{max} | ¢ | Solvent |
|--|------------------|---------|---------------------------------|
| Tetramethy1benzidine | 470 | 7,833 | HOAs -H20 |
| m-Phenylenediamine | 450 | 16,444 | H OAc - H ₂ O |
| l-Amino-7-naphthalenesulfonic acid N(1-Naphthyl)ethylenediamine | 560 | 7,833 | HOAc -H ₂ O |
| Sulfanilic acid N(l-Naphthyl)ethylenediamine | 550 | 33,333 | HOAc -H ₂ O |
| p-Nitroaniline N(l-Naphthyl)ethylenediamine | 545 | 28,333 | HOAC -H2O |
| Proceine N(1-Naphthyl)ethylenediamine | 550 | 30,667 | HOAC: -H2O |
| 2-Naphthylamine-6,8-disulfonic acid N(1-Naphthyl)-ethylenediamine | 550 | 5,333 | HOAS -H2O |
| p-Toluidine N(1-Naphthyl)ethylenediamine | 570 | 11,667 | HOAs -H ₂ O |
| o-Chloraniline N(1-Naphtyl)ethylenediamine | 560 | 22,000 | HOAc -H20 |
| -Aminobenzonitrile (1-Naphthyl)ethylenediamine | 544 | 40,667 | HOAc -H ₂ O |
| o-Phenylazoaniline (l-Naphthyl)ethylenediamine | 498 | 175,000 | HOAC -H2O |
| iaminodiphenyl sulfone [(1-Naphthyl)ethylenediamin/2 | 550 | 34,000 | HOAc ∙H2O |
| -Ethoxy-3,6-Diaminoacridine (1-Naphthy1)ethylenediamine | 553 | 10,167 | HOAC -H2O |
| -Aminobenzotrifluoride (1-Naphthyl)ethylenediamine | 542 | 26,333 | HOAC -H2O |
| iaminodiphenylsulfone ,N-Dimethyl-1-Naphthylamine | 532 | 39,000 | HOAc -H ₂ O |
| -Amino-6-Chloro-m-benzenedisulfonamide (1-Naphthyl)ethylenediamine | 480 | 233 | HOAC -H2O |

TABLE A-8 (Continued)

| Reagent | λ _{max} | ¢ | Solvent |
|---|------------------|--------|------------------------|
| p-Aminoacetophenone N,N-Dimethyl-1-naphthylamine | 538 | 43,000 | HOAC -H2O |
| p-Aminobenzonitrile N,N-Dimethyl-1-Naphthylamine | 528 | 38,333 | HOAc -H2O |
| p-Aminobenzoic acid N,N-Dimethyl-1-Naphthylamine | 535 | 47,333 | HOAE -H ₂ O |
| Sulfanilamide N(1-Naphthyl)ethylenediamine | 544 | 33,000 | HOAC-H ₂ O |
| Sulfanilamide 1-Amino-7-Naphthalenesulfonic acid | 524 | 44,667 | HOAc -H2O |
| 4-Aminoacetophenone 1-Amino-7-Naphthalenesulfonic acid | 530 | 17,333 | HOAC-H20 |
| 3-Aminobenzotrifluoride 1-Amino-7-Naphthalenesulfonic acid | 521 | 15,000 | HOA& -H20 |
| p-Aminobenzonitrile 1-Amino-7-Naphthalenesulfonic acid | 520 | 18,667 | HOAc -H ₂ 0 |
| Diaminodiphenyl Sulfone 1-Amino-7-Naphthalenesulfonic acid | 528 | 39,333 | HOAc -H20 |
| p-Aminobenzoic acid 1-Amino-7-Naphthalenesulfonic acid | 529 | 24,333 | HOAC -H20 |
| Sulfanilamide N,N-Dimethyl-l-Naphthylamine | 529 | 36,667 | HOA6 H20 |
| 3-Auinobenzotrifluoride N,N-Dimethyl-l-Naphthylamine | 532 | 25,667 | HOAc -H ₂ 0 |
| Sulfanilic acid N-Phenyl-1-Naphthylamine | 565 | 2,333 | HOAc ~H20 |
| p-Aminobenzonitrile N-Phenyl-1-Naphthylamine | 556 | 40,333 | HOAc-H ₂ 0 |
| 4-Aminoacetophenone N-Phenyl-1-Naphthylamine | 565 | 43,000 | HOAc -H ₂ O |

TABLE A-8 (Continued)

| Reagent | λ _{max} | ŧ | Solvent |
|--|------------------|--------|------------------------|
| p-Aminobensoic acid N-Phenyl-1-Naphthylamine | 563 | 41,667 | HOAG -H20 |
| 1-Amino-4-Chloro-3-Toluenesulfonic acid | d 535 | 28,667 | HOA c-H ₂ O |
| 1-Amino-4-Chloro-3-Toluenesulfonic acid 1,8-Naphthalenediamine | d 548 | 9,333 | HOA c-H ₂ 0 |
| 1-Amino-4-Chloro-3-Toluenesulfonic acid N(1-Naghthyl)ethylenediamine | d 552 | 8,000 | H0Ac-H2O |
| Sulfanilamide 1,8-Naphthalenediamine | 544 | 17,000 | H0Ac-H ₂ 0 |
| Sulfanilic acid 1,8-Naphthalenediamine | 550 | 9,000 | H0Ac -H ₂ 0 |
| Diaminodiphenylsulfone N-Phenyl-2-Naphthylamine | 518 | 8,333 | HOAc ⋅H ₂ O |
| Di-o-Anisidine 1-Amino-7-Naphthalenesulfonic acid | 564 | 14,333 | HOAc-H ₂ O |
| 4-Aminoacetophenone N(1-Naphthyl)ethylenediamine | 552 | 31,333 | HOAC -H ₂ O |
| 1-Amino-2,5-Dichloro-4-Benzenesulfonic acid 1-Amino-7-Naphthalenesulfonic acid | 540 | 31,333 | HOAC -H2O |
| 1-Amino-2,5-Benzenedisulfonic acid 1,8-Naphthalenediamine | 544 | 13,333 | HOAC -H ₂ O |
| Sulfanilic acid 1-Amino-7-Naphthalenesulfonic acid | 531 | 40,000 | HOAC -H ₂ O |
| 4-Aminoacetophenone N-Pheny1-2-Naphthylamine | 519 | 18,000 | HOAC -H2O |
| Sulfanilic acid N,N-Diethylaniline | 511 | 11,000 | HOAc -H20 |
| Di-o-Anisidine N(l-Naphthyl)ethylenediamine | 598 | 10,333 | HQAe -H ₂ 0 |

TABLE A-8 (Continued)

| Reagent | λ _{max} | • 6 | Solvent |
|---|------------------|-----------------|--------------------------------------|
| 5-Chloro-2-Aminoanisole 1-Amino-7-Naphthalenesulfonic acid | 548 | 33,667 | HOA c-H ₂ O |
| Diaminodiphenylsulfone 1-Amino-7-Naphthalenesulfonic acid | 528 | 44,000 | HOA c-H ₂ O |
| Sulfanilamide 1-Amino-7-Naphthalenesulfonic acid | 523 | 51,333 | HOAC ·H ₂ O |
| p-Aminobenzoic acid N-Phenyl-l-Naphthylamine | 564 | 49,667 | HOA C -H2O |
| Diaminodiphenylsulfone N-Phenyl-1-Naphthylamine | 566 | 47,000 | HOA C-H ₂ O |
| Sulfanilamide N-Phenyl-1-Naphthylamine | 558 | 46,333 | HOAc-H20 |
| Di-julolidino-methane | 636 | 193,333 | HOA C-H2O |
| Di-o-Anisidine 2-Naphthol | 481 | 6,667 | 0.1 NaOH- HOA c-H ₂ O |
| Sulfanilic acid Phenol | 348 | 4,433 | 0.1 NaOH - HOA C-H ₂ O |
| 2,6-bis (dimethylamino) anthracene | 469 | 2,667 | HOA G-H ₂ O |
| | 520 | 433,333 | HOA c-H ₂ O |
| 4,4°,4° Methylidynetris (N,N- dimathylaniline | 590 | 17,000 | HOA C -H2O |
| α,α-bis(p-dimethylaminophenyl)-2- methoxy-p-cresol | 608 | 10,667 | Hoac -H ₂ o |
| 4-chloro-α,α-bis (p-dimethylaminophenyl)- o-cresol | 630 | 8,333 | HOAs-H ₂ O |
| 4,4'(2-Thenylidene)bis(N,N-dimethyl- aniline) | 628 379 | 5,333 25,667 | HOAC-H ₂ O |

TABLE A-8 (Continued)

| Reagent |) max | ¢ | Solvent |
|--|------------|-----------------|-----------------------|
| α,α-bis (p-dimethylaminophenyl)-p-cresol | 607 459 | 21,667 8,333 | HOAC-H ₂ O |
| α,α-b(p-dimethylaminophenyl)-6-methoxy- m-toluenesulfonic sodium salt | 618 448 | 10,833 4,500 | HOAC-H ₂ O |
| Anthranilic acid N(1-Naphthyl)ethylenediamine | 558 | 19,333 | HOAC-H ₂ O |

TABLE A-9 EVALUATION OF NITRATE ESTER REAGENTS FOR REPRODUCIBILITY

| | 1st Eval | uation | 2nd Evaluation | | |
|---|----------|--------|----------------|--------|--|
| Reagent | max | | ^max | e | |
| 1-Amino-7-Naphthalenesulfonic Acid N-N-Dimethyl-1-Napthylamine | 548 | 24,100 | 547 | 24,770 | |
| Sulfanilamide N-Phenyl-l-Napthylamine | 555 | 43,970 | 556 | 44,830 | |
| p-Nitroaniline N-Phenyl-l-Naphthylamine | 558 | 31,370 | 557 | 33,033 | |
| p-Aminobenzoic Acid 8-Amino-1-Naphthol-3,6-disulfonic Acid | 537 | 30,500 | 536 | 25,570 | |
| p-Aminobenzonitrile N-Phenyl-l-Naphthylamine | 557 | 50,300 | 557 | 49,830 | |
| p-Aminobenzoic Acid N(l-Naphthyl)ethylenediamine | 555 | 36,670 | 553 | 32,670 | |
| 4-Aminosalicylic Acid N(1-Naphthyl)ethylenediamine | 550 | 27,300 | 550 | 27,870 | |
| Procaine N,N-Dimethyi-1-naphthylamine | 530-535 | 42,330 | 533 | 45,770 | |
| Nitroaniline N,N-Dimethyl-1-naphthylamine | 528 | 45,300 | 527 | 45,830 | |
| Sulfanilic Acid N(1-Naphthyl)ethylenediamine | 550 | 33,300 | 552 | 19,900 | |
| -Nitroaniline N-(1-Naphthyl)ethylenediamine | 545 | 28,000 | 547 | 25,430 | |
| Procaine N(1-Naphthyl)sthylenediamine | 550 | 30,670 | 548 | 22,170 | |
| -Aminobenzonitrile N(1-Naphthyl)ethylenediamine | 544 | 40,670 | 544 | 32,530 | |
| iaminodiphenylsulfone N(1-Naphthyl)ethylenediamine | 550 | 34,000 | 534 | 39,200 | |
| -Aminobenzontrifluoride N(1-Naphthyl)ethylenediamine | 542 | 26,330 | 543 | 19,270 | |
| iaminodiphenylsulfone N,N-Dimethyl-1-naphthylamine | 532 | 39,000 | 533 | 39,400 | |

TABLE A-9 (Continued)

| Reagent | lst E | valuation | 2nd Ev | aluation 6 |
|---|-------|-----------|--------|------------|
| p-Aminoacetophenone N, N-Dimethyl-1-naphthylamine | 538 | 43,000 | 539 | 41,900 |
| p-Aminobenzonitrile N,N-Dimethyl-1-naphthylamine | 528 | 38,000 | 527 | 38,900 |
| p-Aminobenzoic Acid N,N-Dimethyl-l-naphthylamine | 535 | 47,000 | 539 | 39,270 |
| Sulfanilamide N(1-Naphthyl)ethylenediamine | 544 | 33,000 | 545 | 27,400 |
| Sulfanilamide 1-Amino-7-naphthalensulfonic Acid | 524 | 44,700 | 526 | 44,300 |
| Diaminodiphenylsulfone 1-Amino-7-naphthalenesulfonic Acid | 528 | 39,000 | 528 | 43,700 |
| Sulfanilamide N,N-Dimethyl-l-naphthylamine | 529 | 36,700 | 529 | 37,633 |
| p-Aminobenzonitrilc N-Phenyl-1-naphthylamine | 556 | 40,300 | 556 | 49,230 |
| p-Aminoacetophenone N-Phenyl-1-naphthylamine | 565 | 43,000 | 568 | 52,170 |
| p-Aminobenzoic Acid N-Phenyl-1-naphthylamine | 563 | 41,700 | 565 | 50,970 |
| l-Amino-4-chloro-3-toluenesulfonic Acid l-Amino-7-naphthalenesulfonic Acid | 535 | 28,700 | 538 | 35,833 |
| 4-Aminoacetophenone N(1-Naphthy1)ethylenediamine | 552 | 31,300 | 555 | 34,100 |
| 1-Amino-2,5-dichloro-4-benzenesulfonic Acid 1-Amino-7-naphthalenesulfonic Acid | 540 | 31,300 | 511 | 35,630 |
| Sulfanilic Acid 1-Amino-7-naphthalenesulfonic Acid | 531 | 40,000 | 533 | 41,570 |
| 5-Chloro-2-aminoanisole 1-Amino-7-naphthalenesulfonic Acid | 548 | 33,700 | 549 | 32,000 |
| Diaminodiphenylsulfone 1-Amino-7-naphthalenesulfonic Acid | 528 | 44,000 | 528 | 44,130 |

TABLE A-9 (Continued)

| Reagent | lst Ev | aluation | 2nd E | valuation |
|--|--------|----------|-------|-----------|
| Sulfanilamide 1-Amino-7-naphthalenesulfonic Acid | 523 | 51,300 | 525 | 44,270 |
| p-Aminobenzoic Acid N-Phenyl-1-naphthylamine | 564 | 49,700 | 564 | 51,970 |
| Diaminodiphenylsulfone N-Phenyl-l-naphthylamine | 566 | 47,000 | 562 | 51,633 |
| Sulfanilamide N-Phenyl-1-naphthylamine | 558 | 46,300 | 565 | 49,467 |

TABLE A-10 STORAGE TESTS OF HITTATE ESTER REACENTS (4, b)

| | Intefal | - | 7 Par | ١, | 7 | | | | | | | |
|---|-----------|-------|---------------|-------|-------------|-----|----------------|------------|------------------|-----|-------------|-------|
| Respect | Color | Lieit | Color Limit | Linit | Color Limit | 뒴 | Color | iet Eet | 28 Days Color | 1 | 35 Deys | Linte |
| p-dataobeasoto acid H-Thenyl-1-sephthylamine | Le pink | 0.4 | 0.4 Lt pink | 4.0 | 0.4 Lt pink | 4.0 | 0.4 Le pink | 4.0 | 0.4 Le pink | 4.0 | 0.4 Lt pink | 0.4 |
| P-Astinoscetophenous R-Thenyl - L-esphithylasins | Straw | 4.0 | 0.4 Lt pink | 4.0 | 0.4 Lt pink | 4.0 | Lt pink | 7.0 | 0.4 Lt pink | 4.0 | 0.4 Lt pink | 7.0 |
| Disminodiphenylsulfone H-Phenyl-l-cashthylamine | Lt pink | 4.0 | Lt pink | 4.0 | Lt pink | 4.0 | Lt pink | 4.0 | Le pink | 4.0 | 0.4 Le pink | 7.0 |
| P-Aminobensoultrile E-Phemyl-1-cashthylamine | Lt pink | 4.0 | 0.4 Lt pink | 4.0 | 0.4 Lt pink | 7.0 | Pink- broen | 4.0 | Pink- brown | 7.0 | Brown- | 9.4 |
| Proceine F.H-Dissthyl-l-naphthylesine | Coloriess | 9.4 | 9.4 V lt pink | 7.0 | V lt pink | 7.0 | V lt pink | 4.0 | V lt pink | 4.0 | V 1t pink | 4.0 |
| Sulfacilanide I-Thonyl-l-maphthylamine | Lt pink | 4.0 | Lt pink | 9.0 | 0.4 Lt pink | 9.6 | 0.4 Lt pink | 4.0 | 0.4 Lt pink | 4.0 | 0.4 Le pink | 4,0 |

⁽a) All respents consisted of 0.5 g of each of the primary smine and coupling agent in 150 ml 50/50 HOAc/H20.

⁽b) PEIN used as mitrate ester.

TABLE A-11 EVALUATION OF NITRATE ESTER REAGENTS ON VARIOUS SUBSTRATES (a,b)

| Remarks | | | | Weak positive response to glue |
|------------------------|--------------------------------|--|--|---|
| Detection Limit, µg | 0.4 0.4 | 0.4 0.4 0.4 >100 | 4.0 0.4 0.4 0.4 0.4 0.4 | 0.4 0.4 0.4 4.0 7100 4.0 |
| Composition | 100% cotton | 25% cotton | | , |
| Color | White Yellow | White White White Straw Dk.brown | Med.brown White White White White Yellow Brown | White White/blue White White Lt.brown Med.brown Med.brown |
| Substrate | Papers 20# Bond 16# Bond | Onion skin Plain long grain Index card File folder File packet, glazed | File folder, glazed Blotter paper Xerox copy paper, coated Construction paper Notebook folder Legal pad Grocery bag Wrapping paper | Letterhead bond Airmail Business #10 Airmail Clasp envelope Clasp envelope, glazed Utility shipping bag |

TABLE A-11 (Continued)

| Substrate | Color | Composition | Detection Limit, µg | Remarks |
|---------------------------|-----------|--------------|------------------------|---------------------------------|
| Cardboards | | | | |
| Posterboard | White | | 9. 6 | |
| Lightweight cardboard | Gray | | 6. 0 | |
| Medium weight box board | Brown | | 4.0 | |
| Corrugated, coated | White | | 7. 0 | |
| Corrugated | Brown | | 4.0 | |
| Miscellaneous | | | | |
| Accohyde | Cream | Vinyl | | Color faded |
| Polyethylene sheet | Clear | Pclyethylene | 9. 4 | Color faded |
| Mood | Tan | Pine | | |
| Leather, vegetable tanned | Med.brown | Calfskin | | Leather turned dark and brittle |
| Cloth | White | Cotton | 7.0 | |
| \$ 00 C | White | Polynrethane | 0.4 | |

Stock solutions of PETN (pentaerythritol tetranitrate) used to spot the substrates. **(a**

Substrate sprayed first with a suspension of 10 g zinc dust in benzene followed by a solution of 0.3 g procaine and 0.3 g N,N-dimethyl-1-naphthylamine in 100 ml 50/50 HoAc/EtOH. æ

TABLE A-12 EVALUATION OF RDX REAGENTS

| | <u> </u> | | |
|--|----------|----------|------------------------|
| Reagent |) max | 6 | Solvent |
| p-Aminobenzoic acid N(1-naphthyl)ethylenediamine | 555 | 36,666 | HOAc-H ₂ O |
| Aminosalicylic acid N(1-naphthyl)ethylenediamine | 550 | 27,333 | HOAc-H ₂ O |
| 4-Aminoacetophenone N-Pheny1-2-naphthylamine | 515-525 | 12,500 | HOAc-H ₂ O |
| Di-o-anisidine m-Phenylenediamine | 455 | 25,500 | HOAc-H ₂ O |
| Sulfanilic acid m-Phenylenediamine | 453 | 19,778 | HOAc-H ₂ O |
| p-Chloroaniline N,N-Dimethyl-naphthylamine | 550 | 14,333 | HOAc-H ₂ O |
| 2-Naphthylamine-6,8-disulfonic acid N,N-Dimethyl-1-naphthylamine | 558 | 5,500 | HOAc-H ₂ O |
| N,N,N',N'-Tetramethyl-p-phenylenediamine | 618 | 70,000 | HOAc-H ₂ O |
| o-Tolidine | 440 | 16,500 | HOAc -H ₂ O |
| Procaine N,N-Dimethyl-1-naphthylamine | 530 -535 | 42,333 | HOAc-H ₂ O |
| Sulfanilic acid N,N-Dimethyl-1-naphthylamine | 543 | 21,667 | HOAc-H ₂ O |
| Tetramethylbenzidine | 470 | 7,833 | HOAc-H2O |
| m-Phenylenediamine | 450 | 16 . 444 | HOAc-H ₂ O |
| 1-Amino-7-naphthalenesulfonic acid N(1-naphthyl)ethylenediamine | 560 | 7,833 | HOAc-H ₂ 0 |
| Sulfanilic acid N(1-naphthyl)ethylenediamine | 550 | 33,333 | HOAc-H ₂ O |
| p-Nitroaniline N,N-Dimethyl-l-naphthylamine | 528 | 45,333 | HOAc-H ₂ O |
| Procaine N(1-naphthyl)ethylenediamine | 550 | 30,667 | HCAc-H ₂ O |

TABLE A-12 (Continued)

| Reagent | λ _{max} | € | Solvent |
|--|------------------|---------|-----------------------|
| 2-Naphthylamine-6,8-disulfonic acid N(1-naphthyl)ethylenediamine | 550 | 5,333 | HOAc-H ₂ O |
| p-Chloroaniline N(1-naphthyl)ethylenediamine | 560 | 22,000 | HOAc-H2C |
| p-Aminobenzonitrile N(1-naphthyl)ethylenediamine | 544 | 40,667 | HOAc-H ₂ O |
| p-Phenylazoaniline N(l-naphthyl)ethylenediamine | 498 | 175,000 | HOAc-H ₂ O |
| Diaminodiphenylsulfone N(l-naphthyl)ethylenediamine | 550 | 34,000 | HOAc-H ₂ O |
| Anthravilic acid N(1-naphthy1)ethylenediamine | 558 | 19,333 | HOAc-H ₂ O |
| 3-Aminobenzotrifluoride N(1-naphthyl)ethylenediamine | 542 | 26,333 | HOAc-H ₂ O |
| Diaminodiphenylsulfone N,N-Dimethyl-1-naphthylamine | 532 | 39,000 | HOAc-H ₂ O |
| 4-Aminoacetophenone N,N-Dimethyl-1-naphthylamine | 538 | 43,000 | HOAc-H ₂ O |
| p-Aminobenzonitrile N,N-Dimethyl-1-naphthylamine | 528 | 38,333 | HOAc-H ₂ 0 |
| p-Aminobenzoic acid N,N-Dimethy1-1-naphthylamine | 535 | 47,333 | HOAc-H ₂ 0 |
| Sulfanilamide N(1-naphthyl)ethylenediamine | 544 | 33,000 | HOAc-H ₂ 0 |
| 4-Aminoacetophenone 1-Amino-7-naphthalenesulfonic acid | 530 | 17,333 | HOAc-H ₂ 0 |
| 3-Aminobenzotrifluoride 1-Amino-7-naphthalenesulfonic acid | 521 | 15,000 | HOAc-H ₂ O |
| p-Aminobenzonitrile 1-Amino-7-naphthalenesulfonic acid | 520 | 18,667 | HOAc-H ₂ O |
| Diaminodipherylsulfone 1-Amino-7-naphthalenesulfonic acid | 528 | 39,333 | HOAc-H ₂ O |

TABLE A-12 (Continued)

| Reagent | λ _{max} | ¢ | Solvent |
|---|------------------|--------|------------------------|
| p-Aminobenzoic acid 1-Amino-7-naphthalenesulfonic acid | 529 | 24,333 | HOAc-H ₂ 0 |
| Sulfanilamide N,N-Dimethyl-1-naphthylamine | 529 | 36,667 | HOAc-H ₂ C |
| 3-Aminobenzotrifluoride N,N-Dimethyl-1-naphthylamine | 532 | 25,667 | HOAc -H20 |
| p-Aminobenzonicrile N-Phenyl-l-naphthylamine | 556 | 40,333 | HOAc-H ₂ O |
| 4-Aminoacetophenone N-Phenyl-1-naphthylamine | 565 | 43,000 | HOAc -H ₂ O |
| p-Aminobenzoic acid N-Phenyl-l-naphthylamine | 563 | 41,667 | HOAc-H ₂ O |
| 1-Amino-4-chloro-3-toluenesulfonic acid 1-Amino-7-naphthalenesulfonic acid | 535 | 28,667 | HOAc-H ₂ O |
| l-Amino-4-chloro-3-toluenes::lfonic acid N(l-naphthyl)ethylenediamine | 552 | 8,000 | HQAc=H ₂ O |
| Sulfanilamido 1,8~Naphthalenediamine | 544 | 17,000 | HOAc -H ₂ O |
| Di-o-anisidine 1-Amino-7-naphthalenesulfonic acid | 564 | 14,333 | H0Ac-H ₂ 0 |
| p-Aminoacetophenone N(1-naphthyl)ethylenediamine | 552 | 31,333 | HOAc-H ₂ 0 |
| l-Amino-2,5-dichloro-4-benzenesuifonic acid l-Amino-7-naphchalenesulfonic acid | 540 | 31,333 | HOAc -H20 |
| Sulfanilic acid 1-Naphthylamine-7-sulfonic acid | 531 | 40,000 | HOAc-H ₂ 0 |
| Di-o-anisidine N(l-naphthyl)ethylenediamine | 598 | 10,333 | HQAc-H2O |
| -Chloro-2-aminoanisole -Amino-7-naphthalenesulfonic acid | 548 | 33,667 | HOAc-H ₂ O |
| ulfanilamide -Amino-7-naphthalenesulfonic acid | 523 | 51,333 | HOAc-H ₂ O |
| | | | |

TABLE A-12 (Continued)

| Reagent | λ _{max} | <u> </u> | Solvent |
|---|------------------|----------|--------------------------------|
| Diaminodiphenylsulfone N-Phenyl-1-naphthylamine | 566 | 47,000 | HOAc -H2O |
| Dijulolidylmethane | 636 | 193,333 | HOAc-H ₂ O |
| Di-o-anisidine 2-naphthol | 481 | 6,667 | NaOH:HOAc- H ₂ O |
| 1-Amino-7-naphthalenesulfonic acid N,N-dimethyl-1-naphthylamine | 548 | 24,100 | HOAc -H ₂ O |
| Di-o-anisidine N,N-dimethyl-l-naphthylamine | 544 | 8,300 | HOAc -H ₂ 0 |
| Anthranilic acid N,N-dimethyl-l-naphthylamine | 541 | 4,333 | HOAc -H ₂ 0 |
| Diphenylamine | no visib | le | |
| 5-Chloro-2-aminoanisole N,N-dimethyl-1-naphthylamine | 553 | 8,967 | HOAc-H ₂ O |
| Sulfanilimide N-phenyl-1-naphthylamine | 555 | 43,967 | HOAc -H ₂ O |
| p-Nitrosniline 1-Amino-5-naphthalenesulfonic acid | 540 | 10,500 | HQAc-H ₂ O |
| Sulfanilimide 1-Amino-5-naphthalenesulfonic acid | 526 | 13,133 | HOAc-H ₂ O |
| p-Nitroaniline N-phenyl-1-naphthylamine | 558 | 31,367 | HOAc -H ₂ O |
| Sulfanilic acid 1-Amino-7-naphthalenesulfonic acid | 538 | 19,100 | HOAc-H ₂ O |
| 4-Aminoacetophenone N-Fhenyl-2-naphthylamine | 518 | 18,533 | H0Ac-H ₂ O |
| p-Aminobenzoic acid 8-Amino-1-naphthol-3,6-disulfonic acid | 537 | 30,500 | HOAc -H2O |
| Anthranilic acid 1-Amino-7-naphthalenesulfonic acid | 538 | 14,833 | HOAc -H ₂ O |

TABLE A-12 (Continued)

| Reagene | λ _{max} | ¢ | Solvent |
|---|------------------|--------|-----------------------|
| Di-o-anisidine N-Phenyl-l-naphthylamine | 612 | 21,367 | HOAc-H ₂ O |
| p-Aminobenzonitrile N-Phenyl-1-naphthylamine | 557 | 50,300 | HOAc-H ₂ O |

TABLE A-13 EVALUATION OF RDX AND NITRATE ESTER REAGENTS

| | 1st Eval | ustion | 2nd R | valuation |
|--|------------------|--------|------------------|-----------|
| Reagent | λ _{max} | 6 | λ _{max} | C |
| 1-Amino-7-Naphthalenesulfonic Acid N-N-Dimethyl-1-Naphthylamine | 548 | 24,100 | 547 | 24,770 |
| Sulfanilamide N-Phenyl-1-Naphthylamine | 555 | 43,970 | 556 | 44,830 |
| p-Nitroaniline N-Phenyl-1-Naphthylamine | 558 | 31,370 | 557 | 33,033 |
| p-Aminobenzoic Acid 8-Amino-1-Naphthol-3,6-disulfonic acid | 537 | 30,500 | 536 | 25,570 |
| p-Aminobenzonitrile N-Phenyl-1-Naphthylamine | 557 | 50,300 | 557 | 49,830 |
| p-Aminobenzoic Acid N(1-Naphthyl)ethylenediamine | 555 | 36,670 | 553 | 32,670 |
| 4-Aminosalicylic Acid N(1-Naphthyl)ethylenediamine | 550 | 27,300 | 550 | 27,870 |
| Procaine N,N-Dimethyl-l-naphthylamine | 530-535 | 42,330 | 533 | 45,770 |
| p-Nitroaniline N,N-Dimethyl-1 naphthylamine | 528 | 45,300 | 527 | 45,830 |
| Sulfanilic Acid N(l-Naphthyl)ethylenediamine | 550 | 33,300 | 552 | 19,900 |
| p-Nitroaniline N(1-Naphthyl)ethylenediamine | 545 | 28,000 | 547 | 25,430 |
| Procaine N(l-Naphthyl)ethylenediamine | 550 | 30,670 | 548 | 22,170 |
| p-Aminobenzonitrile N(1-Naphthyl)ethylenediamine | 544 | 40,670 | 544 | 32,530 |
| Diaminodiphenylaulfone N(l-Naphthyl)ethylenediamine | 550 | 34,000 | 534 | 39,200 |
| m-Aminobenzotrifluoride N(1-Naphthyl)ethylenediamine | 542 | 26,330 | 543 | 19,270 |
| Diaminodiphenylsulfone N,N-Dimethyl-1-naphthylamine | 532 | 39,000 | 533 | 39,400 |

TABLE A-13 (Continued)

| | let E | valuation | 2nd E | valuation |
|---|-------|-----------|-------|-----------|
| Reagent |) max | 6 | y mex | E |
| p-Aminoacetophenone N,N-Dimethyl-1-naphthylamine | 538 | 43,000 | 539 | 41,900 |
| p-Aminobenzonitrile N,N-Dimethyl-1-naphthylamine | 528 | 38,000 | 527 | 38,900 |
| p-Aminobenzoic acid N,N-Dimethyl-l-naphth yla mine | 535 | 47,000 | 539 | 39,270 |
| Sulfanilamide N(l-Naphthyl)ethylenediamine | 544 | 33,000 | 545 | 27,400 |
| Sulfanilamide 1-Amino-7-naphthalenesulfonic acid | 524 | 44,700 | 526 | 44,300 |
| Diaminodiphenylsulfone 1-Amino-7-naphthalenesulfonic acid | 528 | 39,000 | 528 | 43,700 |
| Sulfanílamide N,N-Dimethyl-1-naphthylamine | 529 | 36,700 | 529 | 37,633 |
| p-Aminobenzonitrile N-Phenyl-l-naphthylamine | 556 | 40,300 | 556 | 49,230 |
| p-Aminoacetophenone N-Phenyl-l-naphthylamine | 565 | 43,000 | 568 | 52,170 |
| p-Aminobenzoic acid N-Phenyl-1-naphthylamine | 563 | 41,700 | 565 | 50,970 |
| l-Amino-4-chloro-3-toluenesulfonic acid l-Amino-7-naphthalenesulfonic acid | 535 | 28,700 | 538 | 35,833 |
| 4-Aminoacetophenone N(1-Naphthyl)ethylenediamine | 552 | 31,300 | 555 | 34,100 |
| l-Amino-2,5-dichloro-4-benzenesulfonic acid l-Amino-7-naphthalenesulfonic acid | 540 | 31,300 | 511 | 35,630 |
| Sulfanilic acid L-Amino-7-naphthalenesulfonic acid | 531 | 40,000 | 533 | 41,570 |
| -Chloro-2-aminoanisole -Amino-7-naphthalenesulfonic acid | 548 | 33,700 | 549 | 32,000 |
| Diaminodiphenylsulfone L-Amino-7-naphthalenesulfonic acid | 528 | 44,000 | 528 | 44,130 |

TABLE A-13 (Continued)

| Reagent | let Eve | aluation e | 2nd | Evaluation 6 |
|--|---------|------------|-----|--------------|
| Sulfanilamide 1-Amino-7-naphthalenesulfonic acid | 523 | 51,300 | 525 | 44,270 |
| p-Aminobenzoic acid N-Phenyl-1-naphthylamine | 564 | 49,700 | 564 | 51,970 |
| Diaminodiphenylsulfone N-Phenyl-1-naphthylamine | 566 | 47,000 | 562 | 51,633 |
| Sulfanilamide N-Phenyl-1-naphthylamine | 558 | 46,300 | 565 | 49,467 |

TABLE A-14 STORAGE TESTS OF RLX REAGENTS (4)

| | Initial | a] | 7 0936 | | į | | | | | | | |
|------------------------------|-----------|----------|--------------|-------|---------------|-------|---------------|-------|-----------|-----|-----------|-------------|
| THE KENT | Color | Limit | Color | | 14 Days | YS | 21 Dave | | ć | | | |
| P-Aminobenzoic acia | | | | Truit | Color | Limit | Color | Limit | SARG 27 | g : | 35 Days | 73 |
| N-Phenyl-1-naphthylamine | Lt pink | 7.0 | Lt pink | 0.4 | Lt pink | 7.0 | Lt ofnb | 3 | 10102 | | Color | Limit |
| P-Aminoacetophenone | į | | | | | | | • | Lt pink | 7.0 | Lt pink | 4.0 |
| N-Phenyl-1-naphthylanine | SCraw | 7.0 | Lt pink | 7.0 | Lt pink | ·,· | Jt pink | 7 0 | 4 | | | |
| Dissinodiphenylsulfone | Tr. | | | | | | | • | rt pink | 7.0 | Lt pink | 7.0 |
| N-Thenyl-l-maphthylamine | Will have | † | Lt pink | 0.4 | Lt pink | 0.4 | Lt pink | 7.0 | 1 - 2 - 2 | | | |
| P-Aminobenzonitrile | 11,00 | | | | | | ì | | יר אוווע | 7.0 | Lt pink | 9.0 |
| N-Phenyl-l-naphthylamine | r. pank | * | Lt pink | 7.0 | Lt pink | 9.0 | Pink- | 7.0 | ž | | | |
| Proceine | Colorless | | | | | | brown | | brown | 4.0 | Pink- | 7.0 |
| N,N-Dimethyl-l-naphthylamine | | | Vit pink 0.4 | | V lt pink 0.4 | | V It pink 0.4 | | V lt oink | × | | |
| Sulfanilanide | Lt pink | 7 0 | 4 | | | | | | | ; | v te pink | 7.0 |
| c.iy 1 -1 -naphchylamine | : | | or prak | 4.0 | Lt pink | 5.0 | Lt pink | 9.0 | l.r ofnk | | | |
| | | | | | | | | | | * | Lt pink | 7. 0 |

TABLE A-15 EVALUATION OF RDX REAGENTS ON VARIOUS SUBSTRATES (a)

| (b) (b) (b) (b) (b) (b) (b) (c) (c) (d) (d) (d) (d) (d) (d) (d) (d) (d) (d | Limit. 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | Composition 100% cotton 25% cotton | White | Papers 20# Bond 16# Bond Onion skin tissue Plain, long grain Index card File folder File folder, glazed Blotter paper Xerox copy paper, coated Construction paper Notebook filler Legal pad Grocery bag Wrapping paper Envelopes Letterhead bond Airmail Business #10 airmail |
|--|--|------------------------------------|---|---|
| Glue gives a weak positive response (b) | 4 4 4 0 0 0 | | Lt.brown Med.brown Med.brown | Clasp envelope Clasp envelope, glazed Utility shipping bag |
| | 4. 0 | | Med.brown | Utility shipping bag |
| | 7. 0 | | Med. brown | dipping pag |
| | 4.0 | | Med.brown | Ipping bag |
| (a) | ⊃. † | | Hea. Drown | Tope, grazeu |
| | | | - | |
| Glue gives a weak positive respons | 4.0 | | Lt.brown | ope |
| | 7. 0 | | Wnite | - |
| | | | ****** | |
| | 7.0 | | White | |
| | 0. 4 | | White/blue | |
| | † •• | | HITPE | |
| | 7.0 | | White | pond |
| | | | | |
| | | | | |
| | 4.0 | | Brown | lper |
| | • | | | |
| | 0.4 | | Brown | |
| (p) | 7. 0 | | Yellow | |
| | 7.0 | | White | ller |
| | 4.0 | | White | on paper |
| (a) | ٠ • د | | אוודרב | paper, coaced |
| | | | Libit to | 704000 40404 |
| | 7.0 | | White | ær |
| (a) | 0. 4 | | Med.brown | r, glazed |
| (a) | 4.0 | | Dk. brown | ., grazed |
| | 4. | | SLIAW | , |
| | | | Chroni | |
| | 7.0 | | White | |
| (<u>o</u>) | 7.0 | | White | grain |
| | 7. 0 | 25% cotton | White | tissue |
| (a) | † | į | MOTTEL | • |
|) (| | | Vellow | |
| (p) | 9.0 | 100% cotton | White | |
| | | | | |
| ON TARREST | | | | |
| · · · · · · · · · · · · · · · · · · · | T time to | 10 j 4 j 00 0 mo | 10107 | 4040 |

TABLE A-15 (Continued)

| Renarks | (b) | Leather turns dark and brittle |
|------------------------|--|---|
| Detection Limit, µg | 0.0 4.0 4.0 4.0 4.0 | 4.0 4.0 40.0 1 |
| Composition | | Vinyl Polyethylene Pine Calfskin Cotton Polyurethane |
| Color | White Gray Brown White Brown | Cream Clear Tan Med.brown White |
| Substrate | Cardboards Posterboard Lightweight cardboard Medium weight boxboard Corrugated, coated | Miscellaneous Accohydc Polyethylene sheet Wood Leather, vegetable tanned Cloth Foam |

Substrate sprayed first with a suspension of 10 g zinc dust in 100 ml benzene followed by a solution of 0.3 g procaine and 0.3 g N,N-dimethyl-1-naphthylamine in 100 ml $50/50~{\rm HoAc/H}_20$. **3**

Actual limit detected but the reagent might not be useful to this level in other situations. <u>e</u>

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