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A Study of the Use of 2-Nitroso-1-Naphthol as a Trace Metal Detection Reagent

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ABSTRACT: A 0.5% 2-nitroso-1-naphthol acetone solution was studied for its potential as a trace metal detection reagent. A metal object must be held for approximately 1.5 min for satisfactory color and pattern formation to be observed by this procedure. Metal ions transferred through a brief period of holding can be detected within 3 h. Best results were obtained on individuals with high levels of perspiration. That more than one metallic object was held can be revealed if the objects are made of different metals or have distinct shapes or sizes.

KEY WORDS: criminalistics, trace metals, reagents

To prove or disprove the assumption that certain metallic objects used at a crime scene were actually used by the suspect or victim, forensic scientists have developed several trace metal detection techniques (TMDT) [*1*]. These techniques are based on the formation of characteristic color complexes between the spray reagents and trace metals left on the skin. The characteristic pattern and color depend on the shape and the metallic content of the object held.

The most common TMDT involves spraying a 0.2% 8-hydroxyquinoline solution (in isopropanol) followed by viewing under an ultraviolet light. There are two major disadvantages in this procedure: (1) to see the pattern, a crime scene investigator must carry an ultraviolet light source and (2) to record his findings, the investigator must employ special photographic techniques, which include an ultraviolet light source, long photographic exposure time, and special lens filters [*2*].

Recently, it has been suggested [*3*] that 2-nitroso-1-naphthol can be used as a spray reagent to form reactions with various trace metals that are visible without special viewing and photographic equipment. To fully investigate the potential of this reagent, several factors affecting the color and pattern formation were studied at the Training and Applications Laboratory of the Illinois Bureau of Scientific Services and the University of Illinois.

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Experimental Procedure

A 0.5% solution of 2-nitroso-1-naphthol (Matheson, Coleman and Bell, Norwood, Ohio) was prepared in acetone and stored in a nonmetallic bottle. In most instances the reagent was applied in several light sprayings. (If heavy spray is used, colors from the reaction will run down the hand.) Hands were not washed before holding metal objects unless indicated. After the hand was sprayed and reaction developed, the results were recorded and photographed. An Olympus OM-1 35-mm camera was used with Kodak Ektachrome 160 tungsten color film. No special photographic procedure was used.

Results and Discussion

2-Nitroso-1-Naphthol

Color formation takes place when certain metals combine with either of two isomers: 1-nitroso-2-naphthol or 2-nitroso-1-naphthol. Both compounds are regarded as inner complex salts. It is believed that the latter isomer is involved in the salt formation as shown in Fig. 1 [*4*]. The toxic effect of this reagent seems negligible. According to the U.S. Department of Health, Education and Welfare [*5*], the lowest toxic dose is 1 g per kilogram of body weight per year.

Factors Affecting the Pattern and Color Formation

To determine the time required for detectable amounts of metal to transfer from an object to a hand, one individual with a moderate perspiration level was asked to hold a .22 Ruger automatic pistol (Strum Ruger Inc., Southport, Conn.) for different periods of time. (A .22 Ruger automatic pistol was used for this entire study.) Results (Table 1) indicated that 1.5 min was necessary to obtain a clear and distinct pattern of the weapon held. However, this minimum holding time can vary with the condition of the holding hand.

Little or no results were obtained in 1.5 min from people having dry hands. In such cases, the holding time had to be increased considerably. As the individual's perspiration level increased, more detailed color and pattern formation were obtained. The holding

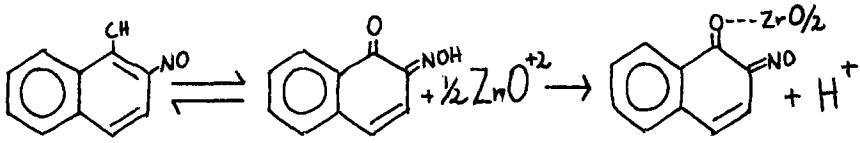

FIG. 1—*Formation of 2-nitroso-1-naphthol.*

TABLE 1—*Holding times and resultant color reactions.*

Time	Results
5 s	very slight reaction visible
15 s	slight reaction visible
30 s	fair reaction visible
1.0 min	good reaction visible
1.5 min	very good reaction visible
2.0 min	very good reaction visible

time required also decreased with increased perspiration. In one case, a satisfactory result was obtained with a 5-s holding time. Other variables such as sex, age, and race were not significant, as was reported by Stevens and Messler [6].

Questionable results were obtained from subjects with hands wet with water. Some color formation took place, but it was not enough to make any interpretation as to the type of metal object held. In one test, a small amount of lubricating oil (Frank A. Hoppe Inc., Philadelphia, Pa.) was spread onto the palm of the examinee. Visible results were obtained that could be used to determine the type of metal object held in the hand. As the amount or the viscosity of a lubricating oil increased the quality of the results decreased in both color and pattern.

Palms contaminated with fine iron dust gave inconsistent results. In one case, the entire palm of the right hand holding the .22 Ruger pistol turned green from the dust, and the pattern of the pistol's back strap could not be distinguished. In another case, an iron-contaminated hand that had held a dagger quickly turned green, but a red-orange pattern of the dagger became apparent. The dagger was made of brass.

To study how long after an object was held this procedure could still be used for detection, a randomly chosen group of laboratory personnel was asked to hold the .22 Ruger pistol for approximately 2 min. Each person then returned to his regular daily activities. Periodically, each individual's hands were sprayed once with the reagent. The results are recorded in Table 2. A great loss of detail in pattern and color formation was observed from 15 min to 3½ h. Depending on the nature of the individual's activity, this timing may increase or decrease considerably.

Color and Pattern Formation

A solution of 2-nitroso-1-naphthol is itself yellow when sprayed on the hands. As expected, not all metals react with the tested solution. Also, metals reacting with the reagent may differ in color formation. To demonstrate this, a series of different metal objects was tested. The results obtained are listed in Table 3. In cases where several objects were held, the metallic composition, size, and shape of these objects became the important variables. For example, the dagger and the .22 Ruger automatic pistol were made of different metals and different colors developed. Figure 2 shows the impressions of the back strap of the .22 Ruger automatic pistol and an iron pipe. Even though both objects left a green pattern on the palm, the individual patterns are distinct and identifiable.

The resulting patterns from the TMDT of three distinct groups of metal objects consisting of knives, hand tools, and guns were studied. Each group of objects could be readily distinguished from the other two. Remarkable differences were also present within

TABLE 2—*Time interval between metal-holding and pattern and color detection.*

Time	Results
15 min	very good reaction visible
30 min	very good reaction visible
1 h	very good reaction visible
1½ h	very good reaction visible
2 h	very good reaction visible
2½ h	very good reaction visible
3 h	good reaction visible
3½ h	poor reaction visible
4 h	no reaction visible
4½ h	no reaction visible

TABLE 3—*Differences in color formation for various metallic objects.*[a]

Metal	Result (Color)
Iron	dark green
Copper	red-brown
Zinc	pale orange
Aluminum	no color change
Gold	no color change
Brass	red-brown
Silver[b]	orange
Lead	no color change
Platinum	no color change
Stainless steel	no color change

[a] Each metallic object was held for 2 min.
[b] A silver ring was used that may have been contaminated with other metals.

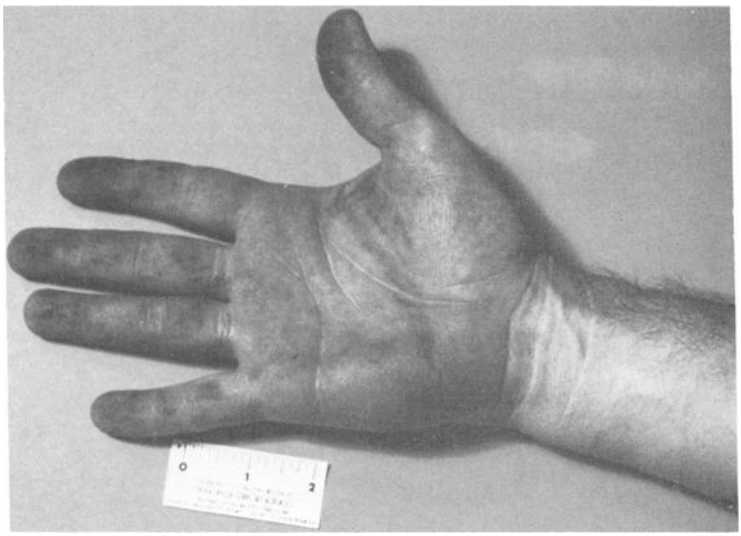

FIG. 2—*Results after spraying with 2-nitroso-1-naphthol the hands of a person who had held a .22 Ruger pistol and an iron pipe.*

each group. Knives were distinguishable by size, shape, location of screws, types of metal used, and other design variations. Tools were distinguished by size, shape, and type of metal. Finally, guns were distinguished by size and shape of grip (mainly back strap), type of metal, presence and location of screws in the grip, and any designs, emblems, or insignia present. (For these reasons some guns were easier to distinguish than others.)

The color formation after a plated gun has been held depends on the wear of the plating. The more worn the plating on the guns the less holding time required for satisfactory results. The authors believe that this is due to the ease of transferring the base metal ions through the worn plating.

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