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Detection of Firearm Imprints on the Hands of Suspects: Effectiveness of PDT Reaction

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ABSTRACT: Pyridyldiphenyl triazine (PDT) and three of its analogues were compared as practical reagents for visualizing unseen impressions left on the hands of a person who has held a firearm. The parent compound, PDT, gave the best results using intensity and clarity as measuring criteria. The effectiveness of the PDT reaction was then studied on 147 volunteers who had held firearms in their hands. Identifiable impressions of the metallic parts of the weapons were developed on the hands of 103 volunteers (70%). Results with females were slightly higher than with males, however, the difference was possibly statistically insignificant, and needs further study. Ferroprint™ and Ferrotrace™,[5] commercial preparations that are based on the PDT reaction, have become a part of the professional equipment of every crime scene technician in Israel.

KEYWORDS: forensic science, field kit, field test, criminalistics, latent imprints, firearms, 3-(2-pyridyl)-5,6-diphenyl-1,2,4-triazine, Ferroprint™, Ferrotrace™

In criminal investigations, the PDT reagent, a successor to 8-hydroxyquinoline, has had proven success in identifying firearms holders (1–6), however the results have not been as clear as one might want in all cases. Sometimes results have been too weak to be visualized. At other times the color of the reaction has been too close to the color of the hand, resulting in poor contrast. In yet other cases the form of the stain does not allow for the positive identification of a specific weapon.

In this second phase of a comprehensive study concerning the optimization of visualizing firearms contact marks on hands, the authors report the results of two series of field experiments with PDT and three of its analogues. In the first part of the study, the performance of three compounds of the D series (D2, D3, D5) (7) (Fig. 1) was compared with the performance of the parent compound, PDT, on the hands of 15 volunteers who had held firearms. In the second part of the study, the PDT reaction on the hands of 147 volunteers, including both males and females, was examined.

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[5] Field testing kits based upon PDT are sold under the commercial names, Ferrotrace (manufactured by Erez Technology, Ltd., POB 35008, Jerusalem, Israel) and Ferroprint (manufactured by Shulamit, POB 170, Hod Hasharon, Israel).

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Experiment 1: Performance of PDT Analogues

Fifteen volunteers (eight males, seven females) between the ages 19 and 44, all employees of the Israel Police (no one assigned to firearm examination), participated in the study.

Two handguns from a preliminary list of ten were chosen for this experiment. These two handguns had produced only "average" results in a preliminary test, yielding impressions that were neither too weak nor too strong (see Experiment 2). A Star™ handgun (larger) was held by males, and a Llama™ handgun (smaller) was held by females to optimize grip. It was subjectively felt that larger weapons held by males and smaller weapons held by females would enable a firmer grasp. For the purpose of this experiment, different metal composition of various handguns was not considered a significant variable. PDT analogues were applied by the same procedure described earlier (4): 0.1% solution in acetone containing aqueous ascorbic acid sprayed on the hands. PDT was sprayed from commercial Ferroprint™ containers, also containing a 0.1% solution.

Each volunteer held the handgun firmly for thirty seconds. His hands were then sprayed with PDT solution, then after a few seconds also with water (which enhances the marks by providing a more polar environment). The visible marks were photographed using a Nikon F3 camera, equipped with a 50 mm Nikon lens and 200 ASA film. The same procedure was repeated with each of the analogues.

The quality of the results was evaluated according to two factors: (1) intensity, and (2) resolution (clarity). Subjective scoring was done independently by three experts, each a veteran officer of the Serious Crimes Mobile Laboratory (Figs. 2*a,* 2*b*).

Experiment 2: Study of the Effectiveness of the PDT Reaction on Hands of Various Individuals

There were 147 volunteer participants in this experiment (104 males and 43 females), all trainees in the Israel Police Physical Training School.

A selection of guns was provided. In the first stage, described above, ten different handguns were tried in an effort to estimate the correlation between specific guns and the quality of the PDT resultant mark. Weapons that yielded marks that were either very intense or very weak with most experiment participants were excluded from the second part of the experiment. Thus, four of the ten handguns were excluded (Table 1).

Each volunteer held one of the six weapons, randomly selected, in his right hand for thirty seconds. The volunteer then held the same handgun in his left hand, again for thirty seconds. The right hand was sprayed with PDT (Ferroprint™) immediately after con-

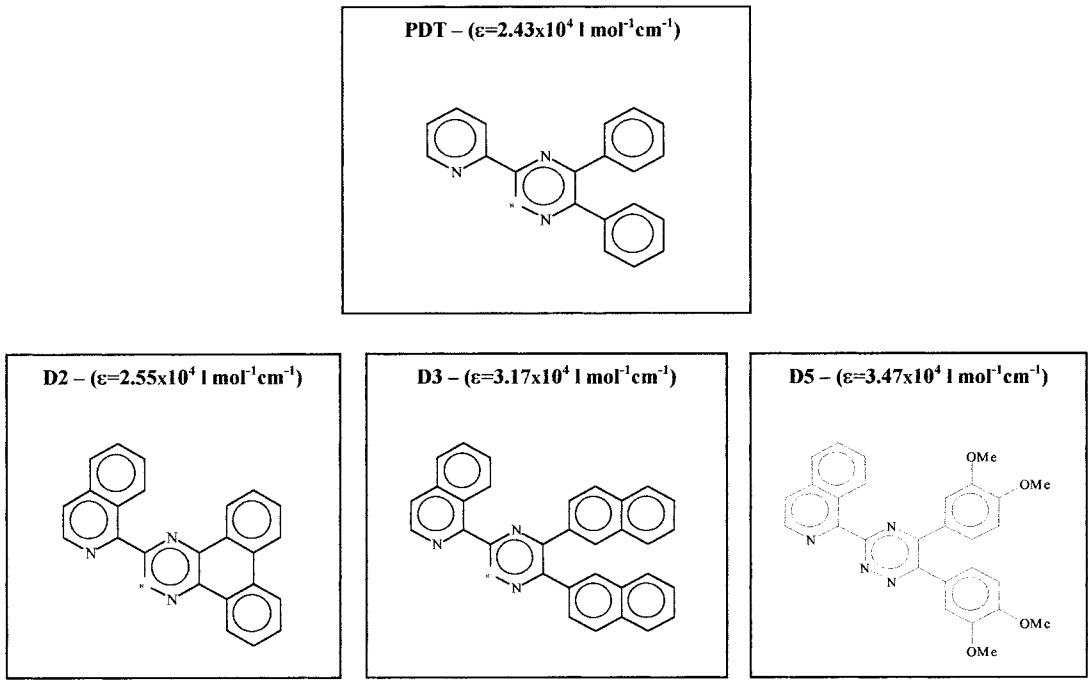


FIG. 1—*Structural formulae of* as-*triazines.*

TABLE 1—Weapons initially chosen for the experiment and summary of test results.

Resolution			Intensity					
Good	Medium	Poor	High	Medium	Weak	Type	SN #	Gun #
39	44	17	39	39	22	STAR CAL 9 mm P	461952	1
35	29	36	18	35	47	STAR MOD.30 M CAL 9 mm P	1641222	2
60	25	15	55	30	15	STAR CAL 9 mm P	777595	3*
40	40	20	80	10	10	COLT M1911A1	927687	4*
57	29	14	42	29	29	UNIQUE MODELE "L"	737026	5
75	25	0	75	0	25	STAR CAL 9 mm P	503609	6*
27	33	40	40	40	20	LLAMA CAL 9 mm P PAR	435471	7
14	29	57	7	21	72	ENFIELD No. 2 Mk1 (R)	3427	8*
33	42	25	50	42	8	STAR CAL 9 mm P	461954	9
22	43	35	48	26	26	COLT M1911A1	937801	10

* Weapons excluded from the experiment.

tact with the weapon; the left hand was sprayed one hour later. As in Experiment 1, the results were photographed and analyzed.

Results

A. Performance of PDT Analogues

All three analogues in the D series produced dark gray, nearly black impressions, compared with the magenta impressions developed by PDT. In most cases the marks developed by PDT were more intense and had somewhat higher resolution than marks obtained using the analogues.

B. Effectiveness of the PDT Reaction

Strong and medium intensity marks were developed on over 70% of the volunteers. Impressions were slightly better on the hands of females. 54% gave strong marks, compared with 45% for males, however, questions were raised if this difference was statistically significant.

Good resolution, important for the association of a stain with a weapon, was obtained on 37% of the volunteers. Results with females were slightly better (40%) than with males (36%).

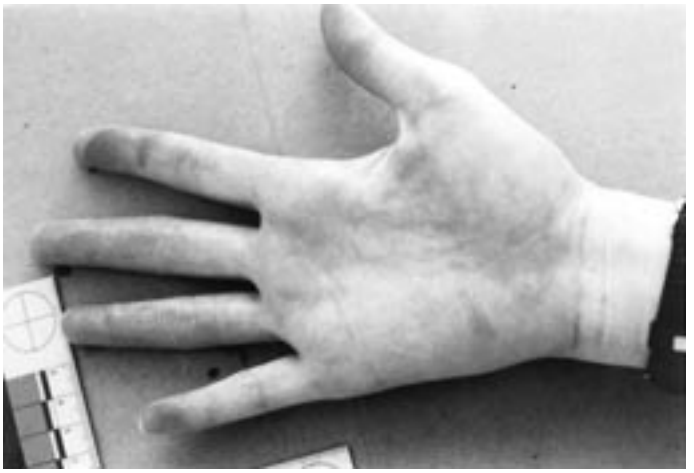
On marks developed one hour after holding a weapon (left hand in the experiment), the intensity distribution was slightly lower, yet 62% of the marks were still evaluated to be either strong or medium.

In both experiments there was no correlation between the quality of the mark and the age of the volunteer.

Discussion

The development of the SEM-based method for the unequivocal identification of gunshot residue (GSR) on the hands of a person suspected of having fired a weapon did not resolve the question,

(1)



(2)

(3)

Intensity	
Weak	Invisible or hardly noticed mark
{Enter here photograph 2a – 1}	
Medium	A colored mark is noticed
{Enter here photograph 2a – 2}	
High	A clear mark and good contrast with the palm
{Enter here photograph 2a – 3}	

FIG. 2*a*—*Intensity of reaction.*

(1)

(2)

Resolution	
Poor	No details of the metallic parts are noticed, or they are very faint
{Enter here photograph 2b – 1}	
Medium	Some detail is visible, but it is insufficiently sharp to be associated with a particular weapon
{Enter here photograph 2b – 2}	
Good	Clear detail that can be associated with a particular weapon model
{Enter here photograph 2b – 3}	

(3)

FIG. 2*b*—*Resolution of reaction.*

"Who held the gun?" which arises in many death investigations. The microscopic (GSR) particles associated with the firing action are difficult to find, and their presence on a particular person does not necessarily prove that he fired the weapon (8,9).

PDT can identify the person who has held a gun regardless if he fired it or not. In this study, positive visual proof was found on the hands of 70% of the people who had held a variety of handguns. In the authors' opinion, this can be a powerful investigative tool (2). In over a third of the examinations the marks were of sufficient resolution to determine weapon model.

It is interesting that females responded slightly better than males in both intensity and resolution. This might be due to a more firm grip on the gun, the use of hand cosmetics, finer skin texture, differences in metabolism and sweet secretion, or mere statistical variation in a limited experiment. Further study is required. In a recent homicide handled by the Israel Police, the husband of a deceased woman was the prime suspect. He contended that his wife had shot herself with his pistol, although no handgun impression was observed using PDT. The defense raised the possibility that perhaps females do not respond to the PDT test (i.e., that she had held the pistol, and that the absence of a PDT mark was due to the hand of women not responding to the reagent). The fact that women apparently respond to PDT even better than men contradicted this assumption.

It was disappointing that PDT analogues that had shown clear advantage over PDT in solution did not perform as well on the hands (7).

It appears that there is no direct correlation between a reaction in solution and a reaction on a surface-particularly a surface so chemically and genetically complex as the human hand. Processes such as iron complexation with skin proteins or ion-migration into the skin may reverse the order of reactivity. Further attempts will be made to increase the sensitivity of the PDT-type reagents. PDT analogues that produce black impressions, particularly D5, will be tried when the palms have a strong pink or red background. The purpose is to increase color contrast to better visualize the PDT reaction.

Conclusion

A significant percentage of the population, both male and female, responded positively to the PDT reagent after holding a handgun. PDT-based preparations are simple, sensitive, and inexpensive tools that can provide crucial information in cases in which firearms have been used. In Israel, PDT canisters have become standard equipment in every serious crimes unit. Given the significant number of cases involving the handling of weapons and the positive PDT results obtained, PDT has been judged to be a very effective tool. To date no health hazard has been encountered with PDT during more than ten years of use by the Israel Police, despite warning (10) that "toxicological properties have not been thoroughly investigated." Goldman and Thornton (1) also reported no carcinogenic effects of PDT; they could only point to a lack of confirming research. Although this was written in 1976, through the date of this writing there is still no negative health evidence on record. Safety data sheets are available from the Israeli manufacturers.

It is recommended that other jurisdictions weigh the use of PDT in their casework.

Finally a word of caution. Although a PDT test on the hands of suspects can be performed by field technicians or scene of crime officers, the interpretation of results should be made only by experienced laboratory professionals.

Acknowledgments

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Dedication

This article is dedicated to the memory of Superintendent Baruch Segal, an outstanding crime scene officer, who died prematurely at the age of 46.

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