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Chemical Reagents for the Development of Latent Fingerprints. II: Controlled Addition of Water Vapor to Iodine Fumes—A Solution to the Aging Problem

The iodine fuming method for the development of latent fingerprints on paper has many advantages. It is simple, fast, and inexpensive; it enables the search of relatively large surfaces in a short time without the development of background coloration; it is suitable for field work; and in case of its failure other methods can still be applied.

Although considered by some forensic scientists an ideal technique [*1*], the common iodine method suffers from several disadvantages: there is a rapid fade of the impressions [*1-5*], photography is not always successful because of poor contrast [*5*], and, moreover, latent prints more than three days old may not be revealed by exposure to iodine vapor [*1*]. (Others indicate limits of one day [*3*], which is in better accord with our own observations.) Finally, a considerable percentage of the population are such "poor donors" that even their fresh latents on paper can hardly become identifiable by the iodine method. In this sense iodine resembles ninhydrin [*6-8*].

Most of the reported modifications to the iodine method intended to improve the durability of the impressions. Thus latent prints revealed by iodine may be fixed by maintaining them between tightly sealed glass plates [*5,9*], by spraying with starch or some ionic solutions [*5,9*], by exposure to steam [*5*], or by application of "tetrabase" [*3*].

In this paper we wish to describe a modified iodine fuming technique that not only increases the sensitivity of the method (the "poor-donors" problem) but also provides a solution to the aging problem. Two devices that apply to the modified technique, one for laboratory use and one for field work, have been designed and successfully operated throughout the course of this work. In many experiments the results obtained by the new technique were comparable to or better than those obtained by the common ninhydrin method.

Method

A collection of over a thousand latent fingerprints on various types of paper was prepared [*10*]. The donors were males and females of different ages, occupations, and countries of origin. The samples were stored in dark envelopes at room temperature and developed at different ages.

Iodine fumes and water vapor were applied in different orders and intensities, at temperatures varying from −70 to 100°C. For evaluation of the method two latent prints

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from the same donor were developed, one by ninhydrin spray [*10*] and one by the iodine fume and water vapor method, and the two images were compared. The initial results have led to the design and assembly of two instruments that use the new technique.

Laboratory Apparatus

Figure 1 shows the laboratory apparatus developed for controlled generation of steam and iodine fumes. The steam that is formed in the flask (3) is forced towards the exit (8) by pressurized air through the inlet (4). The iodine crystals in the external tube (5) are heated by the steam flowing in the inner tube and the iodine fumes thus formed are carried upwards by pressurized air supplied through the inlet (6) and flow through the holes near the exit (8) to mix with the steam (a close view of the exit is shown in Fig. 2). The relative amounts of steam and iodine fumes generated by the instrument are easily controlled by manipulating the valves supplying the condensed air to the inlets (4 and 6). The sample is placed in front of the instrument approximately 10 cm from the outlet (8).

Portable Apparatus

Figure 3 shows the portable apparatus developed for the generation of moist iodine fumes. Hot air from the hair dryer (2) passes through the wet cloth (4). The moist air

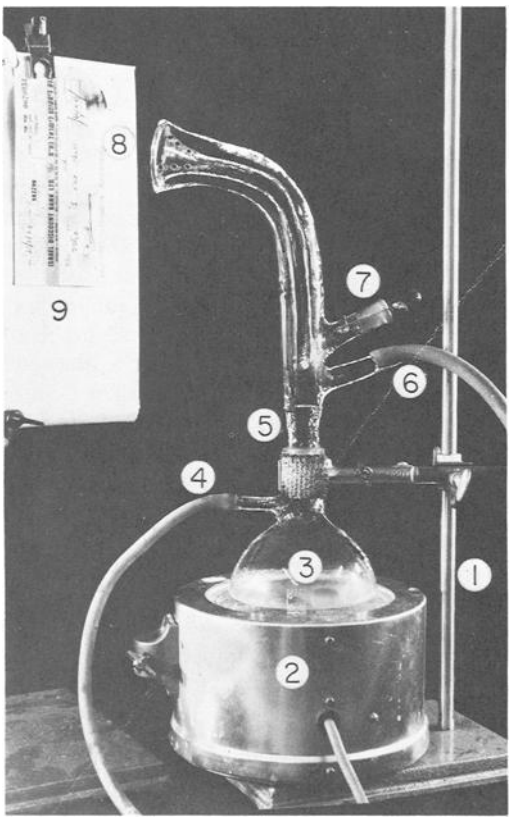

FIG. 1—*A laboratory apparatus for controlled generation of steam and iodine fumes;* (1) *stand;* (2) *1000-W regulated heating mantle;* (3) *500-ml round-bottomed flask;* (4) *pressurized air inlet;* (5) *iodine crystals;* (6) *pressurized air inlet;* (7) *iodine refill;* (8) *iodine and steam outlet; and* (9) *exhibit to be developed.*

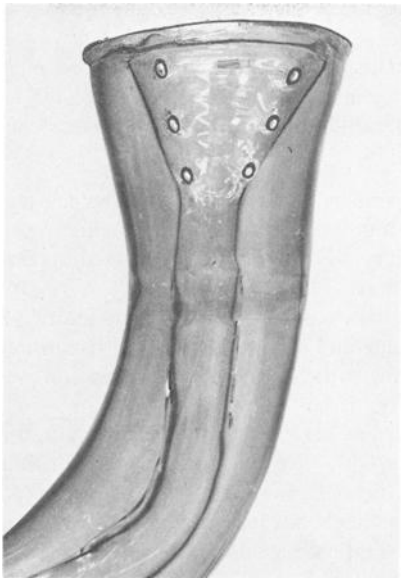

FIG. 2—*Closer view of the outlet of the laboratory instrument.*

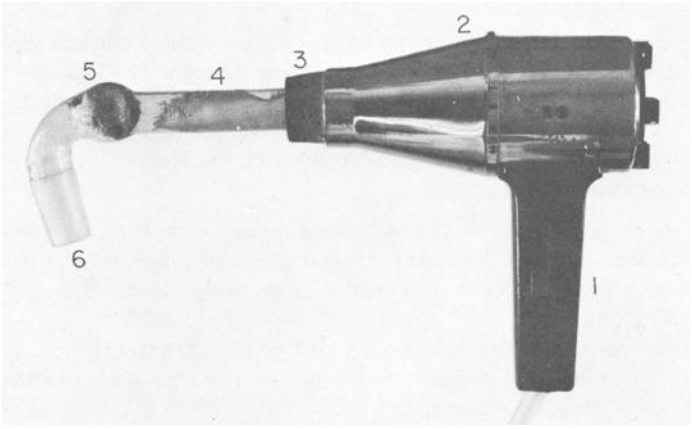

FIG. 3—*A portable apparatus for generation of moist iodine fumes;* (1) *speed selector;* (2) *hair dryer;* (3) *rubber adapter;* (4) *wet fiberglass cloth;* (5) *iodine crystals packed in a fabric bag; and* (6) *outlet.*

then passes through iodine crystals packed in the fabric bag (5), generating moist iodine fumes that are applied to the sample through the exit (6). The cloth (4) has to be wetted occasionally by being soaked in water.

Satisfactory results could also be achieved by replacing the hair dryer (2) and the wet cloth (4) by direct human breath. (It is worthwhile mentioning that commercial mouth-operated iodine fumers always contain a drying agent that absorbs the moisture.)

Results

The following observations have been made in this study:

1. The modification definitely increased the sensitivity of the iodine method towards latents of poor donors.[3]
2. Latent prints up to the age of 110 days could be made visible by the modified technique (Fig. 4). (Older prints have not been examined.)
3. The contrast and durability of the impressions were considerably improved by the modified technique.

Among the types of paper particularly suitable for the new technique are white stationery paper and checks. Less impressive results were obtained on cigarette packages and on brown wrapping paper; very poor results were observed on filter paper, newspapers, and on paper made of glass fibers.

As a rule, the best results were achieved when the iodine fumes and the water vapors were applied simultaneously and slowly. Under such conditions many latents that could not be made visible by the ordinary iodine technique (or even by ninhydrin) produced impressions of good quality.

The impressions, which are dark purple, appear instantaneously. This is true even at temperatures as low as −70°C. (For this experiment the exhibit was placed over a piece of dry ice and there was no need for extra water vapor because the humidity from the ambient atmosphere immediately condensed on the paper.) If too much steam is applied, some faint background coloration may also appear.

In Fig. 4 typical prints obtained by the method are shown together with the ninhydrin impressions of latents collected from the same donors.

Discussion

Olsen [*2*] describes the iodine fuming process as a reversible addition of iodine to the double bonds of the unsaturated fats present in perspiration. The lack of visual reaction of iodine with old fingerprints (the aging problem) was thus attributed to the fast dissipation of oils and fats from the latent prints [*6*]. However, certain observations, made by us and others, strongly suggest that the mechanism of the reaction is physical in nature rather than chemical:

1. The rate of iodine addition to unsaturated organic compounds is known to be very slow [*11*]. The instantaneous coloration of latent prints by iodine, even at temperatures as low as −70°C, thus indicates that iodination is probably not the principal reaction involved in this process.
2. The chemical fixation of iodine-developed prints by tetrabase [*3*], starch [*5*], or silver plate [*5*] can be attributed only to the presence of free iodine. Iodine compounds would not react in the same manner.
3. In another experiment latent marks artificially drawn on paper, by using chemical compounds that did not contain any fatty material, produced visual impressions on exposure to iodine fumes. Among the chemicals tested were saturated hydrocarbons, aqueous solutions of amino acids, inorganic salts, and even plain water. Also, there was no noticeable difference in the speed of reaction and the quality of coloration between saturated and the analogous unsaturated compounds (among the pairs that were examined were ethylbenzene and styrene, undecanoic acid and undecenoic acid, octane and octene).

As water is by far the main constituent of palmar sweat (over 98%) [*5,6,12,13*] and definitely one of the most volatile [*12,13*], we felt that the aging process, at least in part,

[3] The quality of the donors was considered by the quality of the impressions developed from their fresh latents by the ninhydrin method [*10*].

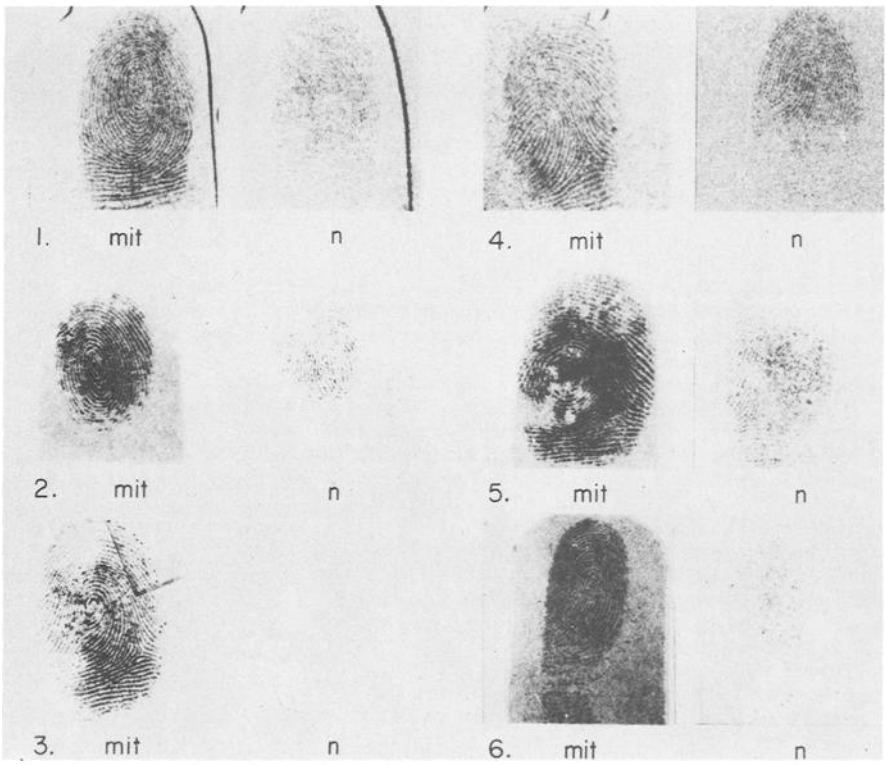

FIG. 4—*Typical pairs of latent fingerprints developed by the modified iodine technique* (mit) *and by ninhydrin* (n) *at 14 days (Pair 1), 21 days (Pair 2), 35 days (Pair 3), 42 days (Pair 4), 60 days (Pair 5), and 110 days (Pair 6). All samples were on a commonly used groundwood free paper.*

can be attributed to the loss of water from the perspiration. The success of "reviving" aged prints by treatment with water vapor supports this hypothesis.

A plausible two-step mechanism is suggested for the main reactions involved in the iodine fuming process. The first stage, which prevails upon reaction with fresh or "freshened" latent prints, is based on the attractive interaction between the constant dipole of water and the induced dipole of iodine. This effect is considerably enhanced by the presence of the inorganic salts in the fingerprint's deposition. In the second stage, which exists in the modified process only, the adsorbed iodine reacts with the paper's starch in the presence of excess water to form the familiar purple complex.

Summary

The controlled addition of water vapor to iodine fumes was shown to improve the sensitivity and versatility of this method for the development of latent fingerprints on paper. Two instruments that use this modification have been designed and successfully operated on latent prints up to 110 days old.

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