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A New Method for Recovering Latent Fingerprints from Skin

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ABSTRACT: The developed method for detecting fingerprints on live human skin involves first fuming the suspected area with iodine, and then placing a 35-mm clear plastic strip with a leuco crystal violet coating and a trace of water over the fumed area. A few seconds later a dark purple reproduction of the ridge pattern develops. It is a stable direct positive and can be mounted in a 35-mm slide mount for direct viewing. Readable prints may be obtained up to 1 h after impression on live human skin and two or three lifts may be obtained from the same print.

KEYWORDS: criminalistics, fingerprints, skin, crystal violet

Until the past few years it was almost impossible to detect and lift a fingerprint from live human skin. The problem of differentiating an oil print on top of the continuously changing thin layer of oils on the skin surface had been insurmountable. Lately, however, five techniques have been developed, each having some degree of success. These are electronography [*1–4*],[3] the Krome-Kote® paper method [*5,6*], the iodine-silver plate method [*4,7–11*], autoradiography [*12*], and laser-induced fluorescence [*13–14*].

Only a few facilities would have the equipment and the expertise to use electronography, autoradiography, and perhaps the laser procedure. The iodine-silver plate method is sensitive but the operator cannot monitor the print development and may subsequently lose it as a result. Some expertise at photography is also necessary. The Krome-Kote process is also simple and provides a good print. The only real drawbacks are that the operator cannot see the intitial print as the transfer is made and if uneven pressure is applied to an older print ridge detail can be lost. Both the iodine-silver plate and the Krome-Kote techniques are usually single trial methods and if a good print is not obtained the first time no recourse is available. While reports of success in fingerprint recovery from the skin of cadavers up to 96 h after placement have been made [*10*], experience indicates that 1½ to 2 h is probably the maximum time available before the ridge detail has been dispersed on "live" skin. Of the five methods three were tested on live skin and reportedly produced usable prints up to 1 h later. In favorable situations up to a 1½-h interval was tolerable.

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In assault and rape situations, most of which occur in the evening when laboratory personnel are likely to be off duty, not much time is available to obtain a fingerprint. Therefore a very simple and rapid method is desirable, one that can be done essentially "on the spot," by whomever is available.

Experimental Procedure

Chemicals and Equipment

The following chemicals were used in the procedure: 4,4′, 4″-Methylidyne tris (*N,N*-dimethylaniline), also known as leuco crystal violet (HCV) (Eastman Kodak Co.) at 1 g/100 mL of mixed xylenes, stored in a dark bottle, which was stable for six months. Discard if it turns amber.

The iodine fuming gun consisted of a section of tubing containing indicating Drierite® (anhydrous calcium sulfate) to remove moisture from breath, followed by 5 g of iodine held in place by glass wool in a usual fuming apparatus configuration.

The iodine fuming bag was composed of a cotton cloth bag approximately 75 by 75 mm (3 by 3 in.) filled with 6- to 16-mesh silica gel (W. R. Grace & Co., Baltimore, MD) treated with 15 g of iodine per 70 g of silica gel. Add iodine to the heated silica gel in a closed container, cool, place in the bag, and let it sit in a closed container for three to five days to equilibrate. The bag appears to be useful up to six months, depending upon the frequency of use.

Other material included transparent rubber cement, Sanfords #942 (Sanford Corp. Bellwood, IL) and fixer from Eastman Kodak Co.

The chemicals used for the interference and antiperspiration tests were all reagent grade and used as received.

The film was Kodak spectrum analysis 5367, No. 1, SA 421, 35 mm by 30.5 m (100 ft). A length of film was stripped of silver salts by immersion in fixer for 4 min, rinsed for 10 min, wiped with a sponge to remove water spots, and allowed to dry. It was cut into 50- to 75-mm (2-to 3-in.) lengths and stored in a clean glass jar. Outdated film may be used.

The 35-mm slide mounts (Ready Mounts) were from Eastman Kodak Co.

Recommended Procedure

Wear plastic disposable gloves when handling HCV-treated strips to prevent inadvertent fingerprint placement on the skin. Dip a 51-mm (2-in.) film strip into the HCV solution for 3 to 5 s, remove it, and let it dry for about 10 min. The initial search for latent prints on the victim should begin with an iodine-silica gel fuming bag to minimize exposure to iodine fumes, which are irritating. After prints for lifting are located as brown ovals, an iodine fuming gun may be used on the immediate area to increase the concentration of iodine in the latent ridges.

Place the film strip over the print and hold it gently but firmly in place for several seconds, applying pressure as needed to give even development. Watch the purple color develop and when it is at the desired intensity remove the film.

To avoid entrapping air bubbles, carefully apply a thin film of transparent rubber cement with a brush applicator to the print to stop further development. Allow it to dry. If desired, the film strip can then be mounted in a 35-mm slide mount for easier handling and projection. Store the print in a slide rack, ensuring that the dried rubber cement does not come into contact with anything that would cause it to peel off. The resultant print may be displayed, photographed, or enlarged using a slide projector.

Second and third impressions can be taken immediately or if needed more iodine may be applied. Often the second lift has sharper ridge definition than the first.

Results and Discussion

The complete details of the development of this method can be found in the thesis by Feldman [*15*].

The equations for the chemistry involved are [*16,17*]

$$I_2 + H_2O \underset{\text{fast}}{\overset{\text{slow}}{\rightleftharpoons}} HOI + I^- + H^+ \quad (1)$$

$$HOI + HCV \rightarrow CV^+ + I^- + H_2O \quad (2)$$

where

HCV = leuco crystal violet,
CV^+ = crystal violet, and
HOI = hypoiodous acid.

The oil in the ridges of the print dissolves a quantity of iodine delivered from a fumer. The film strip retains a small amount of water as well as the HCV applied by coating. When the film strip is placed over the print, the iodine in the ridges, being closer to the film, diffuses more rapidly into the film coating than iodine from the depressions. The iodine reacts with the water to form hypoiodous acid, HOI. This then selectively oxidizes the HCV to CV^+. The CV^+ is an intense purple having a molar absorptivity of 1×10^5 M^{-1} cm^{-1} at 590 nm [*18*].

Interferences

Tests were made to determine if various elements or compounds found on the skin (from the workplace or general environment) would affect the color development. Sodium or potassium salts (0.1*M*) were used. Three sets of tests were performed: (1) The solution was spotted on a glass plate and dried; then a fingerprint was placed over it. The print was then lifted by the recommended procedure. (2) The fingerprint was placed on glass, the solution placed on top and allowed to dry, and the print lifted. (3) A solution of the test substance was simply added to the HCV solution. The following ions had no detectable effect in Tests 1 and 2: SO_3^{-2}, HSO_3^-, SO_4^{-2}, HSO_4^-, $S_2O_3^{-2}$, CN^-, ClO_4^-, ClO_3^-, IO_4^-, IO_3^-, Cl^-, F^-, Br^-, BrO_3^-, TiO_3^{-2}, $Cr_2O_7^{-2}$, CrO_4^{-2}, VO_4^{-3}, NO_2^-, NO_3^-, $S_2O_8^=$, WO_4^{-2}, PO_3^{-2}, PO_4^{-3}, $HPO_4^=$, $H_2PO_4^-$, $S_2O_4^{-2}$, SeO_3^{-2}, SeO_4^{-2}, $KSb(OH)_6$, CO_3^{-2}, HCO_3^-, SCN^-, CNO^-, BiO_3^-, MoO_4^{-2}, MnO_4^-, AsO_2^-, $HAsO_4^{-2}$, $Fe(CN)_6^{-3}$, $Fe(CN)_6^{-4}$, $Fe(CN_5)NO_2^-$, AlO_2^-, BF_4^-, BO_3^-, $B_4O_7^{-2}$, Hg^{+2}, CA^{+2}, Fe^{+2}, Pb^{+2}, Ce^{+4}, Co^{+2}, Cd^{+2}.

The I^- preferentially absorbed the iodine and S^{-2} turned white in Test 1. The I^- and TiO_3^{-2} produced a faint coloration in Test 3; $Cr_2O_7^{-2}$ turned the HCV solution a faint brown and $S_2O_8^{-2}$ turned the HCV solution a deep blue.

Surfaces Tested

The recovery of prints from surfaces other than skin and glass was examined with the results shown in Table 1.

Fuming bag

Several types of cloth and combinations of iodine and silica gel were evaluated [*15*]. The one difficulty not totally overcome was that, with continued use, the silica gel was ground to finer particles which dropped out of the bag onto the print. This very high concentration of iodine produced "hot spots" on the print. It is therefore recommended that the silica gel be

TABLE 1—*Recovery of fingerprints on material other than glass and skin.*

Surface	Time Interval Before Lifting	
	1 h	24 h
Styrofoam® cup	excellent	good
Finished wood	good	good
Unfinished wood	good	fair
Cardboard	marginal	useless
Newspaper	marginal	useless
Cigarette package (glossy paper) and cellophane	excellent	excellent
Baggie®	good	good
Plastic bag	good	good
Oily can	marginal	fair
Medium weave 65% Dacron®/ 35% cotton "Swiss dot" cloth	marginal	useless
100% nylon cloth	fair	marginal
100% rayon with polyester backing	fair	marginal
100% cotton medium weave fabric	fair	fair
100% acetate tight weave cloth	useless	useless
65% acetate 35% nylon coarse weave	useless	useless
Tanned leathers/smooth surface	useless	useless
Dyed leather	useless	useless
Suede	useless	useless

sieved to remove the fines before placement in the bag and then handled as little as possible thereafter. If "hot spots" become excessive a new bag should be constructed.

Fuming Gun

The fuming gun is preferred because it does not smear the print as does rough handling with a fuming bag. However, since the fumes often caused the victim and the applier irritation it was used only after the prints were first located with the iodine bag.

Preserving the Recovered Prints

Some means of containing the continuing reaction of HCV with the hypoiodous acid and stopping its subsequent change into crystal violet was needed to prevent overdeveloping the print. Also a method was desired to stop any lateral diffusion of the CV^+ that would distort the ridge pattern and to reduce the effects of light, which can also cause a violet color to appear.

Many approaches were tried [*15*] but the system that was the simplest, least toxic, and most efficient was to apply a thin coat of transparent rubber cement immediately to the developed print. Thus far, recovered prints have been stored with no loss of detail for up to a year, the length of time lifts have been available by this method.

The only disadvantage found is that the rubber cement remains tacky for a long time, which means care must be taken when the prints are handled or stored.

Camera Film

Spectrum analysis film is used because many other 35-mm films have a purplish cast to them after the silver is removed and so the contrast is reduced. Several other plastic films were evaluated but they either dissolved in the solvent or could not be uniformly coated with the HCV. Parafilm® strips worked fairly well but had a tendency to stretch and distort the ridge pattern.

Solvent for HCV

Of twelve solvents for HCV tested, only xylene would dissolve the compound without either eventually forming a colored solution or leaving fine crystals on the film after evaporation. The xylene is evaporated for the most part by the time the treated film strip is used and will not irritate the victim's skin.

Concentrations of less than 0.75 g of HCV/100 mL of xylene were not able to provide a deep enough color for easy recognition nor were they able to produce a print 24 h after being placed on a glass plate. Concentrations greater than 1.6 g HCV/100 mL of xylene would not give a uniform thickness when placed on the film, smudged easily, and often left crystalline particles on the surface of the film strip. A concentration of 1.0 g HCV/100 mL was judged to be optimum.

Perspiration Studies

A previous researcher [2] had indicated that one way to increase the length of time a fingerprint might be obtained from a skin surface was to retard the normal secretion of perspiration and sebum in the background. The chemicals applied would generally fall into the antiperspirant category such as those used in commercial preparations.

There are basically two types of perspiration, eccrine and appocrine. Eccrine-type sweat glands discharge fluid without the loss of the cell's contents. Appocrine glands lose fluid with the secretion of portions of the cell's structure. Eccrine glands are stimulated heavily during mental and thermal sweating while appocrine glands, which are usually located at the hair follicle, are activated under stress caused by fear or pain [*19*]. Therefore, while the appocrine glands would be most active during a struggle or a rape situation, since they are located at sites where there would be obstruction to lifting a print (hair), depressing eccrine sweat is probably more desirable, though both types of perspiration should be curtailed. The mechanisms controlling perspiration are poorly understood [*20*]. No information on the abatement of eccrine sweat was found in a literature search.

Aluminum chloride, aluminum chlorohydrate, atropine sulfate, atropine methyl nitrate, propantheline bromide, scopolamine methyl bromide, scopolamine methyl nitrate, diphenhydramine hydrogen chloride, formaldehyde, and glutaraldehyde (1,5-pentanediol) were tested and all were found to be unsatisfactory for one or more reasons.

Attempts to retard oil formation were not made.

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