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Laser Detection of Latent Fingerprints: Difficult Surfaces

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ABSTRACT: Fingerprint development techniques that use blue-green laser light suffer from high background fluorescence on substrates such as cardboard, wood, leather, and some metals and plastics. These substrates tend to exhibit little or no fluorescence under ultraviolet light, prompting us to search for procedures that yield visible fluorescence under this illumination. Specifically, chemical development with dansyl chloride and vapor staining with 9-methylanthracene were found to be useful when dealing with these substrates. Fluorescence excitation was possible either with an ultraviolet lamp or an argon-ion laser operating in the ultraviolet. Coumarin 535 vapor staining following 9-methylanthracene staining was also found effective.

KEYWORDS: criminalistics, fingerprints, lasers, ultraviolet, dansyl chloride, 9-methylanthracene, coumarin 535

The ninhydrin/zinc chloride procedure for laser latent fingerprint development [*1*] is very effective on porous surfaces, such as paper. However, cardboard and other darkly colored papers often exhibit a background fluorescence of sufficient intensity under the requisite blue-green laser light to overwhelm latent fingerprints. Rhodamine 6G staining, whether in solution or vapor form is very successful when combined with laser examination, particularly after cyanoacrylate ester fuming [*2*]. However, on some substrates such as wood, leather, and some metals and plastics the background fluorescence again overwhelms the latent fingerprints. Many of these substrates have been found to exhibit little or no background fluorescence under ultraviolet light, however, prompting us to search for chemical reagents and staining techniques that respond to ultraviolet light to produce visible fluorescence.

Several reagents react with aminoacids to form a fluorescent product. These include *o*-phthalaldehyde [*3,4*], fluorescamine [*5*], and dansyl chloride [*6,7*]. The former two reagents require buffer solutions for reaction with fingerprint residue to occur. We found that these are cumbersome to use, tend to smudge the ridge detail of fingerprints, and the fingerprint fluorescence intensities were insufficient to merit further investigation. Dansyl chloride was found to show promise and was further investigated as a complementary reagent to the ninhydrin/zinc chloride procedure.

The failures of staining with rhodamine 6G prompted investigation into alternative dyes that respond to ultraviolet light. Many dyes, including fluoranthene, acridine, luminol, several coumarins, anthracene, and 9-methylanthracene, were compared for fluorescence intensity and preferential adhesion to fingerprint residue. 9-Methylanthracene was the best dye we found and appropriate staining procedures were investigated.

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Dansyl Chloride

Dansyl chloride (DNS-Cl) reacts with fingerprint residue and yields an intense fluorescence under ultraviolet light. The reported solution contained a buffer [*8*] and the possibility of eliminating this buffer was considered. A working solution was prepared by dissolving 10 mg of DNS-Cl in 20 mL of acetone. To this solution was added 80 mL of 1,1,2-trichloro-1,2,2-trifluoroethane (freon). The amount of spraying and possible accelerants were investigated to optimize fingerprint visibility.

The best procedure consisted of spraying the article with several light coats and illuminating with ultraviolet light. Spraying too heavily or heating the article usually resulted in a background fluorescence that severely limited the reagent's sensitivity. A Mineralight, Model UVG-54, ultraviolet (UV) lamp was used for both development and inspection of the fingerprints. One should closely monitor the development of the fingerprints to ensure maximum visualization, since overdevelopment will lead to photodecomposition of the dansylation product.

The sensitivity of the dansylation reaction was compared with the ninhydrin/zinc chloride reaction on darkly colored papers such as cardboard and brown papers. Samples were made by placing a series of consecutively weaker fingerprints on these substrates. The samples were allowed to age for various periods of time before treatments were begun. The samples were cut in half; one side was sprayed with ninhydrin and accelerated by heating while the other side was sprayed with DNS-Cl and accelerated with ultraviolet illumination. As the fingerprints in the series became sufficiently weak, the ninhydrin developed side was no longer visible while detectability was still maintained on the DNS-Cl side. The superiority of DNS-Cl for these types of substrates was demonstrated regardless of the age of the fingerprints. Figure 1 depicts a typical comparison on a dark brown paper. Figure 1 (left) shows the room light photograph of a print the left half of which was treated with ninhydrin and the right half of which was treated with dansyl chloride. Figure 1 (middle) shows the right half of this print under the UV light (100 mW) from an Ar-laser. An UV lamp can be used instead of the Ar-laser operating in

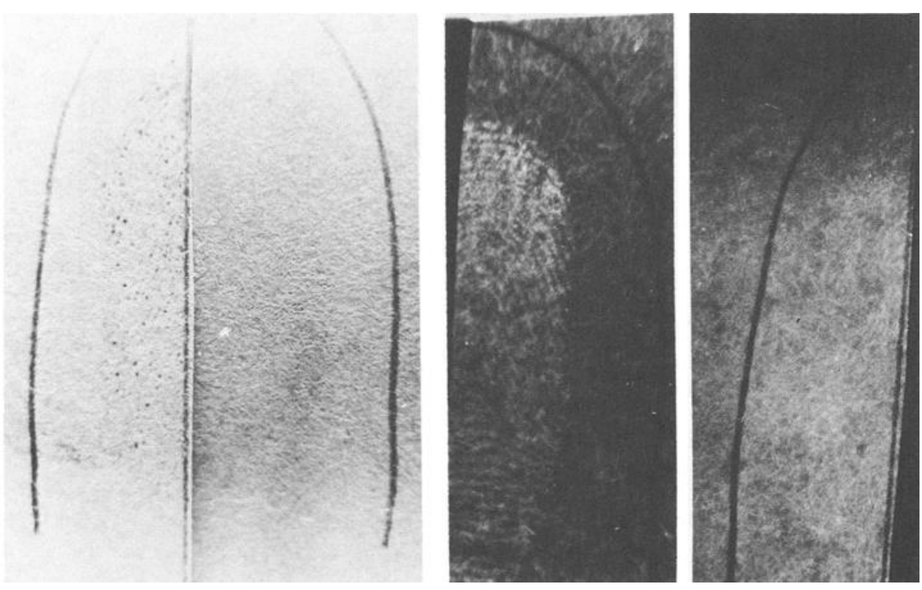

FIG. 1—(left) *Room light photo of latent print on brown paper treated with ninhydrin* (left half) *and dansyl chloride* (right half). (middle) *Right half of print in* (left) *developed under UV Ar-laser excitation.* (right) *Left half of print in* (left) *under blue-green Ar-laser excitation after zinc chloride.*

the UV mode. Indeed, contrast is on many papers better with the UV lamp. On the other hand, the laser is able to produce stronger fluorescence. The left half of the print was finally treated with zinc chloride and examined under the blue-green output from an Ar-laser. This examination was unsuccessful, as seen in Fig. 1 (right).

To optimize the visibility of dansylated fingerprints, their spectroscopic characteristics were investigated. The excitation and emission spectra of dansylated fingerprints were measured and found to agree closely with those previously reported by others for assay of amino acids [*6*]. The absorption maximum was at 360 nm, making an ultraviolet lamp and the UV lines of the Ar-laser suitable excitation sources. The emission spectrum peaked around 475 nm. One should use a long-wavelength-pass filter which cuts off wavelengths below 400 nm when photographing dansylated fingerprints. If contrast with any background fluorescence presents a problem, an interference filter with a center wavelength as close to 475 nm as possible should be used.

9-Methylanthracene

The failure of rhodamine 6G (rh 6G) on certain substrates has prompted investigation of staining with 9-methylanthracene followed by inspection under UV light either from an UV lamp or an Ar-laser. With the latter, particularly when a large laser is on hand, stronger fluorescence can be obtained. Vapor staining of wood and leather articles showed 9-methylanthracene to be a suitable dye for fingerprint detection. Prints were placed on a varnished wood surface and allowed to age overnight. The article was then fumed with cyanoacrylate ester (CA) and vapor stained with 9-methylanthracene. The chemical was readily vaporized from a beaker on a hot plate and quickly adhered to the fingerprints, yielding good ridge detail and contrast with the background. Figure 2 depicts a fingerprint developed in this fashion. No ridge detail was visible in room light. During the time required to photograph the article significant fading of the fingerprint occurred. It was found that CA fuming after treatment with 9-methylanthracene would prevent fading.

Fingerprints were placed on several leather samples with different surface textures to test the feasibility of simultaneous CA and 9-methylanthracene fuming. Fingerprints on these arti-

FIG. 2—*Latent print on wood vapor stained with 9-methylanthracene following cyanoacrylate fuming and developed under excitation with an UV lamp.*

cles ranged from fresh to one day old. The articles were placed in an aquarium and subjected to both fuming processes at once. Initially the hot plate was set at a high temperature to quickly vaporize both fuming agents. Approximately 5 min later the temperature was lowered by way of a transformer to maintain convection currents in the aquarium. The articles were fumed for approximately 30 min. Inspection of the leather articles revealed good development on most of the fingerprints less than 2 h old. Prints one day old were developed on some of the articles. Figure 3 depicts a fingerprint developed in this fashion. The fluorescence intensity was monitored and showed the print to be quite durable. Simultaneous fuming with CA and 9-methylanthracene has been the best procedure found to date for developing latent fingerprints on porous objects which exhibit intense background fluorescence under the argon blue-green lines, and which are unsuitable for development with ninhydrin or dansyl chloride.

Since a number of surfaces exhibit blue fluorescence under ultraviolet illumination, contrast with the blue 9-methylanthracene fluorescence is at times insufficient. It would be preferable to have a vapor staining dye that exhibits green fluorescence under UV excitation. The coumarin dyes have this feature, but fail to exhibit the needed preferential adherence to latent prints. However, we find that the vapor staining sequence cyanoacrylate ester/9-methylanthracene/coumarin 535 is effective and produces much stronger fluorescence than the CA/9-methylanthracene fuming alone. Although the coumarin 535 (Exciton Chemical Co.) does not adhere preferentially to either the fingerprint residue or the cyanoacrylate ester polymer that forms on latent print ridges, it adheres preferentially to the 9-methylanthracene, which, in turn preferentially adheres to latent prints after cyanoacrylate ester fuming. Figure 4 shows a latent print developed under the UV light (100 mW) of an Ar-laser following the fuming with cyanoacrylate/9-methylanthracene/coumarin 535. The detail and fluorescence strength were much superior to those under the laser before the coumarin 535 fuming step.

Attempts were made to solution stain nonporous articles with 9-methylanthracene. Painted metal cans and colored plastics were used as test substrates. After CA-fuming the substrates, a solution of 9-methylanthracene dissolved in cyclohexane (nonpolar solvent) was poured over them. Fingerprint enhancement was often obscured by adhesion of the dye to the substrate. Subsequent rinsing offered no improvement. The solution was diluted and the articles were stained again, revealing far improved contrast with the background. Figure 5 depicts a finger-

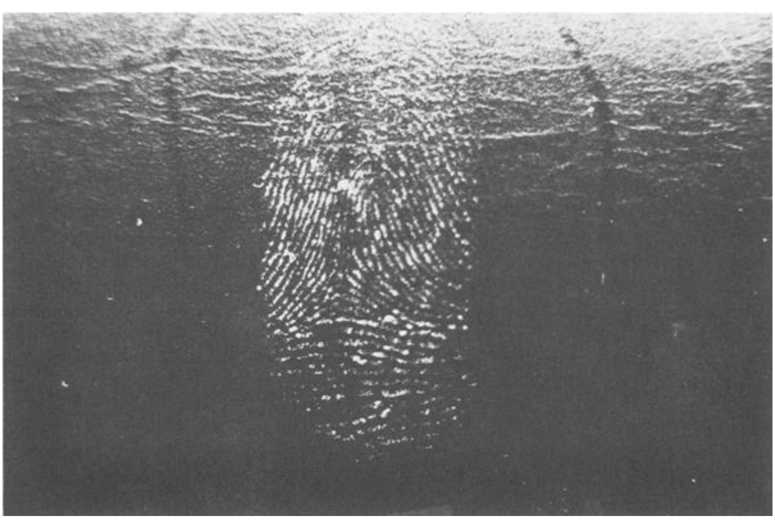

FIG. 3—*Latent print on leather fumed with cyanoacrylate, vapor-stained with 9-methylanthracene, and developed under UV Ar-laser illumination.*

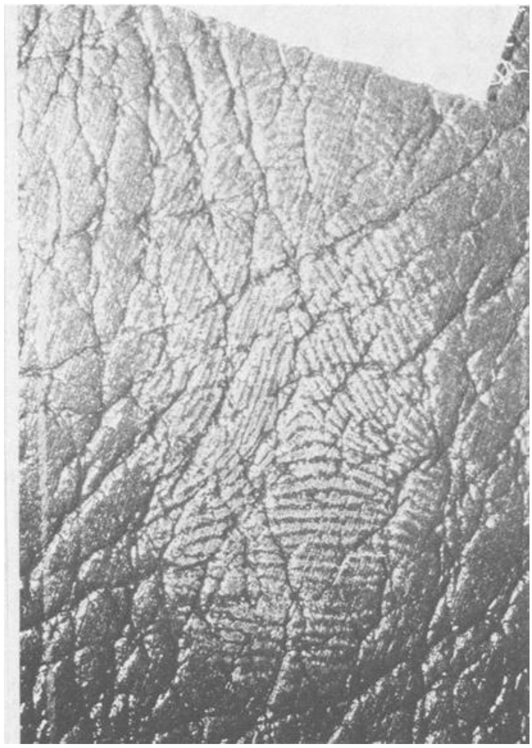

FIG. 4—*Latent print on leather developed by UV Ar-laser after cyanoacrylate/9-methylanthracene/coumarin 535 fuming. See text.*

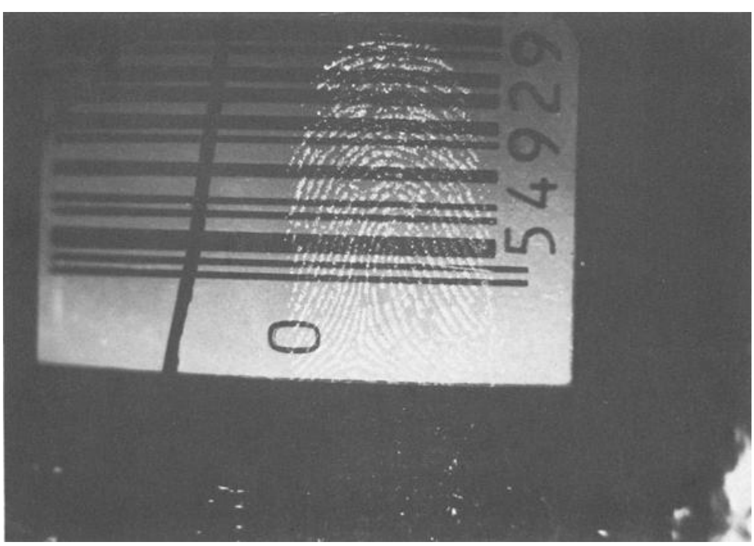

FIG. 5—*Latent print on painted metal developed by UV lamp after cyanoacrylate fuming and 9-methylanthracene solution staining.*

print developed in this manner with an UV lamp. An Ar-laser can be substituted. It was found that no single concentration was suitable for all types of nonporous substrates. It should be noted that rhodamine 6G shows some fluorescence under ultraviolet illumination. If an article has been previously stained for examination under the argon laser's blue-green output and a significant substrate fluorescence is found, one should then examine the article under UV illumination. Significant improvement in contrast may result. Figure 6 shows a print on a painted metal can, developed under UV Ar-laser light after CA/rhodamine 6G staining.

Fluorescent Dye Pink (74613-80, La Pine Scientific Co.) has been reported to fluoresce under UV light and can be used to solution stain latent prints.[3] We find, however, that solution staining for UV illumination is not nearly as good generally as rhodamine 6G solution staining in concert with blue-green laser light after cyanoacrylate ester fuming [*2*].

The spectroscopic characteristics of 9-methylanthracene were investigated and closely agreed with data previously reported [*9*]. Dilute solutions of 9-methylanthracene in cyclohexane show two strong absorption peaks located near 385 and 365 nm, and a strong emission peak near 415 nm, with a weaker emission peak near 440 nm. Again, both an UV lamp and the UV output of the Ar-laser are suitable excitation sources.

Summary

Although lasers significantly improve the sensitivity with which latent fingerprints can be detected, some surfaces that are highly fluorescent under blue and green illumination limit

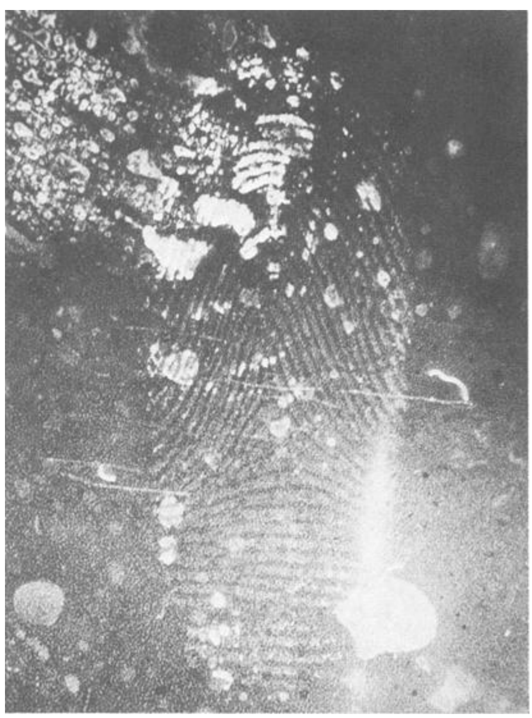

FIG. 6—*Latent print on painted metal developed by UV Ar-laser after cyanoacrylate fuming and rhodamine 6G solution staining.*

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this sensitivity. Complementary procedures, based on UV light, show promise when dealing with these substrates. These procedures, it should be noted, are not designed to replace present procedures on all substrates, but rather to complement present laser techniques if background fluorescence presents a problem. Dansyl chloride, as a chemical reagent, is suitable for papers that fluoresce strongly under blue-green light and 9-methylanthracene vapor staining can be effective on both porous and nonporous substrates that show similar fluorescences. Finally, coumarin 535 fuming after 9-methylanthracene can be very effective. We have not found a very satisfactory solution staining counterpart to date.

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