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Laser Detection of Latent Fingerprints—Treatment with Phosphorescers

Previous articles in this journal [*1,2*] have described the detection of latent fingerprints by argon-ion laser. Basically, the procedure involves illumination of the exhibit under scrutiny with the light from a continuous-wave argon-ion laser followed by observation and photography of the luminescence from the latent print. The luminescence can be inherent fingerprint luminescence, fluorescence arising from treatment of the print with fluorescers (fluorescent dusting powders or fluorescent dyes) [*1-3*], or fluorescence resulting from chemical treatment of latent prints. Such chemicals (fluorescamine, *o*-phthalaldehyde, *p*-dimethylaminocinnamaldehyde) react with fingerprint material in a manner analogous to ninhydrin to form fluorescent reaction products [*2*]. Thus, laser detection of latent prints takes on a wide range of applicability.

However, in all these procedures, fluorescence from the substrate holding the latent print can be problematic. For instance, fluorescamine may fail if strong green or yellow substrate fluorescence occurs. The same problem applies to inherent fingerprint luminescence. *p*-Dimethylaminocinnamaldehyde can fail when there is strong orange substrate luminescence (for example, from some papers, woods, and cardboards).

It would be useful to have a procedure whereby the substrate luminescence, which is generally fluorescence, can be entirely eliminated. A latent fingerprint treatment leading to *phosphorescence* would accomplish this.

Before proceeding to the demonstration that phosphorescence can lead to much improved fingerprint detection, we outline an operational distinction between fluorescence and phosphorescence. Let us suppose that a light beam illuminates a luminescent sample. If the light is suddenly shut off, the sample luminescence intensity will decrease with time after the illumination is cutoff according to the relation

$$I = I_0 e^{-t/\tau}$$

where I_0 is the luminescence intensity just prior to illumination cutoff, t is the time after cutoff, τ is the luminescence lifetime, I is the luminescence intensity at time t, and e is approximately equal to 2.72. When I has decreased to about 0.37 I_0, one lifetime has elapsed. Instead of considering the spin multiplicities of atomic or molecular states involved in luminescence, fluorescence and phosphorescence will be differentiated by the length of the lifetime τ. If τ is on the order of 0.000 01 s or less, the luminescence is called fluorescence. If τ is of the order of 0.0001 s or longer, preferably about 0.1 s or longer, the luminescence is called phosphorescence. One sometimes encounters a third type of luminescence, delayed fluorescence. Like phosphorescence, delayed fluorescence is characterized by a long lifetime. For the purpose of this paper, delayed fluorescence can be treated as if it were phosphorescence.

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Procedure

If a latent print treatment that leads to phosphorescence is on hand, then laser detection can be accomplished by the procedure shown in Fig. 1. The laser beam, suitably expanded by a lens, illuminates the treated exhibit. The exhibit is placed into a cylindrical light chopper, which is simply a rotating hollow cylinder with slots, as shown in the figure (top view). The cylinder rotates in the direction denoted by the arrow in Fig. 1 to give a chopping rate in the range 10 to 1000 Hz. During the time the slots of the cylinder admit laser light, the camera does not see the exhibit. The exhibit comes into the view of the camera some time (dependent on the number of slots and rotation speed) after the illumination is cutoff. By the time the exhibit comes into view, the substrate fluorescence has already decayed completely and only the latent print phosphorescence is seen.

Results

Sirchie dual-purpose latent print powder (catalog No. DP 002) is described by the manufacturer as highly fluorescent when exposed to ultraviolet (UV) radiation. Indeed, when the powder is illuminated by UV light a strong yellowish green luminescence is observed. However, the lifetime of this luminescence is on the order of 0.1 s, and thus this powder is a phosphorescent powder within the framework of this text. It responds to blue-green argon-ion laser light also, but not as well as to UV light. A UV-option-equipped argon-ion laser is excellent for illumination, however. To test the detectability of the DP 002 powder using the phosphorescence procedure shown in Fig. 1, a latent print was placed on yellow notepaper. This paper fluoresces a very strong yellow under blue-green argon-ion laser light. The dusted latent print could not be seen in room light. Under the blue-green argon-ion laser light and normal inspection (no light chopper), no ridge detail could be observed because of the overwhelming paper fluorescence. However, once the exhibit was placed into a cylindrical chopper (Princeton Applied Research Model 125A, with the normal chopping wheel replaced by a homemade hollow cylinder with two slots), which rotated at a speed such that the light chopping frequency was 13 Hz, the paper fluorescence was eliminated entirely, and the latent print could be seen readily by its phosphorescence. A photograph of the fingerprint phosphorescence is shown in Fig. 2. The filter (Fig. 1) in front of the camera is not necessary in principle, but it is used to block laser light that might be spuriously scattered into the camera.

Sirchie Fluoromag latent print powder (catalog No. MFP 01), a gray magnetic powder, behaves essentially identically to the DP 002 powder. It, too, shows a green phosphorescence (lifetime on the order of 0.1 s). Emission and excitation spectra of both materials

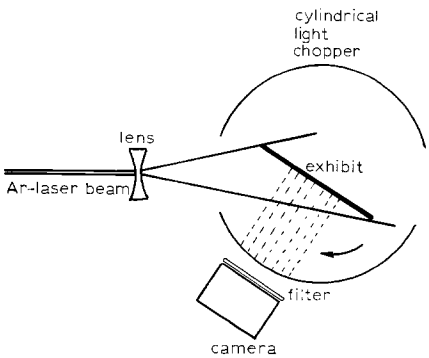

FIG. 1—*Experimental arrangement for laser detection of latent prints by phosphorescence, with elimination of background fluorescence.*

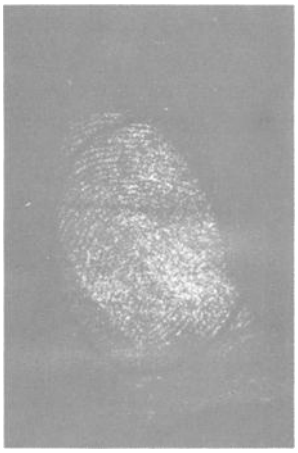

FIG. 2—*Latent fingerprint on strongly fluorescent (yellow) paper dusted with Sirchie DP 002 powder and detected by laser in the phosphorescence mode of Fig. 1.*

reveal a broad luminescence, peaked at about 530 nm, which is adequately excited by wavelengths in the 300- to 430-nm range. Excitation at longer wavelengths can be made, but it is weak. Figure 3 shows the excitation and emission spectral features of the MFP 01 powder. For the excitation spectrum, the emission was monitored at 540 nm. For the emission spectrum, excitation was at 400 nm.

Discussion

The results demonstrate that the detectability of the Sirchie powders can be strongly enhanced when used in the phosphorescence detection mode in those instances in which strong background luminescence occurs. Because phosphorescence is detected, neither the strength nor the color of the substrate fluorescence matters. Phosphorescence detection with a UV lamp is also feasible but is not as effective as with a reasonably powerful UV-option-equipped argon-ion laser. It would be valuable to extend the scope of laser-detected

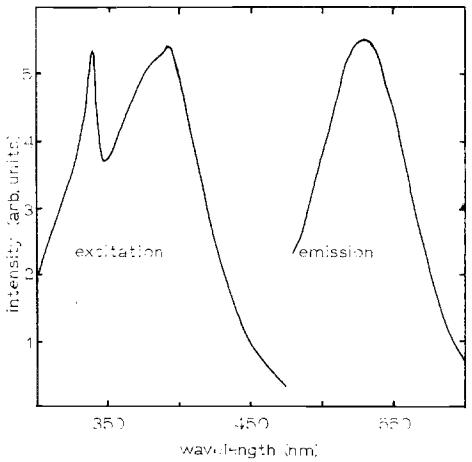

FIG. 3—*Excitation and emission spectral features of the MFP 01 magnetic dusting powder.*

phosphorescence by developing chemical treatments of latent prints analogous to the fluorescent ones [2] such that phosphorescence obtains. This direction is currently under study.

Since the phosphorescence detection mode entirely eliminates background luminescence, even very faint prints can be photographed without difficulty. Arbitrarily long exposures become possible. In instances where the phosphorescent latent print is too weak to be discerned by inspection under the laser, spectroscopic means can be applied to locate the latent print. Thus laser detection of latent fingerprints is further expanded in scope.

References

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