TECHNICAL NOTE

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Infrared Luminescence: Is It a Valid Method To Differentiate Among Inks?

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ABSTRACT: Although infrared luminescence has been accepted as a valid method to differentiate among inks since at least 1963, the effect of household chemicals or body fluids on infrared luminescence properties has not been evaluated. Many ink formulations contain one or more components that luminesce under infrared irradiation. In about 50% of all ink formulations, these components cannot be seen under luminescence. This masking effect was diminished in one of these inks by treating the ink line with body oil, perspiration, acetone, acetic acid, hand lotion, milk, water, Windex®, and twelve other solutions found in a household, allowing the luminescent properties not previously visible to be readily discerned. This phenomenon casts doubt on the reliability of using solely infrared luminescence to differentiate among inks.

KEYWORDS: questioned documents, inks, luminescence, infrared, black luminescence, luminescence-masking components

Infrared luminescence has been portrayed as a valid method to differentiate among inks in the United States since about 1963. Royston J. Packard [*1*], in a paper presented at the 15th Annual Meeting of the American Academy of Forensic Sciences in February 1963, stated, "Various photographic methods have been applied to the nondestructive examination of inks, but with limited success. Of such methods that of infrared luminescence is the most useful, and can be dramatically effective in differentiating some inks." Hoover [*2*] referred to a photographic infrared luminescence technique used in the USSR since 1958, and Somerford [*3*] provided "a historical review of its introduction in this country by Godown, its early application at the Chicago Postal Laboratory by Wilson, and its extensive investigation by Gosling at Eastman Kodak Company."

In June 1980, examination of a questioned signature revealed that the first name luminesced while the surname did not. Visually, the signature appeared to be written with one ink. The signature was examined by the Alcohol, Tobacco, and Firearms Laboratory, Department of the Treasury, which confirmed the signature was indeed written with one ink

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formulation. Whereas the given name luminesced, the surname showed no luminescence under an infrared viewer (Model J, Research Devices, Inc.). Some old technical notes made with a Fisher ball-point pen containing the same blue ink formulation used for the questioned signature demonstrated the same phenomenon. This formulation contained luminescent components that are masked by a nonluminescent component. It was postulated that the written ink line had been disturbed by some substance, probably perspiration, which caused the masking component in the ink to diffuse and allowed the previously masked luminescent component in the ink formulation to become visible.

Experimental Technique

In view of this observation, additional experiments were performed with 20 solutions, including many commonly used around the home as well as perspiration and body oil. Under microscopic examination, all of the solutions were found to either diffuse the masking component or to leach the luminescent components in the Fisher ink formulation. The result was that the writing specimens luminesced to different degrees. It was noted that half of the solutions had little or no effect upon the writing line. The solutions had varying effects upon the visible luminescence, ranging from very bright to barely perceptible using the Model J infrared viewer. Some of the specimens that did not luminesce sufficiently to be visible in the Model J infrared viewer did when viewed with the closed circuit television system available at the Alcohol, Tobacco, and Firearms Laboratory. With the Model J, the Fisher ink appeared nonabsorbing in the infrared mode and dark in the infrared luminescence mode (black luminescence). Some of the solutions were also found to affect black luminescence. This was most perceptible for those solutions that did not induce bright luminescence. Two types of paper were used in the experiment, an unlined white 3 by 5 card and 25% cotton government bond. In most instances the effect of the solution on the ink writing line was not greatly affected by the type of paper. Although none of the solutions luminesced, some did affect the luminescent properties of the paper. The results of these tests are presented in Table 1.

Comments

In any examination of an ink with infrared luminescence, the evaluation should be made relative to the luminescence of the paper. If the ink and paper luminesce at the same level, the luminescence of the ink cannot be distinguished. If an ink luminesces more than the paper, the writing line will be brighter; likewise, if the paper luminesces more than an ink (black luminescence), the writing line will be darker. If a paper does not luminesce, then any luminescence is due solely to the ink. Hence, it is possible for the same ink to luminesce on one paper but not to luminesce on a second.

With regard to their infrared luminescent components, inks can be placed into three classes:

1. The ink contains components that luminesce.
2. The ink contains no components that luminesce.
3. The ink contains some components that luminesce and other components (masking components) that do not.

The third class encompasses about half of all ball-point inks, for example, the Fisher formulation used in the experiment. Some masking components include copper-based dyes, graphite, and carbon.

It will be difficult to differentiate among inks using solely the nondestructive techniques of infrared luminescence because inks in the third class can range from nonluminescent to brightly luminescent depending on their content of masking components and, thus, can become indistinguishable from inks in the first and second classes. Also, as has been shown,

TABLE 1—*Effect of solutions on luminescence of ink and paper and on integrity of ink line.*

Solution	Amount of Luminescence[a]		Disturbance to Ink Line	
	Card	Bond Paper	Card	Bond Paper
Untreated	−2	−2	NA[b]	NA
Perspiration	−1	0	none	none
Skin oil	+2	+1	none	none
Saliva	−1	+1	none	none
Acetic acid 10%	+3	+3	yes	yes
Nitric acid 5%	+3	+2	yes	yes
Acetone	+3	+1	yes	yes
Acetone 10%	−1	+1	yes	yes
Hand lotion	+1	+2	none	none
Hydrochloric acid 10%	+3	+3	yes	yes
Water	−1	+1	slight	slight
Butane	+2	+1	none	none
Clorox®	0	+1	yes	yes
Milk	+3	+2	none	slight
Soda	−1	+1	none	slight
Salt solution	−1	+1	none	none
Vinegar	+2	+2	none	none
Windex	+3	+3	yes	yes
Hair spray	+3	+3	yes	yes
Ammonia	+2	+3	yes	yes
Carbon tetrachloride	+1	+1	none	none

[a] −2 ink luminesces less than paper (black luminescence),
−1 ink luminesces less than paper (black luminescence),
0 ink luminesces same as paper,
+1 visible luminescence,
+2 bright luminescence, and
+3 very bright luminescence.
[b] Not applicable.

ink entries from the same pen and on the same paper can differ in luminescence. Either one or both of the following factors may account for this:

1. A nonuniformity may exist in the paper, which causes localized leaching (or bleeding or diffusion) of the luminescent component(s).
2. Perspiration or other exogenous agents (partial spillage of liquid on the document) may cause selective leaching.

This work has shown that the second can cause a nonluminescent ink to luminesce.

Are there any methods that can guarantee a correct determination? No nondestructive methods are presently known. One method suggested to detect an ink in the third class is to treat the entry with either methanol or ethanol to leach out any luminescent component(s). This makes the entry luminescent if it was previously nonluminescent or more luminescent if previously it was slightly luminescent. Certain cellophane tapes have been observed to cause an ink line to luminesce.

Conclusions

Although infrared luminescence has been accepted and used in the past as a valid method to differentiate among inks, current findings indicate that examiners should use extreme caution in using this method. Before any definite determination is made, some testing is required to determine if the suspect ink contains both luminescent and masking components.

References

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