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TECHNICAL NOTE

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Enhancing Contrast of Fingerprints on Plastic Tape

ABSTRACT: Many of the currently available fingerprinting methods have limited ability to visualize fingerprints on plastic tape without expensive equipment or significant handling of the sample. This is especially true for visualizing fingerprints on black electrical tape. This study sought a hands-off method to produce easy visualization of fingerprints on different types of plastic tape, including black electrical tape, without the need for expensive equipment. The methods selected were to sublime disperse dyes into the tape, both with and without the fuming of cyanoacrylate, everywhere except for where the fingerprint was applied. The resulting color contrasts provided enough differentiation to visualize fingerprints on plastic tape under ambient light. Sequential fuming with cyanoacrylate followed by disperse dyes provided the best visualizations on all tapes, and cyanoacrylate followed by disperse yellow 211 clearly visualized fingerprints on black electrical tape.

KEYWORDS: forensic science, fingerprinting, sublimation dyeing, disperse dyes

Many different methods are available to visualize fingerprints on tape. These techniques typically rely on creating a visual difference between the fingerprint and the background on which it is located by coloring the fingerprint itself. Methods of application range from fumes to sprays to immersion, but in most cases, they require that the contrasting agent (e.g., rhodamine 6G, iodine, cyanoacrylate, ninhydrin, basic fuchsine, etc.) chemically reacts or interacts with the fingerprint (1).

These traditional methods may be damaging to the print (1). They can also be less than effective when the print has no biologic matter available for the necessary chemical reaction. As a result, prints made with household lubricants can be faint even after chemical development (4).

Resolving poorly differentiated latent prints can require specific light sources, lasers or imaging filters. Rhodamine 6G and fuchsine, for example, require a strong UV source or laser to visualize (1,4). This can provide a technological obstacle for some laboratories.

The methods explored in this study differ from the traditional methods in that the intent was to produce contrast by shading the background with distinct visual color. One of the options considered was to immerse the tape in a bath containing a dye that has a greater affinity for the tape than for the fingerprint. However, it was feared that an immersion method increased the potential of washing away material of evidentiary value.

It was decided therefore, to use a sublimation process, with disperse dyes providing coloration to the background of fingerprinted tape samples, minimizing physical interaction with the fingerprint. Disperse dyes are water insoluble colorants with an affinity for various polymer substrates (5). Within this general class of dyes is the subset of sublimation or heat transfer dyes. These dyes provide strong visual color by a sublimation process, which functions differently than the traditional fuming methods familiar to fingerprint examiners.

Unlike iodine or cyanoacrylate fumes, the sublimation grade disperse dyes do not chemically react with the substrate. The dye is heated to vapor. The vapors then penetrate the substrate and crystallize, providing color. This process is used industrially to color a variety of products ranging from textiles to skateboards[3], and can be used to provide color to a variety of plastic tapes (see Fig. 1).

Methods

Fingerprints were applied to sections of a variety of common tapes including: clear mailing tape (3M cat 142), brown mailing tape (3M cat 143) and black electrical tape (Part# 49656)[4]. The tape sections were then fumed with various disperse dyes: alone, concurrent with cyanoacrylate and sequentially with cyanocrylate.

The class, disperse dyes, includes a broad selection of colorants. However, virtually any portion of the visible color spectrum between 400–700 nm can be filled with use of combinations of the proper red, yellow and blue dyes. After preliminary testing, disperse blue 60 (CI: 61104), disperse red 60 (CI: 60756) and disperse yellow 211 (CI: 12755) (7) were selected to be used to fume the tape sections.

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[3] All of the dyes used in this study as well as technical information were provided by Keystone Aniline Corporation, 2501 W. Fulton Street, Chicago IL 60612. 1-800-522-4393.

[4] Textured tapes including silver duct tape, nylon strapping tape and paper masking tape were also evaluated, but did not appear to benefit from the technique. This is in part because the dyes had poor affinity for the material of the tape and in part because texture interfered with the visualization of the finger print pattern.

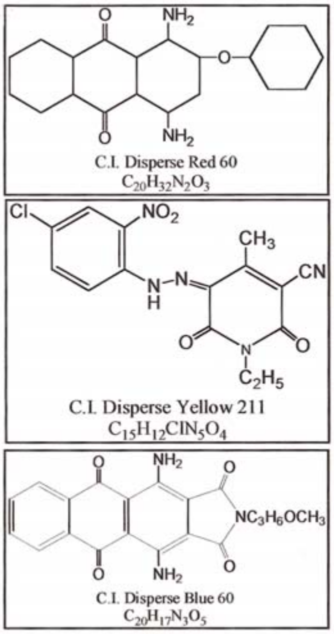

FIG. 1—*Molecular structure of selected disperse dyes. Top: C.I. disperse red 60, $C_{20}H_{22}N_2O_3$. Center: C.I. disperse yellow 211, $C_{15}H_{12}ClN_5O_4$. Bottom C.I. disperse blue 60, $C_{20}H_{17}N_3O_5$.*

Fuming with Sublimation Grade Disperse Dyes

Full sets of fingerprinted tape sections, including all of the tape types under investigation, were placed into a set of sealed jars. Care was taken to make sure that the tape sections did not contact the heating surface because information provided on Keystone Aniline Corporation's technical data sheets indicated that the dyes sublime at temperatures above 200°C. The jars each contained one of the disperse dyes under consideration. The jars were placed on a hot plate until the dye vaporized. They were then removed from the heat until the vapors had cleared. The tape samples were then removed and examined.

Each of the three disperse dyes was found to have good affinity for both the smooth and adhesive sides of the tape, except where the fingerprint was deposited. In all cases, the fingerprint acted like a resist and prevented the dye from penetrating the tape underneath. The effect was to visualize the fingerprints by coloring the background.

For transparent tapes, it was necessary to isolate which side of the tape was exposed to the dye vapor since both sides of the tape are subject to dyeing. This was accomplished by affixing the tape to glass microscope slides before placing them in the jar.

The results of this test were comparable in resolution to fuming with cyanoacrylate; however, due to the variety of the different colors available with sublimation dyes visualization was enhanced (see Fig. 2).

Fuming with Sublimation Grade Disperse Dyes and Cyanoacrylate—One Step Process

Full sets of fingerprinted tape sections, including all of the tape types under investigation, were placed into a set of sealed jars. As before, care was taken to make sure that the tape sections did not contact the heating surface. Each jar contained one of the disperse dyes under consideration and liquid cyanoacrylate resin. The jars were placed on a hot plate until the dye and resin vaporized. The jars were then removed from the heat until the vapors had cleared. The tape samples were then removed and examined.

When the dyes and resin were fumed at the same time, the background was again colored. Although some color was also trapped in the hardened matrix of the cured cyanoacrylate, in general, the dyes had little affinity for the cyanoacrylate and produced only slight coloration of the resin during the curing process. Thus the contrast achieved was enhanced beyond simply using the dye because of the natural whiteness of the hardened resin.

Two Step Enhancing Process

This test was then slightly modified with the fuming being done sequentially. The tape sections were prepared as described in the one step process, except that the jars only contained the tape sections and cyanoacrylate. They were then fumed with the cyanoacrylate and allowed to cool for an hour while the resin cured. Dye powder was then added to the chamber and heated to sublimation. The samples were then removed from the heat and allowed to cool. Once cooled, the tape was lightly rinsed with water to remove any excess dye residue from the surface.

Because of the poor affinity the dyes had for the resin, this process yielded the greatest contrast between the print and the background of the tape (see Fig. 3).

Color Selection

The three disperse dyes selected each had good affinity for the different plastic tape types. Therefore, dyes can be selected and combined according to the necessary color requirements. As shown in the curves in Figs. 4–6, combinations of the three disperse dyes will completely fill the visual range from 400–700 nm. Disperse red 60 absorbs light most strongly from 400–530 nm and reflects light above 550 nm. Disperse yellow 211 absorbs light from 400–430 nm and reflects strongly above 500 nm. Disperse blue 60 absorbs from 450–650 nm and reflects both in the 400–450 nm range and the 650–700 nm range.

In general any of the dyes individually tested will aid the resolution on clear tape against a white background. If the tape is over a colored background then a diametrically opposite color should be used. For example, on the opaque brown mailing tape disperse blue 60 provided the best contrast. Where necessary, combinations of the dyes can be used to produce specific colors (e.g., blue + yellow = green).

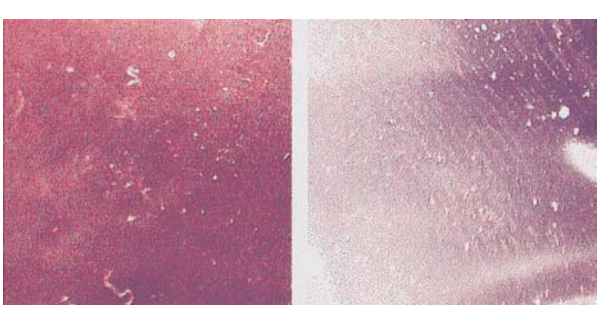

FIG. 2—*Disperse yellow 211 vs. cyanoacrylate. The image of the left is after fuming with cyanoacrylate. The image on the right is after fuming with disperse yellow 211.*

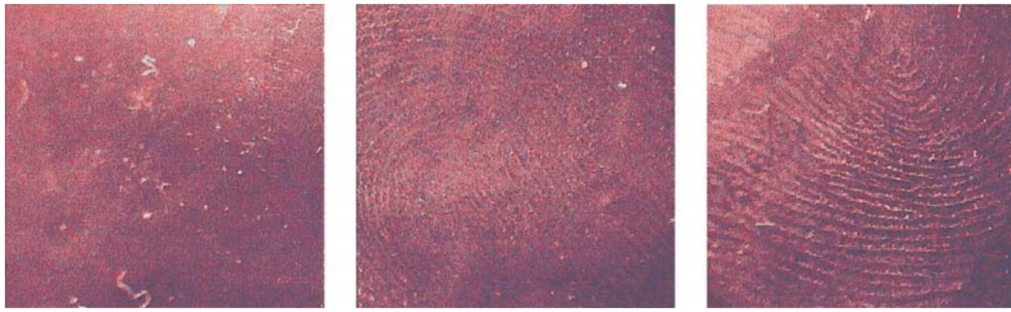

FIG. 3—*Comparison of dyeing methods. Shown here are three pieces of black electrical tape from the same roll. Fingerprints have been placed on all three sections. The image on the left has been fumed with cyanoacrylate vapors. The image in the center has been fumed with cyanoacrylate vapors and disperse yellow 211. The section on the right has been fumed sequentially with cyanoacrylate vapors then with disperse yellow 211. The sections were photographed simultaneously with a CCD camera and a 60W incandescent light source.*

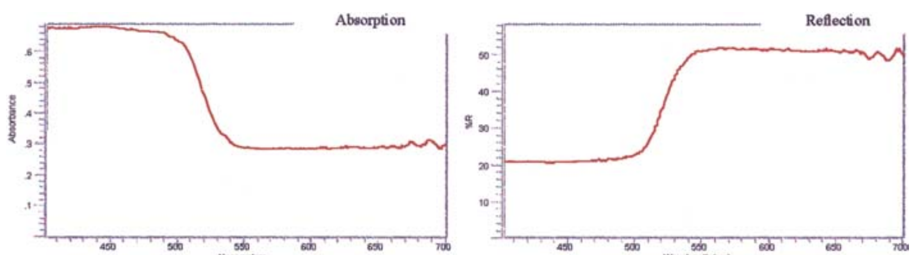

FIG. 4—*Typical absorption and reflection curves for disperse red 60.*

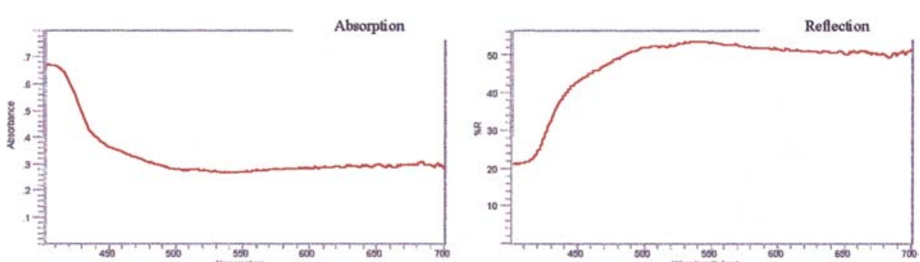

FIG. 5—*Typical absorption and reflection curves for disperse yellow 211.*

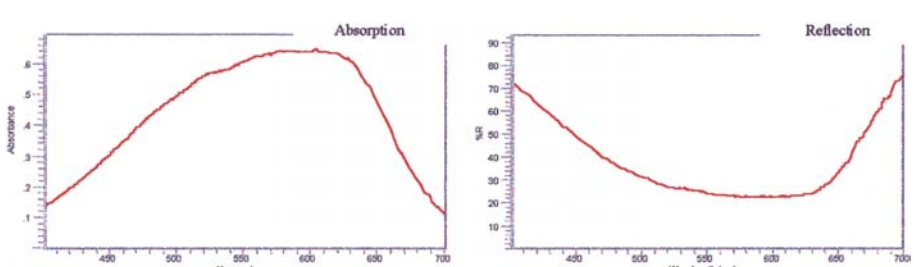

FIG. 6—*Typical absorption and reflection curves for disperse blue 60.*

The most difficult sample on which to visualize a fingerprint was the black electrical tape. However, the disperse yellow 211 noticeably yellowed the shade of the tape 1 to 1.5 units[5], allowing for visual resolution (6).

Results/Discussion

Fuming with dispersed dyes is no more difficult in execution than the existing methods for resolving fingerprints on plastic tape and there are benefits specific to this method. The dyes used penetrated into the tape, dyeing it, giving a permanent inverse image of the fingerprint that will not wash or rub off. As long as a resistive layer remains on the surface of the tape, sublimation grade disperse dyes can be used to provide differentiation even after the biologic matter in the print has broken down. Because the dyes color the tape rather than the fingerprint, this method can provide differentiation of fingerprints made with a variety of mediums.

Simply fuming with disperse dyes resolves the fingerprints at least as well as existing methods such as fuming with cyanoacrylate, while also enhancing visualization through a choice of colors. Fuming with disperse dyes and cyanoacrylate provides better resolution than fuming with only cyanoacrylate as well as enhancing visualization through color differentiation. However, the best results were obtained by utilizing a two step process: fuming first with the cyanoacrylate and then fuming with a disperse dye. This two step process yielded excellent resolution, even on the difficult substrate of black electrical tape, and excellent visualization without the need for special light sources.

[5] The shade shift was measured using the AATCC Chromatic Transfer Scale.

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