Document Title: Specific Heat Capacity Thermal Function of the Cyanoacrylate Fingerprint Development Process, 2012

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Abstract

Multiple methods were explored to increase the resolution of fingermarks obtained through cyanoacrylate (CA) fuming, or improve the ease of resolving fingermarks.

The first method explored was the development of sublimation based co-polymerized coloring. This research stream is an expansion of the work which produced CN-Yellow with an attempt to stretch the excitation range of the fluorescent effect to 530 nm so that it can be used with existing lasers. Many different colorants were evaluated for appropriate fluorescent responsiveness. Once appropriate colorants were identified, they were co-fumed with CN-Yellow in a closed chamber and evaluated with an ALS for detection at 530nm. Colored CA Fingermarks, detectable with a 530nm laser, were successfully produced.

The second method explored was the modification of evidence temperature. Samples of multiple materials were cooled 6°F-20°F below ambient and were CA fumed side by side with fingermarks which had not been cooled. The resulting fingermarks were weighed, tested for opacity and color uptake via dye staining. Our research as shown improvements in visibility: due to increase in opacity and color uptake, of CA fingermarks when the evidence is cooled 6°F-20°F.

The third method explored was the use infrared detection. Fingermark samples were prepared on Plexiglas and aged for two weeks to allow them to fade. The samples were then examined with infrared cameras at ambient temperature and cooled to force condensation and improve infrared visibility. While methods did yield fingermarks, no

prints were resolved which would not have been detectable by more economical visible light means.

The fourth aspect of the research was to find a way to disperse nano-particles onto CA prints. Nano-particles can be applied in a variety of ways ranging from spraying liquid dispersions to creating dust clouds. However, when the particles are produced on the fingermark itself, it is possible to lock the color into the CA matrix with subsequent fuming. Carbon black nano-particles were therefore produced by burning oil and directing the vapor stream onto the print.

The final aspect of the research was to develop a commercially viable temperature and humidity controlled chamber to chill the evidence and allow for standard fuming. A unit was developed and can be purchased through Sirchie Corporation.

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Executive Summary

There are many existing methods for evolving and visualizing fingermarks with cyanoacrylate (CA). This research is directed to produce methods to enhance fingermark recovery. The research includes five aspects each designed to either increase the ease of fingermark development or increase the sensitivity of the fingermark development process.

Expansion of Absorption and Emission Spectra of CN-Yellow to 530 nm

The first aspect of the research was expansion fluorescent excitation range of CN-Yellow to 530 nm. CN-Yellow is a subliming polymer that can incorporate color in a single fuming step when used in place of traditional CA. CN-Yellow produces a yellow fingermark which fluoresces when excited by photons from 365nm to 505 nm. The reasoning behind the desired expansion was that multiple agencies with limited budgets have already invested in single wavelength ALS at 530nm, a wavelength that works with some existing latent chemistries.

Many colorants were examined for fluorescence and visibility at 530nm. Though this trial and error process, multiple dyes were identified a candidates. Through subsequent testing, a sublimation dye, Sublaprint Red R70011 was identified as the best performer.

When heated by itself onto a white tile with cleanly deposited fingermarks, the Red R70011 produced colored prints visible when viewed with an ALS between 470 – 530nm. However, even though the dye adhered to the fingermarks there was no stability in the matrix, and the dye could be easily removed. The next step of the research was to combine the Red 70011 with CN-Yellow and determine if the dye could be locked the CN-Yellow matrix and adds to the chromatic effect.

A series of cleanly deposited fingermarks on American Olean glazed ceramic white wall tiles were allowed to age for a minimum of two days before testing started. Vapor streaming and chamber tests were conducted using a custom built mica-topped hot plate with temperature ranges between 100 – 900 degrees F. Dye materials and CY-Yellow were burned in Tri Tech Forensics aluminum fuming trays and the temperatures were taken with a TIF 7800 quick TEMP Infrared Thermometer with laser sighting. All measurements were taken using a digital Acculab Scale with sensitivities between 0.001 – 120g, and a 12 cubic foot custom build cyanoacrylate chamber was used for all full scale tests.

For visual inspection a Rofin Polilight Flare Plus with removable heads and Sirchie orange and red barrier filters were used for all photography and result determination.

The first test conducted was a visual half and half mixture, heated at a temperature of 450 degrees Fahrenheit. The complete mixture was allowed to sublime off with the tile held between 4-6 inches away before a full visual inspection was made. Positive results between 365-530nm were obtained with stable fingermarks locked in the cyanoacrylate matrix.

Ratio tests using the vapor streaming technique were conducted starting with a set 0.5g of CN-Yellow and an equal weight of R70011. Ratios were then adjusted. The CN-

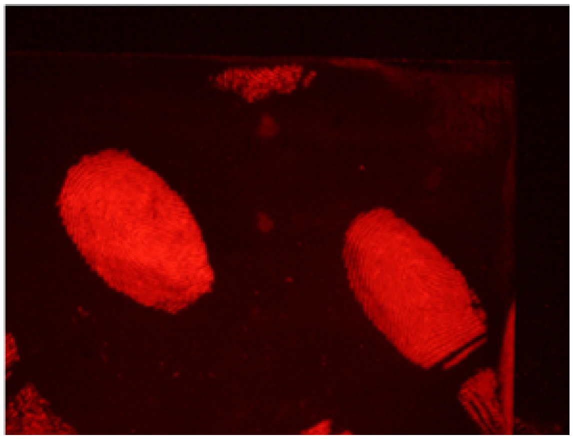
Yellow amount remained the same and the amount of R70011 was decreased 0.1g at a time.

Through multiple tests, a ratio of 0.5g CN-Yellow to 0.1g R70011 was proven to be the best working ratio for vapor streaming the sublimation material. Consistent results with fluorescence between 365 – 530nm were achieved on multiple substrates, include: white tile, glass, plastics, aluminum, and steel.

This ratio increases linearly for full sized chamber tests. The dye mixture works in a standard cyanoacrylate chamber, hot plate requirements of 450 °F, and a steeping period of between 10 – 15 minutes. For the test chamber of 12 cubic feet, a ratio of 3g CN-Yellow to 0.5g R70011 provided the best working results.

After multiple tests on varies substrates the only limitation for this material appeared to be on copper, where the fluorescence faded after a few days. As desired, a sublimation material has been created to assist agencies with limited ALS wavelengths. Fingermark detection at 530nm was successful. (Image 1)

Image 1



Fingerprint Evolved with Red 70011

Cyanoacrylate Dew-Point

The second aspect of the research focused on improving the visibility of deposited CA by varying the temperature of the evidence relative to the ambient in an enclosed chamber environment. Testing has shown that if evidence is cooled, fingermarks developed with CA fuming become more visible.

Image 2 shows three test tubes. The top test tube was processed at 46°F; the middle test tube at 65°F and the bottom test tube at 74°F. Images were obtained using oblique lighting. <u>All three test tubes were simultaneously processed in the same chamber. The only difference was the test tubes surface temperature.</u>

Image 2

Previous research as shown that visibility increases when the evidence temperature was 5°F cooler than the ambient temperature. When the evidence sample was more than 20°F cooler than the ambient no additional increase was observed. Beyond this, the greatest visual impact was seen at specific temperatures for each material. [1] (Table 1)

Table 1

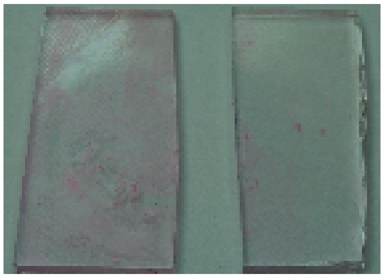
Material	Processing Temp
Steel	65°F
Copper	71°F
Glass	46°F

To confirm previously observed phenomenon and to quantify the increase of visibility of CA fumed fingermarks, three materials were tested: glass, copper, and a zinc/steel alloy. For the glass tests fingermarks were deposited on test tubes and pieces of plate glass which could be weighed before and after fuming to determine deposition. The copper samples were cut from thin copper sheeting used for decorative banding. The steel samples were common steel/zinc washers.

Finger or palm prints were placed on each of hundred preweighed pieces of each material type using medium pressure. The items were then grouped in sets of 25 with one-half being refrigerated and one-half stored at room temperature. When the refrigerated group reached what we earlier asserted as the optimum temperature (see table 1), one group of 25 items were removed from the refrigerator and quickly placed into the fuming chamber with the 25 identical room temperature samples. After the cyanoacrylate was vaporized, the material was left in the chamber for 10 minutes to allow complete polymerization to occur.

After fuming, the materials were removed from the chamber, weighed and examined visually to note any difference in appearance. The statistical increase in the deposition of mass of the cyanoacrylate is too close to the uncertainty of the scale used to give a meaningful statistical value. But consistently an increase in visibility was observed in the cooled samples.

Image 3



Cooled vs Uncooled samples post dyeing

Samples of finger prints on glass were measured for the relative turbidity of cooled vs. uncooled samples using a Continental Hydrodyne Turbidity meter. The turbidity of the cooled sample was 50.2 NTU vs. the ambient sample which was 25.4 NTU.

Cooled and uncooled samples were also subjected to dye staining with Rhodamine 6G. The cooled sample accepted approximately 2.33x the amount of dye as the uncooled sample more dye. (Image 3)

In addition, the fluorescent strength of the post-dye staining cooled samples were 3x to 5x the strength of the uncooled samples.

Forced Condensation with Infrared Detection

The third aspect of the research was to produce a method for viewing fingermarks with Infrared Detection. It had been observed, that condensation on cold evidence preferentially initiated on fingermark residue and was detectable with infrared cameras. It was the intent of this aspect of the research to utilize this phenomenon to visualize fingermarks.

To begin the investigation, four inch by eight inch sheets of clear, 1/4 inch thick plexi-glass were marked into a grid of 20 squares and numbered 1-20. The researcher's hands were washed thoroughly and his right index finger was used to deposit one fingermark into each square intentionally decreasing the deposition as he progressed. The last deposited prints were substantially less visible than the first.

The samples were examined after two weeks and viewed under fluorescent, incandescent, and 505nm light sources and the fingermarks were determined to have substantially diminished in visibility. While the first deposited fingermarks were still observable there was an incremental decrease in visibility with the last deposited prints being undetectable under any light source.

A Better Light camera back scanner Model 6000-HS was positioned into a Crown Graflex large format camera which was mounted on a horizontal camera stand. The device has a pre-scan function for viewing a low-resolution image that can then be adjusted before capturing the highest resolution image of 144 megapixels that was used to verify the focus. The prints that were still visible were then photographed utilizing direct-reflective lighting with an incandescent light source and oblique lighting with a Rofin Polilight Flare Plus using a 505 nm head. The last deposited prints were not observable under any lighting conditions.

The Rofin Polilight Flare Plus fitted with a 940 nm LED head and was placed approximately 12 feet from the sample. The visible prints on the plexi-glass were then photographed with a Fuji digital SLR capable of capturing IR images and scanned with the Better Light.

The samples were then cooled to 42 °F and removed from refrigeration. With the 940 nm light source the "forced condensation" effect made the previously latent prints visible and easy to photograph with the Fuji SLR. The Better Image scanner could capture the detail in the pre-scan mode but the rate of evaporation inhibited the successful capture due to the minimum scan time of 35 seconds.

The samples were then exposed to traditional cyanoacrylate fuming and as expected, all of the fingermarks that were deposited became visible confirming that the fingermark residue was still present.

Multiple types of materials including white and blue ceramic tile, aluminum, copper, and PET clear water bottles were tested in the same manner.

The prints that were visible under traditional lighting methods were easily captured under IR lighting. While the resolution of the Better Light Scanner is superior, there is not increased sensitivity resulting in additional fingermark details being captured. When the cameras were then focused on the squares of the plexi-glass containing the last deposited fingermarks that were not visible under any traditional lighting, images were obtained, but we were unable to capture any ridge detail of these prints under these conditions.

On materials other than plexi-glass where, latent fingermarks deposited without the addition of foreign substances, fingermarks were not able to be captured by utilizing an infrared 940 nm light source and a high resolution 144 megapixel digital scanner.

Although it was possible to resolve fingermarks using Infrared Imaging, even with the inclusion of forced condensation, we were not able to achieve fingermarks which were not viewable with visible light techniques.

Nano-Particle Dispersion Fingerprint Development System.

The fourth aspect of the researched focused on the use of nano-particles pigments. Pigments differ from dyes in that they carry their color in their pigmented form. They are opaque so give a solid color rather than adding to the color of the background as a dye would. In a forensic application, they have the advantage of high visibility. However, as solid particles they have the disadvantage of potentially obscuring fine detail in a fingermark.

To get the advantage of the solid color and opacity and minimize the effect of particulate interference, nano-pigments are used. Nano-pigments are solid colorants which have a particle size of less than one micrometer. They are used in a variety of applications most notable coatings and printing inks. In fingerprinting, in addition to being less obscuring, the small particles size is also more likely to find purchase in the uneven surface of the CA print.

Nano-pigments can be purchased or produced in wide variety of colors, filling the entire visible spectrum. However, these experiments were focused on traditional black powered prints because black has the advantage of being highly visible against most colored surfaces.

Several methods were explored for the application of black nano-particles. The methods included fused, pyrotechnic devices which were ruled out due to impracticality and potential hazard.

A water based dispersion of 10% a sub-micron ground carbon black pigment and 10% acrylic binder was also used. In this case, the dispersion adhered well to the fingermark but also tended to color the background.

The approach that was finally selected was to produce the pigments on the fingermark itself. The carbon black pigments were produced by burning oil and directing the vapor toward the fingermarks. When the fingermark was 10 inches from the flame, the particles that formed on the print were less that one micron in diameter. (Image 4)

Image 4

Fingerprint Evolved with nano-black method

Carbon soot also formed on the area around the print, but was easily brushed away. Carbon particles are highly porous and readily absorb oil and moisture they impact. As a result the carbon adheres better to the fingermark than the surface around it.

Once the carbon has been deposited, the fingermark can be fumed with CA following the traditional methods. Processing the fingermark in this two step manner produces strong black fingermarks with the carbon black locked into the matrix of the resin.

The method offers some unique advantages. The first is that it doesn't require the use of messy dusting powders. The second is that the color can be locked into the matrix of the CA. And the third is that it can use recycled materials. The print seen in the picture above was actually produced by burning used motor oil. And of course, once the finger print is cured, it does not need to be touched or brushed, reducing the potential for damage.

Development and construction of a temperature and humidity controlled environmental chamber for cyanoacrylate fingerprint processing

A two compartment fingerprinting cabinet has been developed with the assistance of Sirchie Corporation. The top compartment of the cabinet is a humidity controlled chamber with a temperature controlled hot plate and a port for wand based fuming. The bottom chamber is a controlled refrigerator which can be used to chill evidence to the desired temperature for the specific evidence material type (Table 1.)

Conclusion

The methods developed, integrate well into current methodology. They can be used singly or in combination with each other. The Temperature and Humidity controlled chamber can be used to set the evidence to the desired temperature as in the Cyanoacrylate Dew-Point experiments. This makes an easy tool to exploit the temperature variations. In this process, the CN-Yellow and Sublaprint Red 70011 combination can be used in place of traditional CA stacking the advantages of the different aspects we present here. It should however be noted that the used of the carbon black nano-pigment with the fluorescent fuming with the CN-Yellow and Red 70011 will seriously reduce the net emission strength of the fluorescent materials.

Over all, the methods developed in these research projects provide ease of use and increased visibility in cyanoacrylate fingermark development.

I. Introduction

1. Statement of problem

The research conducted on this grant was designed to improve the cyanoacrylate based processing of fingermarks. Current methodologies typically color the fingermarks after evidence is fumed at ambient temperature. By modifying the existing processes increases in ease or resolution can be achieved.

2. Literature citations and review

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3. Statement of hypothesis or rationale for the research

Fluorescence Effects

The first aspect of this research is involved with the modification of fluorescent effects of CN- Yellow. CN-Yellow is colored form of Poly(cyanoacrylate) that that allows the evolving of yellow finger prints, which fluoresce when excited between 365 - 505nm with an alternative light source (ALS), UV inspection lamp or equivalent light sources. The polymer is used in place of traditional cyanoacrylate (CA) fuming. Fingermarks recovered with this process fluoresce much like those recovered through dye staining techniques, giving the examiner high quality, easily visible latent images.

CN-Yellow was developed as a way to color fingermarks with florescent fuming color. Fluorescent color was desirable because even if fingermarks are of a different color than substance they are imprinted on, unless there is no overlap in reflection spectra, some of the incident light being used to view a finger print will also reflect off the background causing some optical interference. To overcome this interference, fluorescent materials can be used.

In fluorescence a photon is absorbed by the surface electron of an atom exciting the electron into a higher orbital. As the electron decays back to its original orbit, it will release the energy emitting a photon or lower energy than the photon than excited it. [2] Because the excitation and emission photons are of different energy and therefore wavelengths, fluorescent materials are an excellent way view very faint samples. When a fluorescent material is used to color a fingermark, the incident light can be filtered so that only the emitted light, and thus the only fingermark is viewed.

Another aspect of fluorescent effects is that the strength of the emitted light is relative to the intensity of the incident light. Stronger incident light produces stronger emitted light. Therefore stronger incident lights will be able to view fainter prints.

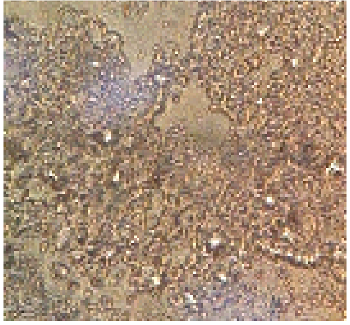
CN-Yellow excites in the range of 365nm to 505 nm, but the lasers used in some labs to provide intense excitation emit at 530nm. Therefore an expansion of the excitation of CN-Yellow to 530 nm was deemed to be desirable.

Temperature Effects on the solidification of Cyanoacrylate

The second and fifth aspects of the research are concerned with modifying the optical properties of Poly(cyanoacrylate) by cooling the sample speeding the rate of solidification.

Under ambient processing conditions, Poly(cyanoacrylate) forms as globs of an essentially clear resin. (Image 5) In fingerprinting applications, this resin can be colored by a variety of means or viewed directly. Regardless of whether or not the resin is colored visualization of Poly(cyanoacrylate) fingermarks is dependent on reflection and refraction.

Image 5



Ethylpolycyanoacrylateat 400x

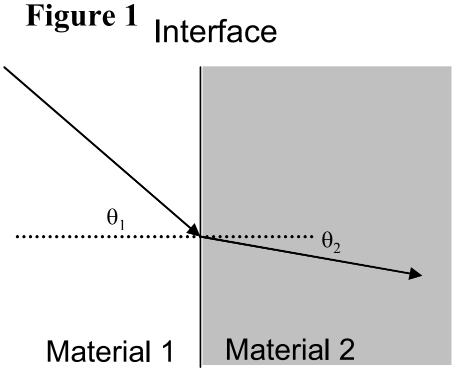
Refraction:

As light passes from one transparent media to another, such as from air to plastic, it will bend relative to the refractive indices of the two materials and the wavelength of the incident light. [3] (figure 1).

Snell's Law: $n_1 \sin\theta_1 = n_2 \sin\theta_2$

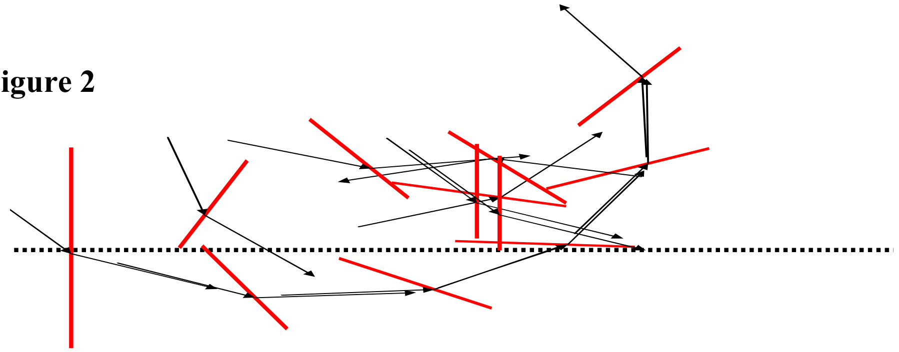
Where:
n_1 = the refractive index of the first material
n_2 = the refractive index of the second material
θ_1 = angel of the incident light
θ_2 = angel of the refracted light

Figure 1



Polymers are a series of semi-ordered to non ordered polymer chains over lapping each other around pockets of air. Light passing through a polymer makes many transitions from air to resin and back again. The more randomly the polymer chains overlap, the more optical distortion alters the path of incident light.

Figure 2



Under conditions of rapid cooling, resins can take on a random lattice-like structures where the interfaces are at angles to each other. (Figure 2) In such cases, even normally transparent the plastic becomes more opaque as light is refracted randomly resulting in a variety of optical interference phenomena.

In fingerprinting applications, increasing the opacity, making the Poly(cyanoacrylate) a cloudy white resin, increases differentiation from colored and dark backgrounds.

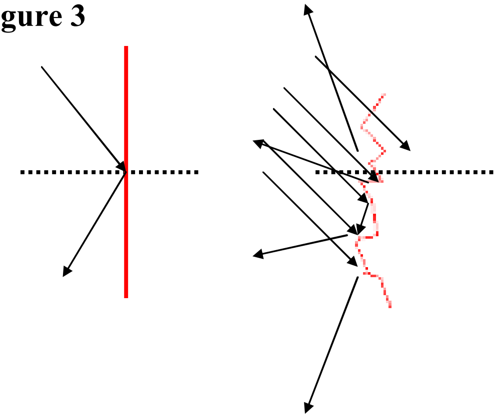
Reflection

When light strikes a reflective surface it bounces off at the opposite angle. When the surface is irregular, the light striking the surface is reflected in many difference directions. (Figure 3)

The randomness of the internal structure caused by rapid cooling can cause the surface to become more erratic, increasing surface area and causing more light scatter.

In fingerprinting applications it can also impact the color uptake. If a dye stain is being used, the amount of color deposited on the fingermark is related to the total surface area. More surface area means more potential dye receptors.

Figure 3



Infrared Capture

The third aspect of the research focused on the capture of latent fingermarks with an infrared capture device. Latent fingermarks can be essentially transparent to visible light (400nm to 700nm). Therefore detection methods which rely on visible light often require additional coloration or optical methods to resolve latent prints.

Infrared cameras actually rely on what is called the Near Infrared (NIR) spectrum, 900nm to 2000nm. Like visible light photons, NIR photons also interact with the surface shell electrons. But, devices using these photons expand the detection range beyond what is normally seen with visible light.

Manufacture of Carbon Black

The fourth aspect of these research projects utilizes the manufacture of carbon black pigments. Commercially carbon black is produced by burning hydrocarbons like oil or natural gas[1]. Which fuel is used is dictated by the process employed and defines the classification of the output. Furnace Black for example, is produced by burning petroleum oil or coal oil. Channel Black is produced by burning natural gas. Acetylene is produced by burning Acetylene. And, Lamp black is produced by burning oils and woods.

The product of each manufacturing process has different properties which make it suitable for different applications. Channel Black, has a high level of purity which makes it suitable for food contact applications. Acetylene Black has a highly ordered crystal state which is needed in electronics. The color of Lamp Black can be modified by the fuel burned, making it useful for inks. And the Furnace Black process is simple to execute, has a high yield and allows for some control of particle size.

The fundamental particle size of furnace black is 10 to 80 nm, in practice these particles form much larger agglomerates up to 5,000nm or greater held together by van der Waals forces. [4] These particles can be broken up by grinding or separated out in production.

When produced by flame, the forming particles are carried by the thermal convection currents. Heavier/larger particles will not fly as far. Particle size can therefore be controlled to some extent by proper placement of the collection vehicle.

In addition to the small particle size carbon black is very porous making it an excellent filtration material and useful for oil absorption. Furnace Blacks are typically sufficiently porous to absorb better than twice their mass in oil. The oil absorption properties make it an excellent pigment for use in fingerprinting as the pores will absorb and adhere to oil and moisture residue in fingermarks.

II. Methods

Expansion of Absorption and Emission Spectra of CN-Yellow to 530 nm

American Olean glazed ceramic white wall tiles with cleanly deposited fingermarks were the principle test material. Vapor streaming and chamber tests were conducted using a custom built mica-topped hot plate with temperature ranges between 100 – 900 °F. Dye materials and cyanoacrylate were heated in Tri Tech Forensics aluminum fuming trays and the temperatures were taken with a TIF 7800 quick TEMP

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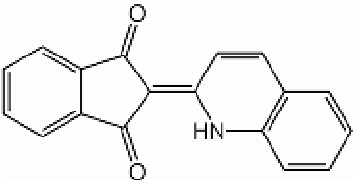
[1] http://www.carbonblack.jp/en/cb/seizou.html

Infrared Thermometer with laser sighting. All measurements were taken using a digital Acculab Scale with sensitivities between 0.001 – 120g, and a 12 cubic foot custom build cyanoacrylate chamber was used for all full scale tests.

For visual inspection a Rofin Polilight Flare Plus with removable heads and Sirchie orange and red barrier filters were used for all photography and result determination.

Many dyes were inspected for their fluorescent properties looking for dyes that would augment the fluorescent spectrum of the CN-Yellow. Of the dyes and colorants tested the best performers were found to be Dense Yellow 33 (Image 6) and Sublaprint Red R70011 (Image 7). These were identified to have the desired optical properties. They would impart a fluorescent color to Poly(cyanoacrylate). Of these R70011 occupied a more desirable color space and was therefore chosen as the test material.

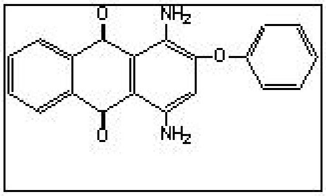
Image 6



Dense Yellow – Smoke Yellow 33, C.I. 47000 $C_{18}H_{11}NO_2$, Transition Temp, 464 °F (Lower in dense form).

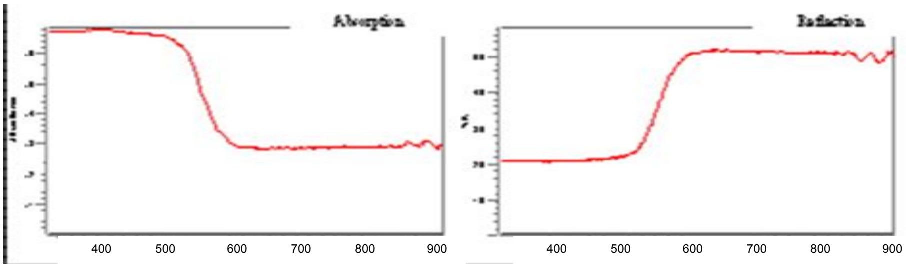
This dye was first fumed onto a white tile with cleanly deposited fingermarks without contaminations was viewed under multiple wavelengths of light using an ALS between 365 – 530nm. The dye exhibited a fluorescent emission when excited between 470nm to 530nm where the dye begins to take on visible color as shown in a standard reflection curve. (Image 8). Based on these successes R70011 was added to CN-Yellow.

Image 7



Sublaprint Red R70011

Image 8



Typical reflection and transmission spectra of Sublaprint Red R70011

A series of white American Olean glazed ceramic wall tiles with cleanly deposited fingermarks were allowed to age for a minimum of two days before testing started. The first test conducted was a visual half and half mixture, fumed at a temperature of 450 °Fahrenheit.

The complete mixture was allowed to sublime from the tin with the tile held between 4-6 inches away before a full visual inspection was made. Positive results between 365-530nm were obtained with stable fingermarks locked in the cyanoacrylate matrix.

Ratio tests using the vapor streaming technique were conducted starting with a weight 0.5g of CN-Yellow. The mass of the CN-Yellow was held constant and the mass of the of R70011 was decreased 0.1g at a time.

Through multiple tests, a ratio of 0.5g CN-Yellow to 0.1g R70011 was proven to be the best working ratio for vapor streaming the sublimation material. Consistent results with fluorescence between 365 – 530nm worked on multiple substrates, include: white tile, glass, plastics, aluminum, and steel.

Image 9

Image 9 shows fingermarks fumed with the mixture of R70011 and CN-Yellow as viewed under various wavelengths. Left to Right: 365nm (No Barrier Filter), 365nm (No Barrier Filter), 415nm, 450nm, 505nm, 530nm.

This ratio increases linearly for full sized chamber tests. The dye/resin mixture works in a standard cyanoacrylate chamber, hot plate requirements of 450 °F, and a steeping period of between 10 – 15 minutes. For our test chamber of 12 cubic feet, a ratio of 3g CN-Yellow to 0.5g R70011 provided the best working results.

After multiple tests on varies substrates the only limitation for this material appeared to be on copper where the fluorescence faded after a few days. As desired, a sublimation material has been created to assist agencies with limited ALS wavelengths. Fingermark detection at 530nm was successful.

Cyanoacrylate Dew-Point

The second aspect of the research focused on improving the visibility of deposited CA by varying the temperature of the evidence relative to the ambient in an enclosed chamber environment. Testing has shown that if evidence is cooled, fingermarks developed with CA fuming become more visible. [1]

Cyanoacrylate fuming was conducted in a controlled environment. The material temperatures, the chamber temperature and humidity were carefully monitored utilizing a digital, infra-red thermometer and a digital hygrometer.

One hundred pieces of each material: glass: test tubes and pieces of plate glass, copper: sheeting used for decorative banding and Steel: steel/zinc washers, were numbered then carefully weighed. Each sample was weighed three times on a scientific, digital scale and the weights were noted. One individual then placed palm prints or fingermarks as appropriate on each sample.

Previous research [1] had shown that visibility increases when the evidence temperature was 5°F cooler than the ambient temperature. When the evidence sample was more than 20°F cooler than the ambient no additional increase was observed. Beyond this, the greatest visual impact was seen at specific temperatures for each material. (Table 1)

Table 1

Material	Processing Temp
Steel	65°F
Copper	71°F
Glass	46°F

The prepared samples were therefore grouped into four sets 25. Two sets of samples for each material were chilled to the desired temperature, 46°F for glass, 71°F for copper, and 65°F for the steel/zinc washers. Two sets of samples were left at ambient room temperature.

For each test, one group was quickly removed from the refrigerator and placed in the fuming chamber with a group of the same material that had been left at room temperature. Fuming was initiated immediately. The amount of cyanoacrylate was pre-measured and the entire fuming event was timed. After the cyanoacrylate was vaporized, the material was left in the chamber for 10 minutes to allow complete polymerization to occur.

After fuming the test samples were weighed and examined visually to note any difference in appearance. As before the samples were carefully weighed three times and the weights were noted for statistical evaluation.

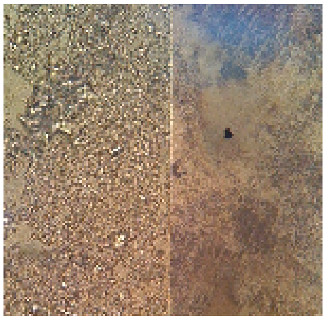
The measured mass of cyanoacrylate deposited when on the cooled samples the samples was on average greater than samples processed at room temperature. However, the uncertainty in data collected is in the same order of magnitude as the values being measured. As a result the actual mass of cyanoacrylate deposited cane only reliably be determined for about 75% of the cooled and ambient samples. This gives a lower than desirable confidence level in the mass data. However, we can state that the resulting mass of deposition at least equal to room temperate processing and offers the potential to improve the resolution of lighter prints.

Ignoring the mass of the deposited cyanoacrylate, visibility was increased in virtually all off the cooled samples when compared to the ambient temperature counter parts.

This visible difference between the cooled and room temperature samples was microscopically detectable. The cooled samples polymerized into substantially smaller globs than ambient temperature samples, visible under magnification. (Image 10) In addition, many long fiber- like strands were seen, indicating that there were many more discrete sites initiating polymerization.

These fiber strands weave together randomly and the smaller particles create a substantial increase in surface area. Assuming that these microscopic geometries are indicative of the pseudo-crystalline habit of the polymer, the increase in opacity seems directly related to the rate of cooling.

Image 10



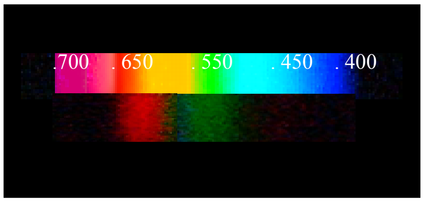
Room Temp Cooled

The macroscopic opacity of the cool prints was measured directly using a Continental Hydrodyne Turbidity meter. Samples of the finger prints on glass from both the cooled and uncooled samples were cut to equal surface area and placed in the Turbidity meter. The average turbidity of the cooled sample was measured at approximately 50 NTU vs. the ambient temperature samples which averaged approximately 25 NTU.

To test the impact on dye uptake fingermarks on glass were developed at two temperatures. Sample set 1 was prepared by cooling the sample to 46°F before fuming at 75°F. Sample set 2 was prepared to 72°F before fuming at 75°F. Each set consisted of 10 pieces of finger printed optical glass.

Both sample sets were then stained with Rhodamine 6G according to the method outlined in the FBI Processing Guide for Developing Latent Prints [5] except that no M.B.D. was used. The samples were stained via dipping for five seconds in the dye solution. Upon visual examination the cooled samples did appear to have significantly more dye adherence and fluoresced more strongly under UV light. (Image 3)

Image 11



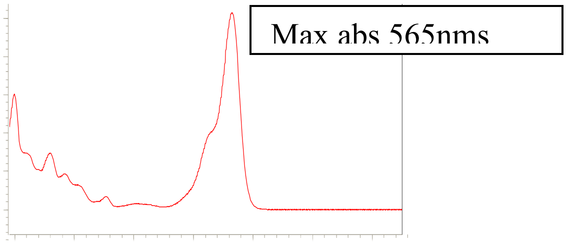
Emission of Rhodamine 6G

The samples were placed in a Turner Fluorometer selected for reflection. Because Rhodamine 6G has a strong emission from 520nm to 650nm (Image 11) the total energy on the detector in this range was collected for each sample when the sample excited. On average the cooled samples exhibited a fluorescence emission INCREASE of 3-5x the un-cooled sample. (Meter readings of 10 to 15V vs. 2-5V)

The samples were then scanned for absorption with a Cary 200 UV/Vis spectrophotometer to determine the actual dye concentration relative to cyanoacrylate deposition. Rhodamine 6G has a strong absorption between 520nm and 580nm peaking near 560nm. (Image 12) Ethyl-Poly(cyanoacrylate) has no appreciable peak at this location and different UV spectra above 340nm. It is therefore possible to quantify the absorption of both components separately via the Beers-Lambert Equation.

Using these data the relative dye concentration per Poly(cyanoacrylate), the cooled samples accepted 2.33x the dye of the un-cooled samples[2].

Image 12



Absorption of Rhoamine 6G

Forced Condensation with Infrared Detection

The third aspect of the research was to produce a method for viewing fingermarks with Infrared Detection. Four inch by eight inch sheets of clear, 1/4 inch thick plexi-glass were marked into a grid of 20 squares and numbered 1-20. The researcher's hands were washed thoroughly and his right index finger was used to deposit one fingermark into each square intentionally decreasing the deposition as he progressed. The last deposited prints were substantially less visible than the first.

The samples were examined after two weeks and viewed under fluorescent, incandescent, and 505nm light sources and the fingermarks were determined to have substantially diminished in visibility. While the first deposited fingermarks were still observable there was an incremental decrease in visibility with the last deposited prints being undetectable under any light source.

A Better Light camera back scanner Model 6000-HS was positioned into a Crown Graflex large format camera which was mounted on a horizontal camera stand. The device has a pre-scan function for viewing a low-resolution image that can then be adjusted before capturing the highest resolution image of 144 megapixels that was used to verify the focus. The prints that were still visible were then photographed utilizing direct-reflective lighting with an incandescent light source and oblique lighting with a Rofin Polilight Flare Plus using a 505 nm head. The last deposited prints were not observable under any lighting conditions.

The Rofin Polilight Flare Plus fitted with a 940 nm LED head and was placed approximately 12 feet from the sample. The visible prints on the plexi-glass were then photographed with a Fuji digital SLR capable of capturing IR images and scanned with the Better Light.

The samples were then cooled to 42°F and removed from refrigeration. With the 940 nm light source the "forced condensation" effect made the previously latent prints visible and easy to photograph with the Fuji SLR. The Better Image scanner could

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[2] A concentration curve of each was not run to put these data into ppm.

capture the detail in the pre-scan mode but the rate of evaporation inhibited the successful capture due to the minimum scan time of 35 seconds.

The samples were then exposed to traditional cyanoacrylate fuming and as expected, all of the fingermarks that were deposited became visible confirming that the fingermark residue was still present.

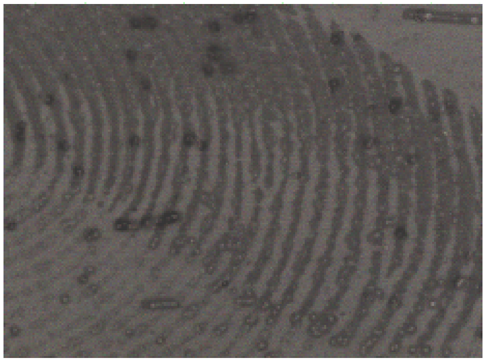
Experiments were also attempted heating the evidence to 100° F to ascertain if it was possible to capture the latent residue with IR as the material cooled. None of the attempts using this approach resulted in being able to visualize any latent prints that were not already visible.

Various evidence types were also exposed to low levels of steam which only resulted in observable prints similar to what is found during the forced condensation process of cooling evidence.

Multiple types of materials including white and blue ceramic tile, aluminum, copper, and PET clear water bottles were tested in the same manner.

The prints that were visible under traditional lighting methods were easily captured under IR lighting. While the resolution of the Better Light Scanner is superior, there is not increased sensitivity resulting in additional fingermark details being captured. When the cameras were then focused on the squares of the plexi-glass containing the last deposited fingermarks that were not visible under any traditional lighting, images were obtained, but we were unable to capture any ridge detail of these prints under these conditions.

Image 13



On materials other than plexi-glass where, latent fingermarks deposited without the addition of foreign substances were not able to be captured by utilizing an infrared 940 nm light source and a high resolution 144 megapixel digital scanner.

Although it was possible to resolve fingermarks using Infrared Imaging (Image 13), even with the inclusion of forced condensation, we were not able to achieve fingermarks which were not viewable with visible light techniques.

Nano-Particle Dispersion Fingermark Development System.

The fourth aspect of the researched focused on the use of nano-particles pigments. Several methods were explored for the application of black nano-particles. The methods included fused, pyrotechnic devices which were ruled out due to impracticality and potential hazard.

A water based dispersion of 10% a sub-micron ground carbon black pigment and 10% acrylic binder was also used. In this case, the dispersion adhered well to the fingermark but also tended to color the background.

The approach that was finally selected was to produce the pigments on the fingermark itself. The carbon black pigments were produced by burning oil reminiscent of the process used to produce furnace black.

The smoke and vapors produced by the oil flame were directed toward the fingermarks. When the fingermark was 10 inches from the flame, the particles that formed on the print were less that one micron in diameter.

Carbon soot also formed on the area around the print, but was easily brushed away. Carbon particles are highly porous and readily absorb oil and moisture they impact. As a result the carbon adheres better to the fingermark than the surface around it.

Once the carbon has been deposited, the fingermark can be fumed with CA following the traditional methods. Processing the fingermark in this two step manner produces strong black fingermarks with the carbon black locked into the matrix of the resin.

Development and construction of a temperature and humidity controlled environmental chamber for cyanoacrylate fingermark processing

Image 15

The environmental chamber, a two compartment fingerprinting cabinet that was constructed for this project by the Sirchie Corporation is intended to improve and automate the cyanoacrylate fuming process in the development of latent fingermarks on non-porous evidence types. (Image 15) It is unlike other cyanoacrylate chambers in that it is two compartments. The top compartment of the cabinet is a humidity controlled chamber with a temperature controlled hot plate and a port for wand based fuming. It is also equipped with wave length specific LEDs to enable the examiner to view fingermarks as they become visible when utilizing one of the fluorescing cyanoacrylate-dye blends developed during this project. The bottom chamber is a controlled refrigerator which can be used to chill evidence to the desired temperature for the specific evidence material type (Table 1.)

With the exception of the temperature of the refrigeration unit, a small circulation fan, and the maximum temperature of the hotplate in the fuming chamber, all functions are controlled by a central, PC based relay. The fan and temperature controls are separate from the relay but located on the control panel of the device. Modifying the relay's program is straight-forward and simple for any user with basic computer skills and adjustments can be saved as files for future use. The purpose of having these various settings is to compensate for differing evidence types, atmospheric conditions, or fuming materials. The high temperature hotplate was necessary because at the beginning of this phase of the research, the only fluorescing dye blend that was available was CN-Yellow which requires a hot plate temperature of 450° F or better to sublime. The most recently developed dye blend that gives us the expansion to 530 nm only requires a hotplate temperature of 250°F to commence the sublimation and provide latent print development.

The first step is set the refrigeration unit to the desired temperature for the evidence. Our unit was adapted from a commercial, two door freezer/refrigerator with the cooling component located on the bottom to easily and quickly transfer the cooled evidence in to the fuming chamber. A stand alone refrigerator would be sufficient for this as long as the temperature can be controlled and monitored. When the evidence has reached the optimal temperature and the proper program is loaded into the relay the process is initiated by pressing the "run" button on the relay. This turns on the humidifier and hotplate. This is a timed event that can be adjusted according to current atmospheric conditions. It is recommended to use a removable hygrometer or humidity strips attached to the glass door to monitor the humidity. A permanently mounted hygrometer would quickly become inoperable from the cyanoacrylate build up.

The relay will turn off the humidifier at the established time, currently set at three minutes and the user will be prompted to insert the evidence in the chamber and place the cyanoacrylate on the hot plate. One and one-half grams of cyanoacrylate in an aluminum tray has proven sufficient for this size chamber. After the evidence has been placed and the cyanoacrylate has been positioned on the hot plate the user will close the door and press "continue" on the relay. The door will lock and the hot plate will remain on for the programmed time to allow complete fuming of the evidence. The hot plate will shut off and a holding period will begin to allow the cyanoacrylate fumes to disperse and effect the development of the latent fingermarks. The adjustable circulation fan contributes to the even distribution of the cyanoacrylate fumes. When using a cyanoacrylate/sublimation dye blend the appropriate LEDs can be turned on to monitor the development.

After the 10 minute hold cycle, a ductless exhaust system will safely remove the remaining cyanoacrylate fumes and the automatic door latch will disengage. The evidence is ready to be removed for inspection.

III. Results

1. Statement of results

A. By combining CN- Yellow with Sublaprint Red R70011 at a ratio of 6:1, colored fingermarks, which fluoresces when excited anywhere in the range of 365 nm to 530 nm can be produced by a one step fuming applications. This addition to the normal fuming process will allow laboratories which use a 530 nm laser to use the CN-Yellow and not have to subject fingermarks to the additional step of dye staining.

B. Proper cooling of a sample relative to the environment results in several changes that increase visualization.

  i. First, decreasing the temperature 5°F to 20°F relative to the ambient environment potentially causes more cyanoacrylate to condense on the fingermark allowing for greater resolution.
  ii. Second, it changes the physical form of the Poly(cyanoacrylate) produced, making the print more opaque, improving contrast.

iii. Third and lastly, the resulting Poly(cyanoacrylate) has substantially more surface area which provides more opportunity for color uptake.

C. Fingermarks can be detected with Infrared Capture devices. Increasing NIR detection with forced condensation may have use in a laboratory setting, but in a field application, the condensate evaporates too quickly to be of significant use.

The most significant result however is that the IR captured devices evaluated, while capable of resolving fingermarks, were not capable of resolving finger prints which were not also resolvable with existing visible light methodology.

D. Carbon Black Nano-Pigments can be produced right on the fingermark and locked into the Poly(cyanoacrylate) matrix producing good quality highly stable black prints.

E. The desired two compartment fingermark fuming cabinet was produced allowing for convenient controlled cooling of sample and controlled fuming procedures.

IV Conclusions

1. Discussion of Findings

The use of CN-Yellow offers a one step, "hands off" approach to producing colored Poly(cyanoacrylate) fingermarks. This has advantages both in time and in maintaining the integrity of samples by decreasing the processing steps. By expanding the excitation wavelength with the addition of Sublaprint Red 70011, laboratories can take advantage of this approach regardless of the light sources they have available to them.

The significant increases in detection sensitivity for cyanoacrylate developed latent fingermarks was achieved by simply manipulating the evidence temperature during the fuming event A pre-cooling evidence of 5°F to 20°F prior to chamber fuming consistently yields higher resolution fingermark development through an increase in opacity. Furthermore, the precooling of the evidence also improves the dye uptake is a dye staining with Rhodamine 6G step is subsequently utilized.

Good quality black prints can be achieved without the need for dusting powders. The method of producing the carbon black pigment directly on the finger print offers some unique advantages. The fist is that it doesn't require the use of messy dusting powders. The second is that the color can be locked into the matrix of the CA. And the third is that it can use recycled materials. The print seen in the picture above was actually produced by burning used motor oil. And of course, once the finger print is cured, it does not need to be touched or brushed, reducing the potential for damage.

The methods developed, integrate well into current methodology. They can be used singly or in combination with each other. The Temperature and Humidity controlled chamber can be used to set the evidence to the desired temperature as in the Cyanoacrylate Dew-Point experiments. This makes an easy tool to exploit the temperature variations. In this process, the CN-Yellow and Sublaprint Red 70011 combination can be used in place of traditional CA stacking the advantages of the different aspects we present here. It should however be noted that the used of the carbon black nano-pigment with the fluorescent fuming with the CN-Yellow and Red 70011 will seriously reduce the net emission strength of the fluorescent materials.

Over all, the methods developed in these research projects provide ease of use and increased visibility in cyanoacrylate fingermark development.

2. Implications for Policy and Practice

While the use of CN-Yellow and/or Sublaprint Red R70011, or the production of carbon black in the cyanoacrylate have advantages over the existing methods, it can be argued that prints of the same quality can be produced by existing methods. It is therefore up to the examiner to determine the most appropriate method to use to process evidence.

By contrast, the obvious impact of chilling the evidence is so dramatic, that it should by be done as a matter of common practice. Whether this is done using the fingermark chamber developed as a part of this research or with the use of alternate refrigeration is not important as long as the transfer of sample from cold to processing is rapid enough that the sample doesn't take on too much heat.

3. Implications for Future Research

Two primary questions remain unanswered. The first is the actual quantification of the increase of mass of deposition of cyanoacrylate. If as the samples suggest there is in fact more cyanoacrylate deposited then prints which would not normally be visible will become detectable.

The second question is whether or not these methods impact the subsequent collection of DNA evidence or the quality of the evidence collected.

V. References:

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2. McHale, J. Molecular Spectroscopy, Prentice Hall Hew Jersey, 1999
3. Halliday, D., Resnick, R., Chapter 39 Geometrical Optics, Fundamentals of Physics 3rd Edition, John Wiley & Sons, United States,1988
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5. Trozzi, T., Processing Guide for Developing Latent Prints, Federal Bureau of Investigation, 2000 Page 22-23

VI. Dissemination of Findings

- *Polymer Coloration in Fingerprinting Applications* was presented to the Society of Plastic Engineers (SPE) Color and Appearance Division RETEC 2010, describing the methods of precoloring sublimation resins for finger applications.

- *Forced Condensation of Cyanoacrylate with Temperature Control of the Evidence Surface Modifies Polymer Formation and Improves Fingerprint Detection/Visualization,* has been accepted to the International Association of Identification (IAI) journal examining the effects of temperature on finger print development. Publication expected in the second or third issue in 2012

- *Fingerprint Detection Expansion to 530nm in tandem with Cyanoacrylate Processing* is being submitted to the AAFS

- *Research into Latent Fingerprint Development Techniques Involving Cyanoacrylate Fuming and Sublimation Dyes, Specific Heat Capacities, and Infrared Capture* was presented at the 2011 NIJ Grantees' Meeting February 2011

- *An on-line presentation for aspects of this research have been posted on line at: http://www.anevalinc.com/virtuallecturehall.html*

- *A validation of the 530 quality of prints obtained through the precoloration of the cyanoacrylate was performed using Fuming Orange and is presented in Appendix 1. This study will be presented for independent publication.*

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Appendix 1: A Statistical Comparison of Fuming Orange Latent Fingerprint Developer to Traditional Dye Staining with Rhodamine 6G

Author: Mason A. Hines, Lead Research Assistant

Abstract

With the optimal goal being to reduce the need for the secondary treatment of dye staining latent fingermarks processed by cyanoacrylate fuming, a quantitative analysis was required to compare the two processes. From observations during the refinement phase of creating Fuming Orange, it was projected that the sensitivity of Fuming Orange would approximate or be slightly less sensitive than the traditional method of cyanoacrylate fuming of non-porous items followed by dye staining. A no-cost extension of the original grant was approved to conduct a comparison of the two processes and the results were substantially better than expected. Latent prints developed with Fuming Orange were equal to or better than latent prints developed with Rhodamine 6G staining.

Introduction

During the initial research period of NIJ grant Award No.: 2009-DN-BX-K196 the goal of developing a cyanoacrylate/dye blend that fluoresced at 532 nm was met with a two-step crystallized product. Independent work was undertaken by Executive Forensics LLC and Aneval Inc. in an attempt to produce a simpler, one step innovation that would function on a hotplate in a fuming chamber and on a portable butane torch for field use. Success was achieved with the development of "Fuming Orange." Subsequently, the validation work was performed with this simpler one step product rather than the two step process discovered as part of the grant.

Method

To perform a comparative analysis of latent fingermarks developed with two methods. One half of each print was processed with either Fuming Orange or Cyanoacrylate fuming followed by dye staining with Rhodamine 6G. Latent fingermark examiners were asked to compare side by side images of the latent fingermarks processed by these two methods and score them based on the continuity of the ridges and their value for identification.

Two hundred fingermark impressions were obtained from 25 individuals, volunteers on the campus of Mountain State University and local law enforcement officers. No identifying information was gathered from the donors. The samples were placed on one and one-half inch wide, strips of consumer grade heavy-duty Reynolds aluminum foil, marked off into one and one-quarter by one and a half inch sections.

Individuals were asked to roll their fingers across the foil in the same manner as taking an inked impression in an attempt to fill the area with the fingermark deposition. The thumb, index, middle and ring fingers from each hand were deposited onto the foil. One strip approximately 6 inches long held the fingers from the right hand and one strip for the left hand. The strips were then carefully placed into standard paper evidence bags for storage until fuming. Due to time constraints, forty samples were processed for this study and of those, three pairs showed no development at all from either process and were excluded from the images distributed for examination. The remainder of the samples has been stored for future testing, including a study on the relationship between the age of the prints and the quality of the development with both processes.

The fuming tests took place over five consecutive days with eight prints chosen at random from all samples being fumed by each method on each day. This was to allow for the aging of some prints to approximate actual evidence processing conditions.

The first sets processed had been collected 24 hours before fuming and the last sets were aged five days. Immediately before each fuming event the sample strips were carefully cut in the middle, leaving approximately one half of an impression on each sample.[7] The strips were secured with clips onto a dowel rod mounted inside a 9.5" x 18", clear .012" thick, PVP disposable fuming chamber (Tri-Tech Forensics part no. DFC-18). A two inch flap had been cut approximately four inches from the bottom to serve as an injection port for the fuming device.

A Sirchie Cyanowand ™ (part no. SCW100) was used for all fuming events. The Fuming Orange blend was loaded into a burned off cartridge designed for use on this torch (Sirchie item SCW200). For the cyanoacrylate fuming, the Sirchie cartridge was used as purchased with a fresh cartridge being utilized for each fuming event. Samples were fumed two strips at a time (eight latent prints) and the order of fuming was reversed with each pair of tests.

The first test was with Fuming Orange, and immediately after removing the samples the chamber was evacuated and the process was repeated using cyanoacrylate. For the second test, cyanoacrylate fuming occurred first followed by the Fuming Orange. The left half of all samples was processed with the Fuming Orange, the right side with cyanoacrylate followed by Rhodamine 6G dye staining. With the fuming events occurring consecutively the ambient temperature and humidity were equal for each pair of tests.

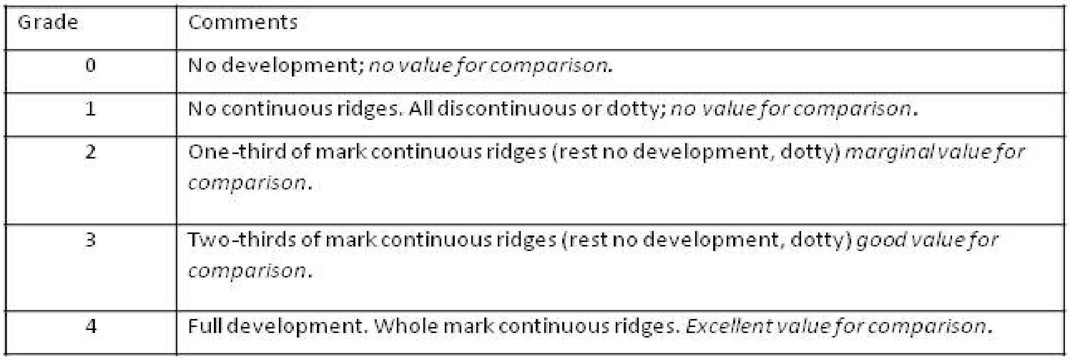
A mixture of Rhodamine 6G (Sirchie item LV505) was prepared with methanol according to the manufacturer's instructions and successfully tested before each use daily for quality assurance. The cyanoacrylate-dye blend was prepared according to the ratios developed during our independent research and introduced to the SCW200 cartridges 24 hours before the first test was conducted to allow for complete polymerization on the steel wool. The samples exposed to traditional cyanoacrylate fuming were lightly dipped as prescribed into a tray of Rhodamine 6G and then immediately rinsed with methanol from a nalgene bottle and allowed to dry. The aluminum strips were then aligned with the corresponding strips that were processed with Fuming Orange for photography.

The prints were photographed side by side with a Canon XTI, 12 megapixel, digital DLR camera fitted with a standard orange barrier filter (Sirchie item BMCF100) and a 10x close up lens. A Rofin Polilight Flare Plus with a 505 nm LED head was utilized to illuminate the latents. With the reflective nature of the foil the light source had to be manually positioned for each photograph to obtain the most accurate image of both halves simultaneously. No computer enhancement was performed on the images. They were however resized using Microsoft Office Word 2007 during the insertion into the documents for dissemination to the examiners. This document was converted to a PDF and emailed to the 41 latent examiners who had expressed an interest in participating in the study. Later, Word documents with the images available for enhancement were transmitted to all examiners at the request of one.

Volunteers from the latent fingermark community were recruited through internet groups, e-mail lists, and from personal contact at the 2011 IAI Conference. Forty-one Examiners responded and were emailed the instructions, PDF documents with images, and Excel score sheets. Twelve working and retired latent examiners with a wide range of experience from 3.5 years to 30 years, 5 IAI certified latent examiners, 7 not certified, responded with scores to the first 22 images that were sent, and ten of those responded to the second set of 15 images for a total of 828 scores, 414 of Fuming Orange and 414 of Rhodamine 6G.

There was a grading chart of 0-4 provided that was developed by Helen Bandey. [7] [3]

Table 1. Scoring Chart



Grade	Comments
0	No development; *no value for comparison.*
1	No continuous ridges. All discontinuous or dotty; *no value for comparison.*
2	One-third of mark continuous ridges (rest no development, dotty) *marginal value for comparison.*
3	Two-thirds of mark continuous ridges (rest no development, dotty) *good value for comparison.*
4	Full development. Whole mark continuous ridges. *Excellent value for comparison.*

The examiners were instructed to not judge on placement of the print in that some latents were not centered and when cutting prior to processing the halves were not evenly distributed.

Results

The data was compiled in an Excel worksheet for analysis and averaging and the results were much better than anticipated. Previous testing warranted the expectation that Fuming Orange would perform at least as well as Rhodamine 6G processed latents, especially on the freshest prints. But the results from the volunteer examiners showed a significant difference in the average quality of all latent fingermarks examined.

On the 0-4 scale, Fuming Orange's mean for 414 scores of latent images was 3.48 and the latents processed with cyanoacrylate and Rhodamine 6G received a mean of 2.94. The data was inputted into the Excel T-Test function for analysis and a P Value of 1.44E-16 was determined confirming the significance of the differences between the processes tested.

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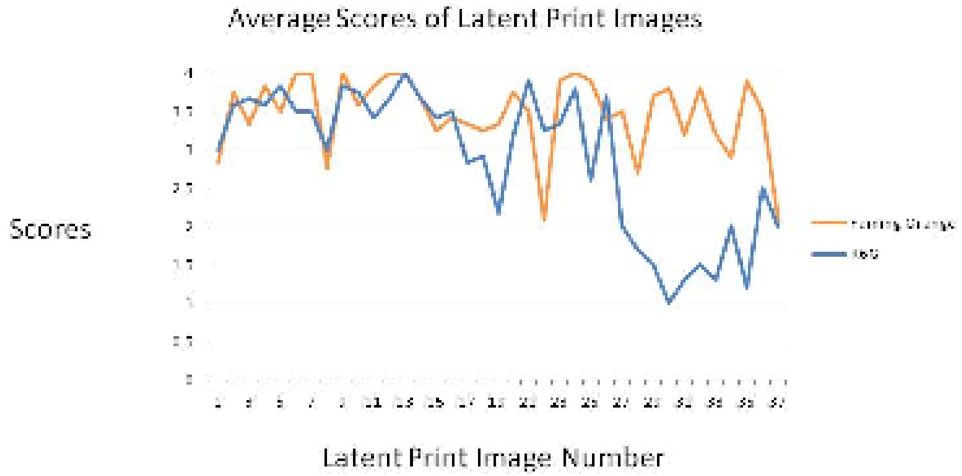
[3] Comments in the chart in italics were added as part of this study for clarification as to the whether the examiner felt the latent had no, marginal, or sufficient value for identification.

Although not intended to be a study on the importance of processing evidence when it is "fresh," the differences in scoring were most discernible in latent prints that were the oldest. There is a significant drop from the examiners in all prints developed on days 4 and 5 but the decrease is much greater of those developed with Rhodamine 6-G.

There is also the possibility that the fingermark residue from the samples used in the latter tests came from individuals with less than average secretion. However these results indicate that no matter the cause of the reduced deposition, Fuming Orange has produced significantly improved detail on this portion of the samples. We anticipate continuing this project into a broader study and close attention will be given to this phenomenon.

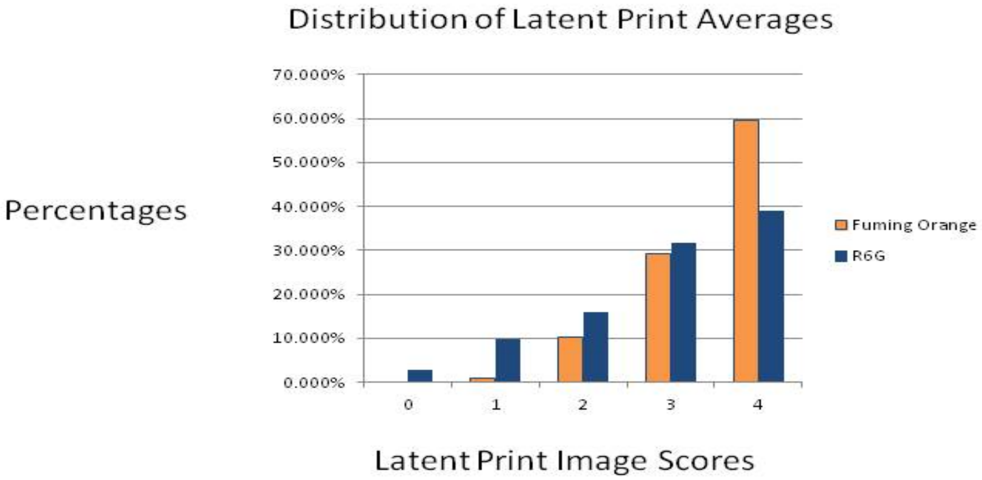
Graph 1.



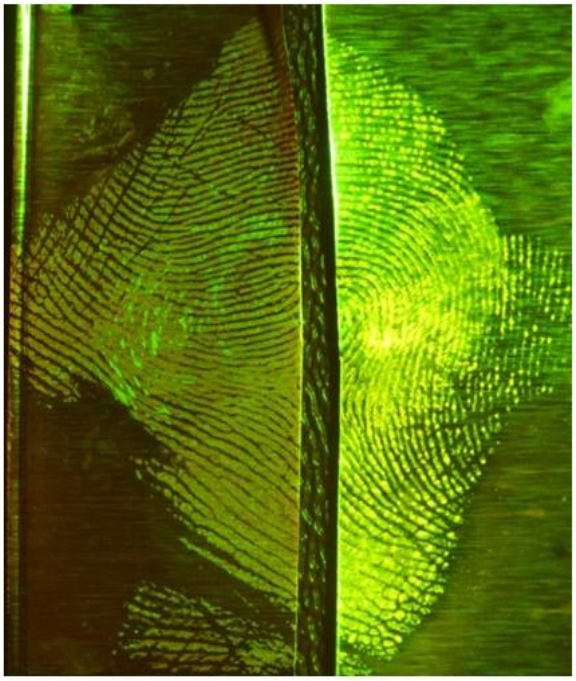
Rhodamine 6G returned 53 latents that were scored as having no value whereas Fuming Orange produced only 4. Sixty marginal latents from the Rhodamine 6G set and 41 from Fuming Orange were reported. The most compelling statistic lies in the difference of identifiable latent fingermarks. 88.889% of latents developed with Fuming Orange were deemed identifiable as opposed to 70.532% processed with the Rhodamine 6G method. (Graph. 2) In fact, there were only two instances in which Rhodamine 6G produced latents that the examiner's average score indicated the prints as identifiable and the Fuming Orange print as of no value, images 8 and 22, and for image 8, eight of the twelve examiners felt that the Fuming Orange print was identifiable. For image 22, two examiners responded with scores indicating that the Fuming Orange latent could be identified.

Appendix 1

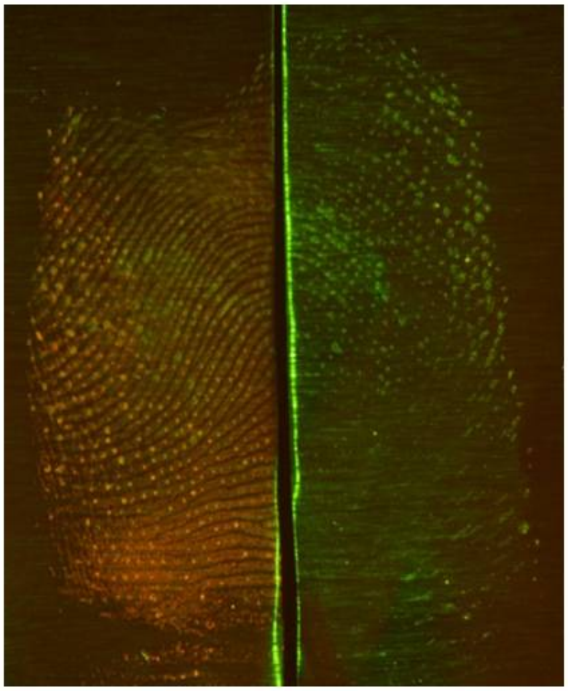
Graph 2.



Sample Images



Latent 7. Fuming Orange development is on the left. This latent was given a score of 4 by all examiners for both processes.



Latent 32. Fuming Orange development is on the left. Average score of 3.125 for FO, 1.25 for R6G.

Conclusion

Based upon the independent scoring of twelve, trained latent examiners, the results of this analysis indicate that Fuming Orange should be considered as a viable option to the current protocol of employing the secondary treatment of dye staining non-porous items of evidence. The quality of latent fingermarks produced with Fuming Orange exceeded all expectations and has now been proven to provide better development than dye staining with Rhodamine 6-G.

An added benefit of utilizing this new process, in addition to saving time and reducing costs is that with an appropriate alternate light source, the development of the latent prints can be observed, reducing the risk of overdevelopment. Latent examiners and evidence technicians should experiment with the product and become comfortable with its use before attempting to process actual evidence and should consider following up with dye staining until they are confident in its abilities.

This study will be expanded and further testing conducted on multiple materials with the results put forth for publication. To date, several varieties of plastics, ceramics, glass and multiple metals have been processed with Fuming Orange with identical results as in this study. Ceramic tile with fingermarks deposited over three years ago have been processed with Fuming Orange with very positive results. Future analysis will include concentrating specifically on the quality of development on aged latent fingermarks utilizing the “forced condensation” phenomenon of cooling the evidence immediately prior to fuming. Preliminary experiments have shown a substantial increase in the luminescence of latent prints processed with Fuming Orange when the substrate has been pre-chilled.

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