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The Effects of Cyanoacrylate Fuming and Fluorescent Dye Staining on Forensic Tape Analysis

ABSTRACT: This paper reports on a study of the effects of latent print processing, specifically cyanoacrylate (CA) fuming and rhodamine 6G (R6G) in methanol dye staining, on various types of tapes to determine if there is a negative effect on subsequent forensic tape analysis. A variety of tapes were chemically and physically analyzed prior to latent print processing. After the tapes were fumed with CA, they were once again chemically and physically analyzed to determine if there was any interference caused by the CA fuming. The tapes were then further treated with R6G fluorescent dye. Examination of the various types of tape after dye staining revealed no adverse effects. CA fuming and R6G dye staining did not have any impact on the physical comparison (end matching, adhesive color, backing color, backing texture, or width) of any of the tapes.

KEYWORDS: Cyanoacrylate, Rhodamine 6G, Duct Tape, Black Electrical Tape, Masking Tape, Packaging Tape, Physical Matches, FTIR

INTRODUCTION

Various types of pressure sensitive tapes are often encountered in forensic casework. In the Bureau of Alcohol, Tobacco, Firearms & Explosives (ATF) forensic laboratories, tape is often found wrapped around improvised explosive devices, various containers (e.g., plastic jugs, bottles), and firearms. If a partial roll or additional piece of tape is recovered from a suspect or secondary location, the examiner is asked to determine if the tape on the item could have originated from the roll or if the pieces could share a common origin. The first step in the tape analysis is to look for any physical association (match) between the tape ends from questioned and known tapes. If a physical association is made, it may be concluded that the questioned tape and known tape at one time shared a mutual origin. If no physical match can be made, analysis of the tape is conducted to determine if the questioned tape has the same physical characteristics and chemical composition as the known tape. In addition to physical matches and chemical analysis, requests may also be made to determine if any latent prints can be

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developed on the tape. The latent print process subjects the tape to cyanoacrylate (CA) fumes and fluorescent dye staining using rhodamine 6G (R6G) in methanol. When working cases in a forensic science laboratory, it is important to coordinate analysis of the exhibits between different disciplines. Knowing what effect other analyses may have on an item of evidence could be very important. The scope of this paper is to understand what effects processing for latent prints with CA and R6G may have on physical comparisons and chemical analysis of different types of tape.

MATERIALS AND METHODS

Fourteen different tapes were selected for this study. The tapes were selected to represent a variety of tapes that have been encountered in casework. The tapes included black plastic (i.e. black electrical) tape, masking tape, friction tape, clear packaging tape, and duct tape. The brands of the tapes were randomly chosen based on availability at a local hardware store. See Table 1 for the brands of tape selected.

Table 1: Brands and Types of Tape Examined

Tape Sample number	Tape Type	Manufacturer/Brand	Model
1	Electrical	Henkel/Duck®	Vinyl electrical tape
2	Electrical	Henkel/Duck®	667 Pro Series
3	Electrical	3M/Scotch®	700
4	Electrical	3M/Scotch®	Professional Grade Super 33+
5	Electrical	3M/Scotch®	Professional Grade Super 88
6	Electrical	Plymouth/Revere® 7	medium grade
7	Friction	Henkel/Duck®	Friction tape
8	Packaging	3M/Scotch®	Packaging Tape
9	Packaging	3M/Scotch®	Sealing Tape
10	Masking	3M/Scotch®	Painter's Grade
11	Masking	3M/Scotch®-Blue ™	Painter's Tape for delicate surfaces
12	Duct	Gorilla®	Duct Tape
13	Duct	Shurtape®	General Purpose Utility Duct Tape
14	Duct	3M/Scotch®	Electrician's Heavy Duty Tape

The tapes were first analyzed before any latent print processing was performed. The tape backing and adhesive were analyzed directly by a Specac MKII Golden Gate Single Reflection Diamond attenuated total reflection (ATR) accessory attached to a Perkin Elmer Spectrum One Fourier transform infrared spectrometer (FTIR). Additionally, approximately 1 milliliter of methylene chloride (CH_2Cl_2) was used to extract the plasticizers from the black electrical tape backings (Tapes 1 thru 6). The dried extracts were analyzed by FTIR-ATR. After initial analysis, a fresh sample of tape was removed from each roll and subjected to CA fuming with Foster Freeman Cyanobloom in a Foster Freeman MVC 3000 Cyanoacrylate Fuming Cabinet for fifteen minutes at 80% humidity. After processing with CA, the tape backing and adhesive for all of the samples were analyzed using the same procedures as described previously and the tape backings of Tapes 1 thru 6 were extracted with CH_2Cl_2 and analyzed by FTIR-ATR.

After analysis of the tapes that were processed with CA fumes, the same pieces of tape were treated with R6G dye in methanol, which is the usual next step in latent print processing used by the ATF laboratories. All of the tape backings and adhesive were analyzed again by FTIR-ATR. The backings of Tapes 1 thru 6 were once again extracted with CH_2Cl_2, in a different area than was previously extracted, and analyzed by FTIR-ATR.

To determine if any interference from the CA could be removed from the tape backing, the CA-treated backings of two black electrical tapes (Tapes 1 and 3), one packaging tape (Tape 9), and one duct tape (Tape 13) were rinsed with acetone and analyzed again by FTIR-ATR. The tape backings of the CA-treated black electrical tapes (Tapes 1 and 3) were also rinsed with methanol and analyzed by FTIR-ATR.

In addition to processing with Foster Freeman CA, additional fresh samples of tapes 2, 3, 6, 7, 9, 10, and 13 were treated with HotShot™ fingerprint developer. The HotShot™ process also uses CA and was developed to allow evidence to be easily fumed in the field. These tape samples were placed in a 16 inch x16 inch x16 inch sealed box with the HotShot™ developer and allowed to fume for ten minutes. After processing, the tape backings and adhesive were analyzed by FTIR-ATR as described previously. The plasticizers were extracted from the backings in Tapes 2, 3, and 6 with CH_2Cl_2 and analyzed by FTIR-ATR.

Control samples of the Foster Freeman CA used in the regular process as well as a sample from the CA used in the HotShot™ developer were collected by placing a glass slide in the cabinet and box used in the development processes. The white residue left on the slides was analyzed by FTIR-ATR.

A control sample of the R6G dye used in processing was placed on a glass slide and allowed to dry. No visible residue remained after evaporation.

In the second part of the study, the 14 tape samples were each prepared to examine the effects of latent print processing on physical matches. Two sets of physical matches for each tape were prepared. The first set of tapes was prepared by hand tearing a piece of tape into two pieces. All of the tape samples were prepared this way except for Tapes 8 and 9, the packaging tapes. These tapes were unable to be torn by hand. The second set of tapes was prepared by randomly cutting a piece of tape from all of the samples into two pieces with a pair of scissors. The torn and cut tapes were placed on glass slides, photographed and examined with a stereomicroscope (Olympus SZX12) to ensure that a physical match could be made before processing.

The cut and torn tapes were divided into two groups based on the tape type (electrical, clear packaging, masking, and duct) so that a representative sample of each type was included in each group. For Tapes 1, 2, 3, 7, 8, 10, and 12, both halves of the physical matches were treated with CA fumes. This was done for both the cut samples as well as the torn samples. The physical matches were then examined with a stereomicroscope to determine if the CA fuming affected the physical match in any way (e.g. distortion). For Tapes 4, 5, 6, 9, 11, 13, and 14, only one half of each physical match was processed with CA for both cut and torn samples. This was done to replicate casework where evidence from the scene may be processed for latent prints prior to obtaining any comparison tape samples. After processing, physical match comparisons were conducted with the stereomicroscope to determine if the CA may have had any effect on the tapes.

To examine the effects of dye staining on physical matches, all of the cut and torn tape samples were processed with R6G. The physical matches were then examined with a stereo microscope to determine if the R6G affected the physical match in any way (e.g. distortion).

In addition to looking at physical (end) matches, the tapes and tape backings were also physically analyzed (adhesive color, backing color, backing texture, and tape width) before and after CA fuming and dye staining.

RESULTS AND DISCUSSION

Part 1 – Chemical analysis

The two cyanoacrylates used in this study during latent print processing gave the same FTIR spectra (Figure 1.). After comparing these spectra with the spectra of the tape backings and adhesives, it was determined that there were seven peaks of interest for the CA (1740 cm^{-1}, 1442 cm^{-1} , 1370 cm^{-1} , 1244 cm^{-1}, 1155 cm^{-1} ,1010 cm^{-1}, and 855 cm^{-1}). In some instances, all of these peaks were detected in the spectra of the tape samples after CA fuming and in other cases, only a few peaks were detected. Tables II thru IX list the peaks of interest after CA fuming that were detected in each sample.

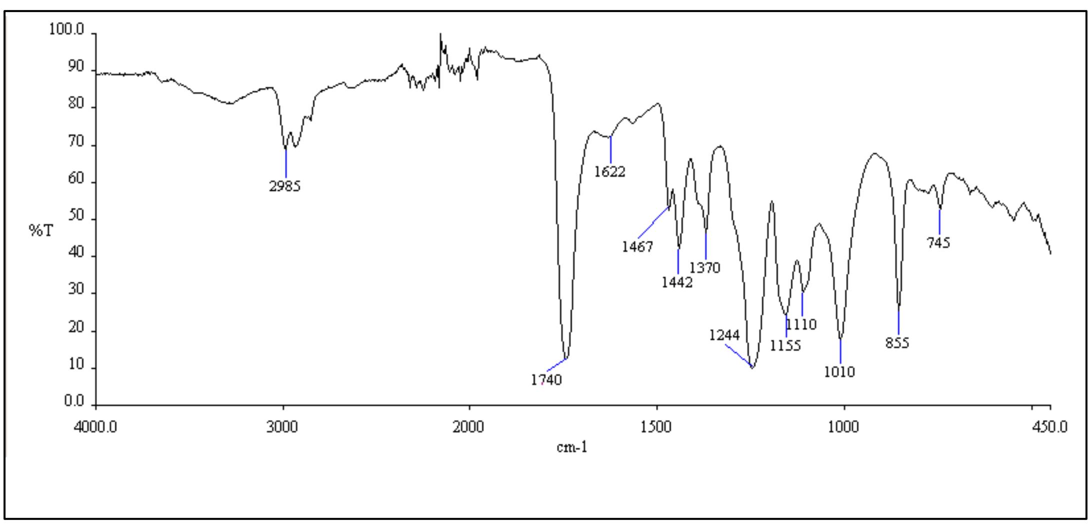

Figure 1. FTIR spectra of cyanoacrylate

ELECTRICAL TAPE AND FRICTION TAPE

As can be seen in Table 2, the peaks at 1010 cm^{-1} and 855 cm^{-1} were detected in the spectra of every electrical tape and friction tape backing even though no visible residue from the CA was observed on the backing. Analyzing the backing in different areas gave the same results. In Tapes 3 thru 6, it was noted that there was a broadening of the doublet at 1171 cm^{-1} and 1137 cm^{-1} after CA fuming. This could be a result of the 1155 cm^{-1} peak from the CA. After rinsing the backing of Tapes 1 and 3 with acetone, the peaks described above were still visible in the spectra. The backings were then rinsed with methanol giving the same result.

Table 2. Electrical tape and friction tape backing

Cyanoacrylate control	1740	1442	1370	1244	1155	1010	855
Tape 1	X	*	*	*	X	X	X
Tape 2	X	*	*	*	X	X	X
Tape 3	X	X	X	*	*	X	X
Tape 4	X	X	X	*	*	X	X
Tape 5	X	X	X	*	*	X	X
Tape 6		*	*	*	*	X	X
Tape 7	X	*	*	X	X	X	X

* = peak present before CA fuming
X = peak present after CA fuming

The spectra of all of the tape adhesives from the electrical tapes (Tapes 1 thru 6) showed the 1010 cm^{-1} and 855 cm^{-1} peaks after CA fuming, as seen in Table 3. It should be noted that in the spectra of Tapes 1 and 2, the 1155 cm^{-1} peak appeared as a shoulder on the previously present 1122 cm^{-1} peak.

Tape 7 showed no differences between the original analysis of the tape adhesive and the adhesive after CA fuming.

Table 3. Electrical tape and friction tape adhesive

Cyanoacrylate control	1740	1442	1370	1244	1155	1010	855
Tape 1		*	*		X	X	X
Tape 2		*	*		X	X	X
Tape 3		*	*	X	+	X	X
Tape 4		*	*	X	+	X	X
Tape 5		*	*	X	+	X	X
Tape 6		*	*	+		X	X
Tape 7	*		*			*	*

* = peak present before CA fuming
X = peak present after CA fuming
+ = peak present before CA fuming and present stronger after CA fuming

CLEAR PACKAGING TAPES

After processing with CA, 1740 cm^{-1}, 1244 cm^{-1}, 1010 cm^{-1} and 855 cm^{-1} peaks were detected in the spectra of the tape backings. As noted in Table 4, some of the peaks were present before fuming with CA but were much stronger after processing due to the contribution from the CA.

White residue from the CA fuming was observed on the tape backings. These areas were used for initial analysis. An area that was clear without residue was also analyzed and no peaks from the CA were observed.

After rinsing the areas where residue was observed on Tape 9 with acetone, the peaks attributed to the CA were no longer present. The spectrum was the same as before CA fuming.

Table 4. Clear Packaging Tape backing

Cyanoacrylate control	1740	1442	1370	1244	1155	1010	855
Tape 8	+	X	*	+	+	X	X
Tape 9	+	*	*	+		X	X

* = peak present before CA fuming and same after CA fuming
X= peak present after CA fuming
+ = peak present before CA fuming and present stronger after CA fuming

After fuming with CA, 1244 cm^{-1}, 1155 cm^{-1}, and 1010 cm^{-1} peaks were detected in the spectra of the tape adhesives, as seen in Table 5. No 855 cm^{-1} peak was detected; however, the spectra of both adhesives had an 837 cm^{-1} peak present before and after fuming. This peak may have been masking the 855 cm^{-1} peak. No other spectral differences were noted.

Table 5. Clear Packaging Tape adhesive

Cyanoacrylate control	1740	1442	1370	1244	1155	1010	855
Tape 8		*	*	+	X	X	
Tape 9		*	*	+	X	X	

* = peak present before CA fuming
X = peak present after CA fuming
\+ = peak present before CA fuming and present stronger after CA fuming

MASKING TAPE

As seen in Table 6, an additional peak was only observed at 1244 cm^{-1} on the spectra of the masking tape backings. No other spectral differences were noted. No visible residue from the CA was observed on the backing. Analyzing the backing in different areas gave the same results.

Table 6. Masking Tape backing

Cyanoacrylate control	1740	1442	1370	1244	1155	1010	855
Tape 10		*	*	X	*	*	*
Tape 11		*	*	X	*	*	*

* = peak present before CA fuming
X = peak present after CA fuming

Table 7 shows that the 1740 cm^{-1} and 1244 cm^{-1} peaks on the spectrum of Tape 10 after fuming with CA are somewhat stronger than what was present in the original spectrum of the adhesive; however, the contribution was not as strong as in some of the previous samples. No other spectral differences were noted in Tape 10 and no changes were observed in the spectrum of the Tape 11 adhesive.

Table 7. Masking Tape adhesive

Cyanoacrylate control	1740	1442	1370	1244	1155	1010	855
Tape 10	+	*	*	+		*	
Tape 11			*	*	*		*

* = peak present before CA fuming

\+ = peak present before CA fuming and present stronger after CA fuming

DUCT TAPE

The 1740 cm^{-1}, 1244 cm^{-1}, 1155 cm^{-1}, 1010 cm^{-1}, and 855 cm^{-1} peaks were detected in the spectra of the tape backings of all of the duct tapes (Tapes 12 thru 14) after CA fuming, as seen in Table 8.

White residue from the CA was observed on the tape backings and these areas were used for the initial analysis. An area that was clear without residue was also analyzed and no peaks from the CA were observed.

After rinsing the areas where residue was observed on Tape 13 with acetone, the peaks attributed to the CA were no longer present and the spectrum was the same as before processing.

Table 8. Duct Tape backing

Cyanoacrylate control	1740	1442	1370	1244	1155	1010	855
Tape 12	X		+	+	X	X	X
Tape 13	X			X	X	X	X
Tape 14	X	X	+	X	X	X	X

X = peak present after CA fuming

\+ = peak present before CA fuming and present stronger after CA fuming

Table 9 illustrates that as in Tape 10, the 1740 cm^{-1} and 1244 cm^{-1} peaks in the spectrum of the Tape 14 adhesive after CA fuming are somewhat stronger than the original adhesive spectrum; however, the variance is not as strong as in some of the previous samples. No other differences were observed.

Table 9. Duct Tape adhesive

Cyanoacrylate control	1740	1442	1370	1244	1155	1010	855
Tape 12	*		*	X	*	*	
Tape 13	*	*	*	+			
Tape 14	+	*	*	+			

* = peak present before CA fuming
X = peak present after CA fuming
+ = peak present before CA fuming and present stronger after CA fuming

No additional peaks or changes were detected in the spectra of any of the tape backings or adhesives (Tapes 1 thru 14) after processing with the R6G dye.

Part 2 – Physical analysis

After processing with CA and R6G, the ends of the tape samples (both cut and torn) were still able to be physically matched to one another. There was no noticeable effect on the tape edges to change the appearance and make it more difficult or impossible to make the physical match. The CA fuming and dye staining with R6G in methanol did not have any effect on the adhesive color, backing color, backing textures, or tape width.

CONCLUSIONS

In this study, it was determined that latent print processing with CA can have an effect on the chemical analysis of tape backings and adhesives. It is important when examining these tapes after CA fuming to account for these peaks before drawing any conclusions as to whether or not they have the same chemical composition. In some cases, such as with the backings of the clear packaging and duct tapes, the interference from the CA can be removed by rinsing with acetone or conducting analysis in an area without visible white residue. Latent print processing with CA and with R6G dye in methanol did not have a negative effect on physically matching the ends of the tapes or on any of the other physical characteristics including backing color, backing texture, adhesive color, and tape width.

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