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Analysis and discrimination of colored pressure sensitive tape backing by microspectrophotometry

ABSTRACT

This study involved the analysis of two different colors (blue and red) of pressure sensitive tape in a variety of types (duct tape, electrical tape and miscellaneous tape) by microspectrophotometry (MSP). The study was performed to evaluate the usefulness of MSP to be used in conjunction with other analytical schemes in the forensic analysis of colored tape backings. The objectives included: 1) To determine if MSP could discriminate similar colored tape backings 2) To determine if MSP would add to the analysis scheme of physical characteristics and Fourier Transform Infrared spectroscopy (FTIR) analysis and 3) To explore the intravariability of MSP spectra for the backing in rolls of duct tape and electrical tape. This study shows that the analysis of colored tape backings by MSP can discriminate between similar colored tape backings as well as add to the discrimination of the traditional analysis scheme of physical characteristics and FTIR. In addition, there was minimal variability among a single tape backing.

Keywords: Colored Tape Backing, Microspectrophotometry, Duct Tape, Electrical Tape

INTRODUCTION

Tape is used in the commission of a crime and routinely analyzed in a forensic laboratory [1-7]. Electrical tape can be used in improvised explosive devices while duct tape can be used to bind victims. Pressure sensitive tape contains multiple components including, at minimum, an adhesive layer and a backing layer. Varieties of colored and patterned tape backings are becoming more readily available. This variety of colors may offer another area of discrimination in the forensic analytical scheme.

Microspectrophotometry measures ultraviolet and visible light absorption in microscopic samples and is a well-accepted technique used in the analysis of trace evidence such as paint and fibers [8,9]. Very little literature has been found on the MSP analysis of colored tape backings. One technical paper concludes that four different colored electrical tapes (blue, green, yellow and red) gave distinct color spectra in the visible range [10]. No literature was found on how discriminating MSP analysis could be with tapes of the same color. The current study was performed to evaluate the usefulness of MSP to be used in

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conjunction with other analytical schemes in the forensic analysis of colored tape backings [11-13].

MATERIALS AND METHODS

Two different colors (blue and red) of pressure sensitive tape, covering the opposite ends of the visible color spectrum, were utilized in this project. Electrical tape, duct tape and a third category of miscellaneous tapes were used in this study. Miscellaneous tapes included masking tape, packaging tapes and tapes for special use. Most tapes were purchased at local stores, sold as general purpose tapes. Appendix A contains all of the tape manufacturing information.

Electrical tape and miscellaneous tape samples were mounted in paraffin wax with the adhesive still attached and cross-sectioned with a Thermo HM 325 Microtome. The adhesive and scrim were removed from duct tape samples prior to mounting in paraffin wax because of the difficulty with cross-sectioning when the adhesive and scrim are present. The optimal thickness for tape backings for MSP was evaluated and determined to be 20 µm.

The samples were prepared for MSP by placing several 20 µm cross sections of the same sample on a glass slide with one drop of Permount® mounting medium (EMS, Hatfield, PA) and placing a coverslip over it. Samples were allowed to dry prior to analysis and given randomized identifiers. The analyzing scientist did not know how many different samples were in each category of tape, nor whether they contained replicate samples from the same roll of tape.

A minimum of five cross sections from each sample was analyzed using a CRAIC 20/20 PV microspectrophotometer with an advanced CCD Array Detector and 75-watt xenon lamp light source. Each sample was analyzed with a 15x Objective, size 5 aperture and a wavelength range of 400 nm – 850 nm with 50 scans. The focus of this research was color therefore only the visible range was utilized.

Single and double layer backing samples were analyzed by a Thermo Scientific Nicolet iS10 Smart Orbit FTIR using Attenuated Total Reflectance (ATR) with a diamond crystal and a DTGS detector. Single layer backing samples were analyzed with no sample preparation. The adhesive and scrim were removed from double-layered backings and analyzed. Each sample was measured with 32 scans at a wavelength range of 525 cm^{-1} to 4000 cm^{-1} and resolution of 4 cm^{-1}.

Backings that contained three layers were analyzed by a Perkin Elmer Spectrum One FTIR spectrometer using an Autoimage microscope with MCT detector (narrow band). Samples were cross-sectioned via microtome, prepared for analysis by suspending in air and analyzed in transmission. Aperture size was approximately 20 µm x 80 µm. Each sample was measured with 16 scans at a wavelength range of 650 cm^{-1} to 4000 cm^{-1}, resolution

of 4 cm^{-1} and approximate aperture size of 20 µm x 80 µm. No spectral processing was performed on any FTIR analysis and only the colored layers were used for comparison.

Backing color and texture was evaluated visually unaided and given descriptive terms for use in comparison of physical characteristics. Tape widths were measured with a ruler and cross sections were evaluated under a stereomicroscope.

RESULTS AND DISCUSSION

Part 1 – MSP results

Tapes were only compared to other tapes within their color and tape categories. All blind samples were correctly associated with their original tape. The total number of comparison pairs (CP) was calculated for each category (color and type) using the formula:

$$CP = \frac{n(n-1)}{2} \quad (1)$$

Where *n* is the number of samples (excluding the blind samples).

Discrimination power (DP) is measuring the ability to differentiate two samples selected at random [3,14]. The discrimination power for each category was determined for MSP by the following formula:

$$DP = 100\% \times \left[1 - \left(\frac{Number\ of\ Indistinguishable\ Pairs}{Total\ Number\ of\ Comparison\ Pairs}\right)\right] \quad (2)$$

The results of the discrimination of colored tape backings by MSP is summarized in Table 1.

Table 1: Summary of the discrimination of colored tape backings by MSP alone

	Number of tested samples	Number of Blind Replicates	Total Samples	Groups by MSP Only	Number of Pairwise Comparisons	Discrimination Power of MSP Only
Blue Duct	18	5	13	7	78	91%
Red Duct	18	3	15	7	105	86%
Blue Electrical	11	3	8	3	28	71%
Red Electrical	8	0	8	4	28	75%
Blue Miscellaneous	5	1	4	2	6	50%
Red Miscellaneous	12	3	9	6	36	89%

Eighteen blue duct tape samples were analyzed and could be categorized into seven groups by MSP. Five of the eighteen samples were blind replicates leaving thirteen different samples within the seven groups. Table 2 shows the brands present in each group and Figure 1 shows the spectrum of one sample representing each of the seven different groups.

Table 2: MSP groupings for blue duct tape samples

Group	Number of Samples	Brands
A	2	Duck Brand
B	1	3M
C	2	Duck Brand and Shurtape
D	1	3M Scotch
E	2	3M Scotch and IPG
F	2	Red Ant Tape Group and ISC
G	3	Bazic, 3M Scotch, Catch

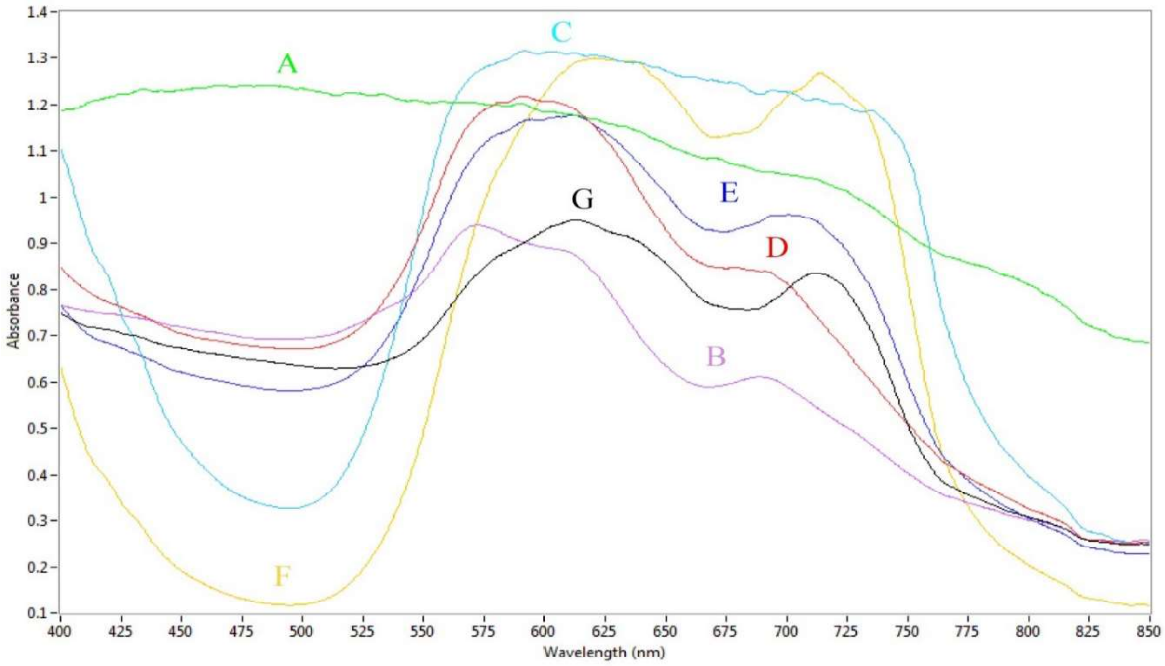

Figure 1: MSP groupings for blue duct tape samples (seven groups designated A – G).

Eighteen red duct tape samples were analyzed and could be categorized into seven groups by MSP. Three of the eighteen samples were blind replicates leaving fifteen different samples within this category. Table 3 shows the brands present in each group and Figure 2 shows the spectrum of one sample representing each of the different groups.

Table 3: MSP groupings for red duct tape samples

Group	Number of Samples	Brands
A	2	Cherry Red 3M Scotch Brand
B	1	Bazic Products
C	2	Duck Brand
D	5	3M Scotch, Duck Brand, Shurtape

E	1	Universal
F	1	Catech: Red DuctPro
G	3	3M Scotch and Duck Brand

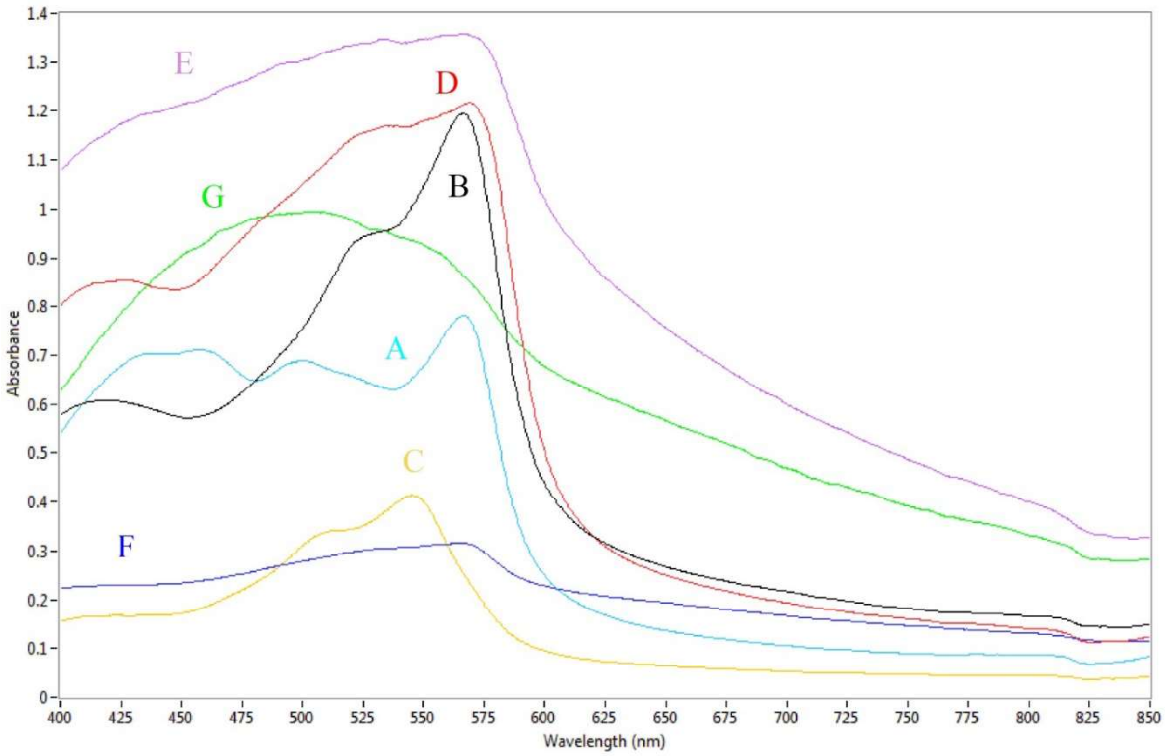

Figure 2: MSP groupings for red duct tape samples (seven groups designated A – G).

Eleven blue electrical tape samples were analyzed and could be categorized into three different groups by MSP. Three of the eleven samples were blind replicates leaving eight different samples within this category. Table 4 shows the brands present in each group and Figure 3 shows the spectrum of one sample representing each of the three different groups.

Table 4: MSP groupings for blue electrical tape samples

Group	Number of Samples	Brands
A	2	Duck Brand
B	2	Ace Brand and Duck Brand
C	4	Gardner Bender

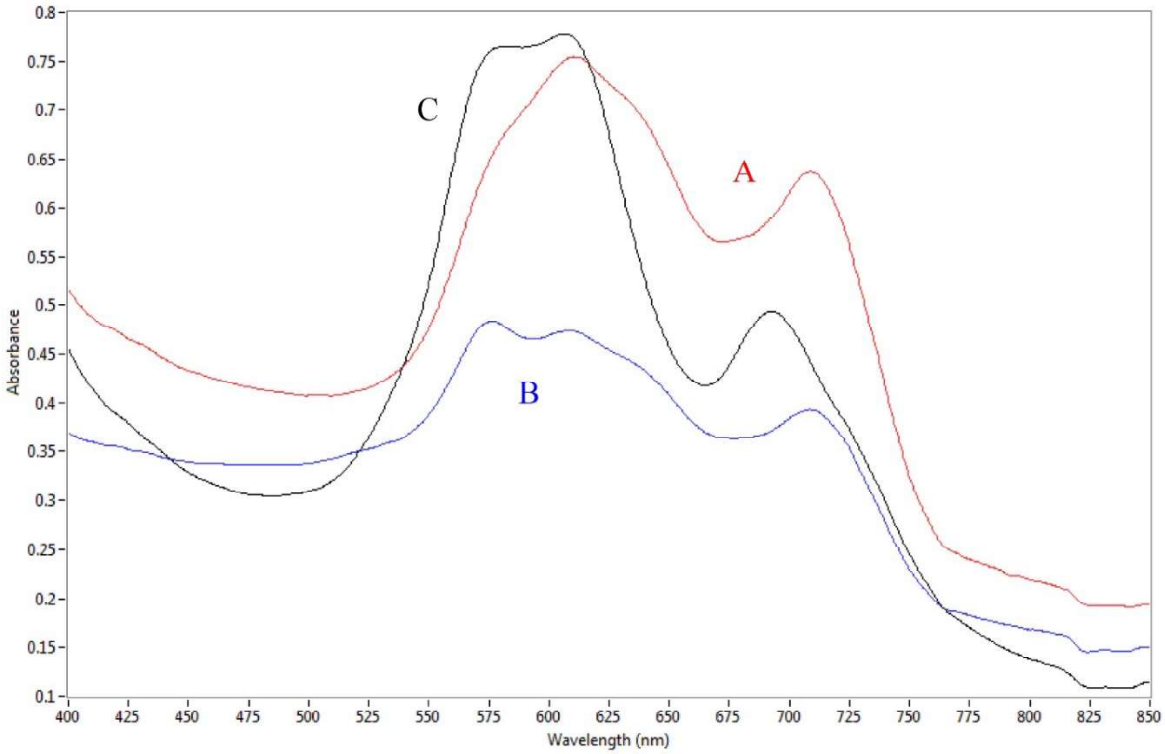

Figure 3: MSP groupings for blue electrical tape samples (three groups designated A – C).

Eight red electrical tape samples were analyzed and could be categorized into four groups by MSP. There were no blind replicate samples within this tape category. Table 5 shows the brands present in each group and Figure 4 shows the spectrum of one sample representing each of the four different groups. By MSP alone, four different brands were differentiated.

Table 5: MSP groupings for red electrical tape samples

Group	Number of Samples	Brands
A	1	3M Scotch
B	2	Ace Brand
C	1	Duck Brand
D	4	Gardner Bender

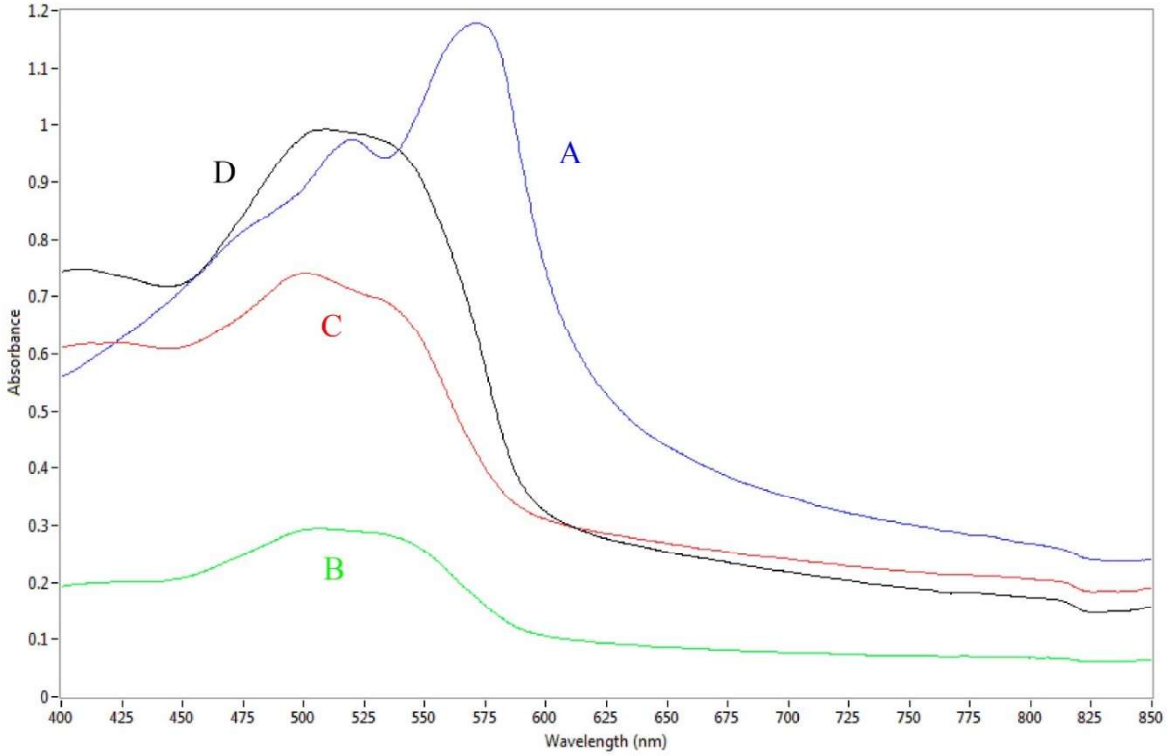

Figure 4: MSP groupings for red electrical tape samples (four groups designated A – D).

Five blue miscellaneous tape samples were analyzed and could be categorized into two different groups. There was one blind replicate within this tape category. Table 6 shows the brands present in each group and Figure 5 shows the spectrum of one sample representing the two different groups. Additional blue miscellaneous tapes were purchased but were unsuitable for this project since they could not be cross-sectioned by the microtome.

Table 6: MSP groupings for blue miscellaneous tape samples

Group	Number of Samples	Brands
A	3	3M Scotch Colored Plastic Tape
B	1	Silicone Rescue Tape

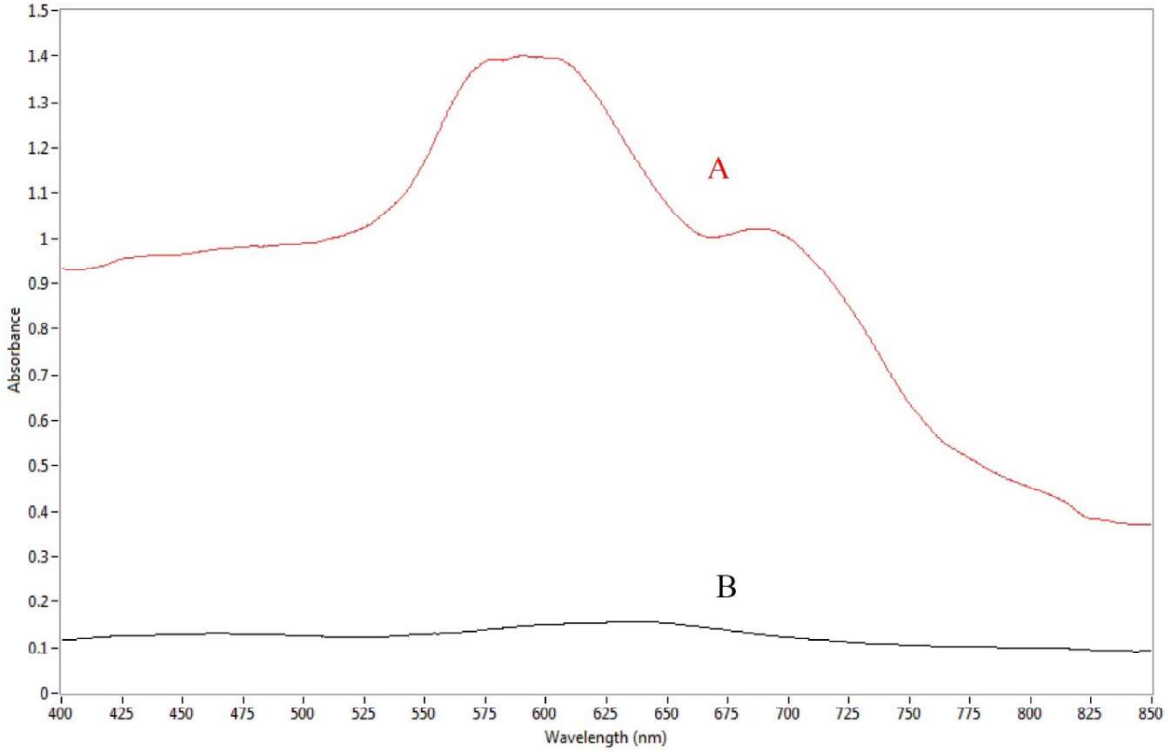

Figure 5: MSP groupings for blue miscellaneous tape samples (two groups designated A – B).

Twelve red miscellaneous were analyzed and could be categorized into six different groups by MSP. Three of the twelve samples were blind replicates leaving nine samples within this tape category. Table 7 shows the brands present in each group and Figure 6 shows the spectrum of one sample representing each of the six different groups. Additional red miscellaneous tapes were purchased but could not be cross-sectioned and therefore, not used.

Table 7: MSP groupings for red miscellaneous tape samples

Group	Number of Samples	Brands
A	1	3M Scotch Brand ColoPlastic Tape
B	1	Silicone Rescue Tape
C	3	3M Scotch Brand ColoPlastic Tape
D	1	Red Box Sealing Tape Evidence
E	1	Unknown brand Medical Tape
F	2	Lynn Peavey, ZiprWeld Evidence Tape

The miscellaneous group contained a variety of tapes where some were easily distinguished by physical characteristics. The reason for comparing the MSP results of these varied tapes was to explore the different colors used and to see if that reflects the manufacturing differences. See Appendix A for the results of brands versus final grouping for each category of tape.

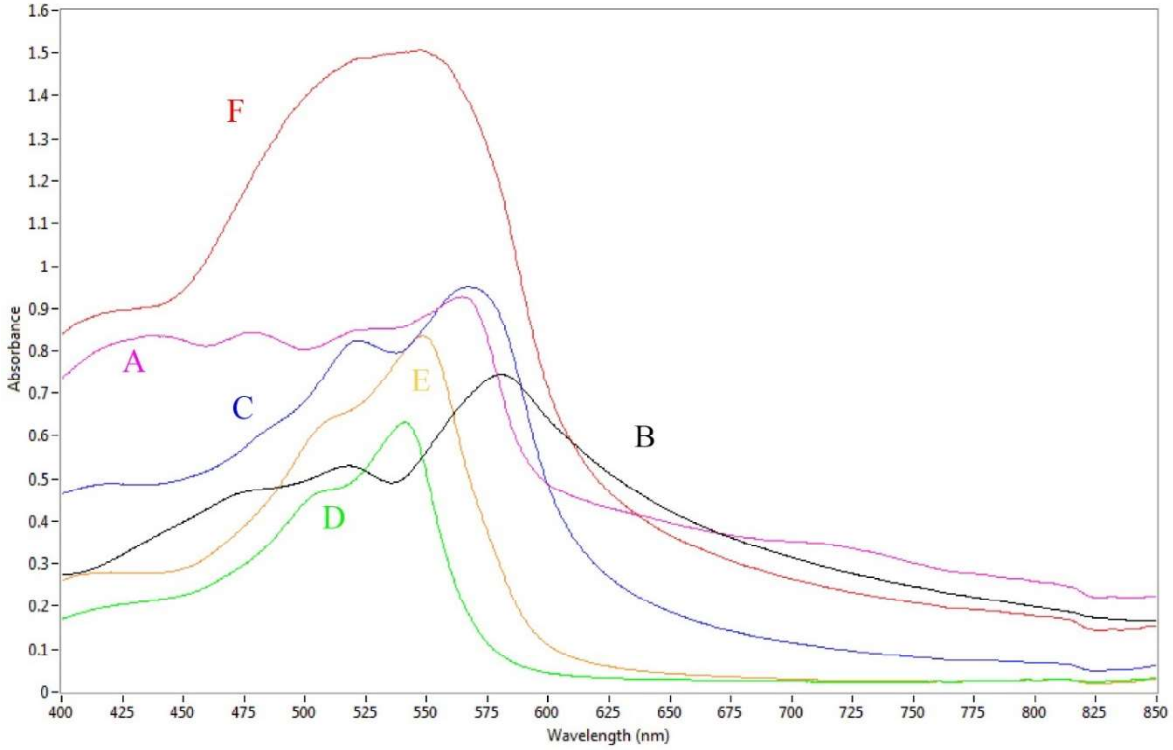

Figure 6: MSP groupings for red miscellaneous tape samples (six groups designated A—F).

Although there were only three and four groupings of the blue and red electrical tape respectively by MSP, each group only contained one brand. Duct tape and the miscellaneous tape, however, had groupings of multiple brands.

Tape manufactures can make their own formulations of backings or they may obtain them from a supplier. When obtaining backings externally, they often come from multiple suppliers for a variety of reasons, including cost savings and ensuring continuous supply. Therefore, on the store shelf the same brand of tape may have different manufactured backings. Backing suppliers may also sell their product to multiple tape manufacturers, which could result in different brands of tape containing the same manufactured backing. In addition, different formulations of backings could be provided from a single supplier. The same variety of source materials can also exist for the scrim and adhesive components of tape [15] (personal communication with Michael Tumey, Pressure Sensitive Tape Council (PSTC) Technical Advisor, on May 22, 2019). The diverse combinations of material sources in tapes is helpful for forensic tape comparison exams and may also explain the ability of MSP to discriminate some samples within brands and not discriminate brand from brand in others.

Part 2 - Routine analysis scheme

Physical characteristics:

The second part of the project was to determine if MSP would add discrimination to the current scheme of tape analysis of physical characteristics and infrared (IR) spectroscopy. The physical characteristics evaluated for the tape samples were limited and only included backing color and pattern, backing appearance, layer structure of backing, and width. As part of the backing appearance, some samples contained dimples or small uniform pockets on the backing, which is consistent with the calendering process of manufacturing [7]. Although there are additional physical characteristics that are routinely evaluated such as adhesive color and scrim, for this study the focus was on the backing. The reason for looking at the backing only and not the other features is because one may only get a small portion of a pressure sensitive tape in a casework sample where the adhesive color may be affected or scrim may not be intact. Blind samples were not used in this portion of the project. The results of the discrimination of colored tape backings by physical characteristics are summarized in Table 8.

Table 8: Summary of the discrimination of colored tape backings by physical characteristics alone

	Total Number of Samples	Groups by Physical Characteristics Only
Blue Duct	13	6
Red Duct	15	7
Blue Electrical	8	2
Red Electrical	8	2
Blue Miscellaneous	4	3
Red Miscellaneous	9	5

The physical characteristics and subsequent grouping of each tape is listed in Appendix B, organized by tape type. The blue and red electrical tape samples were only differentiated by their width placing both into only two groups for each. The four blue and nine red miscellaneous tape samples were differentiated into three and five groups respectively by their physical characteristics. Like the electrical tapes, this was due to the width of the samples. The groupings on physical characteristics are based on the full width of the tape. In actual casework when there is the possibility of only receiving a fragment of the tape, the width of a sample cannot be evaluated. This emphasizes the importance of additional analytical techniques such as MSP and FTIR.

Infrared analysis:

The infrared spectra of tape samples was evaluated within a group where tapes could not be differentiated by the physical characteristics alone. The single and double layer tape backings were analyzed by Attenuated Total Reflectance on a Thermo Scientific Nicolet

iS10 Smart Orbit. The triple layer tape backings were cross sectioned via microtome and analyzed by a Perkin Elmer Spectrum One AutoImage Microscope. Taking into account the physical characteristics and the infrared spectra, the number of groups determined within each tape color/type is summarized in Table 9. Within each category of tape, there were only two or three different infrared spectra, with the exception of the miscellaneous tapes. Due to the variety of end uses within the miscellaneous tapes, the range of materials used for the backing is larger and therefore the larger number of groups after infrared spectra analysis is to be expected.

Table 9: Summary of the discrimination of colored tape backings by physical characteristics and FTIR

	Total Number of Samples	Groups by Physical Characteristics Only	Groups by Physical Characteristics and FTIR
Blue Duct	13	6	7
Red Duct	15	8	9
Blue Electrical	8	2	4
Red Electrical	8	2	4
Blue Miscellaneous	4	3	3
Red Miscellaneous	9	5	8

While analyzing the FTIR samples, a very conservative approach was taken. For example, if one sample within a grouping of the red duct tape had slight, reproducible differences compared to the other three samples within that group then it was not considered different. Some differences that were used to discriminate samples were the presence or absence of peaks as well as large peak intensity differences. For the blue and red duct tape samples, FTIR only increased the groupings by one. This could be because most duct tape backings are made of polyethylene and the FTIR spectra are not very discriminating.

MSP analysis:

Adding microspectrophotometry to the analytical scheme of physical characteristics and infrared analysis increased the discrimination of most of the colored tape samples. MSP did not add any further discrimination to the blue and red miscellaneous groups, which is likely due to a small sample set and the previously noted varied collection of tapes. Table 10 summarized all tape groups.

Table 10: Summary of the discrimination of colored tape backings by combination of physical characteristics, FTIR and MSP

	Total Number of Samples	Groups by Physical Characteristics Only	Groups by Physical Characteristics and FTIR	Groups by Physical Characteristics, FTIR and MSP
Blue Duct	13	6	7	10
Red Duct	15	8	9	11
Blue Electrical	8	2	4	7
Red Electrical	8	2	4	6
Blue Miscellaneous	4	3	3	3
Red Miscellaneous	9	5	8	8

Based on the full analytical scheme, single brands were both differentiated into multiple groups while others remained in a single group. As referenced above, the various ways of sourcing of materials could be the reason for this. When looking at the MSP only data from Part 1, the same brand might fall into multiple groupings with the exception of the electrical tapes, where the final groups contained single brands. For example, multiple blue and red Gardner brand electrical tapes were examined. For both colors, the spectra for Gardner brand tapes were similar to each other but different from other brands. The sample size within this project was relatively small so further research could be done on a larger sample set to see trends of brand correlation. See Appendix A to see the results of brands versus final grouping for each category of tape.

The number of indistinguishable pairs and discrimination power for each stage of the analytical scheme (i.e., physical characteristics, physical characteristics/FTIR, and physical characteristics/FTIR/MSP) is summarized in Table 11. The discrimination power of FTIR alone was not determined as the FTIR spectra were only compared to samples that could not be discriminated by physical characteristics. MSP increased the discrimination power in all types of tapes with the exception of the miscellaneous tapes, which as discussed earlier could be due to the small sample sets and/or the mixture of tape types in this category.

Table 11: Summary of pairwise comparisons and discrimination power

	Total Number of Pairwise Comparisons	MSP Only	Physical Characteristics	Physical Characteristics and FTIR	Physical Characteristics, FTIR and MSP
Blue Duct	78	91%	85%	87%	96%
Red Duct	105	86%	87%	90%	95%
Blue Electrical	28	71%	54%	75%	96%

Red Electrical	28	75%	54%	75%	89%
Blue Miscellaneous	6	50%	83%	83%	83%
Red Miscellaneous	36	89%	86%	97%	97%

Part 3 - Intravariability

The intravariability of a roll of duct tape was also evaluated on a limited basis. Samples were taken from five different areas of the tape including the beginning and the end. Four different rolls of tape were evaluated: red duct tape, blue duct tape, red electrical tape and blue electrical tape. Replicates of each area were analyzed by MSP. There was minimal variation within the blue duct tape, red electrical tape, and blue electrical tape samples. The red duct tape had some variation but this variation was seen in replicate scans from multiple areas analyzed with no discernable pattern. This sample was a three-layered backing with the colored layer being the middle of the three layers so UV degradation would not be a factor. Figure 7 shows the intravariability of all four tape samples.

CONCLUSION

This study has shown that MSP is able to discriminate between similar colored tape backings. It has also shown that MSP can add discrimination to the tape analysis scheme of physical characteristics and FTIR analysis. MSP can easily be added to this analytical scheme of colored tape backings since little sample preparation is necessary and it is quick to analyze. With the limited samples analyzed, it appears there is little variability within a roll of duct tape and electrical tape. In conclusion, this technique is a valuable tool in the analysis of colored pressure sensitive tape backings.

Additional areas of research that could be completed with respect to colored tape samples include determining how the MSP adds to discrimination when the analytical scheme includes an elemental technique such as X-Ray Fluorescence and/or Scanning Electron Microscope/Energy Dispersive Spectroscopy. Larger sample sets could be analyzed to determine if there is any correlation between brand and final grouping. Additional colored tapes other than blue and red could be analyzed as well as achromatic colors such as white, black and grey. Furthermore, additional rolls of tape should be analyzed to confirm the minimal variability of MSP within a roll of tape. Roll-to-roll variability could also be examined.

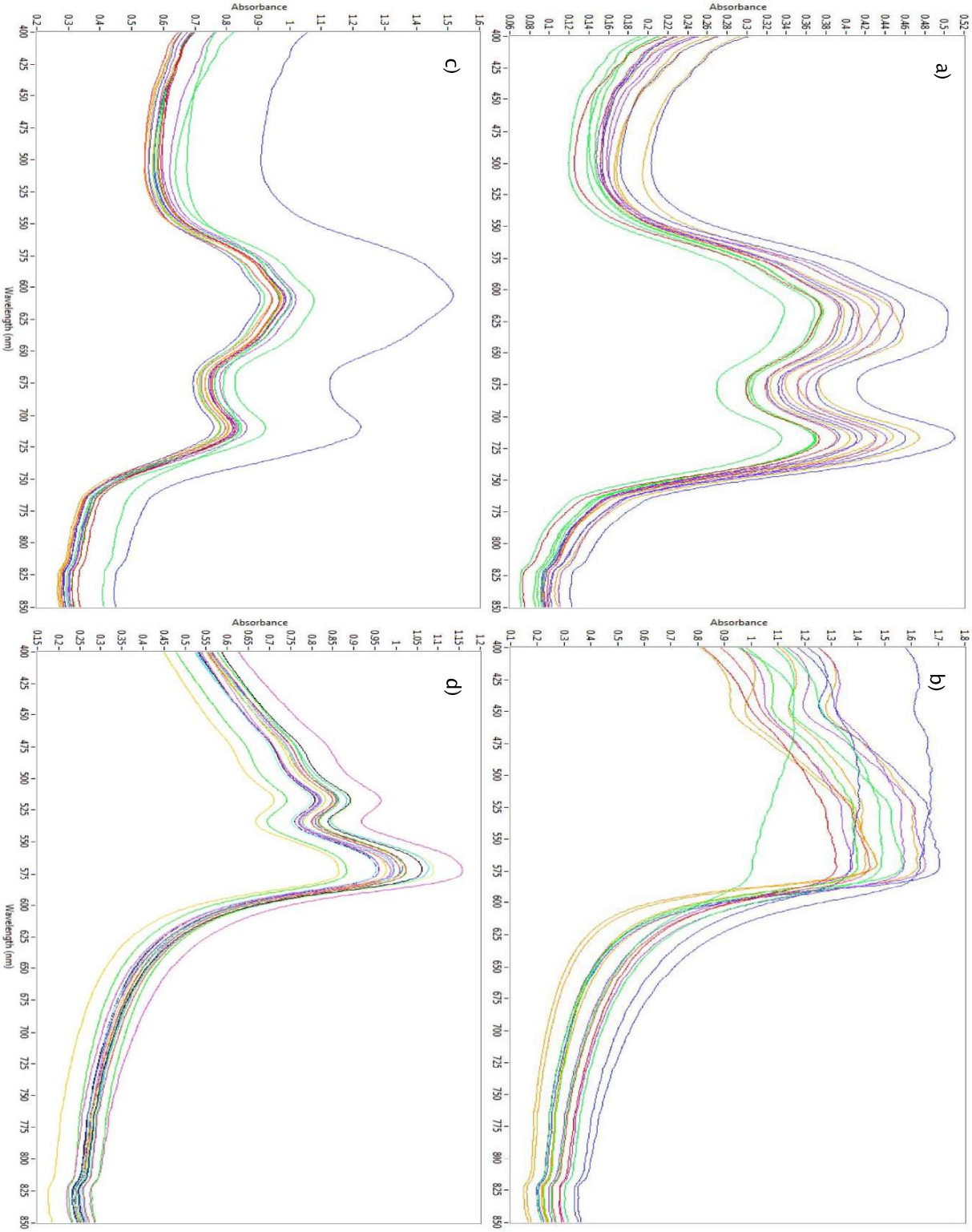

Figure 7: Intravariability seen with MSP for (a) blue duct tape (b) red duct tape (c) blue electrical tape (d) red electrical tape. Each color represents a different area of the tape roll.

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Appendix A: Providing manufacturer description and corresponding grouping based on analysis technique

	Blind #	Brand/Description	Physical Characteristics			MSP Only
			Only	Plus FTIR	Plus FTIR & MSP	
Blue Duct Tapes						
	BD3	Duck Brand; Paint Drop design	A	A1	A1a	A
	BD6	Duck Brand; Purple/Blue Tie-Dye design	B	B1	B1a	A
	BD9	3M Vinyl	C	C1	C1a	B
	BD10	Bazic Products	C	C2	C2a	G
	BD13/15	Red Ant Tape Group; Multi-Purpose	C	C2	C2b	F
	BD8	3M Scotch; Tough	D	D1	D1a	E
	BD17	IPG	D	D1	D1a	E
	BD4/5	Duck Brand	D	D1	D1b	C
	BD12/16	Shurtape; PC-600	D	D1	D1b	C
	BD1	3M Scotch; Sea Blue	E	E1	E1a	G
	BD11/14	Catch; DuctPro	E	E1	E1a	G
	BD18	ISC; Racers Tape Standard Duty	E	E1	E1b	F
	BD2/7	3M Scotch	F	F1	F1a	D
Red Duct Tapes						
	RD3	3M Scotch; Pucker Up design	A	A1	A1a	G
	RD6	Duck Brand; Hello Kitty design	B	B1	B1a	G
	RD5	Duck Brand; Color Duct Tape	C	C1	C1a	C
	RD1	Duck Brand	C	C1	C1a	C
	RD18	Bazics Products	D	D1	D1a	B
	RD11	Duck Brand; Dragon design	E	E1	E1a	G
	RD7	3M Scotch; Cherry Red[b]	F	F1	F1a	A
	RD4	3M Scotch; Cherry Red[b]	F	F1	F1a	A
	RD15/17	Catch; DuctPro	F	F1	F1b	F
	RD13/14	Shurtape; Strong Hold	F	F1	F1c	D
	RD2/8	3M Scotch	G	G1	G1a	D
	RD9	3M Scotch; Tough	G	G1	G1a	D
	RD12	Duck Brand	G	G1	G1a	D
	RD16	Universal	G	G2	G2a	E
	RD10	3M Scotch	H	H1	H1a	D

Appendix A Continued

	Blind #	Brand/Description	Physical Characteristics			MSP Only
			Only	Plus FTIR	Plus FTIR & MSP	
Blue Electrical Tapes						
	BE1/3	Gardner Bender	A	A1	A1a	C
	BE10	Ace Brand	A	A2	A2a	B
	BE8/9	Gardner Bender[b]	A	A2	A2b	C
	BE6	Gardner Bender[b]	A	A2	A2b	C
	BE11	Duck Brand; Vinyl	A	A2	A2c	A
	BE2	Gardner Bender; PVC	B	B1	B1a	C
	BE7	Ace Brand	B	B2	B2a	B
	BE4/5	Duck Brand; Vinyl	B	B2	B2b	A
Red Electrical Tapes						
	RE3	Gardner Bender[a]	A	A1	A1a	D
	RE2	Gardner Bender[a]	A	A1	A1a	D
	RE4	Gardner Bender[a]	A	A1	A1a	D
	RE8	Ace Brand	A	A1	A1b	B
	RE6	3M Scotch; Vinyl	A	A2	A2a	A
	RE7	Ace Brand	B	B1	B1a	B
	RE5	Duck Brand; Vinyl	B	B1	B1b	C
	RE1	Gardner Bender; PVC	B	B2	B2a	D
Blue Miscellaneous Tapes						
	BM1	Silicone Rescue Tape	A	A1	A1a	B
	BM2/4	3M Scotch; Colored Plastic Tape	B	B1	B1a	A
	BM5	3M Scotch; Colored Plastic Tape[a]	C	C1	C1a	A
	BM7	3M Scotch; Colored Plastic Tape[a]	C	C1	C1a	A
Red Miscellaneous Tapes						
	RM1	Silicone Rescue Tape	A	A1	A1a	B
	RM2/6	Duck Brand Tail Light Tape	B	B1	B1a	F
	RM4/7	Red Box Sealing Tape Evidence	B	B2	B2a	D
	RM5/10	3M Scotch Brand ColoPlastic Tape	B	B3	B3a	A
	RM9	3M Scotch Brand ColoPlastic Tape	C	C1	C1a	C
	RM3	ZiprWeld Evidence Tape Lynn Peavey	C	C2	C2a	F
	RM13	3M Scotch Brand ColoPlastic Tape[a]	D	D1	D1a	C
	RM11	3M Scotch Brand ColoPlastic Tape[a]	D	D1	D1a	C
	RM12	Medical Tape	E	E1	E1a	E

[a] *Replicate tape samples purchased from different retailers and/or in different packaging*

Appendix B: Physical characteristics of each tape and their subsequent categorizing

	Blind #	Backing Color	Backing Texture	Width (mm)	Cross Section	Grouping by Physical Characteristics
Blue Duct Tapes						
	BD3	multi-colored	smooth	48	colorless/blue	A
	BD6	blue/violet	smooth	48	colorless/blue	B
	BD9	dark blue	calendered	49	single	C
	BD10	dark blue	calendered	47	single	C
	BD13/15	med/dk blue	calendered	48	single	C
	BD8	med/dk blue	smooth	48	colorless/blue/colorless	D
	BD17	medium blue	smooth	48	colorless/blue/colorless	D
	BD4/5	med/dk blue	smooth	48	colorless/blue/colorless	D
	BD12/16	med/dk blue	smooth	48	colorless/blue/colorless	D
	BD1	medium blue	smooth	48	single	E
	BD11/14	medium blue	smooth	48	single	E
	BD18	med/dk blue	smooth	47	single	E
	BD2/7	medium blue	smooth	38	colorless/blue/colorless	F
Red Duct Tapes						
	RD3	red and purple	smooth	48	colorless/red	A
	RD6	red(pink)	smooth	48	colorless/red	B
	RD5	red	calendered	48	colorless/red	C
	RD1	red	calendered	48	colorless/red	C
	RD18	red	calendered	47	single	D
	RD11	red	smooth	46	colorless/red	E
	RD7	red	smooth	48	single	F
	RD4	red	smooth	48	single	F
	RD15/17	red	smooth	48	single	F
	RD13/14	red	smooth	48	single	F
	RD2/8	red	relatively smooth	47	colorless/red/colorless	G
	RD9	red	relatively smooth	48	colorless/red/colorless	G
	RD12	red	smooth	48	colorless/red/colorless	G
	RD16	red	smooth	48	colorless/red/colorless	G
	RD10	red	smooth	38	colorless/red/colorless	H

Appendix B Continued

	Blind #	Backing Color	Backing Texture	Width (mm)	Cross Section	Grouping by Physical Characteristics
Blue Electrical Tapes						
	BE1/3	blue	smooth	19	single	A
	BE10	blue	smooth	19	single	A
	BE8/9	blue	smooth	19	single	A
	BE6	blue	smooth	18	single	A
	BE11	blue	smooth	18	single	A
	BE2	blue	smooth	12	single	B
	BE7	blue	smooth	12	single	B
	BE4/5	blue	smooth	12	single	B
Red Electrical Tapes						
	RE3	red	smooth	19	single	A
	RE2	red	smooth	18.5	single	A
	RE4	red	smooth	18	single	A
	RE8	red	smooth	18	single	A
	RE6	red	smooth	19	single	A
	RE7	red	smooth	12	single	B
	RE5	red	smooth	12	single	B
	RE1	red	smooth	11	single	B
Blue Miscellaneous Tapes						
	BM1	blue	smooth	27	single	A
	BM2/4	blue	smooth	37	single	B
	BM5	blue	smooth	18	single	C
	BM7	blue	smooth	18	single	C
Red Miscellaneous Tapes						
	RM1	red	smooth	25	single	A
	RM2/6	red	smooth	51	single	B
	RM4/7	red	smooth	50	single	B
	RM5/10	red	smooth	48	single	B
	RM9	red	smooth	37	single	C
	RM3	red	smooth	36	single	C
	RM13	red	smooth	19	single	D
	RM11	red	smooth	19	single	D
	RM12	red	smooth	12	single	E