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Glitter as a Source of Trace Evidence

ABSTRACT: Trace evidence typically consists of small, minute samples that are best visualized and analyzed using a microscope. Examples of trace evidence include common things such as fibers, paint and glass as well as more unusual items such as glitter. Two projects investigating the variability of glitter were completed. This paper outlines a scientific approach to analyzing glitter as trace evidence.

KEYWORDS: glitter, trace, trace evidence

Glitter is seen more frequently in trace evidence casework as its use in cosmetics, clothing, and crafts increases. Lotions, hair styling products, and makeup often contain glitter. Glitter adorns clothing and costumes manufactured for both adults and children. Glitter is often encountered in craft projects and can be seen in pens and glue. Miscellaneous uses for glitter include holiday decorations, photo frames, balloons, party favors and even flooring.

Manufacturers regard specific processes for glitter production as proprietary and are very discreet regarding detailed steps. The general manufacturing process of glitter entails vacuum depositing metal onto a thin polymer film, coating with the intended color(s), and high-speed precision cutting into individual pieces on specially developed machines. The shape of glitter is governed by cost and minimizing waste.

Study I

The initial study documented and demonstrated the physical differences in glitter found in clothing, crafts, and cosmetics. Eighty-nine individual samples of glitter from 36 different sources were examined with respect to color, shape, size, and layer structure. Table 1 lists the 36 sources utilized in this portion of the study. Note that some samples contained more than one type of glitter, and some physical characteristics of cosmetic glitters could not be determined due to their limited size.

Thirteen different colors were observed within the 89 samples of glitter. Samples were visualized using a stereoscope while utilizing the compound microscope with

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either transmitted or reflected light for photographs. The samples included both opaque and transparent glitter. The colors were silver, gold, blue, red, green, purple, pink, pearlescent, orange, light blue, light green, yellow and clear. Figure 1 illustrates some of the various colors of glitter found. Table 2 lists the distribution of the colors. Four distinct shapes were observed within the 89 samples of glitter: square, hexagon, rectangle and diamond or rhombus. Some samples had variations of these shapes including squares with notches, hexagons with notches and squares with curved edges. Both squares and squares with notches were found within the same sample, so these were not interpreted as criteria for further discrimination. Figure 2 illustrates the different shapes found in the glitter samples as well as variations observed within the samples. Table 3 lists the distribution of different shapes among the glitter samples.

Number	Type	Source	Color
CR06	Craft	Mark Enterprises-Designer Glitter	gold, green, silver, red
CR16	Craft	Sprinklers-Premium Glitter	purple, blue, gold, green, silver, red
GL9	Craft	ProvoCraft Art Accents	red, purple, pink, blue
GL10	Cosmetic	Old Navy Glitter Hair Spray	pearlescent
CR01	Craft	Darico Glitter	red, purple, gold, silver, orange, pink, light blue, green, light green
CR17	Craft	Rose Art Washable Glitter Glue	purple, green, blue, silver, gold
CR09	Craft	Sakura Jelly Roll Pen	red
CR02	Craft	Magic Scraps-Glitter	pink, yellow, red, green, blue
GL21	Craft	Elmer's Fun Dimensions Glitter Glue	gold
CR08	Craft	Crayola-Washable Glitter Glue	blue, gold, silver, green, red
GL26	Clothing	My Michelle Dress	blue, pink
GL27	Clothing	Girl Rebel-Bodo Bing t-shirt	silver
GL28	Clothing	Disney Mickey t-shirt	red, blue
GL29	Craft	Creative Beginnings - Craft Glitter	silver
GL30	Clothing	Disney Tinkerbell t-shirt	green
GL31	Clothing	Disney Mickey Mouse t-shirt	red
GL32	Cosmetic	Noteworthy-glitter body mist	gold
GL33	Misc.	American Greetings gift bag	pearlescent
GL34	Clothing	Express cotton tank top	pearlescent
GL35	Misc.	Unique Party hat	silver
GL36	Cosmetic	ACT Glistening body glitter	pink, purple
GL37	Misc.	Barbie purse	silver
GL38	Cosmetic	Mary Kay Cypershine sparkle gel	pearlescent
GL39	Cosmetic	RUSH nail polish	purple, pearlescent
GL40	Misc.	Barbie doll dress	pearlescent
GL41	Clothing	Pajamas	gold
GL42	Craft	craft glitter	clear
GL43	Clothing	Dress	blue, pink
GL44	craft	glue	red, gold
GL45	Cosmetic	GAP	silver
GL46	Cosmetic	Roll-on glitter	gold, pink
GL47	Cosmetic	L'Oreal nail polish	could not be determined
GL48	Cosmetic	Fingr's Nail polish	silver
GL49	Cosmetic	My Generation Nail Polish	blue
GL50	Cosmetic	GAP Nail Polish	silver
GL51	Cosmetic	Noteworthy glitter body mist	gold

Table 1: The sources of glitter utilized in the first study. Thirty six sources of glitter produced 89 samples of glitter that were compared by their physical characteristics.

Color	# samples
Silver	18
Gold	13
Blue	12
Red	11
Green	9
Purple	7
Pink	7
Pearlescent	6
Orange	1
Light blue	1
Light green	1
Yellow	1
Clear	1
Undetermined	1

Table 2: Distribution of different colors among glitter samples.

The number of layers in the glitter samples varied from one to five layers. The layers also varied in sequence of clear, silver and/or color. Figure 3 illustrates some of the different layer structures seen in the glitter samples. Table 4 lists all of the different layer structures and their distribution among the glitter samples.

The size of the glitter can also vary; much depends on its intended end use. Size ranges from the tiny, non-irritating glitter found in cosmetics to the larger pieces common to craft glitter. Some samples had glitter that varied only by size; however, the size difference was clearly discernable. The sizes ranged from 99 µm to 1.1 mm. Figure 4 illustrates some of the different sizes of glitter that were encountered.

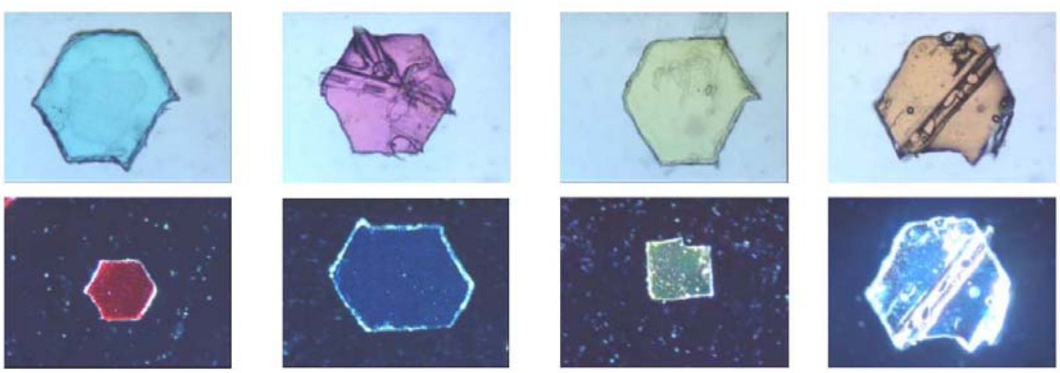

Figure 1: The top row photographed with transmitted light. The second row was photographed with reflected light. It should be noted that the last piece of glitter in the first row is the same piece as the last piece of glitter in the second row—the first under transmitted light and the second under reflected light. All photographs were taken at 100x.

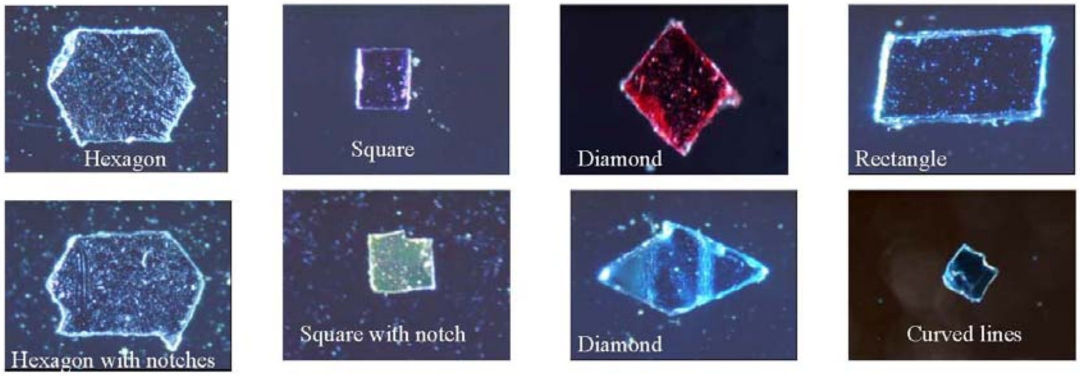

Figure 2: The variety of shapes found in the glitter samples included hexagonal, square, rectangle, and diamond/rhombus. Some samples included notches or curved lines. Photographs were taken at 100x with reflected light.

Shape	# samples
Hexagon	37
Square	24
Rectangle	13
Diamond/ rhombus	8
Undetermined	7

Table 3: Distribution of shapes among glitter samples.

Layer sequence	# samples
Color, clear, silver, color	35
Color, silver, clear, silver, color	12
Color, clear, color	11
Clear, silver	11
Color, silver, color	5
Clear, color	2
Color, color	1
Silver, color, clear, color	1
Clear, silver, color, clear	1
Clear, silver, clear, color, clear	1
Clear	1
Undetermined	8

Table 4: Types of layer structure and their distribution among the glitter samples.

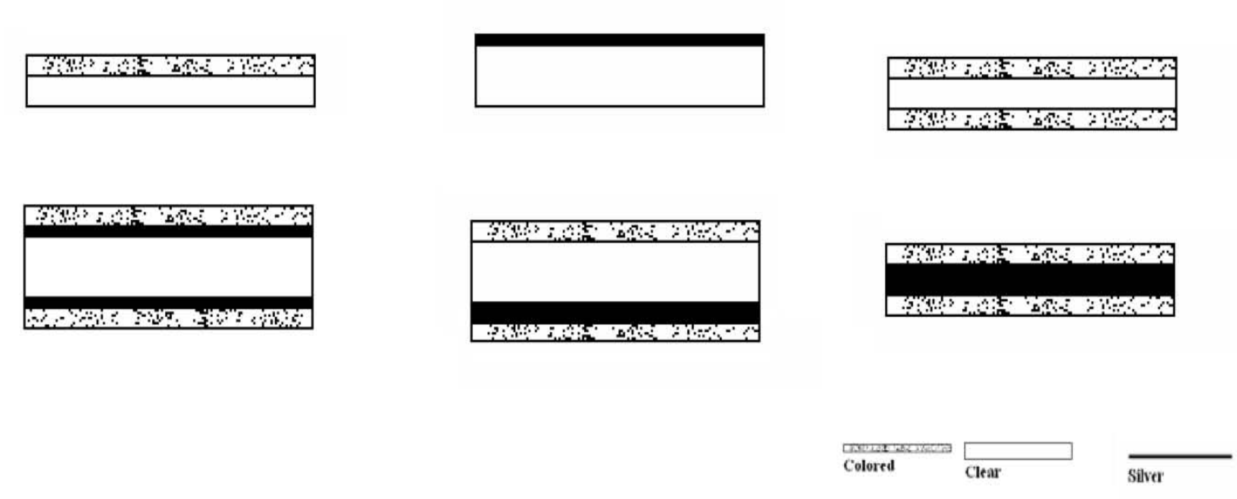

Figure 3: *Some of the different layer structures that were found among the glitter samples. The structure varied from one to five layers.*

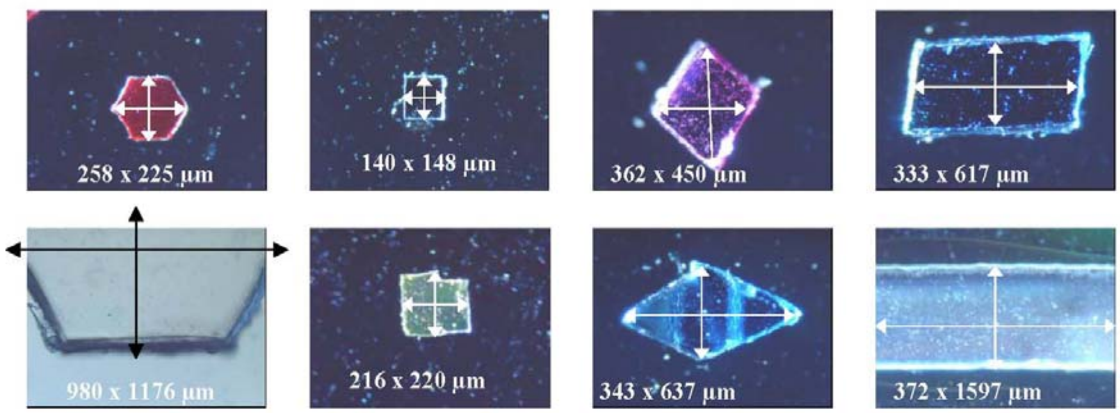

Figure 4: *Some of the varying sizes found in the glitter samples.*

Of the 89 glitter samples, eighty percent (71 groups) could be distinguished by their physical characteristics alone, demonstrating that the physical characteristics of glitter can be highly discriminating.

Study II

The second study determined the variability of glitter in one perceived color group (red). The goal was not to determine which method (physical characteristics, FTIR, SEM or MSP) was the most discriminating but rather to determine the variability within one color group. Twenty-six sources of red glitter were examined which contained 37 different types of red glitter. Some sources contained more than one type of glitter. Table 5 lists the 37 samples utilized in this study.

Number	Type	Source	Shape
CR21	craft	Glitterex Corps glitter	hexagonal
CR11	craft	Art Accentxz Festival Sparkler	hexagonal
CR16	craft	Creative Beginnings Sprinklers premium glitter	hexagonal
CR15	craft	Jones Tones premium glitter 3D paint	hexagonal
CL06	clothing	Icing by Claire's rose accessory pin	hexagonal
CR04	craft	Michael's Megaroll ribbon	hexagonal
MISC01	misc	Claire's Soccer Structure frame	hexagonal
CL04	clothing	Smart Fit Children's shoe	hexagonal
CL05	clothing	O'Neill hooded sweatshirt	hexagonal
CL03	clothing	URit children's longsleeve shirt	hexagonal
CL07	clothing	Energie blue sleeveless shirt	hexagonal
CR02	craft	Magic Scraps glitter	hexagonal , square
CR06	craft	Mark Enterprise Designer glitter	hexagonal
CL08	clothing	Limited Too children's t-shirt	hexagonal
CR23	craft	Mark Enterprise Jewel glitter ultrafine	hexagonal
CR18	craft	Stickopotamus jolee's boutique sticker collage	hexagonal, rectangle, square
CR01	craft	Darico glitter	rectangle
CR17	craft	Rose Art Washable glitter glue pen	rectangle, square, diamond
CL01	clothing	Charlotte Russe thong underwear	rectangle, square, diamond
CR08	craft	Crayola washable glitter glue – bold	square, diamond
CR07	craft	Mark Enterprise Jewel glitter fine	square
CR14	craft	Michael's Christmas Collection wired poinsettia	square, diamond
CR03	craft	Stickles Xmas red glitter	square
CR12	craft	Ranger embossing tinsel	square, diamond
CR05	craft	Krylon glitter spray	square
CR13	craft	Ranger Candy Cane Stickles	diamond

Table 5: The sources of glitter utilized in the second study. Some samples contained more than one type of red glitter.

The samples were first examined for their physical characteristics. Four different shapes of glitter were found in this red sample set (diamond, square, rectangle and hexagonal). Various sizes were observed in the samples as shown in Table 6. Four different layer sequences were also observed:

red, clear, red
red, silver, clear, silver, red
red, silver, red, silver, red
red, silver, red

Shape	Size	# samples
Hexagon (16)	1190 µm x 960 µm	1
	860 µm x 730 µm	1
	550 µm x 475 µm	4
	370 µm x 260 µm	1
	300 µm x 240 µm	9
Diamond (6)	750 µm x 380 µm	1
	350 µm x 400 µm	3
	230 µm x 220 µm	2
Rectangle (5)	980 µm x 660 µm	1
	450 µm x 350 µm	3
	300 µm x 180 µm	1
Square (10)	430 µm x 400 µm	4
	260 µm x 230 µm	5
	120 µm x 120 µm	1

Table 6: Distribution of shapes and sizes of red glitter samples in Study 2.

Next, instrumental methods were utilized to compare the chemical composition of the glitter. Fourier Transform infrared spectroscopy (FTIR) provided polymer information. A Perkin Elmer Spectrum BX FTIR system with an Autoimage microscope was used. Cross-sectional samples were utilized to get a thin layer of both the red colored layer and the clear layer of the glitter for transmission analysis. FTIR identified three different polymer types within these glitter samples: polyester, polyvinylchloride and polypropylene. The infrared spectra of these three polymer types are illustrated in Figure 5.

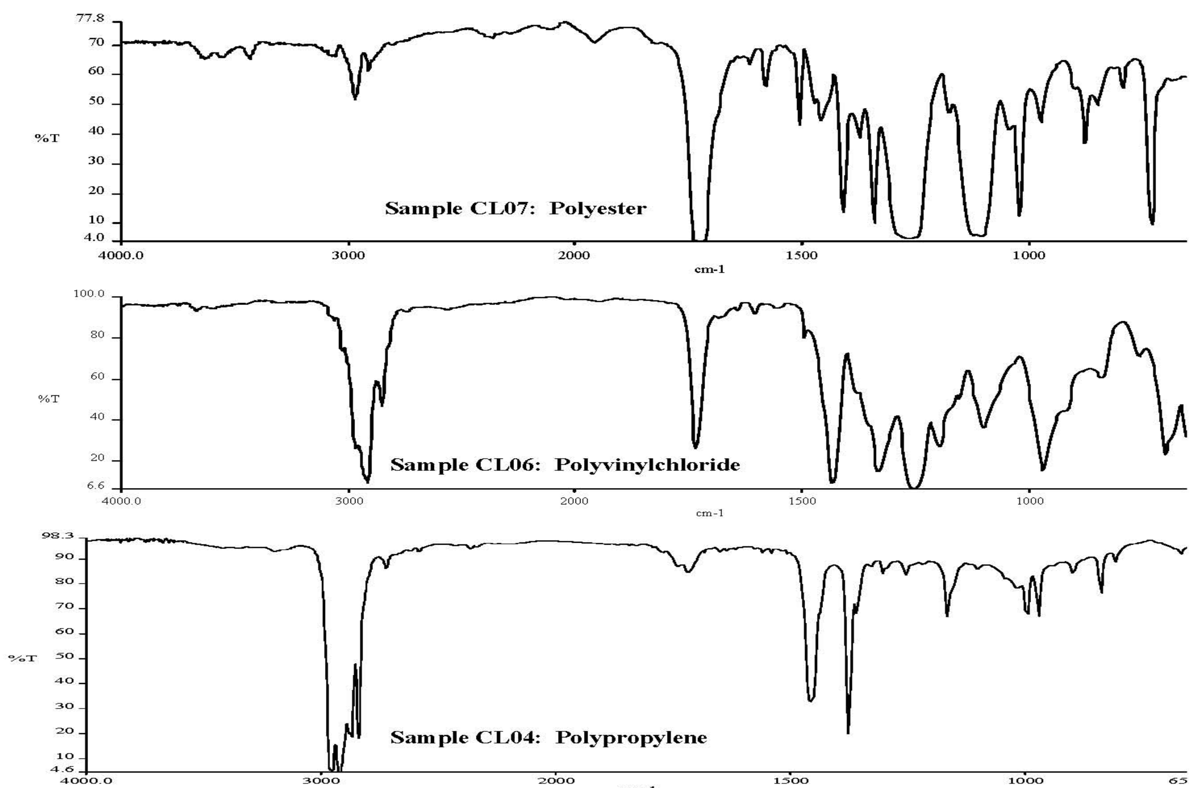

Figure 5: Three different polymer types as determined by FTIR.

Scanning electron microscopy with energy dispersive x-ray (SEM/EDS) provided elemental information regarding the clear and red layers of glitter. A Zeiss Leo Evo 50 SEM with Thermo Noran System Six EDS system was utilized for the elemental analysis. Samples that did not have the red layer as the outermost layer of the glitter piece were cross-sectioned for analysis. Samples were placed on carbon tape and analyzed for 100 live seconds at 20 kEV. Although the clear layer was also analyzed, it was found that SEM/EDS analysis was most useful for the characterization of the colored layer and less useful for the mostly organic clear layer. Figure 6 shows SEM/EDS spectra of two pieces of red glitter that were differentiated by elemental content.

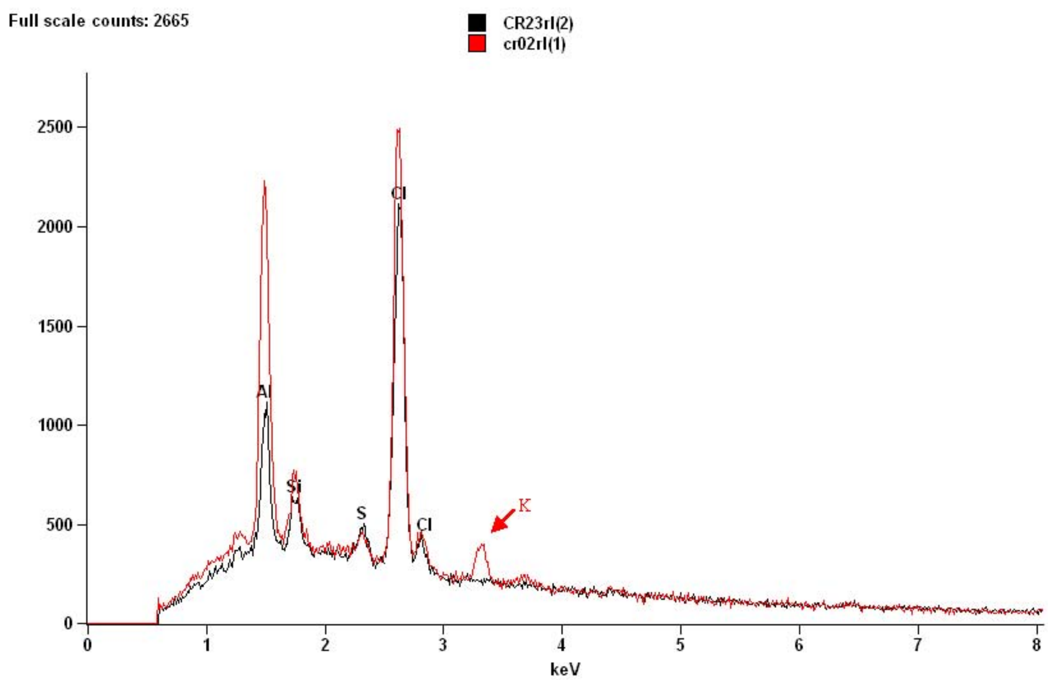

Figure 6: Spectra from SEM-EDS illustrating the differences in elemental composition from two red pieces of glitter. These pieces of glitter could not be differentiated by physical characteristics (color, shape, size, layer structure) or polymer type (polyester).

Color examinations using a microspectrophotometer (MSP) provided additional discrimination power in the analysis of glitter. Samples were either cross sectioned or the red colored layer was separated from the glitter piece and analyzed by transmission on a SEE Inc. Microspectrometer 2100 in the visible range. Some red glitter that could not be differentiated by their physical characteristics or their FTIR spectra, were differentiated by MSP (see Figure 7).

Solubility tests can also be performed on glitter. The entire piece of glitter is not needed to do a solubility test – a small portion of the glitter can be cut off and used for this destructive examination. Grieve (1987) suggested phenol/chloroform to separate the layers but this solvent was not available at the laboratory at the time of this study.

Phenol/chloroform/isoamyl alcohol was used instead. Another solvent that was used was concentrated sulfuric acid. Reactions observed in the solubility testing of the red glitter included the red layer turning yellow, the red layer turning blue, the red layer dissolving, the red layer separating from the substrate and no reaction.

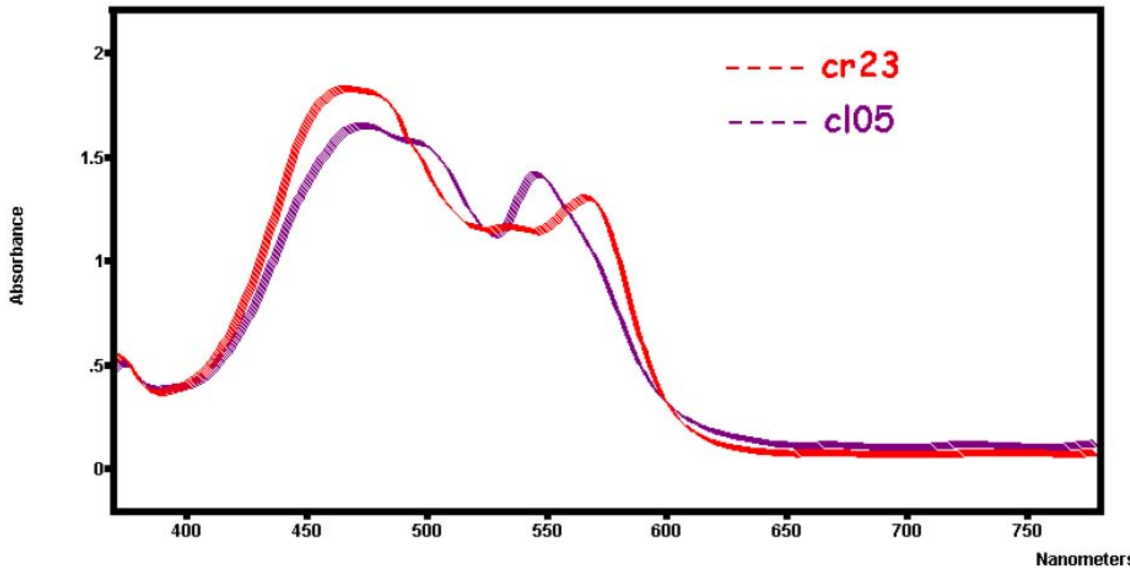

Figure 7: Spectra from MSP illustrating the differences in absorbance from two red pieces of glitter. These pieces of glitter could not be differentiated by physical characteristics (color, shape, size, layer structure), polymer type (polyester) or chemical solubilites.

Thirty-five of the 37 sample sets (95%) could be differentiated by physical characteristics, FTIR, SEM, MSP and solubility tests. Of the two pairs that could not be differentiated, one pair shared a common manufacturer ("Ranger").

Analysis Scheme for glitter

The analysis of glitter should start with the physical features. The shape, size, color and structure of the pieces of glitter should all be carefully examined. The first and foremost examination should be the physical features of color and shape. These two features are readily observed using a stereoscope. The dimensions of the glitter can be measured with the aid of a substage micrometer under a polarizing light microscope (PLM). The layer structure of glitter can be determined by looking at the piece of glitter on end under a stereomicroscope or by cutting a thin cross-section of the glitter with a new scalpel blade in the manner commonly utilized in forensic paint analysis. The layer structure of the cross section can be observed under the PLM with transmitted and reflected light (Figure 8) or by using the SEM to visualize the cross section layers (Figure 9).

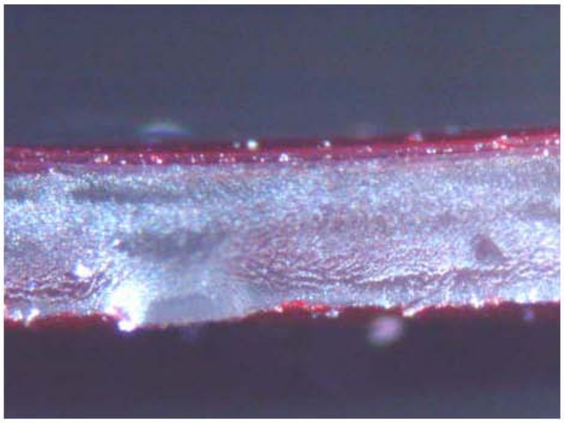

Figure 8: Cross-section of a piece of red glitter illustrating the 3 layer structure (red, clear, red) under a PLM with reflected light.

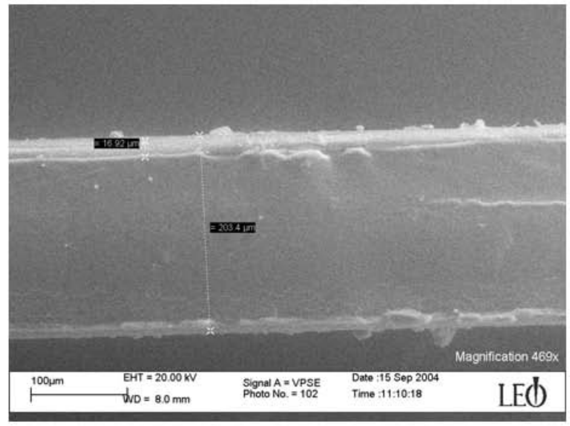

Figure 9: Cross-section of a piece of red glitter illustrating the 3 layer structure (red, clear, red) under the SEM.

Secondly, instrumental methods should be employed to compare the chemical composition of the glitter. FTIR may provide polymer information while the SEM may yield elemental information. The MSP can also further differentiate the colored glitter.

Lastly, solubility tests should be performed. Only a portion of the sample should be used in the solubility tests since they are destructive. A suggested analytical scheme for glitter is illustrated in Figure 10.

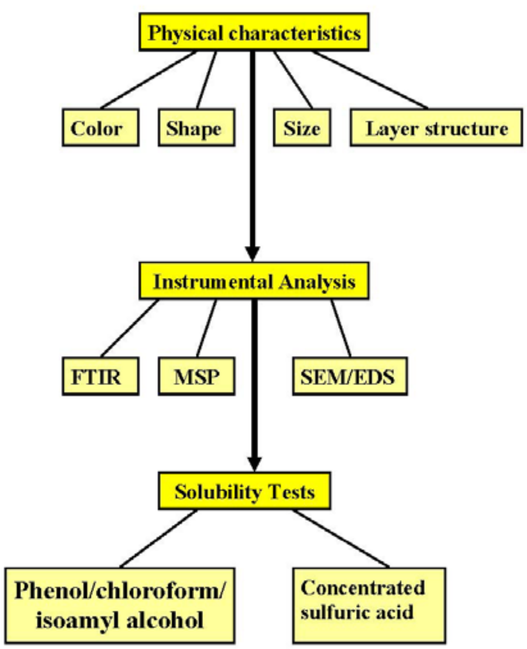

Figure 10: Analysis scheme for the examination of glitter. Since the solubility tests are destructive, they are left for the last step of the analysis scheme.

Pyrolysis gas chromatography (PGC) is not a recommended type of analysis due to the destructive nature of the test as well as the large sample size needed to obtain good pyrograms.

Results:

Eighty-nine samples of glitter were examined by their physical characteristics (color, shape, size, layer structure). Seventy-one groups could be distinguished by these physical characteristics alone. The second study of red glitter showed that using physical characteristics, FTIR, SEM and chemical solubility, 35 of the 37 samples could be differentiated.

Conclusion:

In conclusion, this paper demonstrates that glitter is a meaningful type of trace evidence due to the distinct variability in its observable characteristics. Using a scientific approach similar to that described here, comparisons of physical and chemical characteristics of glitter may provide useful associations among items of evidence, victim(s) and/or suspect(s).

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References:

Communication with Glitterex Corporation.

Bradley MJ, Lowe PC and Ward DC. Glitter: The Analysis and Significance of an Atypical Trace Evidence Examination. Poster presentation at the AAFS Annual Meeting, Chicago, IL 2003.

Grieve MC. Glitter particles – an unusual source of trace evidence. Journal of Forensic Science Society, 1987 (27) pp 405-412.