DETECTION AND DOCUMENTATION OF BLOODSTAINS CONCEALED BY PAINT: A PRACTICAL APPROACH

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ABSTRACT

Blood evidence at a crime scene can have significant value in an investigation as both a source of genetic material and a tool for event reconstruction. One method of concealing bloodstain evidence is to paint the surface on which it was deposited. The purpose of this study was to determine the best process for detection and documentation of bloodstains obscured by paint. Drywall and wood paneling were identified as two common surfaces found at crime scenes that are often painted, with white and black paint being chosen to represent the extremes in color choice. The detection methods tested were Infrared light (IR) photography, Ultraviolet light (UV) photography, Alternate Light Source (ALS) photography, leucocrystal violet (LCV), amido black, and luminol. Paint removal with sanding sponges and chemical paint stripper were tested as means to improve the visibility of the bloodstains. The best detection method was the application of luminol which allowed for 100% detection of blood through 4 layers of paint. After detection, manual paint removal using sanding sponges followed by ALS photography, for surfaces painted white, or IR photography, for surfaces painted black, was the best method to

visualize and document the stains. Additionally, this method physically revealed the bloodstains allowing for swabs of the stains to be collected. The application of hydrogen peroxide was found to further enhance the visibility of bloodstains under black paint. This process allowed for detection, documentation, and presumptive testing of bloodstains on all samples tested. Further testing should be done to assess the value of this method when used with other paint colors and substrates. Also, the sensitivity of this method should be tested using diluted or cleaned bloodstains. Other work could investigate the impact of this method on DNA analysis.

INTRODUCTION

While blood evidence recovered from a crime scene is most often valued for its serological or genetic information, bloodstain pattern analysis is, in some cases, more useful and significant.[1] The size, shape, and distribution of the patterns at a scene can be used to reconstruct the bloodshed event. Some examples of what bloodstain evidence can indicate to the investigator are: distance of the blood source to the target, nature of the force and object used to create the bloodshed, volume of blood lost, attempts to clean the area, and sequence of movements through the scene.[2]

Analysis of the crime scene is made more difficult when the blood evidence has been tampered with, cleaned up, or hidden. One method of concealing pattern evidence is to paint over the surface on which it was deposited. This makes detection more difficult, but not impossible. Recent research by Bily and Maldonado indicates that luminol will detect blood that is under 3 layers of paint; however, the spatter patterns were not identifiable.[3] Vandenberg and Oorschot determined that the Polilight could be used at 415 nm with yellow goggles to detect painted over stains, depending on the thickness and color of the paint.[4] Adair used an alternate light source (ALS) to visualize blood under paint with limited success; however, the use of

chemical paint strippers and manual paint removal methods to reveal the bloodstain patterns was found effective.[5]

In 2007, Lin, et al, demonstrated that bloodstains will absorb Infrared (IR) light.[6] The detection limit of blood on black fabric samples with IR light was found to be 1/8 times dilution. Examination and photography with IR light is not a new technique to be applied to the field of forensics. It has been used to analyze inks and paper from questioned documents, to visualize bite marks and pattern injuries on the skin, and to reveal gunshot residue and blood on dark surfaces.[7,8] IR photography has also been used extensively in the authentication and conservation of art due to the transmission of IR radiation by paint. In 2010, Howard and Nessan used an IR illuminator that emitted only IR wavelengths (700-1100 nm) to detect bloodstain patterns beneath layers of paint.[9,10] The results of this experiment showed that IR photography could detect bloodstain patterns beneath paint up to four layers in thickness. Farrar, et al., expanded on this research by using IR photography to reveal bloodstains hidden by paint of many colors and types.[11] They found that this technique could successfully reveal the blood when paint was applied in thicknesses up to six layers, depending on the pigments in the paint. White acrylic paint provided the least concealment in the visible light photos while effectively preventing IR detection of the blood after two layers. Black acrylic paint concealed the blood in the visible photos after one layer, but required multiple layers to block IR transmission. This indicated that the thickness and pigments of the paint are the most influential factors for successful detection.

The purpose of this study was to identify the best method to detect bloodstains beneath paint that would reveal and preserve the bloodstain pattern, while allowing for further processing of the blood. Several methods, including chemical and non-chemical procedures, were

compared. The non-chemical detection methods used were IR photography, ultraviolet light (UV) photography, and alternate light source (ALS) photography. The application of leucocrystal violet (LCV), amido black, and luminol were the chemical detection methods used. Amido black and LCV are staining reagents that are commonly used to develop pattern evidence deposited in blood.[12] Both reagents have fixative components which preserve the bloodstain patterns. Amido Black contains a diazo dye, naphthol blue black, which stains the proteins in blood black. The hydrogen peroxide and leucocrystal violet in LCV react with the hemoglobin in blood to produce a purple-violet color.[13] Luminol (5-amino-2,3-dihydro-1,4-phthalazinedione) reacts with the heme portion of hemoglobin to produce a blue-green chemiluminescence lasting several minutes, as opposed to a permanent stain. Luminol does not include a fixative, so it tends to dilute the bloodstain patterns. LCV, amido black, and luminol can all be used on porous and non-porous surfaces to visualize bloodstains; however, little research has been found on the success of amido black and LCV in penetrating painted surfaces.

To improve the visibility of the stains and allow sampling of the blood, techniques to remove the paint were tested. The nonchemical method used was manual paint removal with sanding sponges. Chemical paint removal was performed with paint stripper.

The success of all techniques was determined by qualitative assessment of the visibility of the bloodstain patterns on the samples and in the photographs.

MATERIALS AND METHODS

SAMPLE PREPARATION

Sheets of 4’ x 8’ drywall (USG Ultralight, 1/2”) and wood paneling (Braden, cherry, 1/8”) were purchased from a local hardware store. Using a pencil and ruler, the surface was divided into 6” x 1’ rectangles which were identified by lettered columns and numbered rows as shown in Figure 1. For the raw control, a section (1’ x 2’) was removed. The remaining sheet

was primed using white acrylic primer (Glidden PVA Interior Drywall Primer) and allowed to dry for 3 hours. Another section (1' x 2') was removed to serve as the primer control. One layer (L0) of white acrylic paint (Glidden Premium Interior Flat White) was applied to the remaining sheet and allowed to dry overnight. A section (1' x 4') was removed for the primed and painted drywall control. All sections were then separated using a box cutter. This procedure was performed with drywall and white acrylic paint, drywall and black acrylic paint (Glidden Premium Interior Flat White Base, Tint: 00NN05/000 Dark Secret), wood paneling and white acrylic paint, and wood paneling and black acrylic paint. The wood paneling was not primed or painted before the application of the bloodstains.

A 1	B 1	C 1	D 1	E 1	F 1	G 1	H 1
A 2	B 2	C 2	D 2	E 2	F 2	G 2	H 2
A 3	B 3	C 3	D 3	E 3	F 3	G 3	H 3
A 4	B 4	C 4	D 4	E 4	F 4	G 4	H 4
A 5	B 5	C 5	D 5	E 5	F 5	G 5	H 5
A 6	B 6	C 6	D 6	E 6	F 6	G 6	H 6
Raw control (removed)		Primer control (removed)		Primer + Paint control (removed)			

Figure 1. Division of drywall surface.

BLOODSTAIN SIMULATION

The blood used for this experiment was outdated blood from the local blood bank.

Impact spatter was simulated using a hammer attached to two pieces of lumber (2"x4"x2') by a bolt through the base of the handle (Figure 2). This bolt created a pivot point allowing for free movement of the hammer in one dimension.

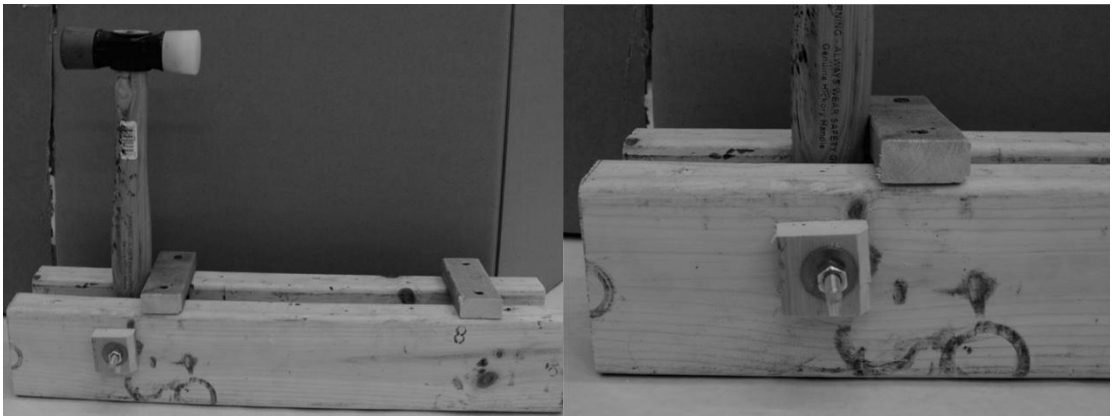

Figure 2. Construction of impact spatter device.

The lid of a pint-sized paint can was used to contain the blood for the hammer strike. Enough blood was used for each simulation so that the lid was completely covered. The lid and the hammer were secured to the floor so that the hammer impacted the center of the blood pool (Figure 3). The hammer was returned to the same vertical position before each simulation to ensure that the same force was applied each time. Large cardboard boxes were unfolded, secured together, and placed around the device to contain the spatter. Smaller boxes were placed within this enclosure to provide a surface to support the sections of substrate (Figure 4).

Figure 3. Placement of lid and hammer.

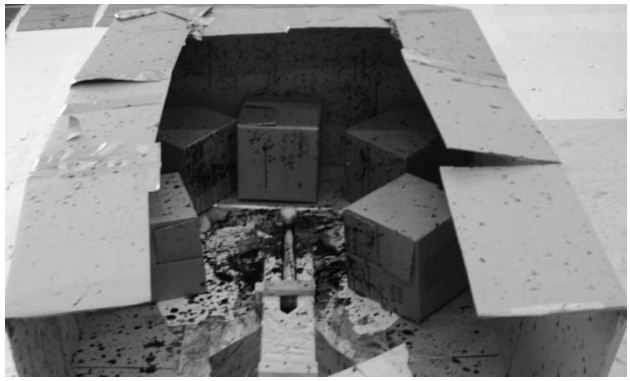

Figure 4. Cardboard box enclosure and supports.

To simulate a transfer pattern, blood was applied to a paper towel which was then wiped across the surface of the substrate. The pattern evidence was created by dipping the sole of a shoe in blood and pressing it on the substrate's surface. Blood stains (impact spatter, transfer,

and pattern) were applied so that each type of pattern was present in each 6” x 1’ rectangle (Figure 5). The stains were dried overnight.

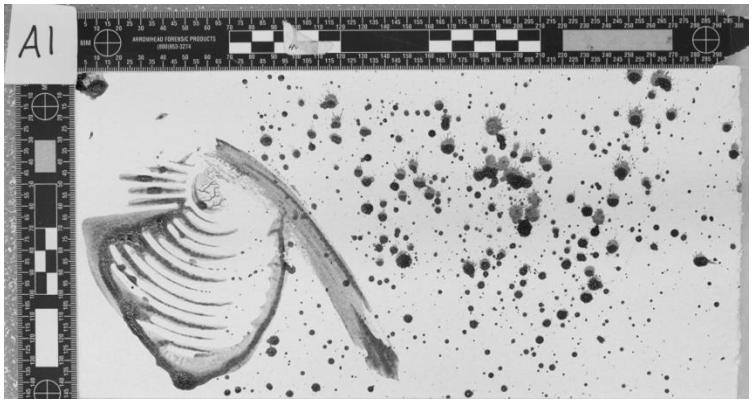

Figure 5. Example of bloodstains applied to white drywall

PAINT LAYERS

Substrate sections from columns A and B were set aside and a layer of paint was applied over the bloodstains on the remaining sections of drywall. One paint layer was considered one pass by a loaded paint roller on each rectangular drywall section. This process was repeated two more times so that columns C and D received one paint layer, columns E and F, two layers, and columns G and H, 3 layers (Table 1). An additional layer was painted on sections from column H to ensure that the bloodstains were completely latent. All paint layers were allowed to dry for a minimum of 24 hours.

Table 1. Paint layers and affected drywall sections.

Paint Layer	0	1	2	3	4
Painted Sections	--	Columns C, D, E, F, G, H	Columns E, F, G, H	Columns G + H	Column H
Finished Sections	Columns A + B	Columns C + D	Columns E + F	Column G	--

PHOTOGRAPHY

A Nikon D700 digital camera was used to take visible light photographs of each section after each layer was painted. Samples were photographed on a grey background with a linear

scale and respective sample number. The photos were taken using a tripod. The camera was in manual mode and the appropriate settings were used to obtain the optimal exposure. After painting one layer, IR, UV, and ALS photographs were taken to determine which type of photography would be best to document each type of paint and substrate. The Nikon D700 was used with an orange filter for the ALS photos. A Fuji ISPRO digital camera was used to capture the IR and UV photographs, using a Peca #904 filter and a Baader UV filter, respectively. The Peca filter only transmitted wavelengths above 700 nm, while the Baader filter only transmitted UV light. The SPEX CrimeScope was used to produce each wavelength of light. The IR light source was emitted from the IR wand on the CrimeScope and the UV light source was the 350 nm light. All ALS wavelengths (400 nm- 690 nm) emitted from the CrimeScope were tested, and it was determined that the 475 nm light provided the best results. Samples were photographed on a grey background with a linear scale and respective sample number. The camera, light source, filter, and settings used for each type of photography and paint were recorded (Table 2).

Table 2. Camera settings for IR, UV, and ALS photography.

Paint Color and Substrate	Camera Settings	Light Source			
		Visible	IR	UV	ALS
White/ Drywall	F Stop	5	5	5	5
	Shutter Speed	1/125 sec	1/2.5 sec	1/640 sec (ISO 1600)	1/3 sec
	Light Source	VIS	IR wand	350 nm	475 nm
	Camera	Nikon D700	Fuji ISPRO	Fuji ISPRO	Nikon D700
	Filter	none	Peca #904	Baader UV	Orange
Black/ Drywall	F Stop	5	5	5	5
	Shutter Speed	1/125 sec	2 sec	1/10 sec	1 sec
	Light Source	VIS	IR	350 nm	475 nm
	Camera	Nikon D700	Fuji ISPRO	Fuji ISPRO	Nikon D700
	Filter	None	Peca #904	Baader UV	Orange
White/ Wood Paneling	F Stop	5	5	5	5
	Shutter Speed	1/125 sec	1/25 sec	1/30 sec	1/2 sec
	Light Source	VIS	IR	350 nm	475 nm
	Camera	Nikon D700	Fuji ISPRO	Fuji ISPRO	Nikon D700
	Filter	None	Peca #904	Baader UV	Orange
Black/ Wood Paneling	F Stop	5	5	5	5
	Shutter Speed	1/125 sec	1/1.3 sec	1/15 sec	1/1.6 sec
	Light Source	VIS	IR	350 nm	475 nm
	Camera	Nikon D700	Fuji ISPRO	Fuji ISPRO	Nikon D700
	Filter	none	Peca #904	Baader UV	Orange

CHEMICAL VISUALIZATION METHODS

All chemical reagents were prepared according to laboratory procedure and tested before use with diluted blood samples.

Leucocrystal Violet (LCV) This lab purchases commercially developed LCV kits (Doje's Forensic Supply, lot #710899) that contain 5-sulfosalicylic acid, leucocrystal violet,

sodium acetate, and 3% hydrogen peroxide. These components were mixed according to the directions provided by the manufacturer.

The segments from row 1 (A1-H1) were sprayed with LCV and allowed to dry. The bloodstain patterns were photographed using visible light photography.

Amido Black To prepare the developing solution, naphthol blue black (1.02 g, Lynn Peavey, Lot #: 5085) was added to glacial acetic acid (50 mL, Fischer, Lot #:125452) and methanol (450 mL, Fischer, Lot #: 127496). The mixture was stirred until the naphthol blue black completely dissolved. The rinse solution was prepared by mixing glacial acetic acid (50 mL) and methanol (450 mL).

The sections from row 2 (A2-H2) were sprayed with developing solution and then rinsed using the rinse solution. This process was repeated until the desired contrast was achieved. Then, a final rinse of deionized water was performed and the sections were allowed to dry. The bloodstain patterns were photographed using visible light photography.

Luminol The luminol was made using three stock solutions. Stock A (0.4N NaOH) was made by mixing sodium hydroxide (NaOH, 16 g) and deionized water (1000 mL). Stock B (0.176M H_2O_2) consisted of 30% hydrogen peroxide (H_2O_2, 20 mL) and deionized water (980 mL). Stock C was made by combining luminol (0.708 g, Sigma Aldrich, lot #: 08996DK), NaOH (0.4 N, 125 mL) and deionized water (875 mL). The working solution was made by combining Stock A (100 mL), deionized water (700 mL), Stock B (100 mL), and Stock C (100 mL).

The sections from row 3 (A3-H3) were sprayed with luminol and the luminescence was photographed immediately with visible light photography.

PAINT REMOVAL METHODS

The segments from row 4 (A4-H4) were sanded with coarse grit (3M®, Level C) sanding sponges until the bloodstains became visible. Citristrip® chemical paint stripper was applied to row 5 (A5-H5) to remove the paint layers. The paint stripper was allowed to react with the paint for only a few minutes before it was scraped off in an effort to remove only one paint layer at a time. This process was repeated until the bloodstains became visible. The segments were photographed using IR, ALS, and visible light photography.

The treatments applied to each piece of substrate are shown in Table 3.

Table 3. Summary of paint layers and treatments.

	L 0		L 1		L 2		L 3	L4
	A	B	C	D	E	F	G	H
1	LCV	LCV	LCV	LCV	LCV	LCV	LCV	LCV
2	Amido Black	Amido Black	Amido Black	Amido Black	Amido Black	Amido Black	Amido Black	Amido Black
3	Luminol	Luminol	Luminol	Luminol	Luminol	Luminol	Luminol	Luminol
4	Sanding Sponge	Sanding Sponge	Sanding Sponge	Sanding Sponge	Sanding Sponge	Sanding Sponge	Sanding Sponge	Sanding Sponge
5	Citristrip	Citristrip	Citristrip	Citristrip	Citristrip	Citristrip	Citristrip	Citristrip

CONTROLS

The segments removed as controls were separated into 4, 6” x 1’ sections (Figure 3). Each chemical method (Amido Black, LCV, and luminol) was applied to a primed and painted control to ensure that their application did not produce any artifacts.

VISUAL EXAMINATION

For each substrate and paint color used, a visual examination was performed at each stage of the painting process. The paint layer under which the bloodstain became latent was observed and recorded. After the application of each method, qualitative analysis was performed on the photographs to determine if and when the bloodstains became visible. The visibility of the stain was rated using a system of 0-3:

- 0: bloodstain not visible
- 1: partial bloodstain visible, but no pattern recognized
- 2: 1-2 bloodstain patterns visible and identifiable, but few distinctive characteristics
- 3: all bloodstain patterns clearly visible and identifiable with unique characteristics

RESULTS

PHOTOGRAPHY

The test photographs taken of bloodstains beneath one layer of paint were compared (Figure 6). IR photography slightly improved the visibility of the stains on drywall under black paint, while the use of 475 nm light improved the visibility of the stains under white paint on both drywall and wood paneling. None of the techniques revealed the bloodstains under black paint on the section of wood paneling that was chosen for the test photos.

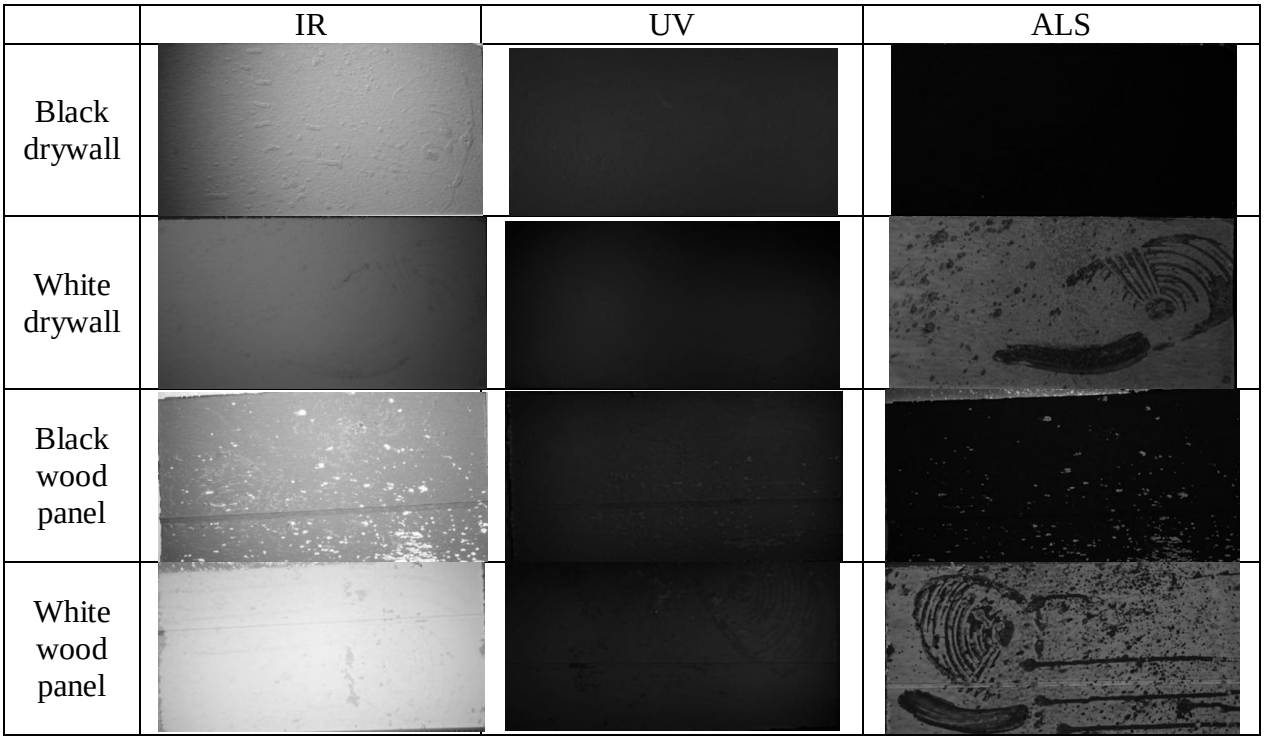

Figure 6. Test photographs with each type of photography and paint/substrate combination.

METHODS

Controls All controls gave appropriate responses and did not indicate any false positive or negative results from the drywall, primer, or paint.

Leucocrystal Violet LCV reacted with the bloodstains on drywall and wood, under both colors of paint (Appendix 1, Table 1). The bloodstains concealed by white paint were stained violet through 2 layers. LCV offered minor, if any, visibility of the stains under 3 and 4 layers of white paint. The violet color of the stain was not visible against the black paint; however, the small white bubbles produced by the reaction of the hydrogen peroxide in the LCV and the blood were visible against the black paint. This foam formed only where bloodstains were present, allowing visualization of the size and pattern of the stains. The reaction product could be wiped off the substrate and another application of the LCV would produce the same reaction again. Results were reproducible several times with the same section of substrate. Unfortunately, the minute details associated with directionality of the blood drops were not maintained. Though less detailed, this reaction was observed through all 4 layers of paint.

Amido Black For initial testing, amido black was applied to bloodstains on drywall under 1 and 3 layers of white paint. The bloodstains under 1 layer of paint were already visible, but the application of amido black resulted in a loss of detail and contrast (Appendix 1, Table 2). Some of the bloodstains under 1 layer of paint appeared dark blue; others appeared white against the blue background. When applied to the blood under 3 paint layers, there was no discernible reaction with the blood. Because of this, testing of amido black was not continued.

Luminol All concealed bloodstains tested with luminol produced a positive, luminescent response (Appendix 1, Table 3). The luminol solution lacked a fixative, so the blue green luminescence did not remain solely on the bloodstains. Instead, the luminescence

appeared as pools across the samples which were horizontal, rather than vertical. Generally, the strength of the luminescence was observed to be inversely proportional to the number of paint layers concealing the blood. Though weaker, the luminescence was still present on substrates with blood concealed by 4 layers of paint.

Sanding Manual paint removal with sanding sponges was successful in revealing the bloodstains on drywall and wood that were concealed by all layers of white paint (Appendix 1, Table 4). The sanding technique was also successful on the drywall painted black; however, the visibility of the stains was not ideal. Due to the consistency and color of the black paint and the texture of the wood paneling, sanding the paint off of the black wood panels proved to be ineffective at revealing the bloodstains. On sections of wood paneling, the paint was susceptible to peeling which resulted in some loss of the bloodstains.

Sanding + ALS or IR To improve the visibility of the bloodstains after sanding, ALS and IR photography were used (Appendix 1, Table 5). Visualization and documentation of the stains under white paint were successful with the 475 nm light and orange filter. Even previously latent bloodstains were visible and most patterns were distinguishable. IR photography was used for bloodstains under black paint. This technique allowed for successful visualization and documentation of the bloodstains on drywall, but not on the wood paneling. Some stain characteristics were distinguishable with this method, but not all.

Citristrip® Chemical paint removal with Citristrip® was successful in revealing bloodstains concealed by all layers of white paint (Appendix 1, Table 6). In general, these stains were distinguishable under visible light. The paint stripper also removed layers of black paint from both surfaces; however, the underlying bloodstains were not readily visible.

Citristrip® + ALS or IR ALS and IR photography were used to improve visibility of the bloodstains after removal of the paint with paint stripper (Appendix 1, Table 7). Visualization and documentation of the stains under white paint were successful with the ALS and orange filter; however, Citristrip® fluoresced at 475 nm. This was distracting, but could be minimized by scraping as much of the paint stripper off as possible. Previously latent bloodstains were visible and most patterns were distinguishable. This technique was most successful on bloodstains on wood paneling covered by white paint. The use of IR photography allowed for successful visualization and documentation of the bloodstains under black paint on drywall, but not on the wood paneling.

VISIBILITY OF BLOODSTAINS

After each paint layer, the sections of drywall and wood paneling were photographed using visible light and either IR (black paint) or ALS (white paint). All photos were then scored on the 0-3 scale depending on the visibility of the bloodstains (Appendix 2: Tables A1, B1, C1, D1). After the use of LCV, amido black, luminol, sanding sponges, and Citristrip, photographs were taken and scored (Appendix 2: Tables A2, B2, C2, D2).

The detection rate of latent stains was calculated based on the layer under which the bloodstains became latent for each type of paint and the visibility of those stains (Table 4). For white paint, the bloodstains were completely latent only after 4 paint layers (column H); for black paint, however, the stains were latent after 2 layers (columns E, F, G, H). Only the scores for these sections were used for this calculation. Any score higher than 0 indicated that bloodstains were detected. The application of luminol resulted in the highest detection rate at 100%.

The average visibility score of latent stains was determined after applying each method (Table 4). Again, this figure was only calculated based on the scores from the sections on which

the bloodstains were completely latent in the visible light photos. Removal of the paint by sanding followed by ALS (white paint) or IR (black paint) photography resulted in the best visibility of previously latent stains with an average score of 1.75 on the 0-3 scale.

The average improvement score of the visibility of all stains was calculated using the scores from all sections tested, even those on which the stains were not latent (Table 4). The improvement was determined by subtracting the initial score (from the initial visible light photo) from the final score (after the application of the method). Removal of the paint by sanding followed by ALS (white paint) or IR (black paint) photography gave the highest average improvement at 1.21. This method was followed closely by the application of LCV at 1.13.

Table 4. Average scores in detection and visibility of bloodstains after applying each method.

Visualization Method	Detection Rate of Latent Stains	Average Visibility of Latent Stains (0-3 scale)	Average Improvement of Visibility of All Stains (0-3 scale)
ALS (white paint)	70%	0.9	1.05
IR (black paint)	91.3%	1	1.05
LCV	50%	1	1.13
Amido Black	66.7%	--	-0.50
Luminol	100%	1	-0.08
Sanding	--	1.125	0.51
Sanding + ALS or IR	--	1.75	1.21
Citristrip	--	1.4375	0.66
Citristrip + ALS or IR	--	1.375	0.9575

DISCUSSION

DETECTION

The purpose of this study was to identify the best process for investigators to use when it is suspected that bloodstains may be present under paint. With 100% detection of painted over stains, luminol had the best detection rate of all methods tested (Table 4). IR and ALS photography were less successful detection methods, but should be employed before the use of luminol. As with any type of evidence, it is essential that every effort be made to document bloodstain evidence prior to the application of any chemical or destructive techniques. High

sensitivity is an advantage of using luminol, but the pooling of the solution on the horizontal samples inhibited observation of the bloodstain pattern of both patent and latent stains. If used on a vertical surface, the chemiluminescent solution would appear where the luminol was applied, but would then run down the surface. This necessitated the use of another method for documentation of the bloodstain pattern.

DOCUMENTATION

In testing the photography methods, it was determined that UV photography was not an effective method for documenting bloodstains under paint. It was also determined that IR photography was more successful when used with black paint than with white paint. This indicated that the white paint did not transmit IR light as effectively as black paint. The 475 nm light source, however, was able to penetrate the white paint. Because of this, ALS photography was chosen as the best method to use if white paint is encountered, while IR photography should be employed if black paint has been used. Though successful through 1 or 2 layers of paint, neither of these methods was particularly adept at documenting latent stains. The average score for the visibility of latent stains using both of these methods was approximately 1, indicating that stains were present but not recognizable. When combined with paint removal by sanding, however, IR and ALS photography were much more successful. The average visibility of latent stains was 1.75, indicating that some patterns were recognizable as spatter, transfer, or pattern stains. Though successful at improving the visibility of stains, sanding to remove the paint at a crime scene would be illogical for use as a detection method. The paint was also removed successfully using Citristrip® paint stripper, and this method could be employed when removing paint from large areas.

It is important to note that the success of the sanding method largely depended on the quality of the sanding performed. This method was fairly time consuming and it was relatively

easy to over-sand certain areas while under-sanding others. It is possible that a power sander, used cautiously, could alleviate some of these problems and produce better results.

The best method for detecting and documenting bloodstains was determined to be a combination of the methods tested. First the suspected area was documented with visible light photography (Figure 7).

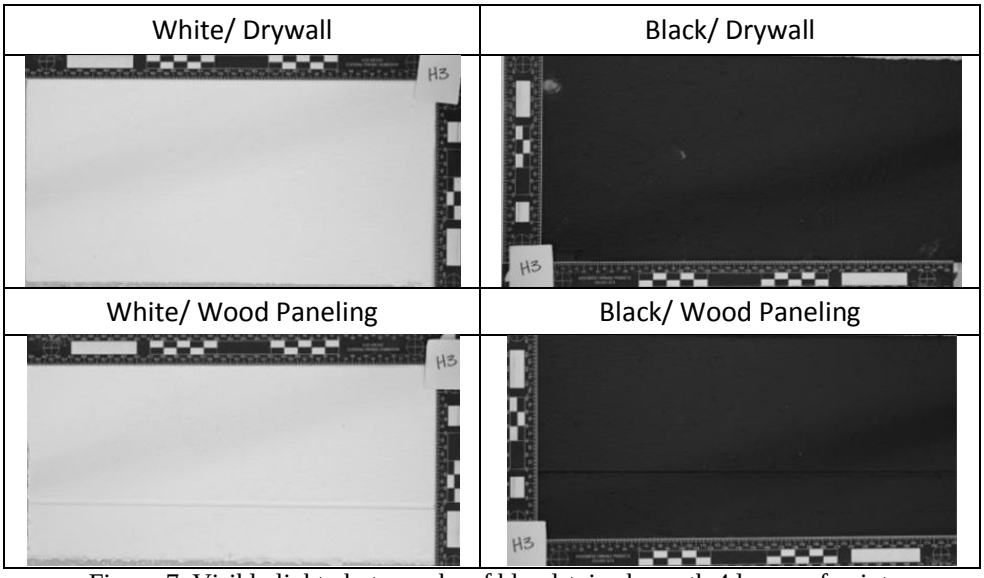

Figure 7. Visible light photographs of bloodstains beneath 4 layers of paint.

Then the area was documented with ALS or IR photography depending on the color of paint (Figure 8).

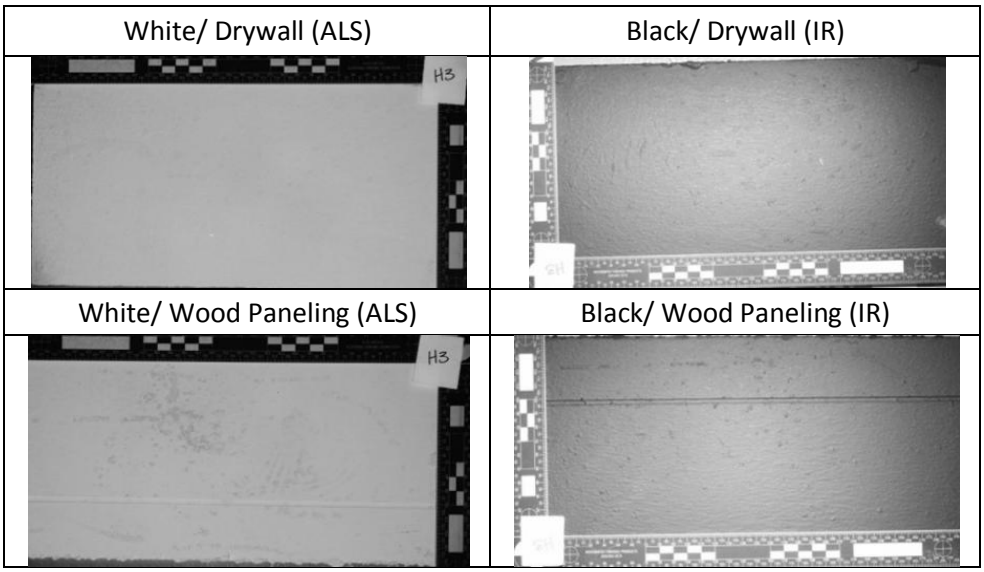

Figure 8. ALS and IR photographs of bloodstains beneath 4 layers of paint.

Luminol was applied to all sections, all of which produced a positive result (Figure 9).

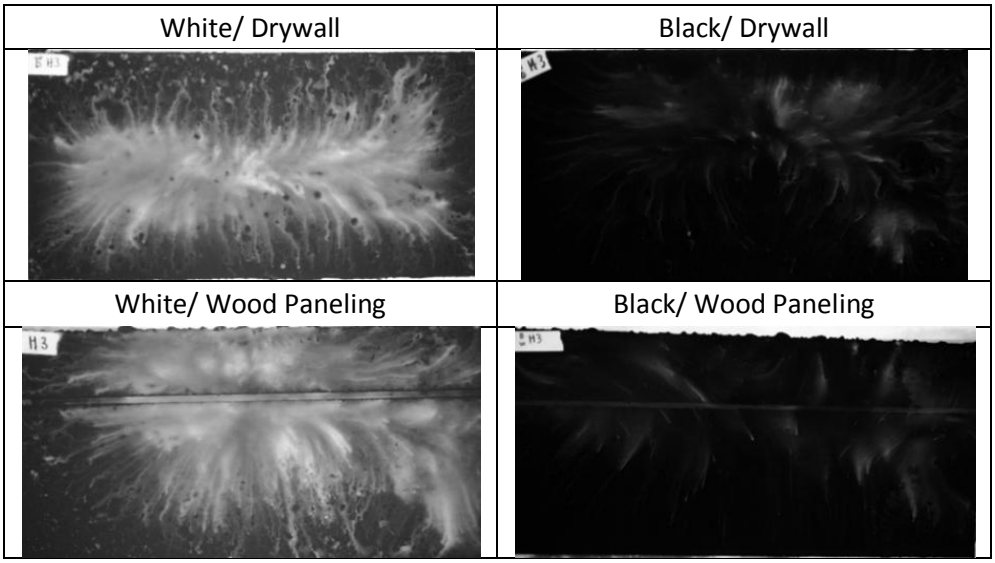

Figure 9. Photographs of bloodstains under 4 layers of paint after treatment with luminol.

After the surface dried, the paint was removed by sanding with coarse grit sanding sponges. The bloodstains became partially visible and were documented (Figure 10).

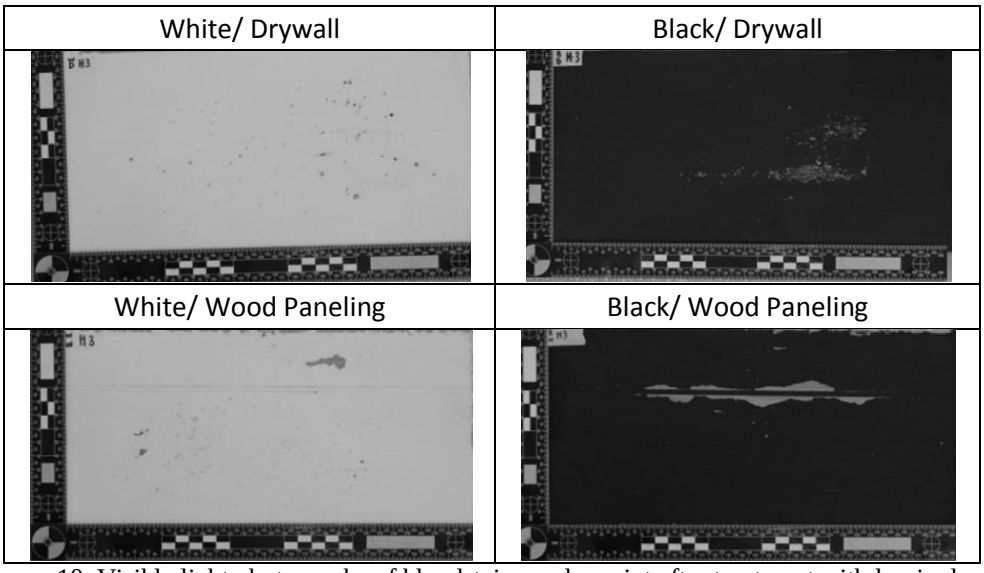

Figure 10. Visible light photographs of bloodstains under paint after treatment with luminol and paint removal by sanding.

IR and ALS photography were used for documentation of the bloodstains (Figure 11). The shoe pattern and some spatter were recognizable beneath the white paint. This indicates that the paint acts as a fixative for the blood as pooling of the luminol did not damage the stains. Despite slight improvements in visibility, the bloodstains under black paint were still not optimal.

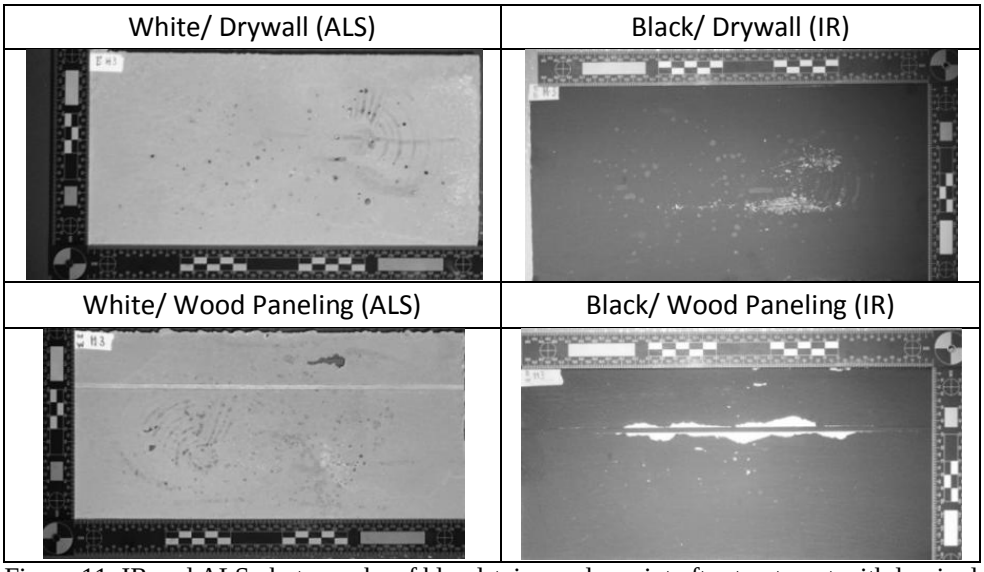

Figure 11. IR and ALS photographs of bloodstains under paint after treatment with luminol and paint removal by sanding.

Because LCV was also relatively successful in previous testing, it was applied to further visualize the stains, especially those under black paint (Figure 12). The LCV did not improve the visibility of the white stains, but was able to reveal the shoe print pattern and spatter on the black drywall. Only spatter was revealed on the black wood paneling.

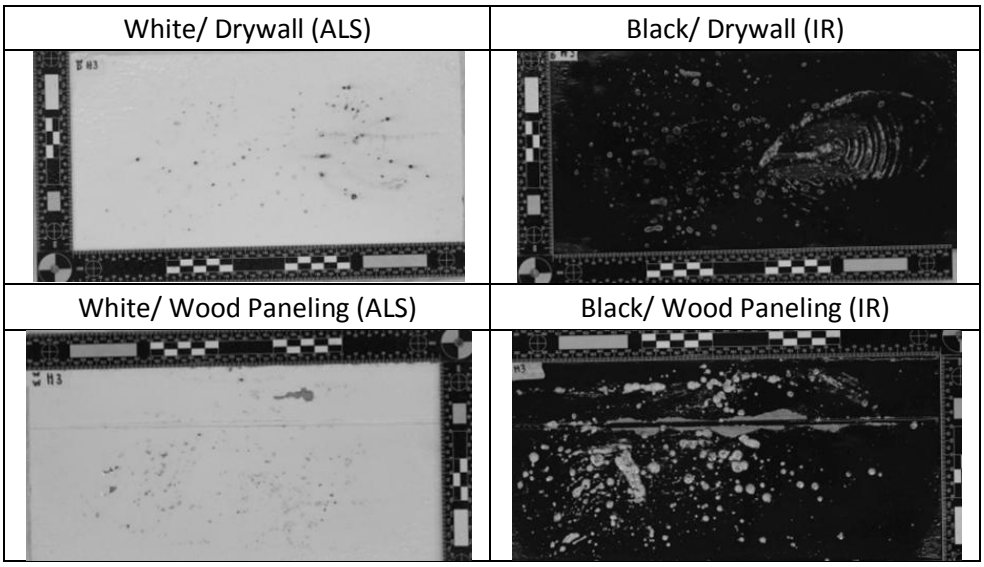

Figure 12. Photographs of bloodstains under paint after treatment with luminol, paint removal by sanding, and application of LCV.

Though the reaction of the hydrogen peroxide and blood was visible on the black paint, it was noted that only 3% hydrogen peroxide was used in the commercial LCV kits. To produce a stronger reaction and possibly visualize more bloodstains, undiluted hydrogen peroxide was applied to the black drywall and wood paneling after removal of the white foam from the LCV reaction. This revealed all aspects of the previously latent bloodstains on both substrates (Figure 13).

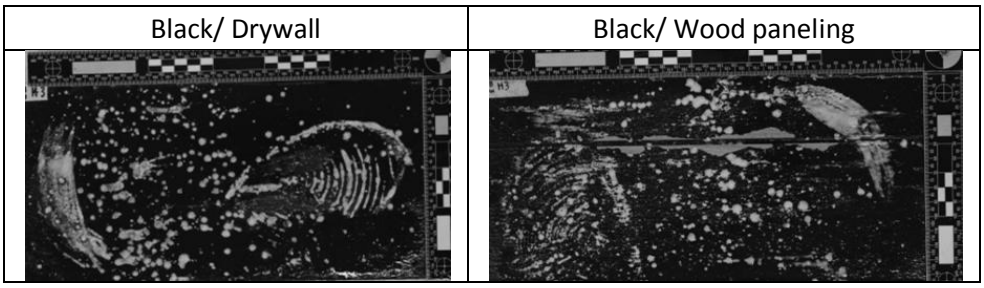

Figure 13. Photographs of bloodstains under black paint after treatment with luminol, paint removal by sanding, application of LCV, and application of undiluted hydrogen peroxide.

Following the application of LCV and hydrogen peroxide, the bloodstains were swabbed to determine whether or not the potential for further forensic testing had been preserved. All samples were tested with the presumptive blood test, Hemastix® (Siemens, lot #: 202026), used by this laboratory. All swabs yielded positive, blue-green results; however, this does not guarantee that the blood would yield a viable DNA profile. To help ensure minimum damage to the DNA, swabs should be taken before the application of the LCV.

Side-by-side photo documentation of the procedure can be found in Appendix 3.

CONCLUSION

This experiment demonstrated that it is possible to not only detect blood concealed by paint, but also to document the bloodstain pattern. Additionally, the paint can be removed to facilitate swabbing for further forensic testing. Luminol was the best method to detect latent blood, but should be preceded by an ALS (475 nm) search with orange goggles or an IR search with an IR-converted camera in live preview mode. After the ALS or IR photography has been attempted, luminol should be applied and the results photographed. Although the luminol was susceptible to dripping and pooling, the paint acted as a fixative for the blood and preserved the bloodstain pattern. Paint removal by sanding and Citristrip® paint stripper successfully exposed the bloodstains for swabbing. Photography with an orange filter and a 475 nm light source produced the best results for documentation of stains under white paint, while IR photography performed better for stains under black paint. The application of hydrogen peroxide was the best way to visualize the bloodstain patterns under black paint, though it should be used only after thorough documentation and sampling. Also, the hydrogen peroxide should be applied to horizontal surfaces whenever possible. This entire procedure could be implemented quickly and

easily as it requires chemicals, procedures, and equipment that are commonly used in most laboratories.

Further testing should be done to assess the value of this method when used with other paint colors and substrates. Also, the sensitivity of this method should be tested using diluted or cleaned bloodstains. Other work could investigate the impact of this method on DNA analysis.

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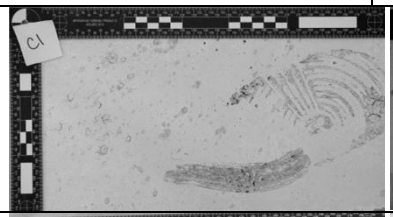
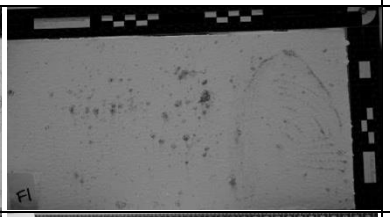
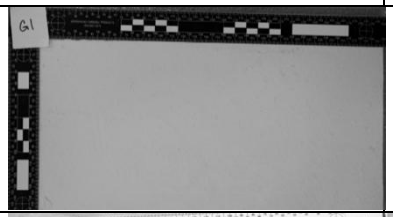
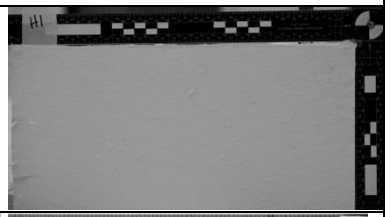
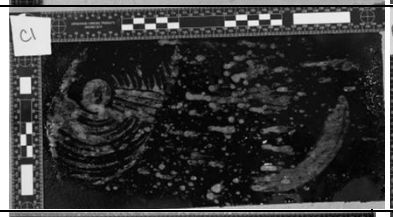
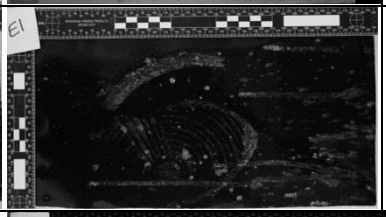
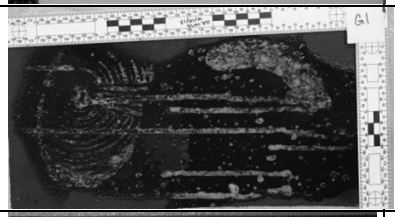
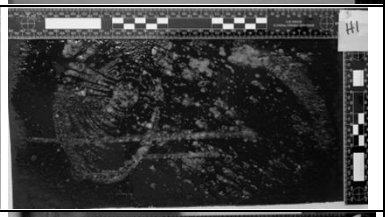
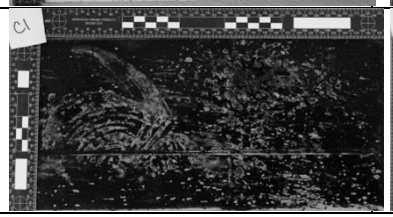
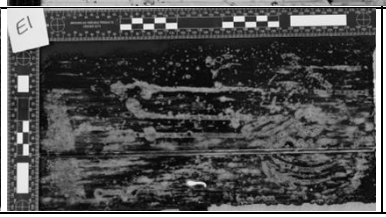
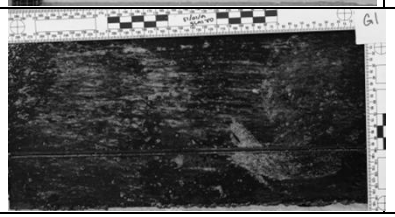
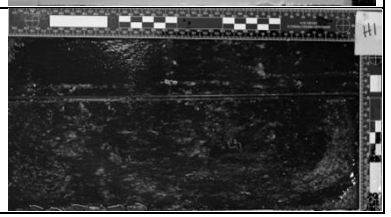
Appendix 1: Detection and Documentation Methods.

Table 1. Photographs of bloodstains under paint after treatment with LCV.

Paint Layer	L1	L2	L3	L4
White/ Drywall				
Black/ Drywall				
White/ Wood Paneling				
Black/ Wood Paneling				

Appendix 1: Detection and Documentation Methods.

Table 2. Photographs of bloodstains under paint after treatment with amido black.

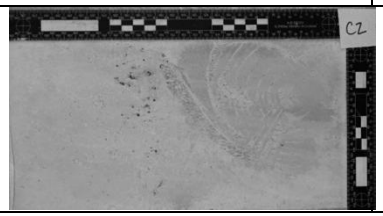
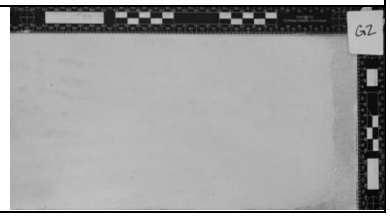
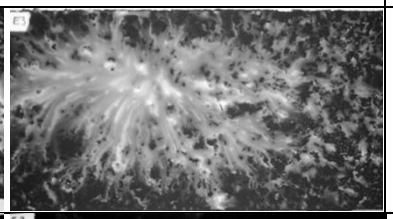
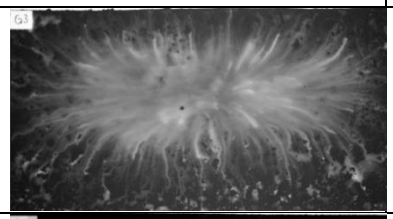
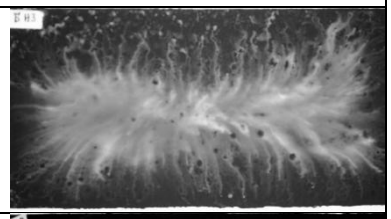
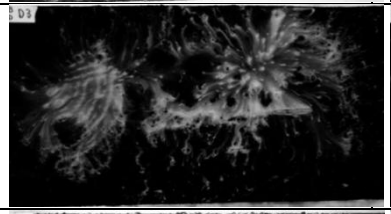
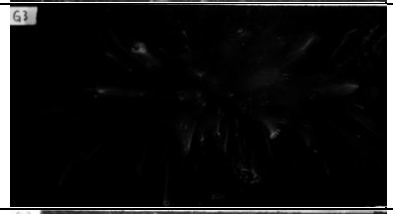
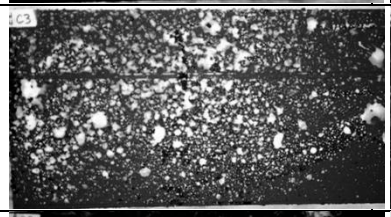
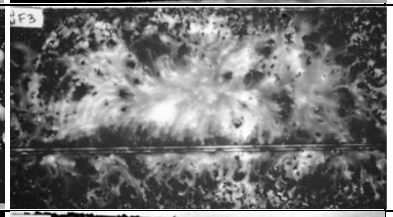
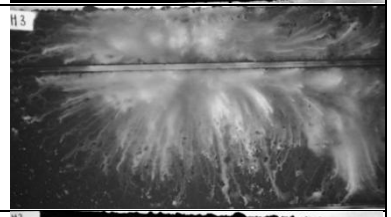
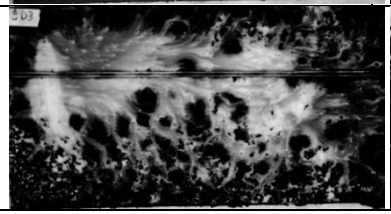
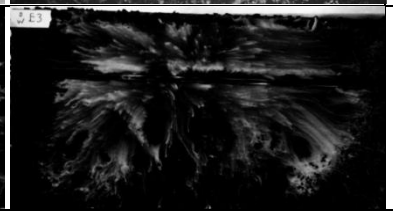
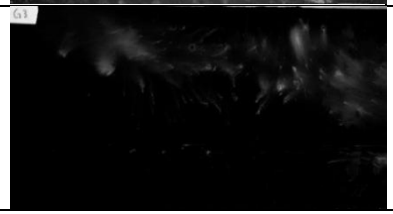
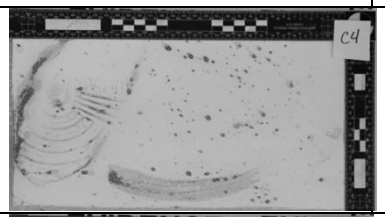
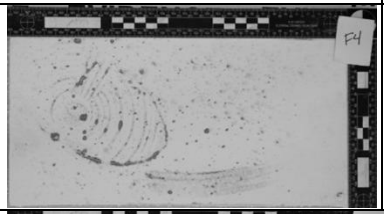
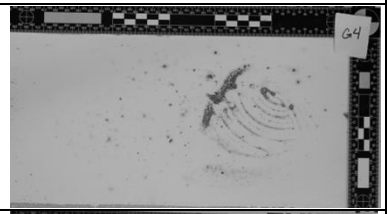
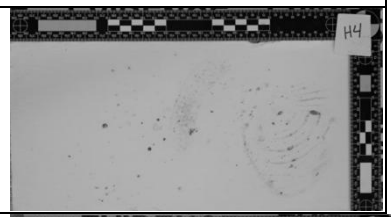
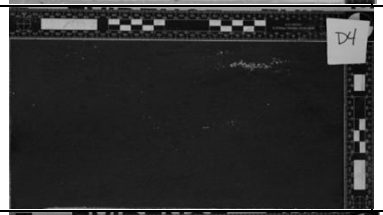
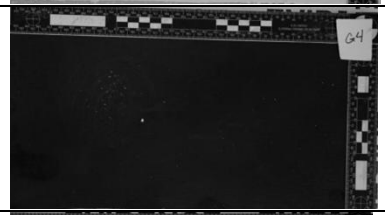
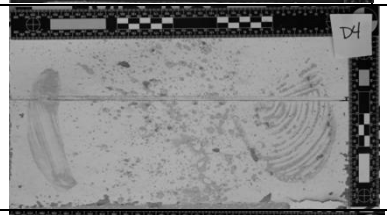
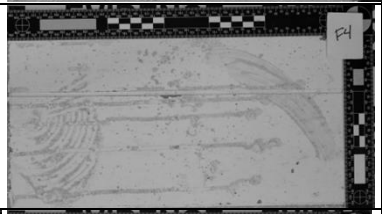
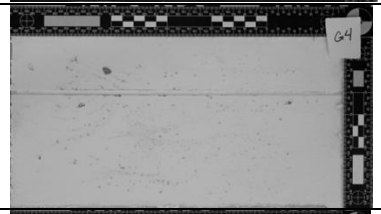
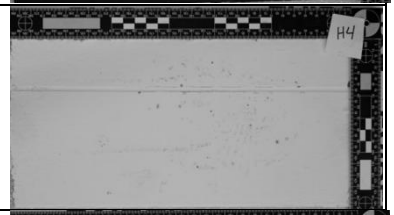
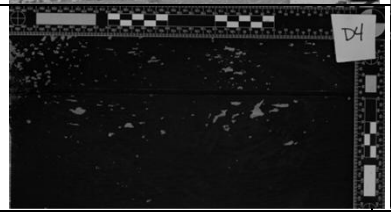
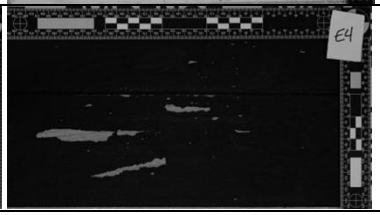
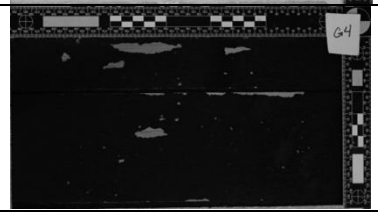
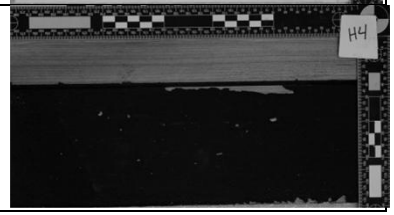
Paint Layer	L1	L3
White/ Drywall		

Table 3. Photographs of bloodstains under paint after treatment with luminol.

Paint Layer	L1	L2	L3	L4
White/ Drywall				
Black/ Drywall				
White/ Wood Paneling				
Black/ Wood Paneling				

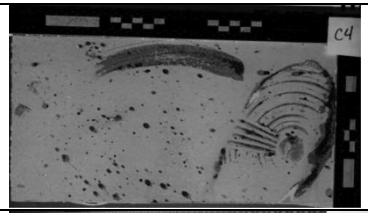
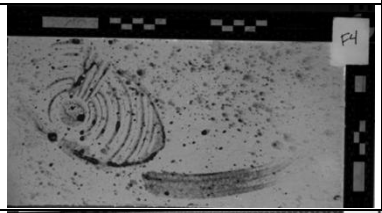
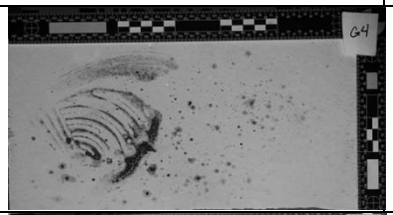
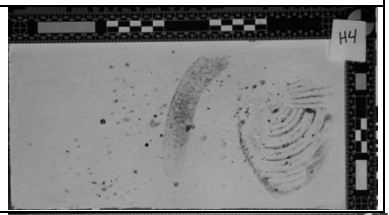
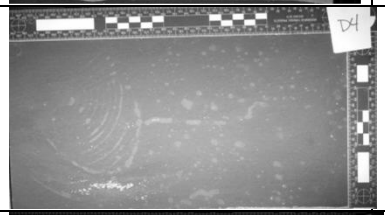
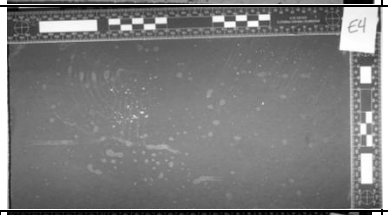
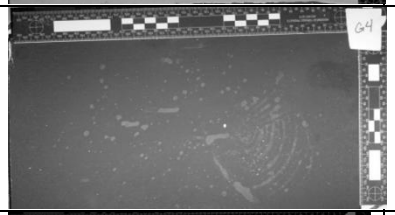
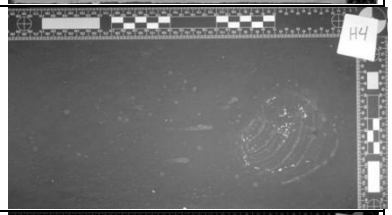
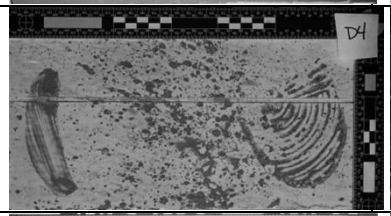
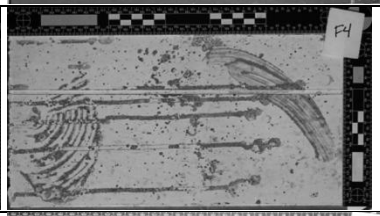
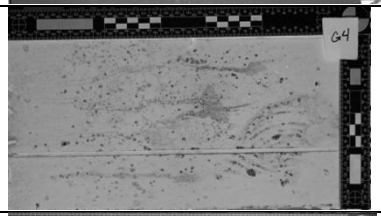
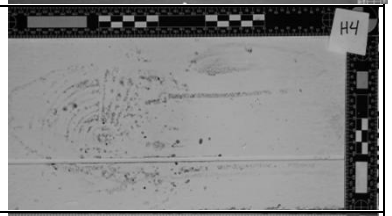
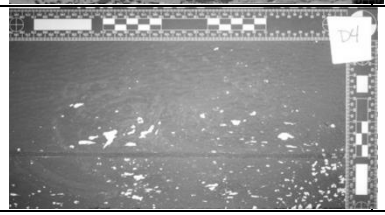
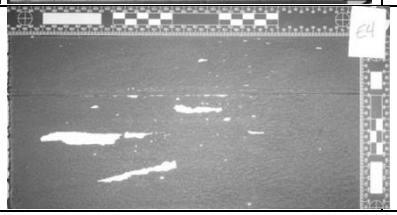
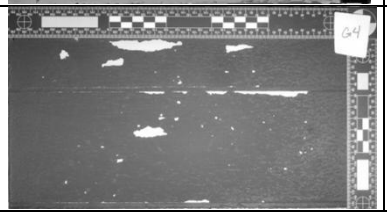
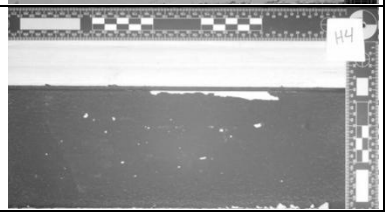
Appendix 1: Detection and Documentation Methods.

Table 4. Photographs of bloodstains under paint after manual paint removal with sanding sponges.

Paint Layer	L1	L2	L3	L4
White/ Drywall				
Black/ Drywall				
White/ Wood Paneling				
Black/ Wood Paneling				

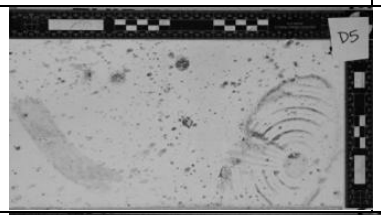
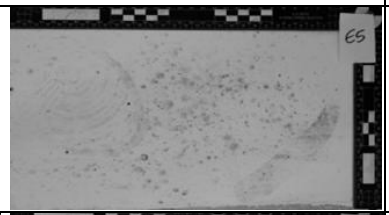
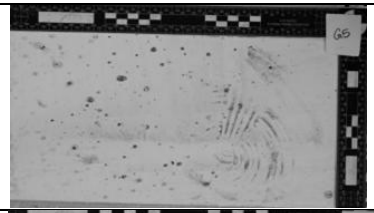
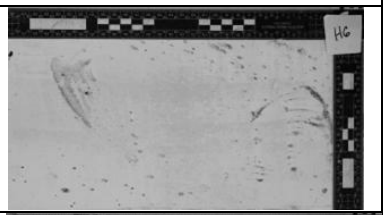
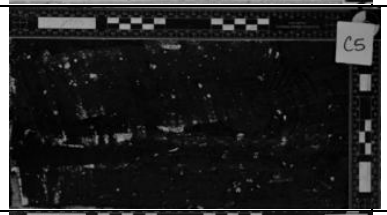
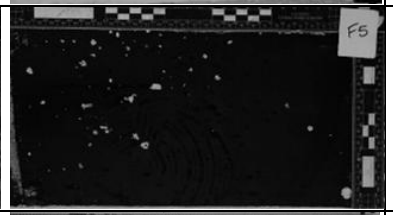
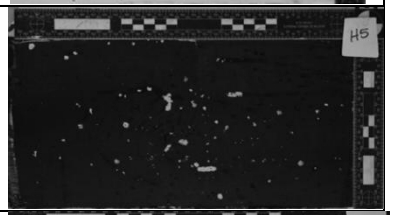
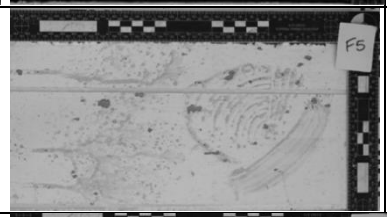
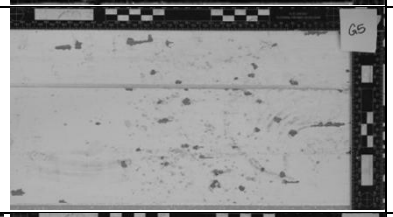
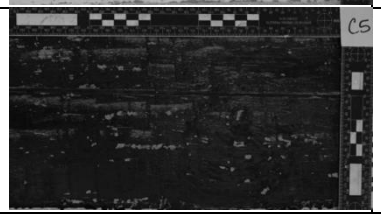
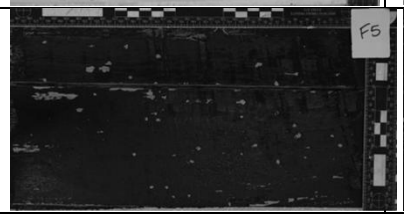
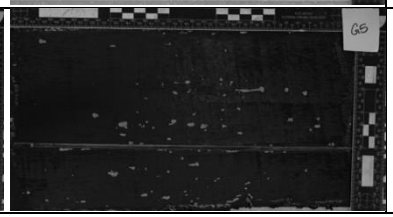
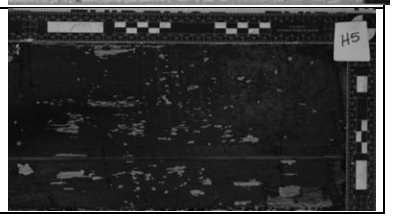
Appendix 1: Detection and Documentation Methods.

Table 5. Photographs of bloodstains under paint after manual paint removal with sanding sponges followed by ALS or IR photography.

Paint Layer	L1	L2	L3	L4
White/ Drywall (ALS)				
Black/ Drywall (IR)				
White/ Wood Paneling (ALS)				
Black/ Wood Paneling (IR)				

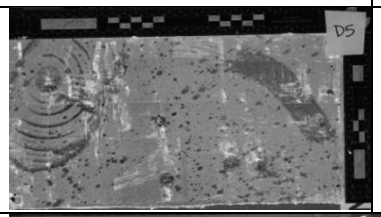
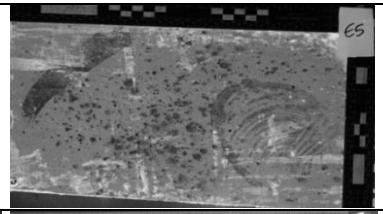
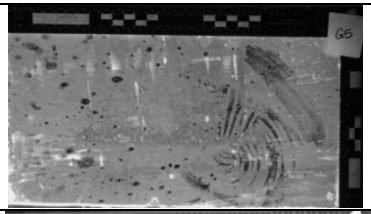
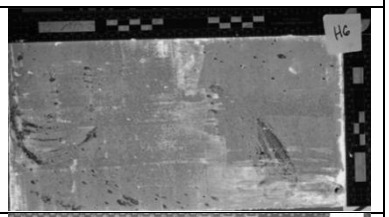
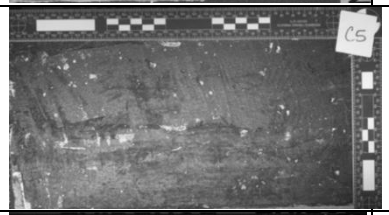
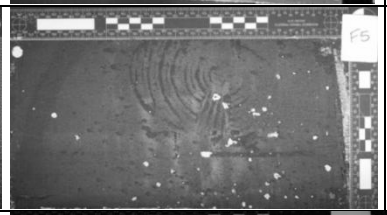
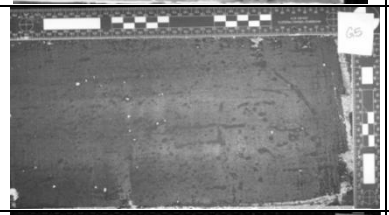
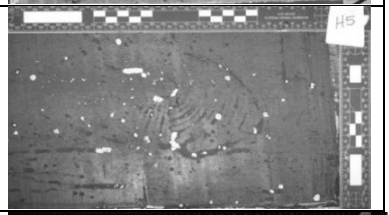
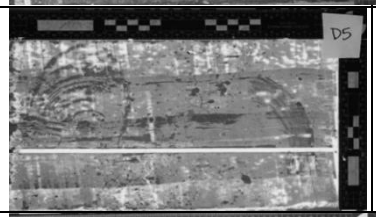
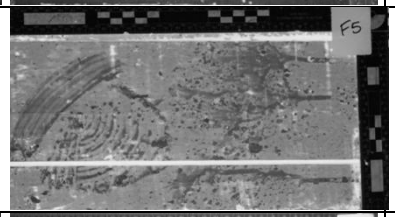
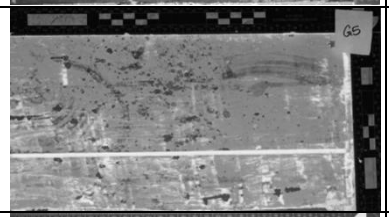
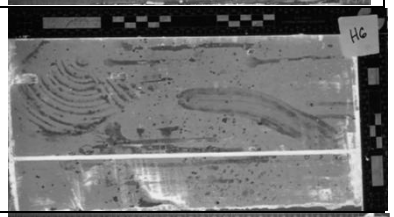
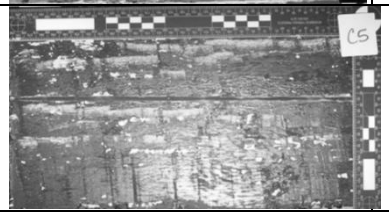
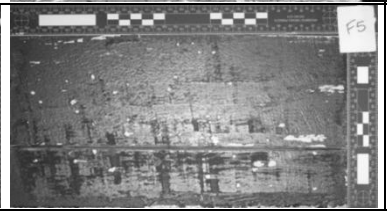
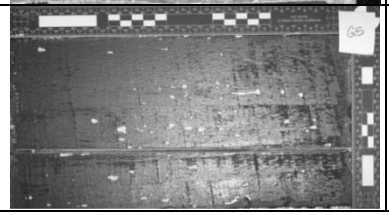
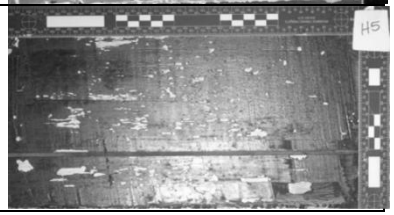
Appendix 1: Detection and Documentation Methods.

Table 6. Photographs of bloodstains under paint after paint removal with Citristrip® chemical paint stripper.

Paint Layer	L1	L2	L3	L4
White/ Drywall				
Black/ Drywall				
White/ Wood Paneling				
Black/ Wood Paneling				

Appendix 1: Detection and Documentation Methods.

Table 7. Photographs of bloodstains under paint after paint removal with Citristrip® chemical paint stripper followed by ALS or IR photography.

Paint Layer	L1	L2	L3	L4
White/ Drywall (ALS)				
Black/ Drywall (IR)				
White/ Wood Paneling (ALS)				
Black/ Wood Paneling (IR)				

Appendix 3. Photographs of Detection and Documentation Procedure

A. Drywall and White Paint

Table A1. Visibility of bloodstains on drywall beneath white acrylic paint.

Paint Layers	0		0		1		1		2		2		3		4	
Light Source	Vis	ALS	Vis	ALS	Vis	ALS	Vis	ALS	Vis	ALS	Vis	ALS	Vis	ALS	Vis	ALS
	A		B		C		D		E		F		G		H	
1	3	--	3	--	3	3+	3	3+	1	2	1	3	1	1+	0	
2	3	--	3	--	3	3+	3	3+	2	3	1	3	1	1+	0	0
3	3	--	3	--	3	3+	3	3+	1	3	1	3	1	1+	0	1
4	3	--	3	--	3	3+	3	3+	1	3	2	3	1	1+	0	1
5	3	--	3	--	3	3+	3	3+	1	3	1	3	1	1+	0	0
6	3	--	3	--	3	3+	3	3+	2	3	2	3	1	1+	0	0

Table A2. Comparison of visibility of bloodstains on drywall beneath white acrylic paint before and after application of various methods.

Paint Layers	1		1		2		2		3		4	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Method	C		D		E		F		G		H	
LCV	3	3	3	3	1	1	1	2	1	0	0	0
Amido Black	3	2	3	--	2	--	1	--	1	0	0	--
Luminol	3	1	3	1	1	1	1	1	1	1	0	1
Sanding	3	3	3	3	1	2	2	3	1	2	0	2
ALS (after sanding)	3	3+	3	3+	2	3	3	3+	2	3	2	3
Citristrip	3	3	3	3	1	3	1	3	1	3	0	2
ALS (after stripping)	3	3	3	3	3	3+	3	3+	3	3+	2	2

Appendix 2: Scoring of Photographs

B. Drywall and Black Paint

Table B1. Visibility of bloodstains on drywall beneath with black acrylic paint.

Paint Layers	0		0		1		1		2		2		3		4	
Light Source	Vis	IR	Vis	IR	Vis	IR	Vis	IR	Vis	IR	Vis	IR	Vis	IR	Vis	IR
	A		B		C		D		E		F		G		H	
1	3	3+	3	3+	1	3	1	2	0	1	0	1	0	1	0	
2	3	3+	3	3+	1	3	1	2	0	1	0	1	0	2	0	1
3	3	3+	3	3+	1	2	1	3	0	2	0	1	0	1	0	1
4	3	3+	3	3+	1	2	1	3	0	1	0	2	0	1	0	1
5	3	3+	3	3+	1	2	1	3	0	1	0	1	0	1	0	1
6	3	3+	3	3+	1	3	1	3	0	2	0	1	0	1	0	1

Table B2. Comparison of visibility of bloodstains on drywall beneath black acrylic paint before and after application of various methods.

Paint Layers	1		1		2		2		3		4	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Method	C		D		E		F		G		H	
IR (average)	1	2.5	1	2.7	0	1.3	0	1.2	0	1.2	0	1
LCV	1	3	1	2	0	3	0	2	0	3	0	3
Amido Black	1	1	1	--	0	--	0	--	0	--	0	---
Luminol	1	1	1	1	0	1	0	1	0	1	0	1
Sanding	1	1	1	1	0	1	0	1	0	2	0	1
IR (after sanding)	1	2	1	3	1	2	1	2	1	2	1	2
Citristrip	1	1	1	0	0	2	0	2	0	1	0	2
IR (after Citristrip)	1	1	0	0	2	3	2	3	1	1	2	2

Appendix 2: Scoring of Photographs

C. Wood Paneling and White Paint

Table C1. Visibility of bloodstains on wood paneling beneath white acrylic paint.

Paint Layers	0		0		1		1		2		2		3		4	
Light Source	Vis	ALS	Vis	Als	Vis	Als	Vis	ALS	Vis	ALS	Vis	ALS	Vis	ALS	Vis	ALS
	A		B		C		D		E		F		G		H	
1	3	--	3	--	3	3+	3	3+	2	3	2	3	1	3	0	
2	3	--	3	--	3	3+	3	3+	2	3	2	3	1	3	0	2
3	3	--	3	--	3	3+	3	3+	3	3	3	3	1	3	0	1
4	3	--	3	--	3	3+	3	3+	3	3	3	3	1	2	0	2
5	3	--	3	--	3	3+	3	3+	3	3	3	3	1	3	0	1
6	3	--	3	--	3	3+	3	3+	3	3	3	3	1	3	0	1

Table C2. Comparison of visibility of bloodstains on wood paneling beneath white acrylic paint before and after application of various methods.

Paint Layers	1		1		2		2		3		4	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Method	C		D		E		F		G		H	
ALS (average)	3	3+	3	3+	2.7	3	2.7	3	1	2.8	0	1.4
LCV	3	3+	3	3+	2	3	2	3	1	1	0	0
Amido Black	3	--	3	--	2	--	2	--	1	--	0	--
Luminol	3	1	3	1	3	1	3	1	1	1	0	1
Sanding	3	3	3	3	3	3	3	3	1	1	0	1
ALS (after sanding)	3	3+	3	3+	3	3+	3	3+	1	2	1	2
Citristrip	3	3	3	3	3	3	3	3	1	2	0	2
ALS (after citristrip)	3	2	3	2	3	3	3	3+	2	3	2	3

Appendix 2: Scoring of Photographs

D. Wood Paneling and Black Paint

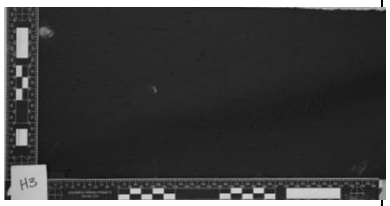
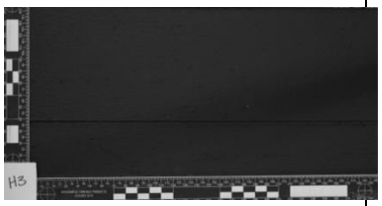
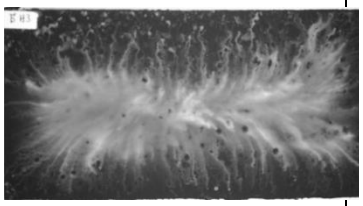
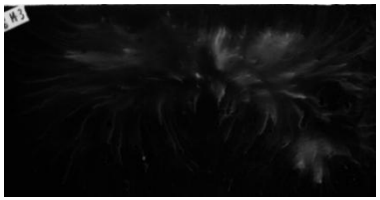
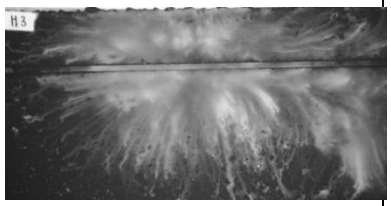
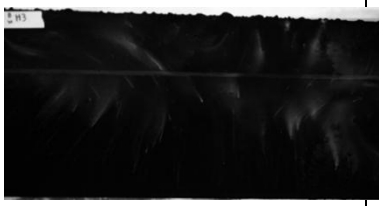
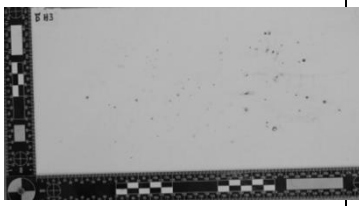
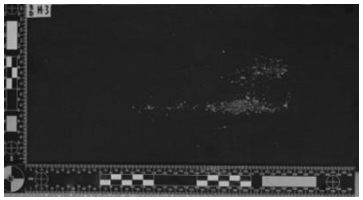
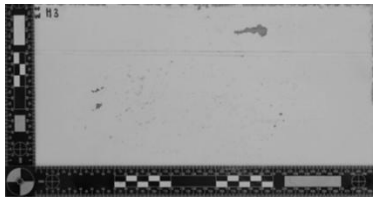
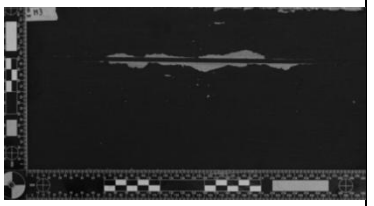
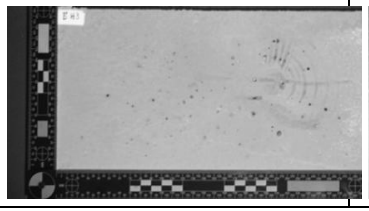
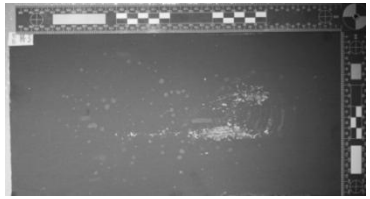
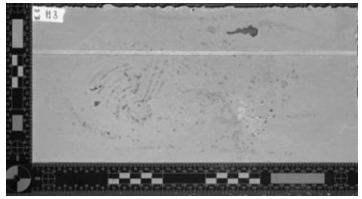
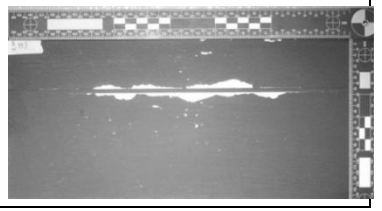
Table D1. Visibility of bloodstains on wood paneling beneath with black acrylic paint.

Paint Layers	0		0		1		1		2		2		3		4	
Light Source	Vis	IR	Vis	IR	Vis	IR	Vis	IR	Vis	IR	Vis	IR	Vis	IR	Vis	IR
	A		B		C		D		E		F		G		H	
1	3	1	3	1	0	1	0	1	0	1	0	1	0	1	0	
2	3	1	3	2	1	2	1	2	0	1	0	1	0	1	0	1
3	3	1	3	1	1	2	1	2	0	0	0	0	0	1	0	1
4	3	1	3	2	1	1	0	1	0	1	0	1	0	1	0	1
5	3	1	3	1	1	2	1	2	0	1	0	1	0	1	0	1
6	3	1	3	2	1	1	1	1	0	1	0	1	0	0	0	0

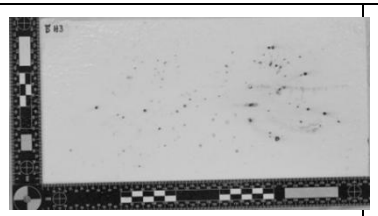
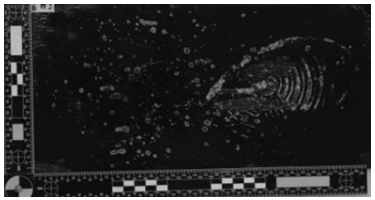
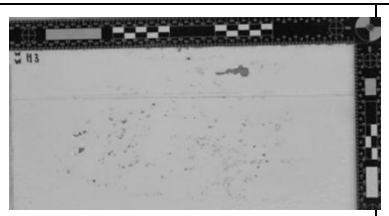
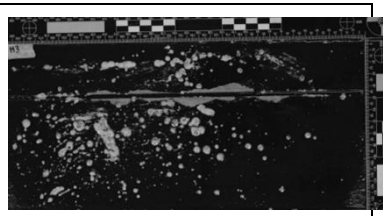
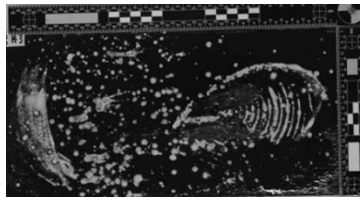
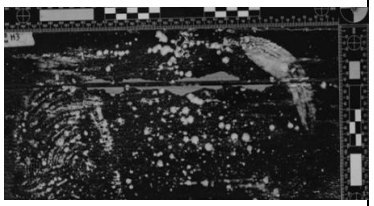
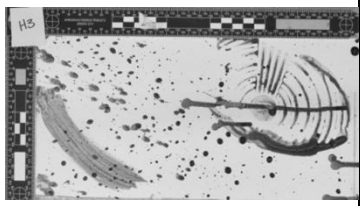
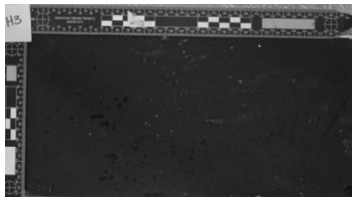
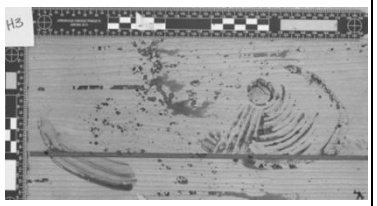
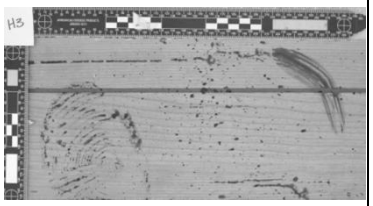
Table D2. Comparison of visibility of bloodstains on wood paneling beneath black acrylic paint before and after application of various methods.

Paint Layers	1		1		2		2		3		4	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Method	C		D		E		F		G		H	
IR (average)	0.8	1.5	0.7	1.5	0	0.8	0	0.8	0	0.8	0	0.8
LCV	0	2	0	2	0	2	0	1	0	1	0	1
Amido Black	1	--	1	--	0	--	0	--	0	--	0	--
Luminol	1	1	1	1	0	1	0	1	0	1	0	1
Sanding	1	0	0	1	0	1	0	1	0	0	0	0
IR (after sanding)	0	0	1	1	1	0	1	0	0	0	0	0
Citristrip	1	1	1	0	0	0	0	0	0	0	0	0
IR (after citristrip)	1	1	0	0	0	1	0	0	0	0	0	0

Appendix 3. Photographs of Detection and Documentation Procedure

	White/ Drywall	Black/ Drywall	White/ Wood Paneling	Black/ Wood Paneling
Initial photos (visible light)				
Luminol photos (visible light)				
Photos after sanding (visible light)				
Photos after sanding (ALS or IR)	ALS 	IR 	ALS 	IR 

Appendix 3. Photographs of Detection and Documentation Procedure

LCV after sanding (visible light)				
Hydrogen peroxide after sanding (visible light)				
Bloodstains before paint				
Bloodstains before paint (IR)