Kowalske Z, J Forensic Leg Investig Sci 2024, 10: 092
DOI: 10.24966/FLIS-733X/100092

HERALD

HSOA Journal of
Forensic, Legal & Investigative Sciences

Research Article

A Comparison of Enhancement and Visualization Techniques of Friction Ridge Bloodstain Patterns on Various Textiles

Zack Kowalske*

Staffordshire University, School of Justice, Security and Sustainability College Rd, Stoke-on-Trent ST4 2DE, United Kingdom and Roswell Police Department, Crime Scene Investigations Unit 39 Hill Street, Roswell, GA 30075, United States

Abstract

This study investigates the feasibility of observing identifiable friction ridge patterns within a blood medium on common clothing textiles, exploring the interaction between blood and fabric surfaces and the effectiveness of various imaging and enhancement methods. Given the complex dynamics between fabric substrates and liquid blood, this research focuses on three common textile blends used in clothing articles and employs four distinct methods for visualizing bloodstained fingerprints: oblique and infrared lighting, Bluestar Forensic reagent, gel lifting followed by amido black dye staining, and titanium dioxide in a methanol carrier. The study's findings highlight the challenges in detecting friction ridge details due to factors such as the texture of the target surface and capillary wicking action, which can detract from the clarity of the ridge impressions. While no method conclusively produced classifiable friction ridge impressions, the study provides valuable insights into the interaction of blood with different textile materials and identifies potential avenues for enhancing the visualization of bloodstain patterns. The research underscores the need for further exploration into the relationship between bloodstains and textiles, aiming to improve forensic methodologies for the examination of bloodstained evidence on clothing.

Keywords: Bloodstain pattern analysis; Enhancement; Fingerprints; Forensic science; Friction Ridge

***Corresponding author:** Zack Kowalske, Staffordshire University, School of Justice, Security and Sustainability College Rd, Stoke-on-Trent ST4 2DE, United Kingdom and Roswell Police Department, Crime Scene Investigations Unit 39 Hill Street, Roswell, GA 30075, United States, Email: zkowalske@roswellgov.com

Citation: Kowalske Z (2024) A Comparison of Enhancement and Visualization Techniques of Friction Ridge Bloodstain Patterns on Various Textiles. Forensic Leg Investig Sci 10: 092.

Received: : March 18, 2023; **Accepted:** March 28, 2024; **Published:** April 05, 2024

Introduction

Bloodstained fingerprints can sometimes be the subject of focus within criminal investigations where blood has been shed. In training scenarios and within these types of cases these impressions are at times observed on non-porous and semi-porous surfaces. This study asked if it was possible to observe identifiable friction ridge patterns within a blood medium on common clothing textiles or would the relationship between the blood and the target impede friction ridge detail? Would the texture of the target surface or the capillary wicking action detract from the ridge impression being identifiable, and if so what would the effective methods of imaging or enhancing these impressions for latent print examination? Three blends of common textiles used in clothing articles were selected as target surfaces with four methods of imaging utilized after the friction ridge blood pattern was deposited and allowed to dry. The four methods of imaging or enhancement included oblique and infrared lighting, Bluestar Forensic reagent, gel lifting followed by amido black dye, and titanium dioxide in a methanol carrier.

The dynamics between fabric substrates and liquid blood is a broad topic with many studies available in the existing literature. Samir Bandyopadhyay and Nabanita Basu expound on the interplay in that, "various surfaces, concrete, [and] fabric react differently to bloodstain[s] dropped by similar physical mechanisms. There also exist intra-surface differences that impact or rather influence the formation of bloodstain pattern[s]" [1]. While a basic explanation, this relationship is identified as a need for further research by the United States' National Institute of Standards and Technology's Organization of Scientific Area Committees for Forensic Science subcommittee on Bloodstain Pattern Analysis (BPA). The subcommittee, which is tasked with the identification of best practices and recommendation the contemporary reach needs of the discipline, conveys the need for further research with blood and fabrics in Research questions regarding the interaction of blood and fabrics/textiles [2]. The subcommittee research needs clearly define that the interaction is complex and the dynamics are not well known. There are many variables that exist within this realm of BPA, from the material types, material blends, thread diameter, surface roughness, wettability angle characteristics, any applied treatments, ect. This study specifically looked to observe the interaction of blood and bloodstain fingerprints with the selected fabrics and four potential options of visualizing the pattern detail. Previous research has focused on enhancing chemically developed visualization with computer aided programing [3]. That stated, there are multiple studies and reference texts available for review on the specific topic of textiles and bloodstain patterns [4-10].

Materials & Methods

This analysis three common blends of clothing textiles: Textile Sample No. 1 was a woven blend of 98% cotton and 2% spandex shorts (Figure 1.1), Textile Sample No. 2 was a knit blend of 60% cotton and 40% polyester shirts (Figure 1.2), and Textile Sample No. 3 was a knit blend of 88% recycled polyester and 12% spandex athletic style shirt (Figure 1.3). The samples varied in color and solid to overlapping patterns that were chosen for the range of difficulty for visualization of the friction ridge blood pattern. Human whole blood, which had been screened for infectious diseases, was obtained from a blood bank and utilized to create the patent impressions. Both commercially available blood reagents and laboratory prepared reagents were used during processing and each will be discussed within their respective sections.

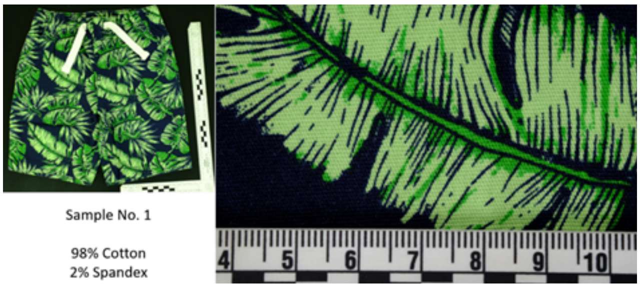

Figure 1.1: Sample No. 1 textile.

Figure 1.2: Sample No. 2 textile.

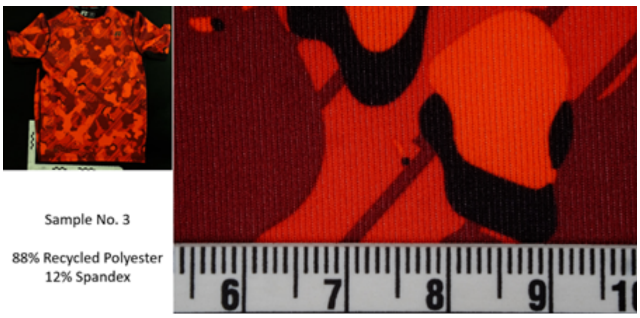

Figure 1.3: Sample No. 3 textile.

The sample textiles were cut into multiple swatches with each measuring roughly 10 cm by 10 cm. The swatches for each textile were then placed into groups, with swatch samples from each textile in each group for various methods of processing. Prior to the experiment, the blood stock was stored by refrigeration at 7˚C for three days. In the preparation phase, the screened whole blood was agitated using a New Brunswick Scientific Excella E2 Platform Shaker at 200 rotations per minute for thirty minutes and then heated to a temperature of 37˚C. Liquid blood was then applied to the examiner's thumb by dipping the friction ridge skin of the thumb into a volume of blood and then the examiner rolled his thumb across each textile sample. The samples were then allowed to air dry for 60 minutes prior to the beginning of any imaging or processing techniques.

Results

Control Group

Samples from each material were utilized for a control group to understand the blood's interaction with the fabric materials. Due to the multi-colored patterned nature of each article, the reverse side, or a section that was light in color or white, was utilized as the target surface for the patent blood impression (Figure 2.1). Multiple impressions of light and heavy pressure were deposited onto each target surface. After the 60 minute drying period, using visual and magnified observation the control stains were clearly patent with defined borders. In assessing these samples No level one ridge detail or level two individual ridge characteristics were observed on any of the control samples. Within latent print examinations, level one detail describes the appearance of class characteristics of the ridge flow, or can the print be classified as a loop, whorl, or arch. Level two detail describes the appearance of minutia points, such as individual bifurcations, ending ridges, or dots.

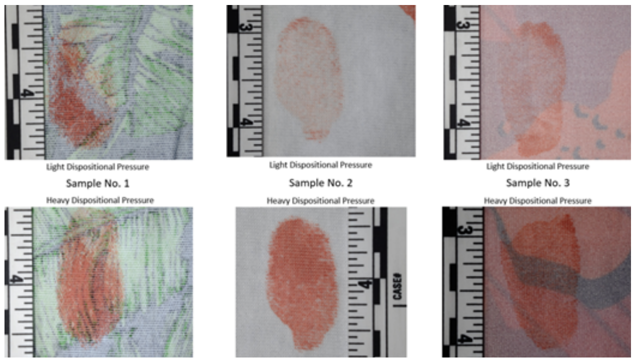

Figure 2.1: Visualization of depositional pressure on each sample.

Closer examination of each stain and textile found that the fabric strands of each textile wicked the blood into the textile to varying degrees, which was dependent upon the depositional pressure. The woven 98% cotton and 2% spandex blend of Sample No. 1 was found to have slight wicking within the individual fibers, traveling from the top exposed surface to the "under" aspect of the over-under style of the plain weave pattern (Figure 2.2). This was more pronounced with the heavy pressure as opposed to the isolation of the blood on the top "over" aspect with the use of the light pressure. The fibers of Sample No. 2, the 60% cotton and 40% polyester knit blend, exhibited more noticeable difference between the light depositional pressure versus the heavy. Within the light pressure impression, the bloodstaining was only observed to the top exposed surface of the textile, with little to no wicking further within the fibers (Figure 2.3). Whereas, with the heavy pressure impression, wicking and complete saturation within the textile was observed. Textile Sample No. 3, the 88% recycled polyester and 12% spandex blend, was the athletic style textile advertised as a fast-wicking material. Observation of the imprinted stains found that both pressures resulted in similar complete saturation of the surrounding fibers (Figure 2.4).

Oblique and Infrared Light Digital Imaging

The individual samples were placed on a copy stand beneath a Fuji XT1-UV/IR mirrorless camera utilizing a Fujinon Aspherical Super EBC f=60mm 1:2.4 lens. The first samples were examined with a UV/IR cut filter and oblique white lighting. No friction ridge detail

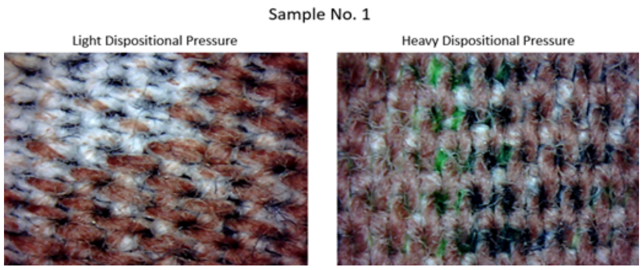

Figure 2.2: Degree of wicking within Sample No.1.

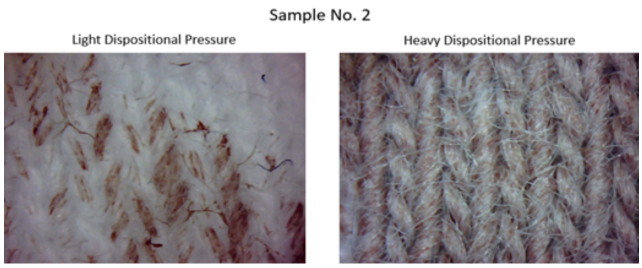

Figure 2.3: Degree of wicking within Sample No.2.

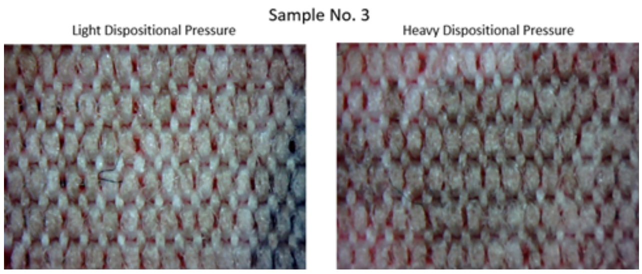

Figure 2.4: Degree of wicking within Sample No.3.

was observed. Observation with the camera just provided a better visualization of the blood's wicking interaction with the textiles. The samples were then examined with an infrared light source applied and a B+W 695 nm filter, which depicted no friction ridge detail. The same result was observed when a B+W 830 nm filter was utilized, with an example seen in (Figure 3).

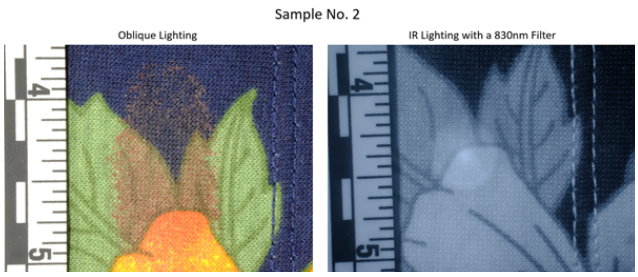

Figure 3: Comparison of oblique lighting versus infrared lighting on Sample No.2.

Bluestar Forensic Reagent

The individual samples were placed on a copy stand beneath a Fuji XT1-UV/IR mirrorless camera utilizing a Fujinon Aspherical Super EBC f=60mm 1:2.4 lens. The camera setting was set to an f-stop of 2.8, ISO 320, and the exposure set to bulb with exposures ranging between ten to thirty seconds. The Bluestar Forensic reagent was mixed per directions and application was done using a small mist spray bottle. Three to five pumps of the mixed Bluestar Forensic reagent spray were applied to samples of the textiles which contained no bloodstain pattern, to verify that no reaction occurred between solely the textile and the reagent. The process for the test samples included the following. The manual exposure was initiated on the camera, this was then followed by a light spray of three to five pumps of the reagent to obtain the chemiluminescent reaction. The best results for exposure time were found to be between 25 to 30 seconds. This process was conducted three times per sample to observe the wicking process of the chemiluminescent stain on the textile.

All samples provided a positive reaction to the reagent, providing a better visualization of the dimensions of the bloodstain pattern in whole, regardless of the patterned background. Sample No. 1 provided a good example over the course of the three exposures to the nature of the wicking process of the reagent (Figure 4.1). The 60/40 blend of Sample No. 2 provided a strong reaction, however remained within the irregular defined borders of the bloodstain. Similar to Sample No. 1, the fast-wicking designed textile of Sample No. 3, provided a positive even reaction, with the wicking process being even around the entire periphery of the bloodstain pattern (Figure 4.2).

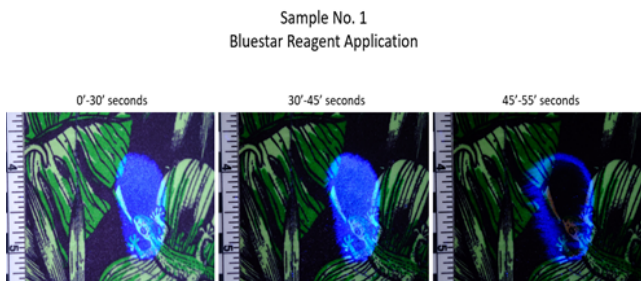

Figure 4.1: Visualization of Blue Star reagent results on Sample No.1.

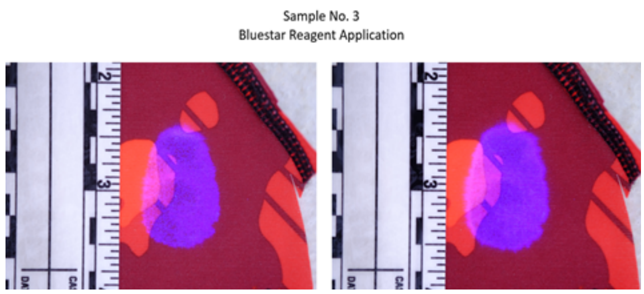

Figure 4.2: Visualization of Blue Star reagent results on Sample No.3.

Gel Lifter and Amido Black Staining

Within this group, a white gel lift was applied to and collected from each stain sample, using moderate pressure for approximately 10 seconds. Application of amido black dye staining was then sprayed upon each gel lift, followed by a methanol rinse. No stain pattern or stain detail was developed, with the dye stain instead discoloring the gel lift. This process was repeated using a clean gel lift with the same reaction, in which the methanol fails to remove the dye stain from the substrate. This reaction was observed across all samples (Figure 5).

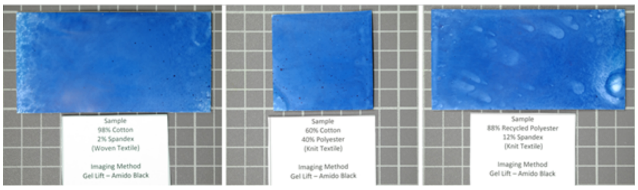

Figure 5: Comparison of gel lift and amido black lifts.

Titanium Dioxide and Methanol

A mixture of 1.0 gram of titanium dioxide to 10 milliliters of methanol was prepared for mist spray bottle application [11]. Under a fume hood, each sample set was saturated by spray, followed by an additional methanol rinse. The results were then photographed with oblique lighting (Figures 6.1-6.3). The titanium dioxide bound to the stain pattern within the stain borders in all three samples. Stain No. 1 exhibited better visualization of the stain area in the solid dark color area, but the process did not aid in increasing the contrast in the multi-colored patterned areas (Figure 6.1), this was equally true within the fabric of Sample No.3 (Figure 6.2). The textile of Sample No. 2 was better suited to the process, with clear delineated impression areas observed on the multi-colored patterns (Figure 6.3). While no friction ridge detail was found to be present, the method of bloodstain pattern visualization with titanium dioxide was better suited for the 60/40 cotton-polyester blend.

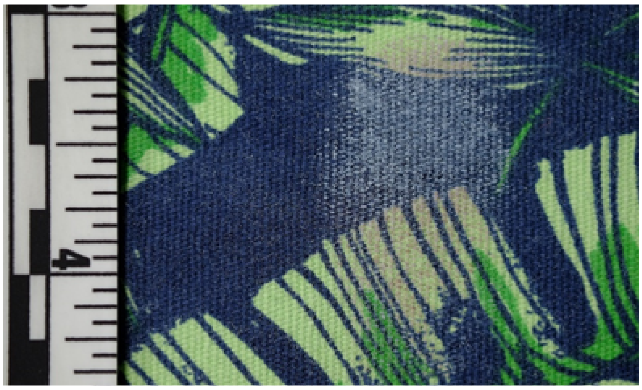

Figure 6.1: Titanium Dioxide and Methanol results on Sample No.1

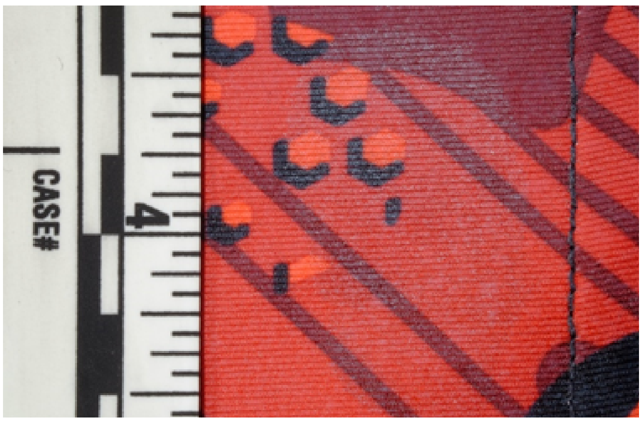

Figure 6.2: Titanium Dioxide and Methanol results on Sample No.3.

Figure 6.3: Titanium Dioxide and Methanol results on Sample No.2.

Discussion and Conclusion

Multiple variables exist between the interaction of textiles and deposited bloodstains. This becomes apparent when considering the two and adding the fine detail of friction ridge impressions. This brief study examined a very narrow scope of common clothing fabric blends and did not at this time expand into other types of knit, weaves, blends, or chemical treatments. It is understood that the overall sample size of this study was relatively small with less than fifty impressions being examined. The intent was not to determine reliability, but to offer the possibility and give reference to various attempted methodologies of the opined hypothesis. With the ultimate findings failing to produce any classifiable friction ridge impressions, of which were peer reviewed by another latent print examiner, the focus then shifted to the manner in which the blood medium interacted with the different textile target surfaces; and in turn which method was best to visualize those bloodstain patterns.

The woven 98% cotton and 2% spandex blend of Sample No. 1 provided clear and observable wicking. The capillary action promoted the spread of the liquid blood outside the initial boundaries of the deposited impression (i.e. the outline of the deposited thumb print). This reaction seems to have taken any friction ridges of blood and drawn them within the linear weave lines of the fabric. Sample No. 2's 60% cotton and 40% polyester blend provided more depth absorption as opposed to a lateral wicking process. These impressions showed a defined difference of observation between the amounts of depositional pressure from the imprint. The light pressures being very superficial to the top layers of fabric causing less wicking, whereas heavy pressure caused a more complete saturation. With the athletic blend of Sample No. 3, the knit is very tight and close. This characteristic would initially seem to be more conducive for the transference of friction ridge impressions; however, the wicking characteristic of the material renders any potential friction ridge detail awash.

With the initial question of this study posed at the observation of patent fingerprint evidence and the subsequent findings being of no observation, the study then shifted to the findings of the best methodology of imaging the bloodstain pattern themselves on these difficult multi-colored patterned target surfaces. In previous casework, the author has had positive results in the application of infrared digital imaging to visualization bloodstain patterns on dark or patterned clothing. However, within this study, the method was found to be poor to non-effective. The conclusion for these results would be that the volume and extent of saturation is a factor that requires further research. As expected Bluestar Forensic reagent yielded positive and observable reactions to the presence of blood, but failed in exhibiting fine detail of friction ridges. The gel lift and amido black rinse were found to be non-effective. This aspect and the application of using other types of dye staining, such as Hungarian Red, Coomassie Blue, or Acid Yellow requires additional research. As an alternative, this study did attempt using the binary casting product Accutrans as a method of lifting. In previous research [11], the author had found excellent results in the casting of bloodstain patterns on non-porous surfaces with the product, the sample set was not included within the text of the study because the Accutrans bound to the fabric to the extent that it was not removable. While based on previous literature [11], the titanium dioxide and methanol carrier has had beneficial results with non-porous surfaces; this study confirmed the previous literature research of poor results on porous surfaces. The developed impression was visible and even photographable, but the quality was not that of the Bluestar Forensic results; a larger sample size consisting of a wider range of solid colors and fabric types would be beneficial in the understanding of titanium dioxides application within this setting. In conclusion, this study has demonstrated several methods that can be successful in bloodstain pattern detection on clothing. However, more research is required in the exploration of the relationship between patent friction ridge bloodstain patterns and various textiles target surfaces, with the overall objective being the visualization of ridge detail.

Sources of Funding

None

Disclaimers

None

Conflicts of Interest

None

Acknowledgement

None

References

1. Bandyopadhyay SK, Basu N (2015) Bloodstains Analysis on Fabric from Contact in a Crime Scene. International Journal of Computer System 2.
2. National Institute of Standards and Technology (2016) OSAC Bloodstain Pattern Analysis Subcommittee. Research Questions regarding the interaction of blood and fabrics.
3. Hill T (2011) Visualizing Bloodstain Patterns on Dark or Multi-colored, Multi-designed Clothing using Luminol and Adobe Photoshop® Layers. Journal of Bloodstain Pattern Analysis 27.
4. Miles H, Morgan R, Millington J (2014) The influence of fabric surface characteristics on satellite bloodstain morphology. Science & Justice 54: 262-266.
5. White B (1986) Bloodstain patterns on fabrics: The effect of drop volume, dropping height and impact angle. Canadian Society of Forensic Science Journal 19: 3-36.
6. Wu J, Michielsen S, Baby R (2019) Impact spatter bloodstain patterns on textiles. Journal of forensic sciences 64: 702-710.
7. Bevel T, Gardner RM (2008) Bloodstain pattern analysis with an introduction to crime scene reconstruction. 3rd ed. Boca Raton, FL: CRC Press.
8. James SH, Kish PE, Sutton TP (2005) Principles of bloodstain pattern analysis: Theory and practice. Boca Raton, FL: CRC Press.
9. Holbrok M (2012) Evaluation of Blood Deposition on Fabric: Distinguishing Spatter and Transfer Stains. IABPA News 26: 3-12.
10. Bergeron J (2003) Development of Bloody Prints on Dark Surfaces With Titanium Dioxide and Methanol. Journal of Forensic Identification 53: 149-159.
11. Kowalske Z (2016) Casting Bloodstain Patterns: Accutrans vs Mikrosil. Journal of Forensic Identi 66: 381-387.