

# Visualization of Bloodstains on Dark Surfaces using Polarized Light

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For further information, contact [rbucht@gc.cuny.edu](mailto:rbucht@gc.cuny.edu)

# Why Visualization is Important

- Accurately visualizing and documenting bloodstains and patterns is an integral part of crime scene investigation and provides crucial information for both the analysis of evidence in the laboratory and crime scene reconstruction efforts.
- Visualization of bloodstains is trivial on white or lightly colored surfaces. However, on darkly colored or black surfaces, it can be extremely difficult.
- There are three main aspects of bloodstain analysis that visualization and documentation contribute to:
  - 1: The presence of blood may not be recognized at critical stages in the investigation:
    - The presence, location and morphology of blood stains are often of great importance in any investigation, and the earlier this information is available, the better.
    - Where the presence of blood is not recognized, handling of the evidence may disrupt and compromise the bloodstain evidence.

# Why Visualization is Important

2: Intelligence driven sampling-being able to visualize the stains allows for more selective processing of the surface:

- Stains are commonly analyzed in order to confirm that they are blood, and often further analyzed to determine their origin.
- In cases where the surface examined is large, fewer samples need to be taken as the sampling can be focused on specific areas.
- Where there are multiple sources of blood, the occurrence of mixed profiles in consequent DNA analysis can be minimized by sampling stains individually.

3: Interpretation of the evidence:

- The location and morphology of the stains are key elements not only in the investigation, but also in any event reconstruction efforts.
- In a significant number of cases knowing how the bloodstains were formed is more important than knowing the biological source of the stains. In most cases the two types of information are complementary.
- The ability to assign a DNA profile to a particular stain as opposed to a surface or collection of stains is important both in cases with multiple sources of blood or DNA but also where there is a single source of blood or DNA.

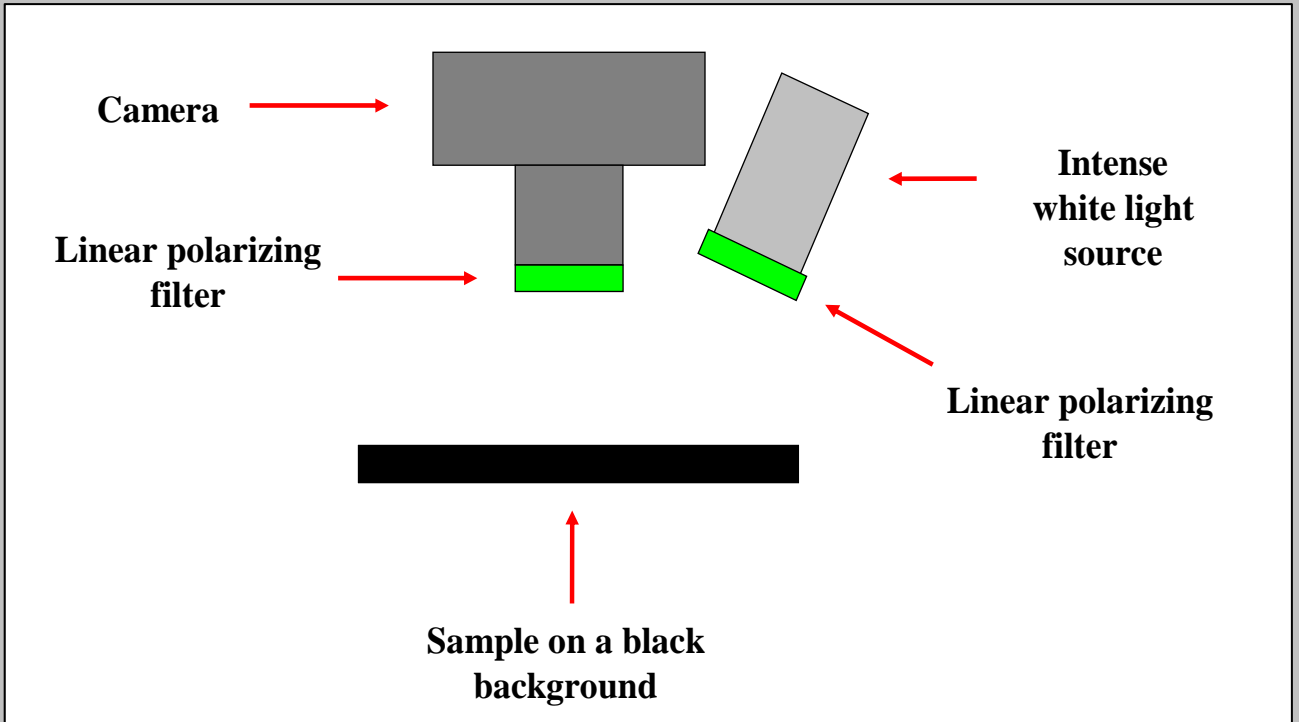
# **Crossed Polarized Light Visualization: Advantages and Disadvantages**

- No contact with the stain or substrate
- Easily adaptable to regular cameras
- Quick and simple procedure
- Can also be used with stereoscopes
  
- Thick bloodstains are not enhanced
- Uneven surfaces and some types of substrates can be difficult to process
- Screen larger than camera LCD display needed for best results

## **BUT...**

- Even under less than ideal circumstances, polarized light visualization produces a dramatic improvement in the contrast between the otherwise subtle bloodstains and the dark or black background.

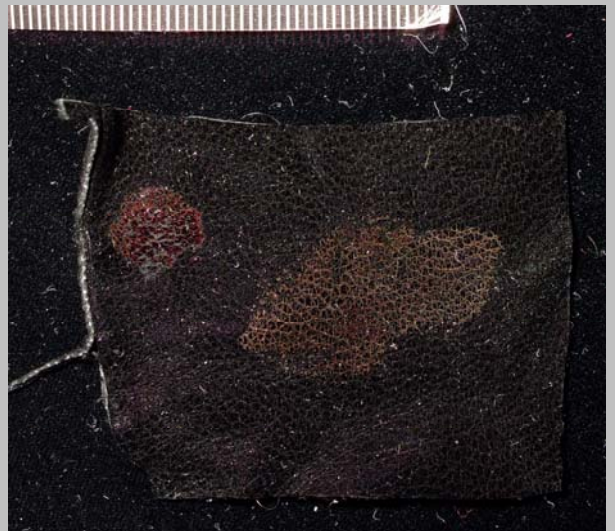
# Polarized Light Method Setup



## Blood on Leather



Uncrossed

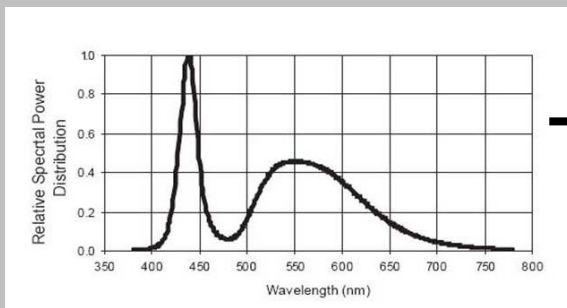


Crossed

# Polarized Light Method Components: Light Source

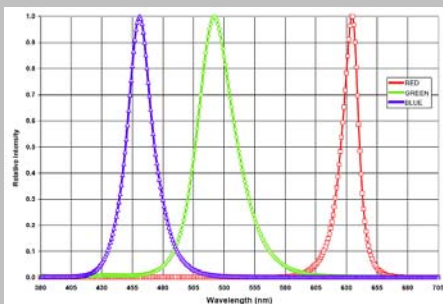
- Full spectrum of white light needed
- Fiber Optics and Xenon lights work well but cause significant heat damage to the polarizing filter in a short amount of time
- LEDs do not cause heat damage to the polarizers
- Not all LEDs output a suitable spectrum, 'white' LED's performance is significantly inferior to that of RGB LEDs
- Zylight Z90 RGB LED chosen for our research

## White vs RGB LED Technology



Spectrum of 'white' LED

Blood on leather



Spectrum of RGB LED

Blood on leather

# Polarized Light Method Components: Polarizing Filters

- Linear polarizing filters, not circular, are required
- The Hoya filter performed the best out of the ones tested

## Performance of a selection of Polarizing Filters

Hoya



Schneider



Heliopan

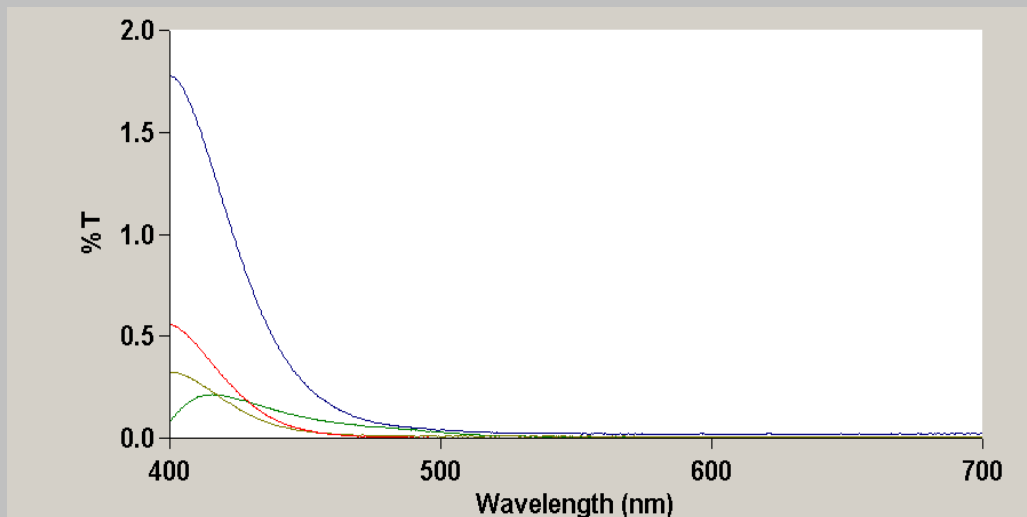


Uncrossed



B&W

## Transmission of Crossed Polarizing Filters

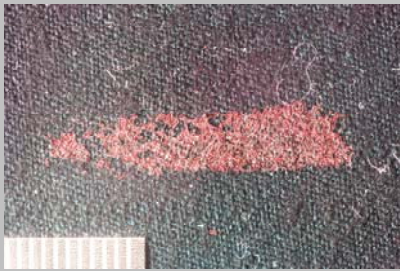


Blue = B&W, Red = Heliopan, Khaki = Hoya, Green = True Pol

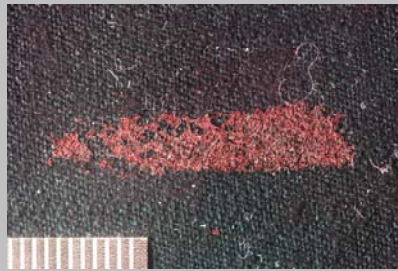
# Polarized Light Method Components: Camera Settings

- Long exposure times required, camera must be on tripod or copy stand
- Exposure compensation between -1.5 to -3.0 recommended
- On digital cameras, hard tone and slide film equivalent film simulation settings produce the best contrast

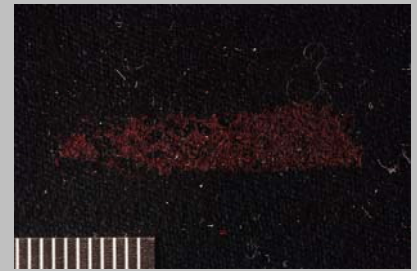
## Exposure compensation



+/- +1



+/- 0



+/- -3

## Tone



Org



Standard



Hard

## Film simulation



F1



Standard



F2



# Features & Limitations: Stain Types

- Stains that were absorbed into the substrate and did not leave a thin film on the surface of the substrate were harder to visualize
- Thick stains are not enhanced, but can be visualized using oblique light

## Smear stain on leather, wool and cotton

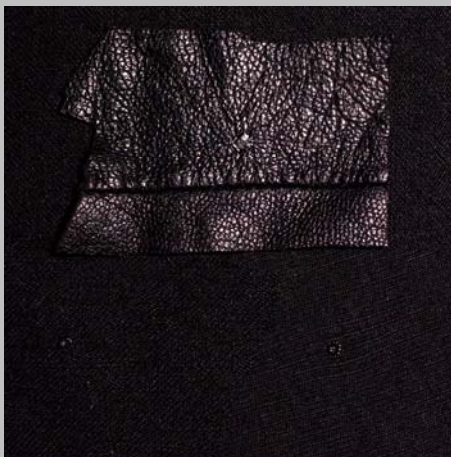


Uncrossed



Crossed

## 10 $\mu$ L drop on leather, wool and cotton



Uncrossed



Crossed

# Features & Limitations: Stain Types

- Small spatter was particularly successfully enhanced
- Small spatter was very seldom apparent when looking through the viewfinder

## Contact stain on leather, wool and cotton



Uncrossed

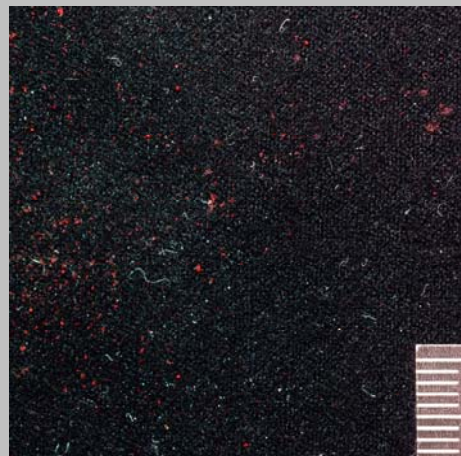


Crossed

## Small spatter on wool



Uncrossed

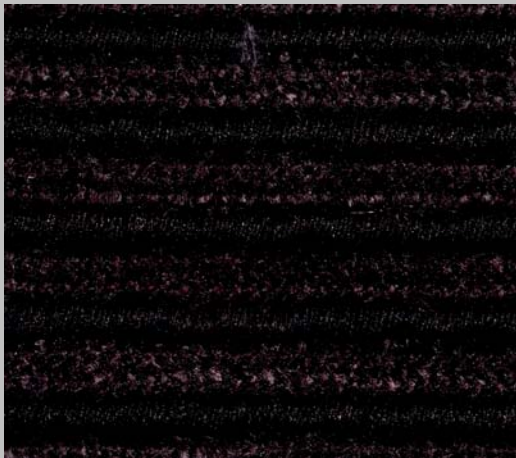


Crossed

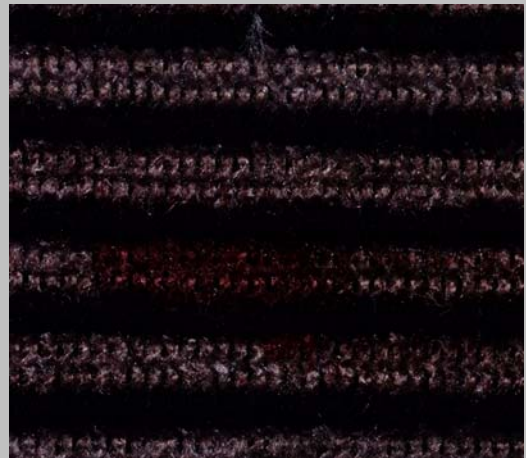
## Features & Limitations: Substrate Types

- Substrates did not interact with the blood or the polarized light in a uniform manner
- If the substrate is uneven, it can be difficult to illuminate it so that the entire field of view is under crossed polar lighting simultaneously.

### Grey/black striped carpeting with smear and spatter

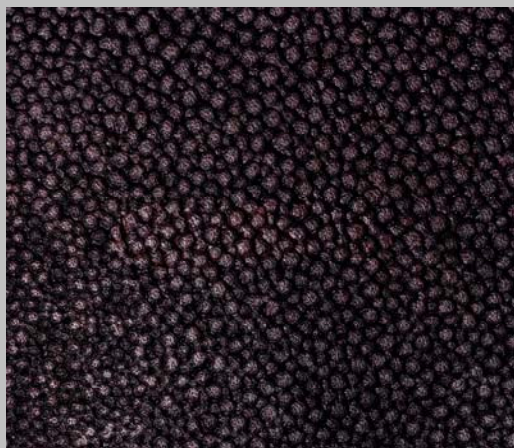


Uncrossed



Crossed

### Leather upholstery fabric with smear and spatter



Uncrossed

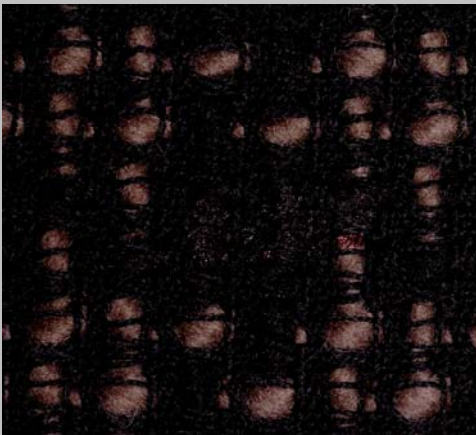


Crossed

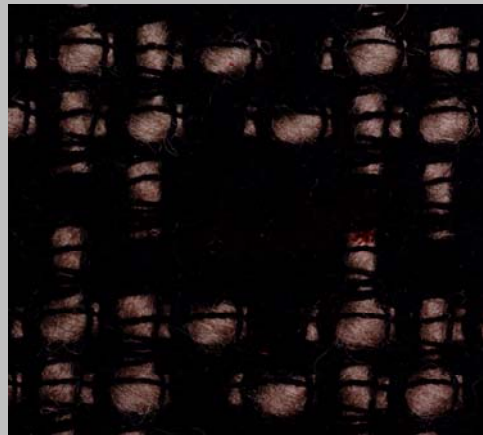
# Features & Limitations: Substrate Types

- Stains on substrates which contain one or more lighter colored elements show barely any enhancement
- On suede, stains can be visualized with regular lighting by the localized matting of the surface. This subtle matting can be less apparent with crossed polarized illumination, making the stains more difficult to visualize

## Black/white upholstery fabric with smear and spatter



Uncrossed

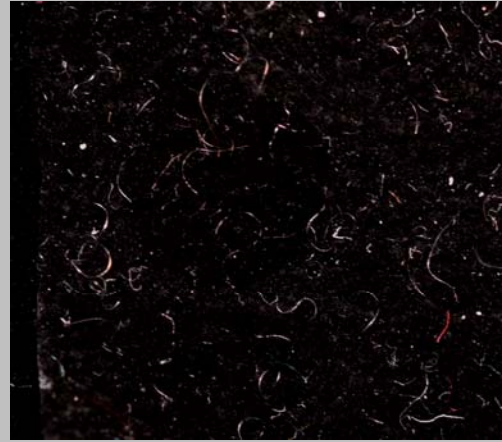


Crossed

## Suede with contact stain



Uncrossed



Crossed

# Features and Limitations: Orientation of Incident Light

- The effect of the orientation of the incident polarized light is substrate dependent
- This change in substrate appearance is not readily apparent through the viewfinder
- The orientation of polarized light can affect the general color of the substrate or its darkness.

## Polyester



Uncrossed



Crossed



Crossed rotated  $\sim 20^\circ$

## Silk



Uncrossed



Crossed



Crossed rotated  $\sim 20^\circ$

# Features & Limitations:

## False Positives, Negatives and Dilutions

- This enhancement method is not unique to blood
- Several red substances produced stains similar in appearance to bloodstains
- While mixing the blood with certain chemicals changed its appearance, the stains remained visible
- Dilutions up to 1:10 and 1:25 could be visualized on less absorptive substrates
- As is the case with blood on lighter substrates, one should be aware of the possibility of false positives, false negatives and the effects of dilution.

### Dilutions



Uncrossed on Wool



Crossed on Wool



On Paper

### False positives



Uncrossed on Wool



Crossed on Wool

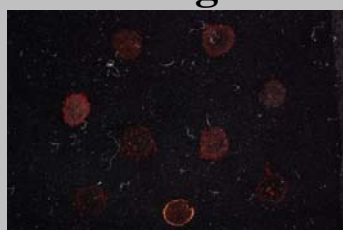


On Paper

### False negatives



Uncrossed on Wool



Crossed on Wool



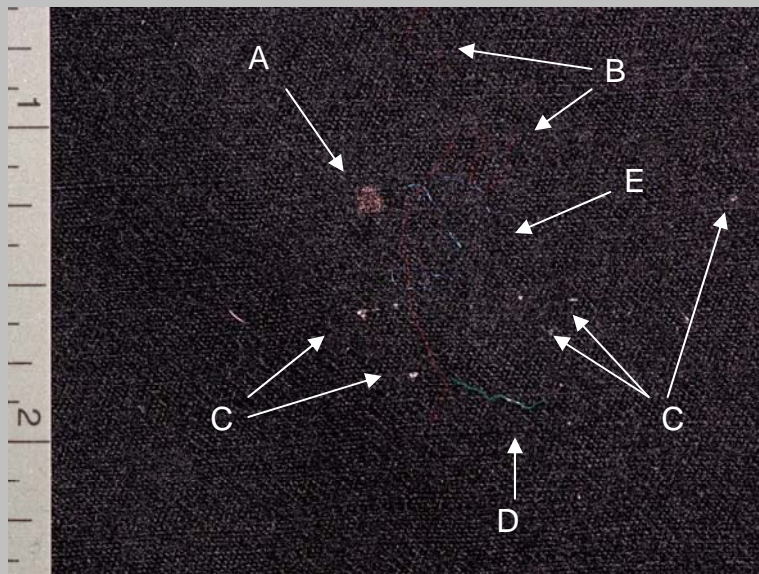
On Paper

# Features & Limitations:

## Materials other than Blood

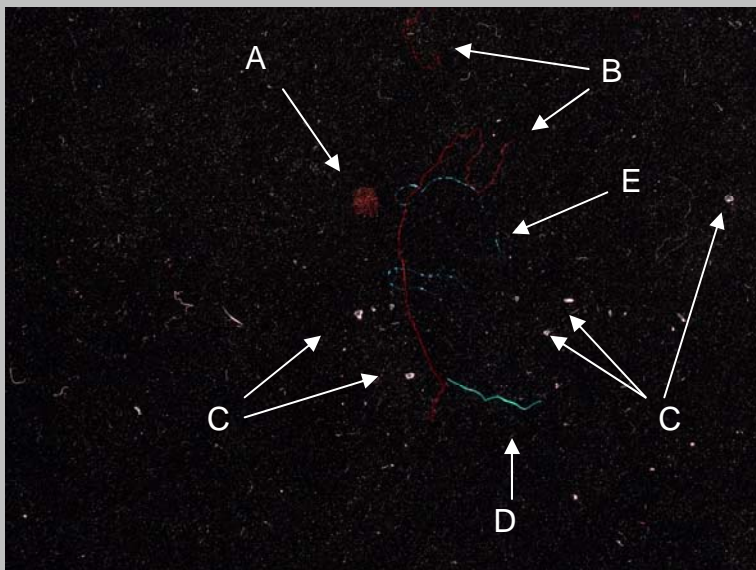
- As was apparent from the false positive testing, this enhancement is not unique to blood
- Other brightly colored items are also enhanced
- This is particularly useful for visualizing fibers and small glass fragments

### Blood, Fibers and Glass on Wool



- Bloodstain (A)
- Red Acrylic fiber (B)
- Glass shards (C)
- Green Olefin fiber (D)
- Blue Rayon fiber (E)

N.B. Scale in inches



- Bloodstain (A)
- Red Acrylic fiber (B)
- Glass shards (C)
- Green Olefin fiber (D)
- Blue Rayon fiber (E)