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Economical Light Sources:

Detecting and Collecting Luminescent Evidence Using Forensic LED Lamp Kits

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Economical Light Sources

Detecting and Collecting Luminescent Evidence Using Forensic LED Lamp Kits

There are many types of materials that emit light when they are excited by electromagnetic radiation. Some of these materials tend to be useful as evidence in forensic investigations. This article will briefly outline the mechanics of luminescence, its use in forensics, and discuss the use of inexpensive LED Forensic Light Source Kits.

Luminescence is the term we use to describe a material's propensity to emit light when it is exposed to a certain type of stimulus or excitation. When discussing luminescence in the context of forensics, investigators are frequently concerned with materials that emit light in response to excitation by light. This light can be visible light of a specific color or it might be invisible light in the case of ultraviolet or infrared light, as determined by the light's radioactive wavelength. In general terms, there are two types of such luminescent materials: those that emit fluorescence and those that emit phosphorescence. The difference between these types of luminescent materials is solely the period of time for which the luminescence continues when the source of excitation is removed. Fluorescent materials cease their fluorescence as soon as the excitation is removed. In the case of phosphorescent materials, they continue to phosphoresce for a period of time after the excitation is removed. This can continue for a very short period of time or a very long period of time. When it is not known if a material is fluorescent or phosphorescent, it is best to refer to that material as luminescent since this term includes both.

The emission of light associated with luminescence is caused when the material is subjected to exposure by radiation that affects electrons within its atomic structure. The device used to introduce this type of radiation in forensic applications is commonly called an Alternate Light Source or ALS. When radiated, these electrons enter an excited state, and change their orbit around the nucleus of their atoms. As they return to their ground state, these electrons emit a photon, which is a particle of light. The emitted light is usually lower in energy than the radiation that caused its emission. As a result of this phenomenon, luminescence that is created through the use of ultraviolet radiation can usually be observed in the visible portion of the spectrum, and luminescence that is created through the use of visible light is usually found in a region of the spectrum that exhibits a longer wavelength. Luminescence that is created through the application of ultraviolet or violet light frequently appears as yellow in color, luminescence that is created through the application of blue light frequently appears as orange in color, and luminescence that is created through the application of green light frequently appears as red in color. This shift from the higher to lower energy wavebands is known as Stokes' Shift. It is named after the 19th Century Irish physicist, Sir George Stokes, who first described the phenomenon.

The spectrum of electromagnetic radiation includes Gamma Radiation, X-Ray Radiation, Light, and Microwave Radiation. When discussing light, we generally break the categories down to ultraviolet light (10 – 400 nanometers (nm) in wavelength), visible light (400 – 750nm in wavelength), and infrared light (750nm – 1mm in wavelength). Like the determination of whether light is ultraviolet, visible, or infrared, the color of visible light is dependent on its wavelength. The chart on page 3 delineates light color with its correlating wavelengths or waveband.

Property or Color	Wavelength
Ultraviolet	10 – 400 nm
Violet	400 – 450 nm
Blue	450 – 490 nm
Green	490 – 560 nm
Yellow	560 – 590 nm
Orange	590 – 630 nm
Red	630 – 750 nm
Infrared	750 – 1 mm

Chart 1. When viewing this chart, bear in mind that many colors exist in the spectrum, not simply the six shown here. When theorizing the waveband in which luminescence might occur, under most conditions the luminescence color will be found in an area below the excitation color as noted above.

In order to observe and photograph luminescence, a two-step process is required. First, the material that is to be affected must be excited with the correct wavelength of radiation. While this is accomplished, the excitation wavelength light must be blocked from the eye while the luminescence wavelength light is permitted to pass. This technique is known as "barrier filtration." Barrier filtration is required because in most cases, especially those where visible light is being used to excite, the light reflecting from the excitation source is more intense than the luminescence. Selecting the correct barrier filter is essential because an incorrect filter will permit the transmission of both the excitation wavelength and the luminescence wavelength, permit the transmission of the excitation wavelength and *not* the luminescence wavelength, or permit the transmission of neither. In any case, the luminescence will not be visible.

Examples of evidence that are commonly sought using luminescence include but are not limited to the materials listed in the following table.

Body Fluids	**Trace Materials**
◉ Semen	◉ Hairs
◉ Urine	◉ Fibers
◉ Saliva	◉ Fire Accelerants (Hydrocarbons)
Osteological Materials	**Fingerprints**
◉ Bones	◉ Treated with fluorescent media
◉ Teeth	**Drugs**
	◉ Powders & Pills

Luminescence can be used to visualize evidence in two ways. Both involve increasing contrast between the evidence and its background. When luminescence of the evidence takes place, it tends to make that evidence more visible, especially when the background does not luminesce. Another way luminescence works to increase visibility is demonstrated when luminescence of the background, not the evidence, occurs. An example of when this second method is commonly employed is when the forensic investigator is searching for bloodstains. Blood normally absorbs light energy without excessive reflectance or luminescence to any degree. An issue that can interfere with the visualization of luminescent evidence arises when the evidence and the background are both luminescing. In such an event, selection of a slightly different colored barrier filter might be helpful, provided it continues to block the excitation wavelength and pass the luminescent wavelength. (See Fig. 12, Fig. 13, Fig. 14)

Fig. 1. Semen stain on clothing in visible light. Note the placement of scale indicates orientation of garment.

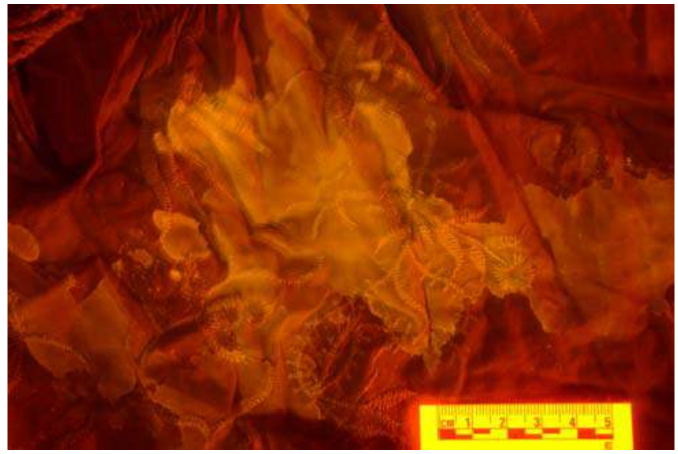


Fig. 2. Same stain illuminated by a 450nm LED and photographed using an orange filter. This filter matches the color of goggles supplied with the kit.

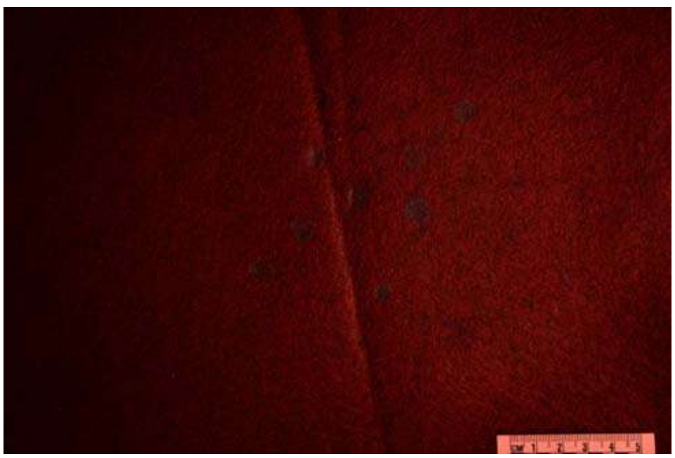


Fig. 3. Because blood normally absorbs light, it can be difficult to visualize on dark backgrounds.

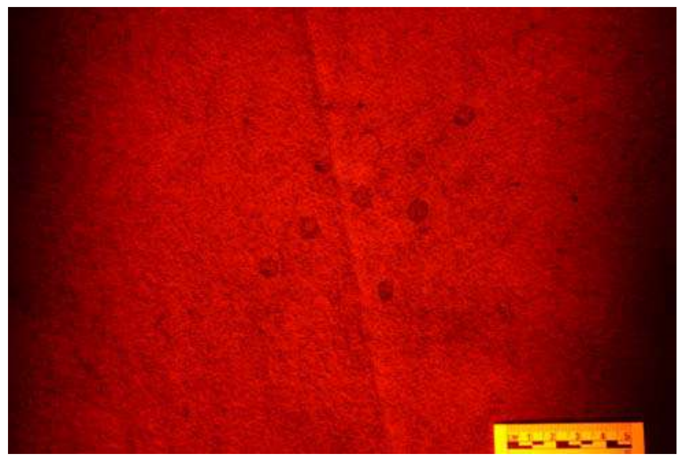


Fig. 4. Using the 450 LED and orange goggles can cause the background to fluoresce as has happened here, making the bloodstained area more visible.

Fig. 5. depicts a urine stain on a garment illuminated by visible light. **Fig. 6** depicts the same garment illuminated by the 450nm LED and photographed through an orange filter that matches the goggles supplied with the kit. For best results, the viewing goggles and the camera filter should be the same color. In the event that no camera filters are available, the photographer may succeed in capturing usable images by photographing through the lens of the goggles. (See Fig. 18 for an example.)

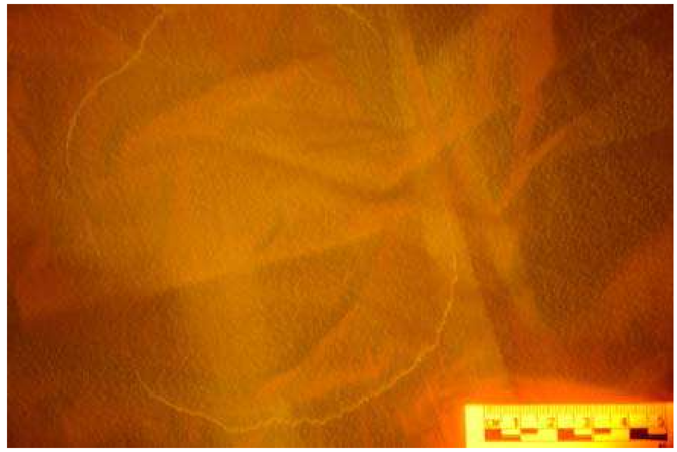


Fig. 7. Saliva stain on a garment photographed under visible light.

Fig. 8. Same saliva stain shown at left illuminated by the 450nm LED light source with an orange filter. Saliva, when it does luminesce frequently displays a weaker reaction than other body fluids. Note the area of stronger reaction at the border of the stain.

When using the techniques outlined in this article, it is important to remember that evidence is not the only thing that displays luminescence. In the course of examining scenes, investigators frequently encounter other materials that emit light when excited by the light source. For example, the following materials luminesce in a manner that is consistent with the luminescence emitted by bodily fluids: cleaning fluids, liquid fabric softener, bleach, and honey. There are many more. The best practice to be followed at the crime scene in such a case is to document and collect anything that might be evidence. In the documentation, it is best to refer to this material as an unknown luminescent stain.

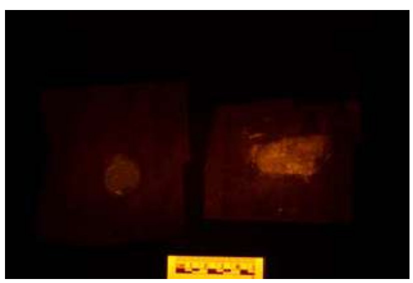


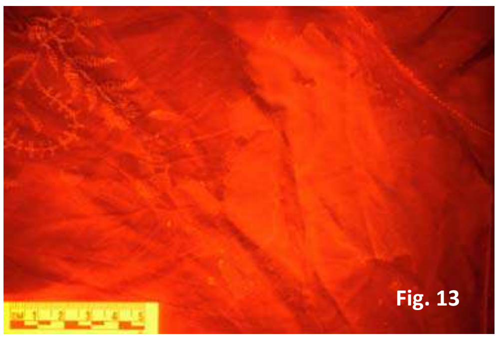
Fig. 9. Examples of fluids that mimic body fluids in their luminescent properties. This photo was taken under visible light.

Fig. 10. Pepto-Bismol® (left) and liquid fabric softener (right) on cloth, illuminated by 450nm and viewed through orange goggles.

Fig. 11. Honey (left) and chlorine bleach (right) on cloth, illuminated by 450nm and viewed through orange goggles.

When selecting the equipment to be used at the crime scene, there are three general types of ALS from which to choose. The first in order of cost from highest to lowest is the laser. Lasers are usually the most costly choice but frequently have the brightest output and are very specific as to their wavelength. Some lasers are intended primarily for use in the laboratory and might be difficult to use in a crime scene setting, especially if there is limited availability of alternating (household) electrical current. Next in order of price is the ALS that uses a high-power, white-light-emitting bulb and glass filters to achieve different wavelengths of light. These are also very useful, and some battery-powered units such as the Projectina SL-450 Crime Scene Lamp are very portable, lending themselves to use at the scene. Light sources such as those listed above can cost in excess of $10,000, and some are in multiples of that figure. One technology that is relatively new and affordable is the ALS powered by a Light-Emitting Diode (LED) or multiple LEDs. LED powered units excel in the area of power consumption, making them ideal for crime scene work. These units are extremely lightweight and portable and have relatively small batteries that can power the light source for hours.

Unlike most bulb-based and some lasers, LED light sources emit one color of light. If a different wavelength is required, a different unit might be required. Some units employ interchangeable lamp heads. On these, changing the lamp head permits the emission of a different color or wavelength of light. Examples of this type of LED-powered ALS are the Optimax OFK-8000 Multi-Lite LED Forensic Lamp and the UltraLite ALS Ultra Turbo Kit.



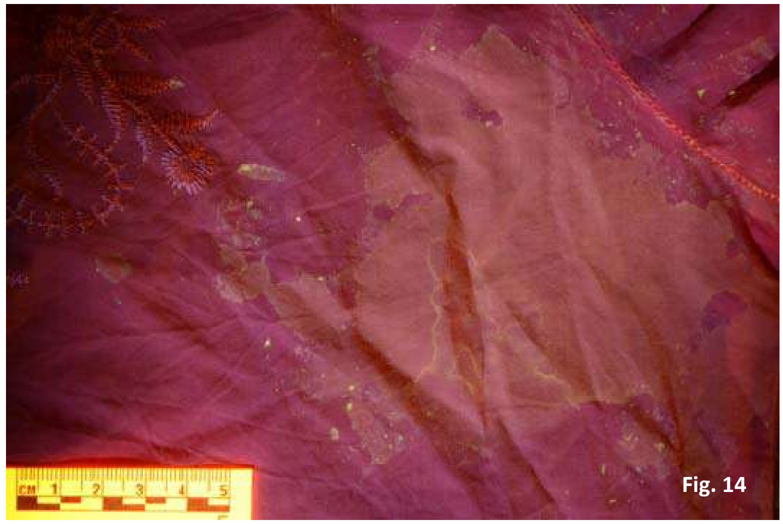


Fig. 12. Semen stain on pink fabric under visible light. **Fig. 13.** Same stain illuminated by 450nm and visualized through orange filter. **Fig. 14.** Same stain and illumination visualized through *yellow* filter. When the stain and the background luminesce a similar color, visualization can be difficult. In this case, switching to a yellow filter improved visualization of the stain while reducing the background interference.

Several manufacturers selling ALS kits offer kits that contain a single 450nm LED light source. Those selecting a 450nm light source as their sole wavelength should not be disappointed. Many types of luminescent evidence such as body fluids, bruises, gunshot residue, and hairs and fibers react well when excited with 450nm. Though one of these units might lack the versatility of light sources capable of outputting multiple wavelengths of light, they can be extremely useful when used properly.

Fig. 15. Under visible light, a bullet hole can be seen near the center of this piece of black felt fabric as indicated by the white arrow. Gunshot residue is usually difficult to see on dark backgrounds such as clothing and this piece of black felt.

Fig. 16. Same fabric illuminated by a 450nm LED and photographed with an orange filter. The size of the particulate matter that accompanies a gunshot can tend to be small in size. The material is luminescent, but is frequently difficult to see because it is very small. Also note the presence of previously unseen fibers.

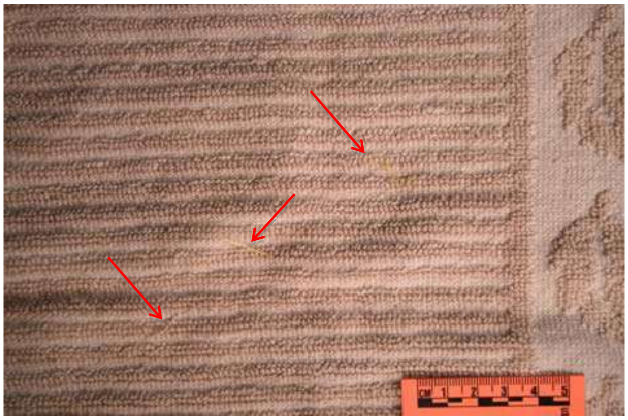


Fig. 17. Fiber evidence on cotton towel under visible light.

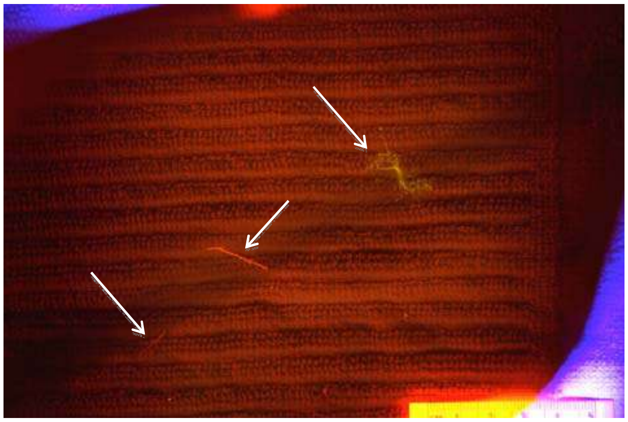


Fig. 18. Same fiber evidence illuminated by a 450nm light source. The fibers are more visible when viewed and, in this case, photographed through a pair of orange goggles.

About the Author

PHIL SANFILIPPO

Phil's law enforcement career spanned nearly 33 years. He was employed by the Miami-Dade Police Department (MDPD) in Miami, Florida for over 30 years and retired at the end of 2011. For the last 18 years of his career, Phil was the Coordinator of Forensic Training Programs at the Miami-Dade Public Safety Training Institute (formerly known as the Metropolitan Police Institute). As such, Phil was responsible for administering the department's Crime Scene, Fingerprint Identification, and other forensic related training courses.

As a photography instructor, he was additionally responsible for teaching all of the Department's photography-related courses. Students from agencies around the world attended these courses. Phil is also an award winning forensic photographer, being named Nikon Evidence Photographer of the Year for 2003. He continues to teach forensic photography and is an Adjunct Professor of Forensic Photography at Broward College (a state college in the Florida University System.)

Phil is a State of Florida Certified Law Enforcement Instructor and a Certified Evidence Photographer. He is a past-president and past chairman of the board of directors of the International Association for Identification (IAI), from 2010-2012. He is also a past-president and past chairman of the board of directors of the Florida Division of the IAI, from 2004-2005.

In addition to his work with MDPD and the IAI, Phil served as a member of the Scientific Working Group on Imaging Technology (SWGIT) from 2004-2011. Phil served as that group's Outreach Chairman for 6 years.

ABOUT TRITECHFORENSICS and TRITECH TRAINING

A leader in the forensics market, TRITECH**FORENSICS** provides evidence collection and crime scene investigation products and training to crime labs and crime scene investigators throughout the world. With over 30 years of experience, we are the nation's most proficient developer and manufacturer of forensic kits. We are committed to providing our customers with state-of-the-art forensics products and services at affordable prices. It is our goal, through our research and development program, to continue to develop superior products and training to aid in all aspects of crime scene investigation and crime lab analysis. We know how important our products and training are to the forensics community, from investigation to prosecution – that is why our slogan, Identify. Collect. Preserve., represents the mission of our customers.

In 2013, TRITECH**FORENSICS** launched its Training Division (TFT), created to meet the needs of modern forensic professionals who want to expand their investigation and evidence collection skills. With courses ranging from Crime Scene Investigations to Fingerprinting to Understanding Terrorism and more, TFT provides world-class, experienced forensic instructors in either an agency's own location or in several Florida locations. Our instructors have many years of experience and many serve on prestigious boards, such as the IAI, the Pennsylvania State Coroner's Association, and the International Association of Bloodstain Pattern Analysis. Several have written books and manuals for their areas of expertise. Several have written books and manuals for their areas of expertise. As our training division continues to grow, we are increasing both our instructor base and the course subjects offered, and we are proud to provide a training-only website, tritechtraining.com, where students can locate white papers, learn more about our courses and instructors, and even register for courses.