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How Luminol Works

Introduction:

There's a lot of unbelievable technology in cop shows and movies -- computers that can zoom in and "enhance" a tiny section of a video frame; machines that can isolate a particular background voice from a muffled recording in a matter of seconds. Most of this stuff is pure fiction, fabricated by the writers to move the plot along. But one of the most outlandish TV cop tools, a special chemical that reveals invisible blood traces, is entirely real.

In this article, we'll find out how this strange compound, commonly known as **luminol**, reveals hidden crime scenes. As we'll see, this chemical is just as cool as it sounds, but it does have drawbacks and limitations not usually addressed on TV.

A simulation of luminol at work: Before spraying luminol, there's no sign of blood. After spraying luminol, the latent blood traces emit a blue glow.

What Does Luminol Do?

Much of **crime scene investigation**, also called **criminalistics**, is based on the notion that nothing vanishes without a trace. This is particularly true of violent crime victims. A murderer can dispose of the victim's body and mop up the pools of blood, but without some heavy-duty cleaning chemicals, some evidence will remain. Tiny particles of blood will cling to most surfaces for years and years, without anyone ever knowing they're there.

The basic idea of luminol is to reveal these traces with a **light-producing chemical reaction** between several chemicals and **hemoglobin**, an oxygen-carrying protein in the blood. The molecules break down and the atoms rearrange to form different molecules In this particular reaction, the **reactants** (the original molecules) have more energy than the **products** (the resulting molecules). The molecules get rid of the extra energy in the form of visible light

photons. This process, generally known as **chemiluminescence**, is the same phenomenon that makes fireflies and light sticks glow.

Investigators will spray a suspicious area, turn out all the lights and block the windows, and look for a bluish-green light. If there are any blood traces in the area, they will glow.

The Chemical Reaction

The "central" chemical in this reaction is **luminol** ($C_8H_7O_3N_3$), a powdery compound made up of nitrogen, hydrogen, oxygen and carbon. Criminalists mix the luminol powder with a liquid containing hydrogen peroxide (H_2O_2), a hydroxide (OH^-) and other chemicals, and pour the liquid into a spray bottle. The hydrogen peroxide and the luminol are actually the principal players in the chemical reaction, but in order to produce a strong glow, they need a **catalyst** to accelerate the process. The mixture is actually detecting the presence of such a catalyst, in this case the **iron** in hemoglobin

To perform a luminol test, the criminalists simply spray the mixture wherever they think blood might be. If hemoglobin and the luminol mixture come in contact, the iron in the hemoglobin accelerates a reaction between the hydrogen peroxide and the luminol. In this oxidation reaction, the luminol loses nitrogen and hydrogen atoms and gains oxygen atoms, resulting in a compound called 3-aminophthalate. The reaction leaves the 3-aminophthalate in an energized state -- the electrons in the oxygen atoms are boosted to higher orbitals. The electrons quickly fall back to a lower energy level, emitting the extra energy as a light photon (see How Fluorescent Lamps Work for more information on light production). With iron accelerating the process, the light is bright enough to see in a dark room.

Investigators may use other chemiluminescent chemicals, such as **fluorescein**, instead of luminol. These chemicals work the same basic way, but the procedure is a little bit different.
How Investigators Use Luminol

If luminol reveals apparent blood traces, investigators will photograph or videotape the crime scene to record the pattern. Typically, luminol only shows investigators that there *might* be blood in an area, since other substances, including household bleach, can also cause the luminol to glow. Experienced investigators can make a reliable identification based on how quickly the reaction occurs, but they still need to run other tests to verify that it is really human blood.

Luminol in itself won't usually solve a murder case. It's only one step in the investigative process. But it can reveal essential information that gets a stalled investigation going again. For example, hidden blood spatter patterns can help investigators locate the point of attack and even what sort of weapon was used (a bullet makes blood splatter very differently than a knife does). Luminol may also reveal faint bloody shoe prints, which gives investigators valuable information about the assailant and what he or she did after the attack.

In some cases, luminol leads investigators to more evidence. For example, if luminol detects trace amounts of blood on a carpet, investigators may pull up the carpet and discover a lot of visible blood on the floorboards below.

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One problem with luminol is that the chemical reaction can destroy other evidence in the crime scene. For this reason, investigators only use luminol after exploring a lot of other options. It is definitely a valuable tool for police work, but it's not quite as prevalent in crime investigation as presented on some TV shows. The police don't walk into a crime scene and start spraying luminol on every visible surface.

Analysis Questions:

1. What can happen if a murderer does not clean up the crime scene with heavy duty cleaners?

2. Explain how luminol reveals traces of blood.

3. What is chemiluminescence?

4. What is luminol composed of?

5. What is the catalyst of the reaction?

6. How is the light produced by the reaction?

7. What should investigators do if blood is revealed?

8. How can luminol be important in a case?

9. What is a problem with luminol?