Luminol—Casting a Revealing Light on Crime

By Tim Graham

On a summer morning in July 1992, Chris Campano phoned Oklahoma City police to report that his wife Karen was missing. Following their quarrel, she had not returned home on the previous evening. She had not shown up at work the following morning. Upon interviewing Chris, police reported that nothing appeared unusual at the Campano home, but they asked permission to search the house after Chris mentioned that the house had been burglarized just a few days before Karen's disappearance.

Chris Campano's story was inconsistent, and he soon emerged as the primary suspect. Police suspected that an argument between Chris and Karen over Chris's drug use had escalated into a violent encounter. Oklahoma City police soon found evidence that indicated that if a murder had taken place, it probably had occurred within the house.

Police found a large stain on the bedroom carpet that was still wet and appeared to be blood. Investigators soon concluded that a violent murder had taken place and that the victim was most probably Karen Campano. Investigators returned to the residence at night to conduct more tests, this time using the chemical 3-aminophthalhydrazide, commonly known as *luminol*.

Apart from the bloodstained carpet, the house appeared normal to the naked eye. But when investigators sprayed the bedroom with luminol and turned out the lights, the room glowed with an eerie blue color, casting light on a gruesome and brutal crime.

Dr. Walter Rowe, who teaches forensic science at George Washington University in Washington, DC, describes the process as being pretty simple. "The luminol reagent is mixed up and sprayed on the suspected stain, using an atomizer. The reagent consists of luminol dissolved in a buffer with hydrogen peroxide or sodium perborate. Sometimes, a thickening agent may be added to reduce the running of fresh stain."

Dr. Rowe cautions that the suspected stain must be sprayed repeatedly since the luminol chemiluminescence fades quickly. "The spraying is done in total darkness and the chemiluminescence is recorded with a tripod-mounted camera set for time exposure. High-speed black and white film is used."

Luminol is a chemical substance that will luminesce (give off light without any heat, "cold light") when it is oxidized. Substances that tend to give off light as the result of a chemical reaction of this sort are said to be chemiluminescent. You are probably familiar with a chemical light stick or necklace that you might purchase at a concert or at the circus. The outer plastic container holds one chemical reactant while an inner glass container holds the second reactant, hydrogen peroxide. Bending the plastic breaks the inner glass ampule, and the chemicals react and give off light . . . often for several hours. (See "Chemiluminescence, the Cold Light" by Gail Marsella in the October 1995 issue of *ChemMatters*.) Many living organisms such as a firefly also have the ability to create light by means of a similar chemical reaction. This type of chemiluminescence is called bioluminescence.

All chemiluminescent systems work basically the same way. Although many reactions that you might be familiar with tend to release energy in the form of heat, some chemical reactions emit light instead. For a chemical reaction to produce light, it must first produce a molecule or ion in a high-energy or *electronically excited* state.

The excited molecule has at least one electron in a higher-energy orbital than would normally be found if it were in its lower-energy ground state condition. But as the electron loses energy, it falls from its excited state back to ground state, and emits energy in the form of light (see Figure 1).

In fact, any source of light—whether luminescent or incandescent (the glow emitted by a very hot object)—can be traced back to the absorption of energy and its release as light. To understand the process of absorbing energy and emitting light, imagine an electron on a roller coaster ride. Ordinarily, the electron is on the ground. When it gets on the ride, energy pushes it up. The electron can only go as high as the tallest hill of the roller coaster and no farther. But it's not very stable up there! The electron soon heads back to its lower energy ground state, emitting its own version of a scream—light!

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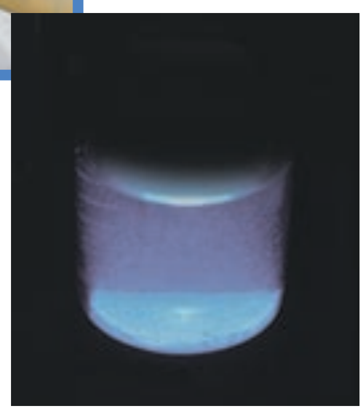


Luminol undergoes chemiluminescence in the presence of an oxidizing agent like hydrogen peroxide, a base like sodium hydroxide (NaOH), and a catalyst. Various metallic ions will catalyze the reaction. Iron found in the hemoglobin molecules of red blood cells is particularly effective. The resulting aminophthalate ion is first produced in an electronically excited state. As electrons return to the lower-energy ground state, energy is emitted as light.

Here's how luminol reveals a bloodstain. The iron-containing heme protein in the blood sample acts to decompose the hydrogen peroxide component of the luminol reagent. When this happens, the luminol is oxidized to form a product with electrons in a high-energy state. As these electrons return to their lower energy ground state, the visible result is a bluish light.

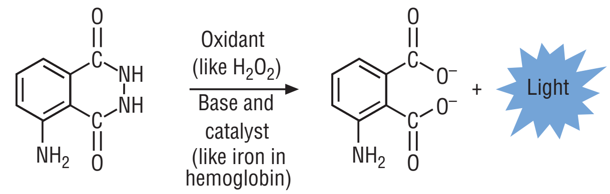
But a positive luminol test doesn't prove that the sample is blood. In fact, many other substances, both inorganic and organic, can set luminol aglow. Substances of animal origin such as pus, saliva, brain tissue, and bone marrow, as well as inorganic chemical oxidants like copper, potassium ferricyanide, potassium permanganate, potassium dichromate, nickel and cobalt nitrates, rust, and iodine can all initiate the luminol reaction, thus giving false postives. Even vegatable oxidases—enzymes found in apples, apricots, beans, horseradish, potatoes, turnips, cabbage, and onion—can start the decomposition of hydrogen peroxide, leading to false positive results.

It's interesting that during the O.J. Simpson trial for the murder of Nicole Simpson-Brown, Simpson's defense attorneys challenged the luminol results on stains found in O.J's Ford Bronco with the remark that the dried substance could just as well have been taco sauce. They argued that oxidases from the onion in the taco sauce could have resulted in a false positive. In forensic terms, the luminol test is called a *presumptive* test, meaning that positive results suggest without proving the presence of blood. Other tests are necessary before the presence of blood is confirmed.

When crime scene investigators sprayed the darkened Campano bedroom with luminol, the room glowed with so much light that they could easily see each other! With dramatic positive test results, luminol remains the preferred presumptive field test for blood. It easily reveals even the smallest traces, even if the crime scene has been scoured and cleaned to remove all visible evidence.

In the Campano house, luminol told a grim tale. Besides reacting with the blood spatters on the walls, ceiling, and window curtains in the bedroom, it illuminated cast-off trails probably tossed by an object swung through the air. The blue glow continued, tracing a pathway from the bedroom, through the kitchen, into a utility room, and outside down the back steps. It continued into the driveway where the trail abruptly stopped.

Forensic investigators had ample evidence to suggest that a violent murder had occurred and that the body, presumably that of Karen Campano, was dragged through the house and out into the driveway where it was probably placed in the trunk of a car and carried away for disposal. More tests completed the story. A species-determining test called the Ouchterlony test determined that the blood



Luminol (3-aminophthalhydrazide)

Aminophthalate ion

Figure 1

was human. Finally, a DNA analysis confirmed the blood to be that of Karen Campano.

The use of luminol directed investigators to the presumptive evidence from which they were able to piece together the events of that fateful night in July 1992. Just as Chris Campano's murder trial began, the remains of Karen's body were discovered in a remote area. Dental records and DNA analysis of the bone marrow confirmed the identification. The skull showed upward of 15 fractures that could only be the result of the blunt force trauma experienced during a severe beating.

With the overwhelming evidence against him, Chris Campano confessed to the murder and in January 1994 was found guilty of manslaughter and sentenced to 1000 years in prison with no possibility of parole.

Tim Graham teaches chemistry at Roosevelt High School in Wyandotte, MI. His most recent article "Light-Emitting Diodes—Tune in to the Blues" appeared in the April 2001 issue of *ChemMatters.*

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