Exotic Materials Make an Impact in Forensics

Interview with Linda A. Lewis, Oak Ridge National Laboratory

In recent years, there has been significant interest by the public in the general area of forensics and crime scene investigations. Some of this is due to the widely viewed television series which feature crime scene investigations, but we have also experienced a greater interest in forensics due to the possibility of domestic or foreign terrorism. Since this is a very exciting field that can be significantly impacted by ongoing research in the materials community, we have chosen to interview Dr. Linda A. Lewis of Oak Ridge National Laboratory, who has been active in various aspects of forensics from the perspective of chemical and materials analysis. Dr. Lewis, an analytical chemist, has been involved in such diverse forensic research such as latent fingerprint extractions to trace dye and fiber analysis and identification, which has been published in journals such as Analytical Chemistry.

—S.M. Prokes, interviewer

Linda, many of us have watched the TV series CSI and how the crime scene investigators solve the crimes. Obviously, the series simplifies reality. Can you give a better view of real forensics?

The TV series *CSI* makes it look so simple and uses techniques that really aren't possible. That's frustrating because it gives the individual the feeling that "Well, I can do that" and so some forensics investigators had problems with nontrained individuals trying to process their own crime scenes. For example, they try to collect fingerprints as they see it done on TV, and what they end up doing is compromising the crime scene.

Also, there are more groups that participate in a crime scene investigation than is shown in *CSI*. These groups include forensic sciences; criminalistics, which involve the trace evidence such as fingerprints and blood stains; and engineering sciences, who assist in an investigation when something appears to have been tampered with. There is also juris prudence, which involves the legal aspects of forensic sciences, such as court testimony. In addition, there is odontology, which is the study of the dental evidence, as well as pathology and biology, which involves autopsy investigations, as well as physical anthropology, which involves the assessment of time since death and conditions under which death occurred. Here in Knoxville, an anthropological research center nick-named The Body Farm has been established where research on human decomposition processes is conducted.

Also included in the area of Forensic Sciences are psychiatry and behavioral sciences, an area that covers criminal profiling and the study of an individual's habits. Another area supports document investigation, which includes methods of identifying counterfeit monies and counterfeit signatures. To support document analysis, a significant amount of scientific support goes into understanding inks, and how they age. And then there's toxicology. Here in the United States, a large part of the forensics programs are found in the chemistry/biology departments, but in other parts of the world, such as Italy, the forensics program is under the medical school, where toxicology and the body evidence fits well.

In the TV version of *CSI*, the scenes are much more alluring, whereas in reality, we see images from crime scenes that are just horrendous. There's nothing glamorous about it.

I am sure that a real life crime scene is not even close to the TV version. I can see a huge role for materials and their potential impact on various areas in forensics, though.

One thing that is very important is the understanding of new materials. Exotic materials are present at a crime scene and we need to understand those materials and their origin.

Teams from Oak Ridge National Laboratory (ORNL) and the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) prepare samples for residual fingerprint detection experiments.

What kind of exotic materials?

Something as simple as glass may contain unusual impurities, which can help in determining its origin. This is also true with plastics or other products, such as carpet fibers.

Are there any materials that you could envision that would really help in forensics?

Titania nanoparticles, for example, have been combined with a new perylene diimide dye and then used in powder form to dust for prints, which resulted in very high contrast, allowing better imaging for the fingerprints. We also have need for new materials for use in developing prints, or identifying blood stains, or new materials that would support DNA characterization. Researchers have even looked at fingerprints to see if one can extract DNA directly. We need materials not just to process the evidence, but also to make the analytical instrumentation—optics and detection capabilities—more sensitive, portable, and robust.

So it's also an ultimate sensitivity issue.

Exactly. The lower we can push the detection limits, the better and easier and more accurate is the analysis. For example, we have worked with carpet fibers, where we extracted the dyes to characterize the dye constituents. What we found was that three dyes are typically used in different concentrations to make different colors. However, one cannot detect the subtle changes that might produce a different color from the dye using a spectrophotometer, whereas when using a mass spectrometer, we can push the limits of detection down and identify the dye combinations and concentrations, and thus very accurately determine the distinct color. This can help to identify the manufacturer.

How did you get involved in the area of forensics?

I was a chemist at the Oak Ridge, Tennessee Y-12 National Security Complex. At the end of the Cold War, our workload was greatly reduced. So, the DOE [Department of Energy] looked at how their scientists could help in other areas of research. As a result, DOE signed a memorandum of understanding with the FBI/Department of Justice. One of my first projects under that protocol was to research mechanisms on

how superglue vapor worked in fingerprint detection.

It's amazing that superglue has been so successful and that it is a technology which is still being used.

Yes, but now that we understand the pitfalls (it's not 100% effective), we're trying to replace it. Superglue has been used in the United States since the 1980s; it worked, but practitioners didn't understand how. I started working on this in the late 1990s, when I tried to determine the reaction protocol [to determine what needs to react in order to bring out the fingerprints]. We found that the main initiator, which is lactate, photo-degraded, and thus fingerprints exposed to the sun and fluorescent light would not develop. We are also trying to determine other methods of developing latent fingerprints on evidence that would not normally have survived the environmental or physical conditions.

Naval Research Laboratory and ATF teams set up stand-off sensing experiments.

I envision forensics being extended to other areas, not just murder investigations.

It is. The funding to support that is low, however.

You would imagine that insurance companies would be interested, maybe even health insurance companies?

Exactly, mostly because of insurance fraud. There is also forgery, such as counterfeit documents and money. One of the areas that could benefit from new materials is counterfeit securities, because we can mark the currency with certain materials, as well as high-end clothing, where materials are needed to distinguish the brand for originality.

Perhaps incorporating unusual nanoparticles, into the ink, so that it would be very difficult for a counterfeiter to reproduce?

Yes, like we do with fluorescence, for example.

Since the MRS Bulletin *is read by many students and people who may want to go into nontraditional careers, how might they prepare for this type of profession?*

For criminalistics, the best way is getting an analytical chemistry degree. There are many more forensic science programs now than there were five or 10 years ago. With other fields, such as forensic pathology, they need to prepare to be a pathologist; with odontology, one must train to be a dentist first. Forensics is just a twist, and they can start working and making contacts in forensics, maybe work with someone who is known in this area of science.

One can also have a materials science degree for this kind of work, right?

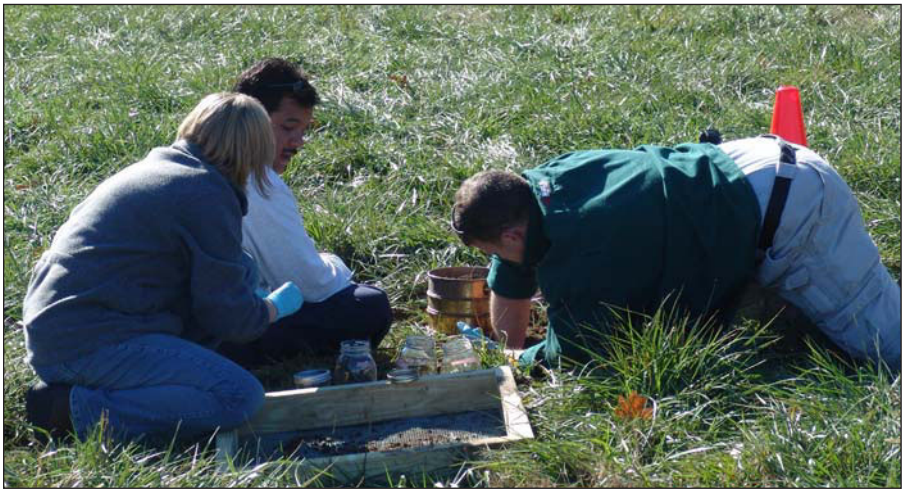
Absolutely. Even though I'm an analytical chemist by training, I'm learning about other materials. It's not as if when you get your degree, you're done. If you're in research, you're continuing to learn. That's what I enjoy about research; I'm always learning, not only in my field, but in other fields.

By the way, in biology, there is a new forensics category that's evolving, called biological forensics in the environment. For example, is the pollution from a certain company causing the demise of a certain plant; or what is causing this plant to die? And how are certain crimes to the environment affecting animals?

We've developed all these forensic tools and materials and there are always dual uses, such as environmental issues. Can you think of other areas that might be impacted by forensics?

Areas such as oil exploration, for example, where one could look for trace amount of oil residue on the surface, thereby avoiding expensive drilling. All of these tools are analytical tools which we've learned to apply to forensics. We're always leveraging, and that's one of the things that I just love: to stretch your research dollar and collaborate with someone else's research dollar, working together, and coming up with a better product for a solution at the end.

Thank you so much for taking the time to discuss this exciting and growing research and application area. I hope that our readers will find this as fascinating as I did, and perhaps we can encourage some students or recent graduates to follow a more nontraditional path in research, such as you have done.



ORNL and ATF teams collect fingerprint data after field tests.

Linda A. Lewis *of the Chemical Sciences Division at Oak Ridge National Laboratory in Knoxville, Tenn., focuses on research, including forensic sciences, specifically fingerprint development, trace analysis, and nuclear sensors development.*

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