Keeping an Eye on Exposure

Video Monitoring in the Lab

Digital Vision, Photodisc, Chris Reuther/EHP

The pharmaceutical laboratory can be a dangerous place. Although much of the work in pharmaceuticals goes on in well-controlled manufacturing plants, basic research and batch-scale production of new compounds are done as bench operations, whether in companies large or small or in academia. And although considerable attention is paid to workplace safety in pharmaceutical manufacturing, oftentimes less formal attention is paid to assessing safety at the basic end of the research-and-development spectrum. The impact of bench workers' exposure to toxic solvents, reaction intermediates, and new compounds is not well understood, but application of an established environmental hygiene technique, video exposure monitoring, is providing a new tool for understanding and controlling the risks found at the bench.

At the Purdue University Exposure Assessment Research Laboratory, James McGlothlin, an associate professor of industrial hygiene and ergonomics, and his research team are developing wireless video exposure monitoring systems to help fill the safety gap in early pharmaceutical research. These systems combine real-time recording of relevant exposure indicators with video capture of workers in the workplace. The result is a single display that shows how a particular exposure varies over the range of motions and activities a worker may perform while doing an experiment.

Video monitoring has already proven valuable in understanding human–environment interactions in a range of industrial applications including metal foundries, metal grinding, engine repair, sanitary pottery (such as toilets and sinks), furniture stripping, jackhammering, and commercial dry cleaning. "It tells you when exposure happens," explains Leroy Mickelsen, acting deputy director of the National Institute for Occupational Safety and Health Division of Applied Research and Technology, which has developed video monitoring in several of these industries. "We've done some work where ninety percent of [an] exposure turns out to happen during one procedure. If you can change the behavior during that short window during the workday, you can eliminate most of the exposure."

Known Threats, Unknown Exposures

The toxicants in pharmaceutical laboratories are not trivial. Solvents such as ether, dichloromethane, chloroform, and benzene are commonly used; all of these target the eyes, skin, and other organs, as well as the central nervous system. Benzene is used as a reagent, solvents are used to distill chemicals, and tremendous amounts of toluene, xylene, and other hazardous solvents are used to derive chemical intermediates.

"These solvents can possibly contaminate workers' gloves, and they can touch their hair or their face, and breathe in these solvents," says McGlothlin. "Also, dry powder formulations can produce a lot of particulates that can become airborne, and this presents a potential respiratory hazard."

The Occupational Safety and Health Administration has set well-defined exposure limits for each of the major laboratory solvents. But undefined hazards, including reaction intermediates and new products, also lurk. "Some of our interest comes from not knowing what these exposure profiles are," says McGlothlin. "We don't know the toxicology or pharmacokinetics of a lot of intermediate compounds. New formulations are coming forward every year where we have absolutely no idea about their toxicity." In low doses, as medicines, they might be fine, he says, but at higher exposures and over longer periods of time, they may be hazardous to the people who are manufacturing them.

Contrary to full-production pharmaceutical facilities, where industrial hygienists and environmental engineers work to keep the workplace safe and healthy for its employees, protection in small research settings is often limited to good laboratory practices, properly operating hoods, and suitable personal protective equipment. Specific monitoring for exposures to known hazards is not the norm. And, in most labs, there's definitely something in the air. "We understand that most labs have some strange odors in them that we can't quite put our fingers on," says George H. Wahl, Jr., a professor of organic chemistry at North Carolina State University. "So anyone who just presumes that there is no problem is kind of foolish." Wahl chaired the committee that established the university's chemical safety plan as well as the American Chemical Society Committee on Chemical Safety.

The Next Step in Monitoring

One common, inexpensive approach to understanding workers' exposure is to use detector badges worn on the lab coat to record signs of encounters between the worker and a specific hazard, such as radiation or a particular organic solvent. These badges use a number of strategies to communicate exposures, including dosimetry and diffusion of airborne gases into tubes or filters containing color-changing indicators. But badges mark total exposure over a period of time, and even color-changing badges do not call specific attention to the behavior that led to a worker's exposure.

Personal air sampling pumps, which pull air from a worker's breathing zone into a charcoal filter trap, can provide another level of personal safety, allowing analysis of dusts and particulates as well as solvents, but they are cumbersome and require careful calibration.

Air samplers pulling samples from broader areas—for example, from a room within a laboratory facility—allow monitoring of more workers, but these devices are generally calibrated to one particular vapor or substance, and so provide only limited insight into the laboratory's pattern of exposures. Using "grab samplers," which pull in short bursts of air at defined time points for analysis, allows the air to be sampled regularly but risks missing transient exposures. On the other hand, using "integrated samplers," which pull in air over extended periods, risks missing brief but important peaks of exposure because the measured substance may be diluted over the sampling time.

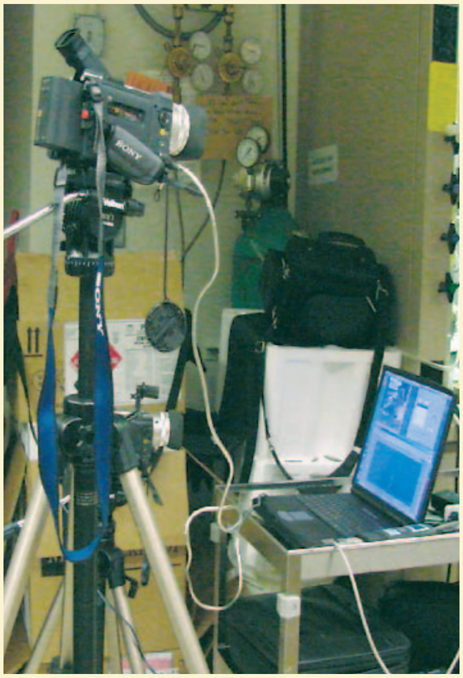
In a more comprehensive approach, the McGlothlin group's system synchronizes real-time data collected by any of a range of possible detectors, which are sent to a computer by telemetry along with video images from cameras positioned within the workstation. Essentially, McGlothlin's approach turns simple components into a tool to provide insight into what's happening at the bench.

"This approach is really versatile, in that whenever a new detector comes out, you can use it with this technique," Mickelsen says. That flexibility makes it easy to adapt video monitoring to fit the needs of multiple kinds of workplaces.

Chemical, biological, radiological, and physical data detectors can all be used to gain information about exposures during a given experiment. Photoionization detectors, for example, can be used to watch solvent exposures, or light scattering can monitor exposure to aerosols. A moving bar or graph on the display screen indicates changes in exposure level, highlighting what the worker is doing when peaks of exposure occur.

Spotting these moments is critical. Exposures usually are task-driven, says Paula Kaufmann, a certified industrial hygienist and senior project manager for the New Jersey–based consulting firm Emilcott Associates. Chemical exposures are not continuous, she says; instead, exposure typically happens any time something—a vial of solvent, a sampling port, a stopcock on a glass apparatus—is opened or closed around a laboratory. Those are the points where the opportunity for exposure arises, she explains.

McGlothlin's pilot work, which monitored Purdue graduate students and technicians in pharmaceutical laboratories, found that simple mistakes were also important opportunities for exposures. One researcher whose work was monitored had more exposure from a bad habit—touching her hair as she worked, transferring contaminants from her glove—than from any planned part of the protocol. Another's exposure peaked when he removed his reaction product from the hood and brought it close to his breathing zone so that he could visually check the product under an ultraviolet light. Another was exposed to solvent not while working on his own reactions, but rather from a hidden danger: the vapors escaped from the laboratory refrigerator as he opened its door.



Focused on health. Detectors (above, in backpack) collect real-time exposure data, which are sent to a computer (left) and merged with footage of the worker performing a procedure. The result is a video "diary" showing fluctuations in exposure corresponding with each step in the procedure.

These dangers would normally go undetected in an academic research laboratory, not because they are hard to see but because, generally, no one is watching. "A lot of industrial hygiene and safety issues are just common sense," Mickelsen observes. "A lot of times if you walked in there without any equipment and just observed, you would pick things up." In laboratories doing chemical synthesis, human nature can be especially dangerous. People look for shortcuts, observes Wahl, "and sometimes the shortcut can be fatal."

The new system has value for the drug manufacturing process beyond detecting and monitoring exposures. It is being installed at Purdue's new Allen Chao Center for Industrial Pharmacy, a 12,000-square-foot facility dedicated to giving students hands-on experience with manufacturing pharmaceuticals to Food and Drug Administration standards. There, video exposure monitoring is expected not only to enhance worker safety, but also to help maintain the quality of the drugs produced.

"In batch operations," McGlothlin says, "you want to make sure that the purity of the compound, whatever you're making, is one hundred percent. The higher that percentage, the better it is for the drug manufacturer." Manufacturers do a good job of guarding product purity, he says, but there is always the potential for human error in, for example, contaminating one product with the residue of another. "By having a visual and real-time output for each of the production stages, they will ensure the integrity of how the pills are handled and how they come through the process," he says.

McGlothlin hopes to develop video exposure monitoring into a stand-alone commercial system, a wireless sensor and video setup that could be hooked up to an existing computer. He and his group are doing a market analysis, and they believe they could get the units out the door for $1,000–1,500.

A Picture Paints a Thousand Words

Video monitoring could also prove a valuable training tool, helping researchers and laboratory workers to recognize dangerous situations and avoid mistakes. Understanding how and where mistakes happen is important, according to Mickelsen. "People at universities should be trained in safety and health because they're going to be doing the research in the future. What habits they develop [in their university years], they're going to carry with them," he says.

"Nothing speaks better than a photograph to explain what's really happening," emphasizes Kaufmann. "And as a tool for training, no one's going to argue with you about whether something happened, because it's there. You can talk to people and show them, 'Look, when you open this valve and this pours out, if you stand downwind, you get exposure, and if you stand upwind, you don't.' What I've witnessed with video monitoring combined with real-time monitoring is that you can actually see where the exposure takes place and then visually show the workers what works and doesn't work from a minimizing-exposure standpoint. It works."

But knowing how and when exposures take place does not replace an even simpler safety principle. "The rule of thumb," says Wahl, "is to minimize all exposures. So if you need toluene, for example, think—how much do you really need? And then, think twice—do you really need that much?"

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Suggested Reading

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