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Learning From UCLA

Details of the experiment that led to a researcher's death prompt evaluations of academic safety practices

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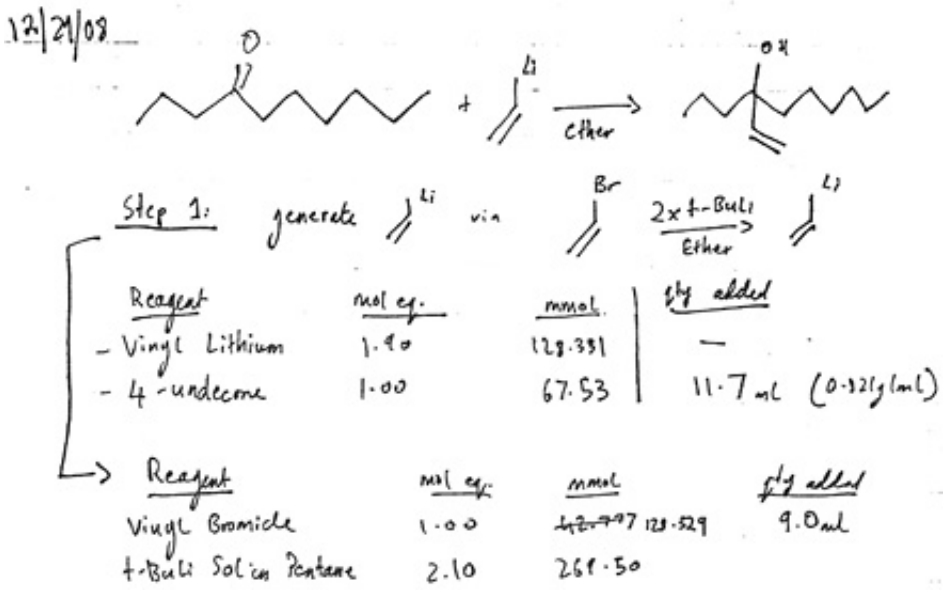

UCLA View Enlarged Image

REACTION Sangji's lab notebook reveals that she planned to react vinyl bromide with tert-butyllithium as the first step of a larger synthesis.

Courtesy of Naveen Sangji

Sangji

Dow Chemical

EQUIPPED Davis dons goggles, gloves, and a flame-resistant lab coat to do experiments at Dow.

John Palmer/UC San Diego

PYROPHORIC A recommended set-up for syringing tert-butyllithium includes inert gas supply and venting to a bubbler, as well as a glass syringe.

On Jan. 16, Sheharbano (Sheri) Sangji, a 23-year-old chemistry research assistant, died from injuries sustained in a chemical fire on Dec. 29, 2008, in a laboratory at the University of California, Los Angeles (*C&EN Online* Latest News, Jan. 22).

The incident has trained a spotlight on safety practices in academic labs, with researchers highlighting the need for awareness of risks and regular hazard assessments, while cautioning against developing an adversarial relationship with campus environmental health and safety officials.

Before researchers can learn from what went wrong, however, they must first understand what happened.

Sangji had started work in the lab of Patrick Harran, a chemistry professor at UCLA, on Oct. 13. According to copies of Sangji's lab notebook obtained from UCLA through a California Public Records Act request, Sangji planned in December to scale up a reaction she'd run once before, on Oct. 17, to produce 4-hydroxy-4-

vinyldecane from either 4-undecanone or 4-decanone—the structure and molecular weight written in her lab notebook are inconsistent with the named reagent.

The first step of that reaction was to generate vinyllithium by reacting vinylbromide with two equivalents of *tert*-butyllithium (tBuLi), a pyrophoric chemical that ignites spontaneously in air.

That's an acceptable way to approach the synthesis Sangji was doing, says E. J. Corey, a Nobel Laureate and chemistry professor at Harvard University. A Grignard reagent could be used instead of vinyllithium to do the addition to the ketone, Corey says, but side reactions would reduce the yield. And the best way to generate a clean lithium reagent, Corey says, is to use two equivalents of tBuLi (*J. Am. Chem. Soc.* **1972,** *94,* 7210).

When Sangji had done the reaction in October, she added 28 mL of anhydrous ether to a flame-dried 200-mL flask. Next, she added 3.0 mL of vinyl bromide and stirred the mixture for 15 minutes at –78 °C. She then charged the flask with 53.79 mL of 1.67 M tBuLi in pentane. She further stirred the mixture for two hours, then moved it to a 0 °C bath for 30 minutes, and finally took it back to –78 °C.

Separately, she added 6 mL of ether and 3.90 mL of 4-undecanone to another flame-dried flask and cooled the mixture. She then used a double-tipped needle to transfer the material to the tBuLi flask. She stirred the reaction at –78 °C for two hours, then warmed it to –10 °C before quenching the reaction with 80 mL of $NaHCO_3$. Her crude yield was 3.60 g of 4-hydroxy-4-vinyldecane, or 86.75%.

At the end of December, Sangji's goal was to generate three times that amount of material—a "moderate" scale reaction, Harran said, according to a transcript of his interview with Joel E. Aplin and Maurice S. Jurado, deputy fire marshals at UCLA, that was obtained by C&EN through a public records act request.

Using information from the notes and reports from the UCLA fire marshal, UCLA Fire Department, UCLA Police Department, UCLA Environmental Health & Safety Office (EH&S), Los Angeles City Fire Department, and California Division of Occupational Safety & Health (Cal/OSHA), also obtained through public records requests, C&EN has tried to put together as detailed an account as possible of what happened to Sangji that day.

Sangji was working on a nitrogen manifold in a fume hood in a lab on the fourth floor of UCLA's Molecular Sciences Building. She had titrated the tBuLi twice to determine its concentration—1.69 M—and needed 159.5 mL of the reagent to react with 9.0 mL of vinyl bromide. She was drawing up the tBuLi in roughly 50-mL aliquots in a 60-mL plastic syringe equipped with a 1.5-inch, 20-gauge needle.

For unknown reasons, the syringe plunger came out of the barrel and the tBuLi was exposed to the atmosphere. Although it wasn't part of her experiment, an open flask of hexane was also in the hood and Sangji knocked it over. The tBuLi ignited and the solvent caught fire, as did Sangji's clothes. She was wearing nitrile gloves, no lab coat, and no one remembers if she was wearing eye protection.

Although there was a safety shower in the lab, Sangji did not use it. Instead, Weifeng Chen, a postdoctoral researcher in Harran's group who was cleaning up one of the lab's benches, wrapped a lab coat around Sangji to try to put out the fire. "She was screaming and was moving around and I was attempting to wrap her tightly," Chen told Cal/OSHA Investigator Ramon Porras. Chen abandoned the lab coat when it started burning. He then started pouring water on Sangji from a nearby sink, while she sat on the floor.

INCIDENT INFORMATION (PDFs)

Sheri Sangji's lab notebook pages

UCLA EH&S Harran lab inspection report

UCLA EH&S accident report

Los Angeles Fire Dept report with Sangji interview

UCLA Fire Marshal Harran interview

Cal/OSHA Harran statement

Cal/OSHA Chen statement

Cal/OSHA Ding statement

Cal/OSHA UCLA citation

California State Fire Marshal report

California Fatality Assessment and Control Evaluation report

Hui Ding, a postdoctoral researcher in an adjacent lab, heard Sangji screaming. He went into the lab and saw Chen trying to put out the fire. Ding also saw that "the tip of the reagent bottle was positioned sideways and was also on fire," he told Porras. Ding returned to his lab and called 911, then checked on Chen and Sangji again before going to get Harran from his office on the floor above.

When Ding returned to the lab with Harran, Harran saw that Sangji's hands, torso, and neck were burned. "Her clothing from the waist up was largely burned off and large blisters were forming on her abdomen and hands—the skin seemed to be separating from her hands," he told Porras in an e-mail. Sangji was conscious, asking for more water, where emergency responders were, and for someone to call her roommates. When Harran heard sirens, he went down to the road to tell the emergency personnel where they needed to go.

UCLA police dispatch recorded the 911 call at 2:54 PM as an "unknown type chemical fire." Emergency crews were dispatched at 2:57 PM, and Christopher Lutton, a UCLA deputy fire marshal; a fire engine; and emergency medical personnel arrived at the building at 3:01 PM. Lutton donned full protective gear and went up to the lab to assess the situation, with dispatch recording at 3:06 PM that the fire was out upon arrival. Lutton cleared the other emergency responders to go up to the lab. Once medical personnel arrived, Sangji was put on a rolling chair and moved under the safety shower for decontamination. She was then transported to UCLA Ronald Reagan Medical Center. From there she was transferred to Grossman Burn Center, in Sherman Oaks, Calif., where she died on Jan. 16.

Harran told Cal/OSHA and fire marshal investigators that the lab generally follows Aldrich Technical Bulletin AL-134 for handling air-sensitive reagents. The bulletin first recommends heating glassware in an oven to eliminate any adsorbed moisture, then cooling it in an inert atmosphere. Sangji refers in her notebook to using flame-dried flasks and the syringe found at the scene was plastic.

Additionally, if a researcher is using a syringe to transfer the reagent, the bulletin says to use a 1- to 2-foot-long needle. The Cal/OSHA report says that Sangji's was 1.5 inches.

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The Aldrich bulletin also recommends pressurizing the reagent bottle with high-purity dry nitrogen such that the pressure in the bottle pushes out the syringe plunger. "The plunger should not be pulled back since this tends to cause leaks and create gas bubbles," the bulletin says.

But Harran told fire marshal investigators that he prefers not to pressurize the bottle to push out the material. "I find that a little dangerous because then it can jump on you," he told Aplin and Jurado. Harran said that he

favors using a nitrogen line with a bubbler, under enough N_2 pressure so that as he withdraws the syringe plunger to pull in reagent, the bubbler keeps going.

"Aldrich recommends regulating the inert gas to about 3 to 5 psi to pressurize the bottle," says Mark Potyen, a R&D scientist at Sigma-Aldrich. "Through a 16-gauge needle, the largest Aldrich recommends, the movement of the plunger is manageable and is a safer technique than pulling the plunger of the syringe to use the reduced pressure in the syringe to draw up the material." This is partially why Aldrich recommends glass rather than plastic syringes, Potyen says, because pressure at 3 to 5 psi cannot push up a plastic syringe plunger.

Aldrich also recommends using a syringe that is twice the volume that you intend to deliver and advises against reusing syringes for multiple transfers, Potyen says, since a dirty syringe could result in a locked-up barrel.

SAFETY INFORMATION

Sigma-Aldrich technical bulletin on handling air-sensitive materials (PDF)

Imperial College London hazard assessment form (PDF)

C&EN Safety Letters

For amounts larger than 50 mL, Aldrich advocates that researchers transfer the reagent by cannulating, or using a double-tipped needle to transfer the reagent under pressure from the bottle into a sealed graduate cylinder, then again from the cylinder into the reaction flask.

"I would have preferred that [Sangji] had done the cannula technique," Harran told Aplin and Jurado. "We use both methods in the laboratory. .... I don't know if she had done the cannulation technique previously, so she may have been repeating the procedure that she had done simply on a larger scale."

Although Harran told Cal/OSHA Investigator Porras that he talked with Sangji on the morning of Dec. 29 about what she planned to do that day, he did not indicate whether they discussed specific experimental procedures.

Looking at what actually went wrong with Sangji's experiment, there is not enough information available to say for certain. In the materials obtained by C&EN, no one documented the state of the hood immediately after the accident. And although Fire Marshal Lutton took photographs of the scene, he did so after fire officials asked Harran to shut down the experiment to ensure that the hood was safe.

Postdoc Ding noted that, when he first entered the lab, a reagent bottle was sideways and on fire—but he did not say whether that was the tBuLi bottle or the hexane flask. If it was the tBuLi bottle, and it was not clamped as specified by the Aldrich bulletin, it could have been a clue that perhaps Sangji, using a needle too short for the reagent bottle, had upended the bottle in one hand while trying to handle a 60-mL syringe with the other, and things went awry from there.

Alternatively, although Harran told C&EN in an interview in May that he remembered that the bubbler on the nitrogen manifold was active when he later returned to the lab and shut down the experiment, he couldn't recall if the port to the tBuLi bottle was open. Perhaps Sangji had simply forgotten to turn on the gas to the bottle, then pulled too hard on the syringe plunger, not realizing that she was fighting a lack of pressure in the bottle.

Other possibilities include that the tBuLi reacted with moisture in the undried syringe, or with air that got into the syringe while Sangji was pulling up the reagent. Or Sangji was on her second or third transfer with a used syringe, it locked up, and she tried to release it.

Last but not least, since she was using a 60-mL syringe for 50 mL or more of tBuLi, perhaps she simply overshot while pulling out the plunger.

Los Angeles Fire Department investigators were able to speak briefly with Sangji at the emergency room, where she told them that "she pulled the plunger out too far, the plunger came out of the housing of the

syringe, and the chemical spilled out and flashed." She also told them about the spilled hexane.

But UCLA fire marshal investigators never spoke with Sangji, despite being told on Jan. 6 that she could be interviewed.

Sangji's family also did not discuss the incident with her while she was in the hospital, says her sister, Naveen Sangji, because they were trying to stay focused on the positive and "we thought we had all the time in the world to get to the unpleasant stuff."

Whether Sangji should have been doing the experiment under closer supervision is an open question. Both Harran and Kevin S. Reed, UCLA's vice chancellor for legal affairs, have said in written statements that Sangji was an experienced chemist. Sangji graduated from Pomona College in May 2008 with a bachelor's degree in chemistry. While at Pomona, she spent three years working for chemistry professor Daniel O'Leary doing peptide chemistry. Neither of her published papers involves alkyllithium or similarly hazardous reagents (*Org. Lett.* **2005,** *7,* 5721; *J. Am. Chem. Soc.* **2006,** *128,* 7754).

After graduating from Pomona, Sangji went to work at Norac Pharma, in Azusa, Calif. Daniel Levin, president of Norac Pharma, says that, although he can't disclose the specific chemistry Sangji did for the company, she did not work with pyrophoric materials. He adds that, although he thought Sangji had more research experience than average for a chemist with a bachelor's degree, she was still closely supervised in both the planning and execution of her experiments at the company.

Lab workers "have to have the mind-set that something can always go wrong."

At UCLA, Harran told Aplin and Jurado that Sangji had trained with an unnamed postdoctoral fellow who had done the tBuLi procedure multiple times. Sangji "had executed it successfully, I think three times, previously," Harran said.

But UCLA has no evidence that Sangji used tBuLi more than once before the day of the incident, says university spokesperson Carol Stogsdill. "However, her résumé and work history show that she was familiar with pyrophorics—and, importantly, the techniques we use to handle t-butyllithium are common to those employed when handling a wide range of air- and/or moisture-sensitive chemicals," Stogsdill says. Sangji "had prior experience with those techniques and was further trained in them in Dr. Harran's lab."

Because Sangji was an employee rather than a graduate student, Cal/OSHA investigated the incident; as a result of the investigation Cal/OSHA fined the university $31,875 (C&EN, May 11, page 7). The agency cited the UCLA chemistry and biochemistry department for lack of training; failure to document training; failing to correct unsafe laboratory conditions and work practices identified in an Oct. 30, 2008, inspection of Harran's lab; and failing to ensure that employees wore appropriate personal protective equipment (PPE), such as lab coats.

On the training front, prior to the incident, the UCLA EH&S office conducted general laboratory safety training at the beginning of every quarter, while principal investigators provided laboratory-specific training.

Having started in mid-October, Sangji missed the EH&S training and would have been expected to attend in January, says James Gibson, director of EH&S. Neither Chen nor Ding had received general safety training from EH&S, either—Chen started at UCLA on Oct. 10, 2008, and Ding told Cal/OSHA investigator Porras in January that he had been at UCLA for four months. Harran and UCLA maintain that all researchers had the laboratory-specific training needed to perform their work safely. EH&S now provides general safety training monthly, and researchers cannot receive keys to their labs until the training is complete, Gibson says.

UCLA has also now purchased flame-resistant lab coats for researchers using flammable reagents.

The October laboratory inspection was the first for the Harran lab since the group had moved to UCLA from the University of Texas Southwestern Medical Center on July 1, 2008. Several of the violations described in the inspection report involve things that could be due to differences in Texas versus California law. The report notes that gas cylinders were not properly restrained, for example, and California requires that gas cylinders have two straps whereas Texas requires only one.

Other violations flagged in the inspection include keeping more than 10 gal of flammable solvents outside of the flammable storage cabinets, and that lab researchers were not wearing PPE. UCLA's standard practice is to correct such deficiencies at the time of the inspection and in a Nov. 5, 2008, e-mail to Harran, UCLA Chemical Safety Officer Michael Wheatley says that the lab "was able to correct some deficiencies on the spot," although he doesn't specify what those were. But in the aftermath of the incident Cal/OSHA investigators again flagged flammable solvent storage and PPE issues, noting that photos of the lab taken after the incident showed approximately 14 gal of flammable liquids inside a hood, and Sangji was not wearing a lab coat.

Generally, UCLA rules at the time gave Harran 30 days to correct the deficiencies. In that Nov. 5 e-mail, Wheatley asked Harran to set up a time to go over the report.


Courtesy of Patrick Harran

Harran

Harran replied on Nov. 12, asking if the meeting could wait until his group moved out of their temporary labs and into their permanent location, which was still under construction. "Our labs on four are overcrowded and disorganized," Harran wrote. "I wasn't planning to be in temporary space for this long. We should be moving soon."

"That should be no problem," Wheatley responded. The labs did not relocate until early January.

Gibson says that UCLA historically has inspected labs once a year, and new labs were simply added to the cycle without necessarily getting additional support from EH&S officers during the setup period. UCLA is considering how to remedy that gap, Gibson says.

Gibson also says that, although the incident occurred over the winter holiday for the university and administrative offices were closed, UCLA expects that research labs will generally be open 365 days per year.

The California State Fire Marshal Arson Bomb Investigation Division reviewed the information collected by UCLA fire marshal investigators and concluded that the incident was an accident and closed the case. Although UCLA requested that the California Office of the State Fire Marshal review the Aldrich-recommended syringe procedure to see whether it meets the fire-code requirements for a closed system for a solid or liquid hazardous material, the state fire marshal declined to consider the matter, says Ernie Paez, chief of the South Fire & Life Safety Division of the Office of the State Fire Marshal.

Cal/OSHA is reviewing the incident, as is standard for a case involving a fatality, to determine whether to forward its findings to the Los Angeles district attorney's office to evaluate whether criminal prosecution is warranted. UCLA has withdrawn its appeal of Cal/OSHA's citations (C&EN, June 29, page 30).

Sangji's family has been very unhappy with how the various investigations have gone, Naveen Sangji says. She notes that, except for Cal/OSHA Investigator Porras, everyone else directly involved in investigating the incident was a UCLA employee. She also questions Cal/OSHA's thoroughness, given that the Cal/OSHA report says Sangji was syringing 20 mL of tBuLi, not three 50-mL aliquots.

"We feel like we've gotten nowhere with the state agencies and the university," Naveen says. "We think it's time for the district attorney to step in and figure out what's going on. We want to know who was responsible and who failed in their duties to make sure Sheri was safe at work, and those people should answer for their failures."

The family wrote to the American Chemical Society on July 6, asking the society to issue a public statement

reprimanding Harran for disregarding the safety of his researchers, and to demand full disclosure of the events of the day.

In her July 17 response to the letter, Madeleine Jacobs, executive director and chief executive officer of ACS, which publishes C&EN, writes that "issuing a rebuke to a specific individual or individuals is not an option consistent with our role. There are entities, such as Cal/OSHA, which investigate and apportion blame in these circumstances, and we are obliged to respect their oversight role." Jacobs adds that "there may be an opportunity for ACS to develop a statement that highlights the tragedy of deaths such as Sheri's as compelling examples of the need for stronger safety practices in academic laboratories."

Anna Davis, who is approaching her first anniversary as a research scientist working on catalyst discovery for water-soluble polymers at Dow Chemical, agrees that academic lab safety could be improved. She says that safety at Dow is generally much more a part of the laboratory culture than in the academic institutions at which she's worked. Davis received her Ph.D. from UC Berkeley and did postdoctoral research at Northwestern University.

"I was fortunate to work for professors that took safety seriously," Davis says, "But I think that the culture varies too much from one research group to another" in academia, and consequences are minimal when something bad happens. In contrast, at Dow it's emphasized from day one that, no matter what your job is or where you work, safety is a job expectation and is a critical part of your job performance, Davis says.

When asked whether the emphasis on safety is a deterrent to being open and honest when things go wrong in the lab, Davis responds: "You're certainly going to get in trouble if you're lax about safety here. But I think that if you do an earnest job of trying to follow safety practices, then no, I wouldn't say that you're afraid to discuss a near miss or an accident."

Sangji's death has inspired at least some members of the academic chemistry community to take stock of the safety procedures in their labs. Robert M. Waymouth, a chemistry professor at Stanford University, works in the area of organometallic chemistry and catalysis. Although Waymouth typically spends part of every group meeting discussing safety issues that come up in his group, news of the UCLA fire inspired a meeting devoted entirely to talking about what was known about the incident and whether any lab procedures should be changed, Waymouth says.

In keeping with federal OSHA lab standards, certain things in his lab have always had trigger points—for example, using more than 500 mL of an extremely flammable solvent like diethyl ether—that require an explicit risk assessment. In those cases, the researcher doing the experiment must fill out a form and go over it with someone else, to explain what they're doing and why and to review the appropriate safety procedures if something goes wrong. And everyone in the lab is informed of the experiment so the group knows what's going on.

That protocol now applies to any reaction involving tBuLi. The group's lab-safety manual has also been revised to contain more explicit directions regarding use of PPE, Waymouth says.

Waymouth emphasizes that evaluating safety risks needs to be a constant and ongoing thing. Safety shouldn't be something done at a training seminar and then forgotten, he says. Faculty "need to make sure that there's an awareness in the real day-to-day environment about what's the best way to do things safely," he says. "You need to establish a safety environment where people can encourage others to have safe practices and not be embarrassed about it."

And just as essential, lab workers "have to have the mind-set that something can always go wrong," Waymouth says. "If you have thought about it beforehand, you will be more prepared to deal with it. If you're surprised, then it is more difficult to respond rationally. A prepared mind is the most important safety attitude that you can have."

Tom Welton, head of the department of chemistry at Imperial College London, would agree. Risk assessments in the U.K. started to become part of the research culture there about 20 years ago—when Welton was a postdoctoral researcher—after an incident at the University of Sussex.

A third-year graduate student at Sussex was distilling a triacetylene under nonstandard conditions, says

Anthony McCaffery, a Sussex chemistry professor who was head of his department at the time. The apparatus exploded, blowing out a window and embedding a large piece of metal in the student's abdomen. The researcher lost a foot or two of his intestine, if McCaffery recalls correctly, and returned to the school to finish his Ph.D. after recovering from his injury.

The U.K. government had recently created the country's Health & Safety Executive to prevent death, injury, and ill health in workplaces. The Sussex incident was the first case the agency decided to prosecute. "I was required to appear in the local Magistrate's Court and the County Court to defend the indefensible, since they charged us with failure to carry out a proper risk assessment, which was not a widely accepted procedure in university research at the time," McCaffery says. The university pled guilty and was fined.

The end result for academic chemistry research in the U.K. was that risk assessments have become an integral part of experiments. The assessments don't apply just to chemical reactions but also to equipment such as lasers. The initial assessments were "much like some kind of legal record where if we got sued we could say we'd done this," Welton says, but the paperwork has evolved over the years into a simple table that is printed on one side of every page spread in his department's lab notebooks—risk assessment on the left, experimental notes on the right. "Twenty years ago, it was very much about a legal defense should it be necessary," Welton says. "Now it is about making the person engage in the risk management of what they're doing."

Chemistry students in the U.K. start doing risk assessments in their very first undergraduate lab, so the process is second nature by the time they get their bachelor's degree, Welton says. He adds that the training is critical not just from a safety perspective, but also for future employment. "If we don't train students in risk management and safety procedures, then we're not training them for employment in modern industry," Welton says. "If we want someone to turn up in a job and be productive, they can't do that if they're not safety aware."

UCLA has made significant changes to its health and safety program in the aftermath of Sangji's death, beyond fixing the specific issues identified by Cal/OSHA.

UCLA laboratory safety inspections have been standardized and expanded. Items identified as critical—for example, missing or inoperable fire extinguishers or eyewash stations, or lack of PPE—must be corrected within 48 hours; other deficiencies, within 30 days. Gibson's office is working to develop a computer system that will streamline much of the inspection process.

University research labs are also now required to quantify chemical, biological, and other hazards; to assess risks based on laboratory activities; specify appropriate PPE; and train all lab personnel in the appropriate use of PPE for their experiments.

And if a lab balks at any point? Chancellor Gene Block "has made it very clear in his communications that EH&S has the authority to shut down labs, and we take that responsibility very seriously," Gibson says. If a lab is shut down, it can't reopen until the professor appears before the university's newly formed safety committee and provides an action plan to improve safety in the lab.

The safety committee recently issued its first report to the chancellor. It said that UCLA still has more to do to develop a top-down culture of safety consciousness and suggests that reward systems should be developed to encourage compliance with safety procedures in labs. It also says that the university needs to increase accountability and oversight, improve and expand outreach and training, improve laboratory design, and improve inventory and record keeping.

As UCLA works to develop a new safety culture on campus, it needs to watch that an adversarial relationship doesn't build up between researchers and EH&S officers, says Rick L. Danheiser, a chemistry professor and chair of his department's safety committee at Massachusetts Institute of Technology. MIT has twice won the ACS Division of Chemical Health & Safety's College & University Health & Safety Award, in 1991 and again in 2005.

In Danheiser's opinion, the key to his department's success in developing a safe laboratory environment is that the department recruited graduate students and postdocs to help develop the policies and procedures that they would be expected to follow. "Everything is done in groups that involve the faculty and graduate

student or postdoctoral researchers so that all regard it as an enterprise that we are all involved in," Danheiser says. "In my experience that's really important in ensuring that there's full compliance."

This approach includes having faculty and student members of the safety committee participate in unannounced laboratory inspections twice a year. Having that self-inspection component also helps prevent adversarial relationships from developing between researchers and safety officials, Danheiser says.

When Danheiser talks to new students and postdocs joining his lab, he emphasizes to them that it is their responsibility to evaluate whether or not they are comfortable performing an experiment. "I expect them to be able to make the determination whether they are certain they have enough knowledge and experience to do an experiment safely," Danheiser says. If not, then they need to seek assistance from others in the group, him, the department safety coordinator, or even from MIT EH&S.

Danheiser adds that one issue of concern at MIT has involved postdocs who were trained in other countries and thus are used to a different laboratory culture. "It's sometimes more difficult to retrain them to follow the rules we have, as compared to a beginning graduate student," Danheiser says.

In those cases, it's not only important to have the faculty adviser make the rules clear, but also to have a culture that reinforces them through peer pressure in the lab, Danheiser says. "If the great majority of people enthusiastically comply with the safety program and support it and understand why all of the rules are in place to protect people, then they can police themselves."

One of the challenges in lab safety is that the lab setting becomes very familiar to people who work in it day in and day out. "When you do something over and over, your perception of the risk may change even though the risk itself doesn't change," says Lawrence M. Gibbs, associate vice provost for EH&S at Stanford. His department tries to use information about incidents to remind researchers not to get too comfortable. In that way, hopefully something positive can come out of Sangji's death. "It was a tragic, tragic incident," Gibbs says. "We all have to learn from it and use it as reinforcement to help people understand the potential risks of working with high-hazard materials in this environment.

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