UNLV Innovation

Volume 8

Article 6

2015

Bullish on Research

Dan Michalski

Shane Bevell

Bullish *on* Research

UNLV patent applications have tripled in the last two years, and three startup companies have been formed, demonstrating the university's revitalized commitment to bringing its research to the marketplace. Learn about three innovative discoveries that are contributing to the remarkable growth in commercialization of UNLV research.

TEAM APPROACH Life sciences professor Penny Amy (left) discusses treatments for AFB with research assistants Rebecca Kolstad (center) and Diane Yost.

Bee Line

Microbiology professor Penny Amy leads a formidable team in honeycomb warfare.

MORE THAN 40 PERCENT OF THE American honeybee population died prematurely in 2014, a sharp rise over 2013's already distressing total. Both in the U.S. and around the world, the honeybee's devastating decline continues to alarm both environmentalists and farmers, who rely on commercial beekeepers to pollinate nearly a third of all crops on the planet.

"These numbers are unsustainable," says Amy, a UNLV life sciences researcher who is on the front lines in the war against honeybee pathogens. Her primary target is American foulbrood disease, a bacterial infection responsible for millions of bee deaths each year.

The weapons of choice for Amy and her research team are specific bacteriophages (or "phages" for short) that can be used as a natural way of preventing American foulbrood infestation and hive destruction. A bacteriophage is a virus that infects and replicates within a bacterium.

"We found that if we treated honeybee larvae with these phages they survive almost as if they were never exposed," she says.

Her research also has spawned Colony Shield, a startup company based in

Henderson, Nevada, that has entered into an exclusive licensing partnership with UNLV. The company aims to expeditiously bring products derived from her lab's discoveries to beekeepers anxious to find a way to save their hives. The stakes are high. Honeybees support nearly $15 billion worth of agricultural industry in the U.S. alone.

* * *

AMERICAN FOULBROOD DISEASE, OR AFB, wreaks havoc when the *Paenibacillus larvae* bacterium finds its way into the gut of a bee in the larval stage. The deadly microbe eats the developing larva from the inside out until it eventually dies, leaving behind a gooey mess filled with contagious spores. Nurse bees then spread the spores to additional larvae. Eventually, the entire colony collapses.

Current environmental regulations require infected hives to either undergo a costly remediation process or for beekeepers to destroy the hives, bees, and associated equipment by fire. Preventative treatments with antibiotics have shown short-term promise but also leave behind environmentally questionable chemical residues in honey. Such treatment methods have also been shown to produce *Paenibacillus* strains that quickly developed resistance to the antibiotics, making the treatment ineffective and the bacteria potentially more dangerous in the long term.

Amy's solution is a natural process that, when administered properly, is showing great success in preventing AFB infection and some success in treating hives that have already been infected. It is also completely safe for bees and humans.

Amy and her research team presented their latest results in June to the American Society for Microbiologists. The society awarded its 2015 undergraduate research fellowship to one of Amy's students, Lucy LeBlanc, for her work identifying and isolating an enzyme that helps facilitate phage therapy by protecting larvae that are already under attack.

While Amy's lab is doing fundamental research and establishing UNLV's expertise in the study of phages, UNLV's startup partner Colony Shield is helping transfer these theoretical insights into a deliverable technology. Currently, Colony Shield is producing freeze-dried phages that beekeepers can add to sugary syrup for nurse bees to distribute around the hive.

R. MARSH STARKS

"I'm extremely grateful that both UNLV and Colony Shield have seen the value in supporting a treatment that promises to prevent some of the devastating loss of honeybees in the United States and worldwide."
— Penny Amy

"I am a scientist, and I understand the need to let the basic science and applied science inform each other without obscuring the other," says Amy. "I love biotechnology, and I'm always thinking about real-world applications for this science."

Her primary goal, she says, is to stop the ravaging effects of the disease. But Amy also hopes to help the beekeeping industry.

"We hope that those who keep bees will find this a successful prevention method to avoid devastation from American Foulbrood," she says, adding that the economic impact of preventing AFB would be tremendous. "Every hive costs several hundred dollars to set up, and each one not lost to disease means cost savings."

* * *

IN ADDITION TO LEADING THE UNLV research that has led to a successful startup, Amy has provided 14 students with valuable research opportunities. The research has led to many theses, dissertations, and publications in leading journals — most recently in the July 2015 *Journal of Insect Science*. Several students' names also appear on two patent applications.

Amy's students have also visited several Clark County elementary, middle, and high schools to teach young children about bees' significance in maintaining a sustainable food supply. One recent presentation to third graders at Tartan Elementary in North Las Vegas included a demonstration of the "phage dance," created by LeBlanc to inspire the next generation of microbiologists.

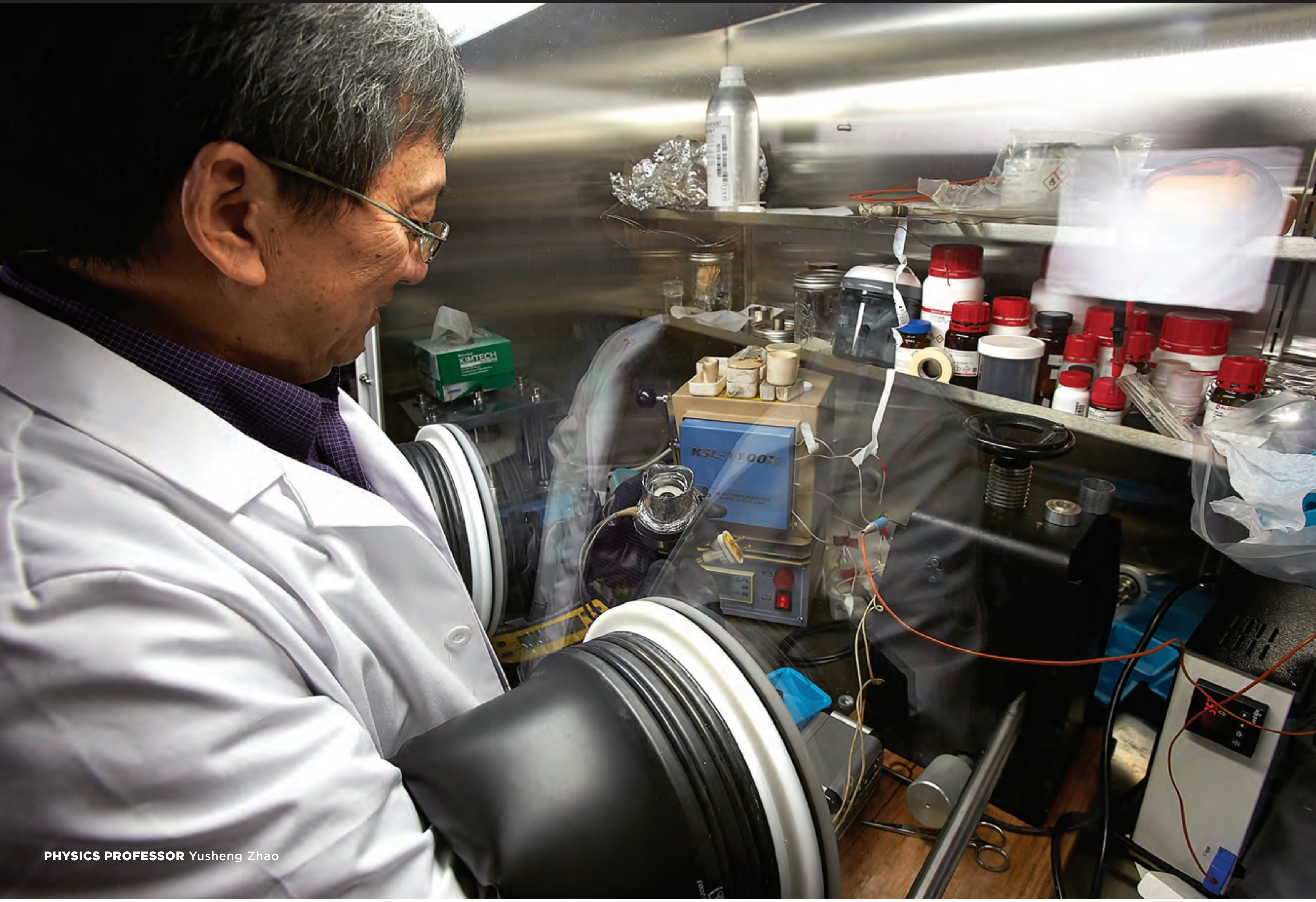
Amy says she's gratified to see the benefits the research has produced, from student successes to community outreach to the startup launch.

"I'm extremely grateful that both UNLV and Colony Shield have seen the value in supporting a treatment that promises to prevent some of the devastating loss of honeybees in the United States and worldwide," she says.

Officials at UNLV's Office of Economic Development are quick to return the compliment.

"We are very excited about this licensing agreement," said Zachary Miles, associate vice president of economic development. "Penny is an amazing researcher who can have a great impact in this area. Colony Shield is going to be a strategic partner for getting this technology into the global marketplace."

— **DAN MICHALSKI**



PHYSICS PROFESSOR Yusheng Zhao

Powered by Discovery

UNLV's advanced energy research team is changing batteries from the inside out.

"SEE, IT JUST LOOKS LIKE A pile of sand," says post-doctoral researcher John Howard, pointing to the dirty-white chalk-like powder.

But this is no ordinary pile of sand. It came from a mix of ingredients that, when heated to 300 degrees Celsius, forms a new kind of material that, Howard says, could represent the next big leap in battery technology.

Howard is part of a team of UNLV researchers led by Yusheng Zhao, head of the university's new energy materials lab. Fueled by $2.9 million in grant funding from the U.S. Department of Energy, Zhao, Howard, and their team are making advances in fundamental research about energy storage and transfer that could change what's inside the batteries that power our personal gadgets and electric vehicles.

"We want battery-powered vehicles that go faster, go farther, and are safer," Zhao says.

Their current focus involves development of a substance called lithium-rich antiperovskite, or LiRAP for short. (LiRAP is an electronically inverted form of "perovskite," a crystal structure that's abundant deep in the Earth's mantle.) When synthesized in UNLV's labs, LiRAP forms the basis of a new battery material Zhao and his team are working to develop. If their effort succeeds, it would lead to a new generation of batteries that could compete with current technology at a fraction of the cost while also providing added safety benefits.

To facilitate the ion transfer that generates energy, all batteries consist of three parts — a cathode, an anode, and an electrolyte in between. Zhao explains that current lithium-ion batteries contain a liquid electrolyte that is toxic, flammable, and leak-prone. For vehicles that rely on lithium-ion batteries, including airplanes and electric cars, leakage and combustion can be serious issues. Boeing's highly touted new 787, for example, was initially plagued by batteries that could overheat and catch fire; similarly, electric vehicle manufacturers have faced concerns over fires resulting from routine car accidents.

Zhao's battery material — the sand-like substance produced in his lab — creates a solid electrolyte that is impact-resistant and nonflammable, making it less dangerous and more environmentally friendly. Such innovations, Zhao says, are key to his lab's success.

Recently, his team found a way to replace a typical carbon anode (the battery part indicated by a minus sign) with one made of lithium. The change increased the battery's energy density, which could lead to more compact batteries able to provide more energy.

"This kind of discovery is why we do what we do," Zhao says. "The unexpected is what makes research exciting."

If the team's work continues to go well, the resulting technology could lead to a new generation of batteries constructed as singular solid-state cells — cells that could safely and efficiently power devices ranging from phones and laptops to wearable electronics and electric cars.

Initial funding for Zhao's battery lab came from the Advanced Research Projects Agency-Energy (ARPA-E), a federal initiative supporting important applied research related to energy. Competition for ARPA-E grants is intense, with about 1 percent of proposals receiving funds. Zhao's $2.9 million grant, awarded in 2013, funds the lab at UNLV for three years and also facilitates collaboration with researchers at University of Texas and Los Alamos National Laboratory, where Zhao worked prior to joining the UNLV faculty.

Zhao credits his work at Los Alamos for laying the foundation for his current research at UNLV. He came to the university in 2010 to lead the High Pressure Science and Engineering Center. That work led to the research now being conducted at UNLV's new energy materials laboratory, he says.

Zhao says research exploring materials to serve as solid-state electrolytes in batteries has been conducted for decades, but only recently was his team able to secure the resources necessary to take significant next steps.

"We are not just working on one battery component," Zhao explains. "We are considering the battery as a whole. Our experiments serve as a bridge between fundamental science and practical applications."

He cautions, however, that there is still much to explore. The team is currently working on crystal-structure manipulation, for example, to increase ionic conductivity and power capacity. They also are investigating the LiRAP electrolyte's compatibility with different electrode materials, as well as exploring the LiRAP material's functionality as a cathode (the plus-sign part of a battery).

"Dr. Zhao is conducting cutting-edge research in battery and battery-related technologies," says Zachary Miles, associate vice president of economic development at UNLV. "The collaboration with ARPA-E has created some innovative opportunities for energy research with commercial promise, and we are enthusiastic about the future of this team's work."

— **DAN MICHALSKI**

ENERGETIC RESEARCH Yusheng Zhao confers with laboratory team members Jinlong Zhu, a research associate, and Shuai Li, a postdoctoral fellow.

R. MARSH STARKS

Cleaner Rare Earths

Our high-tech marvels demand rare earth metals and oxides. UNLV researchers are working to make extracting them less toxic and more efficient.

THERE ARE 118 ELEMENTS ON THE periodic table. The familiar ones include hydrogen (1), oxygen (8), as well as the noble gases helium (2) and neon (10). But there is a subset of the periodic table that includes less familiar elements. Count among them atomic numbers 57 through 71 — a group of metallic chemicals collectively referred to as "lanthanides," or rare earth metals.

Found in the Earth's crust, these rare earth metals are valued for their unique magnetic, optical, and catalyst properties. Many of the items we take for granted in modern life — consumer electronics, computers, clean energy, health care technology — depend on lanthanides to perform with the efficiency, speed, and durability to which we've grown accustomed.

China currently controls approximately 97 percent of the world supply of rare earth metals and oxides, says David Hatchett, a chemistry professor at UNLV. For the rest of the world this, obviously, is a source of some consternation.

RECLAMATION PROJECT
Bottles containing dissolved rare-earth minerals used in the electrochemical recovery process.

R. MARSH STARKS

"China is reducing exports and increasing prices to foreign consumers," says Hatchett, who has been developing a more efficient way to separate rare earth metals from mineral deposits for six years. "The global impact of these restrictions is greatest in countries with large high-tech manufacturing sectors such as the USA, Japan, and Germany."

Lanthanides are typically found in mineral deposits that require laborious and costly processing and refinement. They are difficult to extract — a characteristic that defines them as much as their silver color, sensitivity to contamination, and sometimes high levels of reactivity.

Like most processors, the Chinese typically rely on an "acid-leach" process — essentially exposing material containing rare earths to a chemical bath — to extract the desired elements. Contaminated water left over is then consigned to waste pits. Unfortunately, these pits are seldom effective in keeping acids and other contaminants from leaking into groundwater. In China, where regulation is lax and there are few environmental protections, local residents are left to live with the environmental fallout.

Hatchett and his research team believe there is a better way. They are the principal investigators on a patent protecting their process of electrochemically recovering and separating a variety of rare earth metals. It is a process that would decrease the cost of processing high purity metals. The new separation technology, Hatchett says, enables more rapid, flexible, efficient, and environmentally friendly extraction and separations of individual lanthanides from mixtures.

"We discovered a way to electrically reclaim these rare earth metals and possibly separate them," he says. "The refining process produces a mixture of rare earth metals, but if you can separate out the one you want and leave the other stuff behind, it is a beneficial process.

"It is an electrochemical approach rather than a chemical approach, meaning we are not using leach pits and taking the extract out to neutralize," he adds. "We actually dissolve the materials directly into an ionic liquid, and we then electrochemically recover one in the presence of others. We use an electrode to collect the one species we want."

In terms of materials, rare earth metals are the hardest to reduce, Hatchett explains. They are extremely electropositive, meaning they don't want to be reduced to metal. They are not found in nature as a metal.

The electrochemistry of the ionic liquid is the key. The ionic solution is a salt — not in the more familiar crystallized form, but a liquid.

"The materials we use are nonvolatile, environmentally stable, and they provide high electrochemical reduction potentials," he says. "The process allows us to reuse the materials because the solvent or ionic liquid doesn't degrade."

Hatchett says the next question is to determine if this process is cost effective.

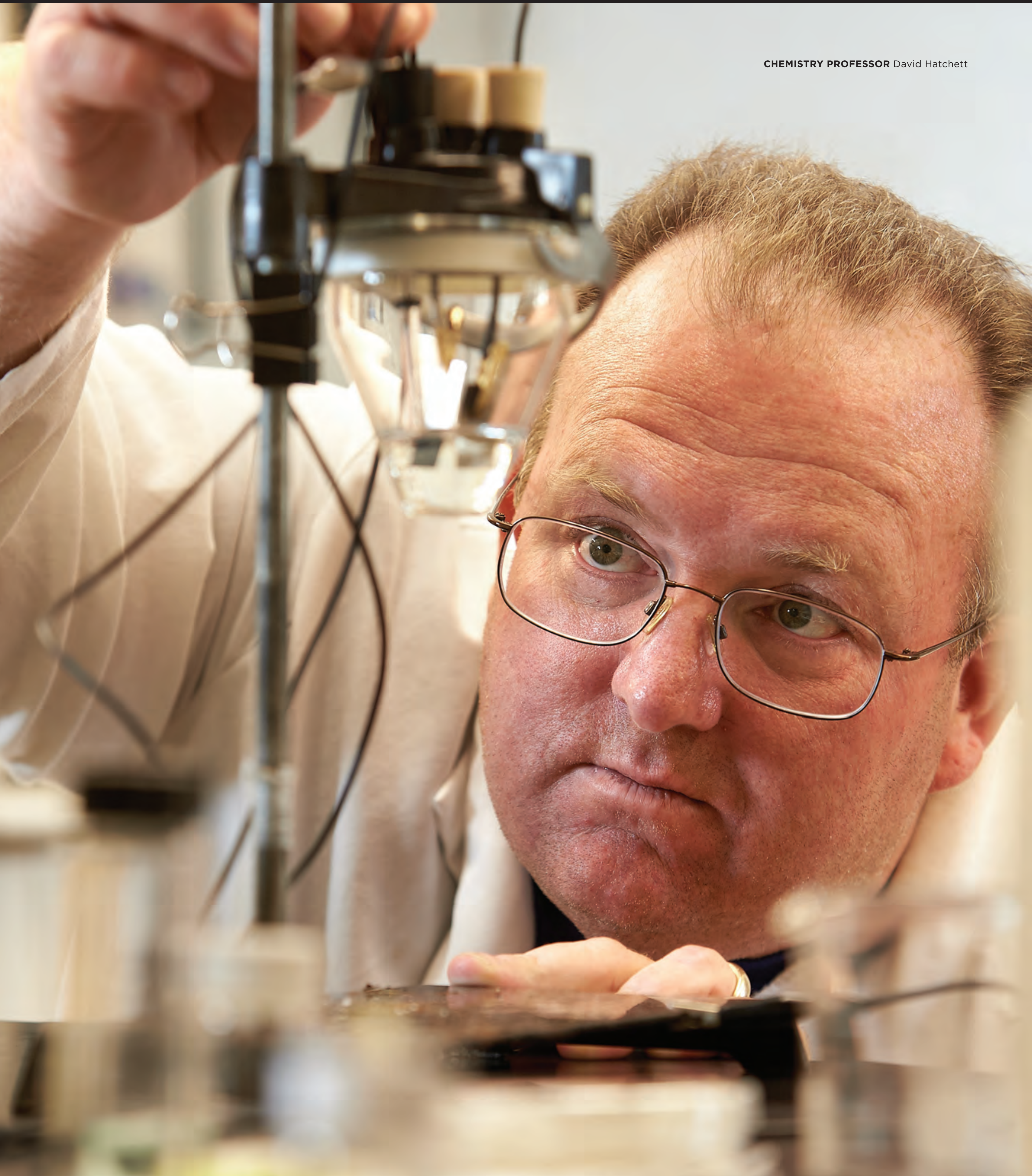
This method isn't just for mining rare earth metals from the Earth; it could also be used for consumer-based recycling. Rare earth metals are present in many materials that are discarded, such as fluorescent light bulbs. Hatchett notes that there might be a time when it will be financially feasible to reclaim these materials. His team's process could conceivably be used for reclaiming rare earth materials found in discarded electronics.

The process may also be useful in recovering rare earth metals from spent nuclear fuel or from manufacturing byproducts, as well as in the mining industry, according to Zach Miles, associate vice president of economic development.

"The prospect of introducing a less toxic, more efficient process for recovering or separating these materials would be a tremendous opportunity for a number of industries," he says. "The research opens the possibilities for new types of industry as well."

Miles added that the process is represented in two published patents and is available for licensing by the university.

— SHANE BEVELL



CHEMISTRY PROFESSOR David Hatchett