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Chemical Engineering Progress

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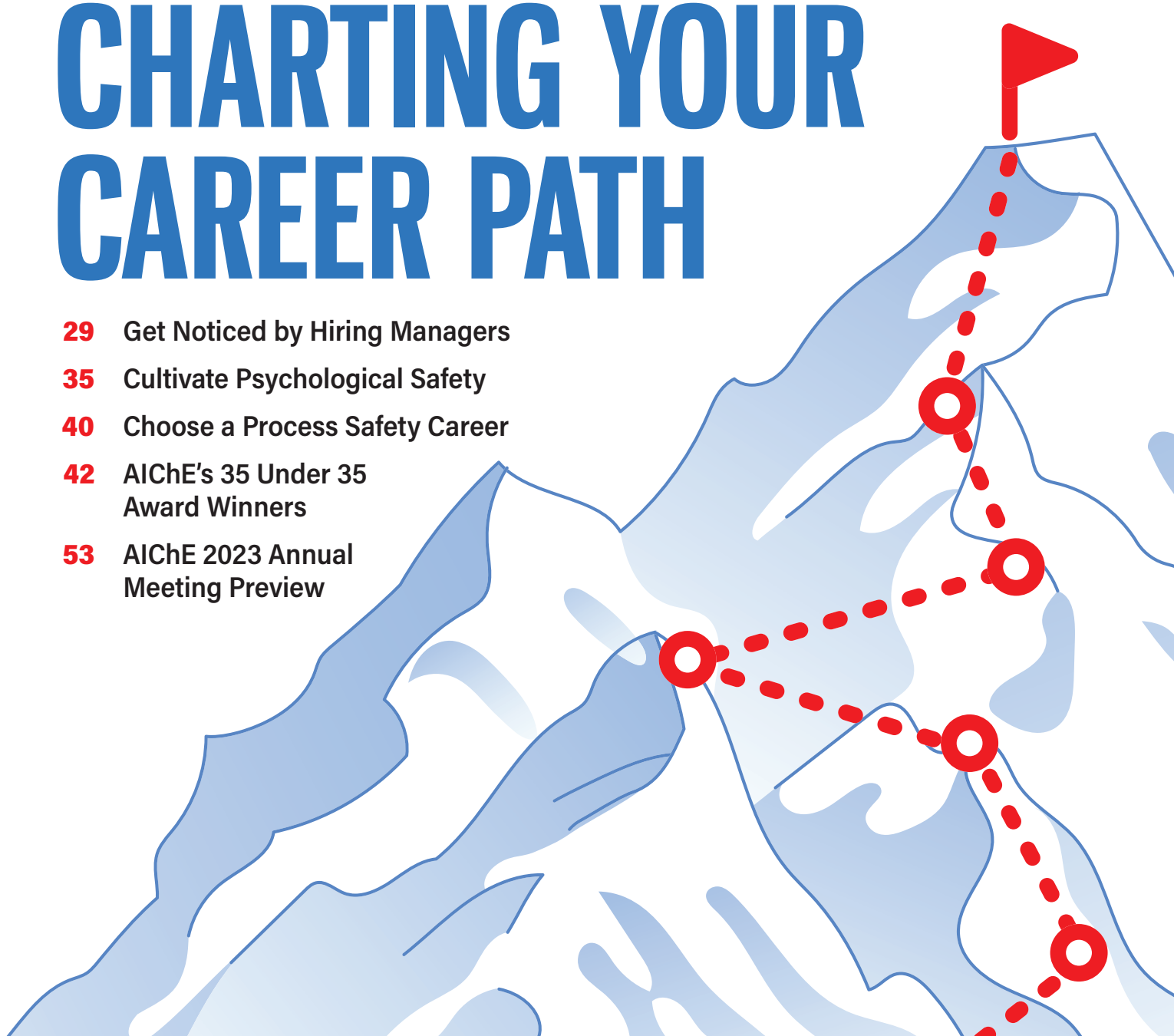
SPECIAL ISSUE:

CHARTING YOUR CAREER PATH



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Features

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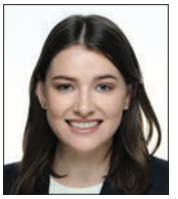


Taking Your Next Career Step

Sometimes, when you get bogged down in the minutia of a job, it can be difficult to take a step back and look at the big picture — *i.e.,* where exactly are you headed, career-wise? Our October issue, dedicated to professional development, encourages some introspection.

If you are feeling unfulfilled in your current job, it can be important to reflect on your team's culture and whether it encourages psychological safety. "A psychologically safe workspace fosters collaboration, inclusion, learning, creativity, productivity, and satisfaction…" writes Dennis W. Hess in his article on pp. 35–39. Psychological safety has a direct impact on team performance, as it allows workers to feel comfortable enough to ask questions, learn from mistakes, challenge the status quo, and maintain open dialogue. A workplace without a culture of psychological safety may leave team members feeling excluded, emotionally isolated, or unable to share viewpoints and new ideas. Although it is certainly possible to improve a workplace's dynamic, often the easiest solution is simply to pursue a job with a healthier work environment.

For those readers who have decided that they need a change in career trajectory, the column on p. 24, "Flip Your Job Search Strategy — Target Companies, Not Jobs," may be useful. In the column, career management professional Kate Williamson encourages job seekers to focus on high return-on-investment job search strategies, like networking and conducting informational interviews. For those job seekers who aren't sure about the best place to start, she advises them to build a list of desirable companies they want to work for and proceed thoughtfully, rather than applying at random to dozens of jobs online.

After you've narrowed down the search and have started applying to positions, the next step is interviewing. The feature article on pp. 29–34, "What Do Hiring Managers Look For in Chemical Engineers?" gathers the perspectives of four industry recruiters who share their tips for navigating the hiring process. I was surprised to learn that hiring managers often look for non-traditional skills — like proficiency in data analytics, financial acumen, and commitment to community service — in job candidates. Although this article is targeted toward young professionals and engineers right out of college, more-established professionals will find some value in the recruiters' insights into the key mistakes that engineers commonly make during the interview process.

There is no better place to put everything you learn into action than at next month's 2023 AIChE Annual Meeting in Orlando, FL (Nov. 5–10). Search out representatives of companies and strike up a conversation. Or, simply talk to someone you don't know to build your network. You won't be alone — hundreds of first-time job seekers will be at the meeting, and many will be presenting their research at the "Meet the Faculty and Post-Doc Candidate" and the "Meet the Industry Candidate" poster sessions.

If you plan on attending the meeting, I encourage you to stop by the poster sessions — I always find that the graduate student presenters bring a wonderful energy to the conference that reinvigorates my love for what I do. Meeting the next generation of inspired engineers just might motivate you to consider your own professional development and chart your next career move.

Emily Petruzzelli, Editor-in-Chief

New Device Collects Clean Water from Fog

The sky could provide a solution to mitigate water scarcity, according to a new study from ETH Zürich. Its scientists have unveiled an innovative, energy-neutral system capable of collecting clean water from the atmosphere. Using a net made from specially coated metal mesh, the device captures water from fog while simultaneously purifying it.

"When we talk about climate change, a very pressing problem today is water scarcity," says study coauthor Thomas Schutzius of the Univ. of California, Berkeley, who formerly held a position at ETH Zürich. "In any given month, we take more water out of the ground than we put back in. It's to the point where people are starting to look at alternative sources."

One such alternative that is gaining traction is atmospheric water harvesting. In contrast to conventional water sources such as lakes, rivers, and groundwater, atmospheric water harvesting collects freshwater by capturing moisture from the air, including rain, fog, dew, and vapor.

Among these sources, fog harvesting stands out as a particularly promising approach. In foggy regions across Peru, Bolivia, and Morocco, it is common practice to hang up nets to catch droplets of water. Extensive research has been dedicated to the optimal geometry of these nets, resulting in devices capable of harvesting substantial quantities of water. For instance, a 1-m^2 mesh can yield up to 70 L of water daily, while large-scale installations, such as a 5,000-m^2 mesh, have the potential to collect up to 100,000 L of water each day.

However, not all of the harvested water is suitable for consumption. "The challenge is air pollution," notes Schutzius. "What you are collecting as water probably doesn't have a lot of utility because it's contaminated."

Ritwick Ghosh, a scientist at the Max Planck Institute for Polymer Research in Mainz, who also worked on the study, adds, "Our system not only harvests fog, but also treats the harvested water, meaning it can be used in areas with atmospheric pollution, such as densely populated urban centers."

The key to the novel system's operation is a specially engineered photocatalytic coating on the metal mesh. When exposed to ultraviolet (UV) light, the coating, made from titanium dioxide nanoparticles embedded in a polymer matrix, is activated as a chemical catalyst, breaking down organic molecules and pollutants present in water droplets.

Importantly, researchers designed the coating to continue to operate in the absence of UV light. "The challenge is to make the surface reactive even when it's foggy and there's not ample sunlight," says Schutzius. "That's what's new with our work."

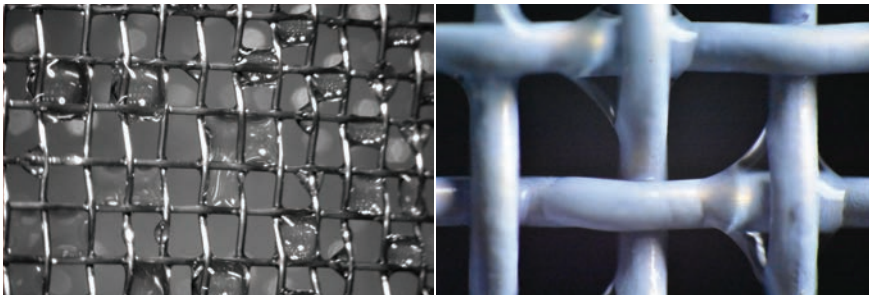
To optimize the fog harvesting process, the researchers skillfully manipulated wettability, or how the surface of the coated mesh interacts with liquids. They experimented with two coatings with contrasting wettability properties — one hydrophobic (repelling water), the other hydrophilic (attracting water) — and ran experiments on how the coatings affected system performance.

Overall, they determined that the hydrophilic coating outperformed the hydrophobic counterpart in both harvesting and contaminant treatment capabilities. This is because the hydrophilic surface encourages fog droplets to spread out across the wire mesh, making more contact with the reactive surface and facilitating treatment.

Conversely, hydrophobic coatings resulted in larger droplets on the mesh, accelerating water collection. Yet these posed a challenge for purification, as the contaminants were situated further away from the reactive surface where catalytic action occurs, leading to slower water treatment times.

The researchers coated a metal mesh with both types of reactive coatings and tested their water-harvesting and purification capabilities using a fog machine. In indoor tests, coated meshes were activated using UV radiation for 30 minutes — the only energy required for system operation. Then, fog containing a model contaminant was directed at the mesh in the dark. Similar to laboratory tests, researchers found that the hydrophilic coating performed better overall.

Subsequently, outdoor experiments were carried out using only the hydrophilic coating under direct sunlight. Tests were conducted under high-UV conditions in July and



▲ In foggy regions, a metal mesh (left) can be used to collect water. Researchers from ETH Zürich coated the metal mesh with a hydrophilic coating (right) capable of treating the harvested water by breaking down organic molecules and pollutants. Images courtesy of ETH Zürich and Ritwick Ghosh.

low-UV conditions in January. In the low sunlight experiment, the mesh had been pre-activated using a UV light source.

Encouragingly, researchers found that once the catalysts were activated, the system consistently demonstrated the ability to decompose organic materials, regardless of UV radiation levels. Across all experimental settings, the water treatment efficiency exceeded 85%. It performed best in the outdoor test with constant sunlight, achieving a pollution reduction value of 94%.

Moving beyond the laboratory, Schutzius envisions that the novel fog-harvesting system could be used in both industrial and natural settings. The nets could be applied to industrial cooling towers to capture and decontaminate water. They could also populate the foggy hillsides of regions like the San Francisco Bay Area, offering an alternative and sustainable solution to securing one of our most precious resources.

Ghosh, R., *et al.,* "Photocatalytically Reactive Surfaces for Simultaneous Water Harvesting and Treatment," *Nature Sustainability,* doi: 10.1038/s41893-023-01159-9 (Aug. 17, 2023).

ChatGPT Outperformed Students on Common College Assignments

The launch of the artificial intelligence (AI)-powered language model ChatGPT in late 2022 has spurred a global conversation about the implications and ethics of an AI tool that can convincingly mimic original human writing. One common concern is that AI will change the face of education by rendering plagiarism essentially undetectable.

Now, new research suggests that this could indeed be a concern at the university level. In nine of 32 university courses studied, ChatGPT's responses to essay prompts matched or exceeded the performance of human students.

"As these tools become more accessible, students across the globe may use them to assist with their homework," study coauthors Talal Rahwan and Yasir Zaki, both professors at New York Univ. (NYU) Abu Dhabi, write in an email to *CEP*. "However, it was still unclear whether ChatGPT's performance is advanced enough to pose a serious risk of plagiarism."

To find out, Rahwan, Zaki, and their team asked faculty members at NYU Abu Dhabi to provide ten questions from a course they'd taught at the university along with three random student responses to each question. They then used ChatGPT to generate three new responses to each question. After that, a set of three different graders rated each response without knowing whether they were human- or AI-generated.

ChatGPT outscored students in six (of 32 total) courses: Introduction to Public Policy; Biopsychology; Cyberwarfare; Object-Oriented Programming; Climate Change; and Management and Organizations. It matched their performance in an additional three: Data Structures; Quantitative Synthetic Biology; and Structure and Properties of Civil Engineering Materials.

"These findings suggest that evaluating students through homework assignments may no longer serve its purpose in the age of AI, raising a serious challenge for educational institutions worldwide," Rahwan and Zaki say.

Current AI-detection programs were unable to reliably differentiate between ChatGPT and student writing, the researchers found, especially when they took steps to disguise ChatGPT's output. For example, running ChatGPT's answers through the widely used rephrasing tool Quillbot rendered AI-detection software useless. Without any attempts at obfuscation, these tools were wrong about half the time; with an obfuscation attempt, they misclassified AI writing as human almost every time.

The researchers also surveyed 1,601 students and faculty about AI in Brazil, India, Japan, the U.S., and the U.K. They found that there were wide disagreements about the ethics of using AI in schoolwork. Students in India and the U.S., for example, were more likely to see AI use as unethical than students in Brazil. But across those students surveyed, 74% said they would use ChatGPT to assist their studies. The most cited reasons were to improve skills and to save time. Of the 26% who said they wouldn't use ChatGPT, the most common reasons were that they had no need for AI or that they did not know how to use it.

▲ The AI-powered language model ChatGPT outperformed college students on a series of assignments in a variety of classes. And, current AI-detection programs were unable to differentiate between ChatGPT and student writing.

Some students saw promise in ChatGPT's language skills, with educators in Brazil and Japan, the two non-English-speaking nations in the study, saying the tool might help reduce inequality in education. "In our study, we found that there is a general consensus among educators and students that the use of ChatGPT in schoolwork will increase the competitiveness of students who are non-native English speakers, thereby leveling the playing field in the classroom," Rahwan and Zaki say.

Given students' apparent willingness to use ChatGPT regardless of how they feel about its ethics, college instructors may need to create assignments that take advantage of AI rather than trying to ban it, Rahwan and Zaki say.

"Current AI text classifiers cannot reliably detect ChatGPT's use in schoolwork, due to both their propensity to classify human-written answers as AI-generated, as well as the relative ease with which AI-generated text can be edited to evade detection," they say. "This suggests that educators need to come up with alternative solutions to integrate, rather than prevent, the use of AI in schoolwork."

Ibrahim, H., *et al.,* "Perception, Performance, and Detectability of Conversational Artificial Intelligence Across 32 University Courses," *Scientific Reports,* doi: 10.1038/s41598-023-38964-3 (Aug. 24, 2023).

Examining the Gender Gap in Patenting

Securing a patent as a doctoral student can be a career boon, helping to make graduates competitive in industry jobs. New research, however, reveals a gender gap in patenting as a PhD across multiple science, technology, engineering, and mathematics (STEM) fields.

Overall, the likelihood of a female PhD student becoming an early inventor during her doctorate or in the first two years after graduating with her PhD was 39% lower than the chances for a male PhD student, at a 2.6% vs. a 4.2% probability, the study found. Even when female students were advised by faculty who were themselves prolific inventors, they were less likely than the same advisors' male students to secure their own patents.

"There is a gender gap in the likelihood of becoming new inventors," says Mercedes Delgado, an associate professor of strategy and innovation at Copenhagen Business School, who coauthored the new study along with Fiona Murray, a professor of entrepreneurship at MIT.

Prior to this study, there was no centralized way to track patenting among doctoral students. But 60% of STEM PhDs work in industry in fields where patenting is common, Delgado says, and a demonstrated familiarity with the process can be appealing to employers. This might provide a leg up early in one's career, she says, and could have long-lasting impacts.

Delgado and Murray built a new dataset to investigate gender disparities in patenting for STEM PhDs, focusing on the top 25 universities by patent count and covering PhDs who graduated between 1995 and 2015. They used a name-gender match algorithm to categorize inventor gender and also created a list of top inventor faculty who frequently file patents.

They found that, across STEM fields, 3.7% of PhD students become new inventors during or immediately after their graduate education. This number has been growing at 7% per year, faster than the growth in STEM doctoral graduation, indicating that more students are engaging in patenting over time.

The analysis indicated that compared to the U.S. inventor pool as a whole, the gender gap in academic patenting was smaller: Women accounted for 20.7% of new inventor PhDs, compared to 13.1% of all new inventors in the U.S. overall during the study period. But there were still gaps; while 34% of all STEM PhDs in 2015 were female, only 25% of PhDs filing their first patent were female. The gap held across the time period studied and across universities.

One factor that can contribute to a student's likelihood of patenting is their advisor, Delgado says. She and Murray thus looked at the role that having a "top inventor" as a faculty advisor played. These top inventors tend to guide their students through the patenting process by working together on patentable projects, the researchers wrote; it's rare for a PhD student to file a patent if their advisor is not a co-inventor. In fact, 22.6% of PhDs with a top inventor as an advisor secured a patent. That's much higher than the 3.7% of STEM PhDs overall who patented an invention during their doctorate or in the two years after.

Top inventor advisors have fewer female PhDs than average, at 25.5% compared to 30.1% at the top 25 patenting universities as a whole. Even among advisees of top inventors, though, there is a gender gap: Female advisees of top inventors are about 17% less likely to patent an invention than male advisees of top inventors, even when controlling for thesis topic and advisor. "This is regardless of the gender of your advisor," Delgado says. "Whether your advisor is a female or male top inventor, it doesn't matter; the magnitude of the gap is the same."

In fields related to chemistry, 23.4% of male advisees of top inventors secured patents in their doctoral programs, compared with 18.9% of female advisees.

These findings suggest a few pathways toward achieving parity, Delgado

says. One is to try to improve the matching process between top inventors and female students so that more female students are trained by prolific patentors. And though the gender gap in patents does persist regardless of advisor gender, it may still be helpful to get more female faculty to become top inventors, Delgado says, because female faculty tend to have a higher share of female PhD students.

The new analysis did find that female students were not any less likely to work on patentable doctoral research than male students, but there are other factors that might be playing into the gender disparity, Delgado says: grant money, or other resources for example, or gender bias that undervalues the contributions of female students. More work is needed to unravel those potential causes and target interventions to overcome them, she says. The next step, Delgado says, is to follow early inventors through their careers to see how getting patents early might affect people throughout their lives.

"Women face more family constraints [in their careers]," she says, "and maybe some of those barriers may be reduced if, early on in your career, you have commercial science skills and are visible as an inventor."

Delgado, M., and F. E. Murray, "Faculty as Catalysts for Training New Inventors: Differential Outcomes for Male and Female PhD Students," *Proceedings of the National Academy of Sciences,* doi: 10.1073/pnas.2200684120 (Aug. 28, 2023).

Innovating a New Method for Green Propane Production

A team of researchers from the Illinois Institute of Technology has engineered a novel electrolyzer capable of converting carbon dioxide, a major greenhouse gas, into propane, an energy-dense fuel source. The method works by electrochemically splitting CO_2 molecules and reformulating them into larger propane (C_3H_8) molecules.

Making chemical manufacturing more renewable is really important,

according to Mohammad Asadi, assistant professor of chemical engineering at the Illinois Institute of Technology, who coauthored the study. "It's the best way to close the carbon cycle without losing the chemicals we currently use daily," he says.

At the center of the technology is a new catalytic system. In the new study, the catalyst minimizes the energy required to convert CO_2 — a stable molecule with a high activation energy barrier — into other products by way of a reduction reaction.

Up until now, efforts to convert CO_2 into other valuable chemicals and fuels have typically employed metal catalysts like copper, gold, and silver. While these methods have been effective at making single-carbon, or C1, products like carbon monoxide (CO) and methane (CH_4), they have not been able to generate multi-carbon products like propane, a molecule that contains three carbons.

The difficulty arises from the numerous chemical reactions involved in the conversion. When attempting to transform CO_2 into hydrocarbons, several intermediate compounds are formed at various stages of the reaction, leading to a low propane yield.

"The CO_2 reduction reaction is a complex process," says Asadi. "A lot of criteria need to be met in order to make this reaction happen. One of those is the catalytic environment," he says.

In the new study, Asadi and his team sought to redesign both the catalytic surface and its environment. They moved beyond existing catalysts, such as copper, and utilized a transition metal phosphide known as tri-molybdenum phosphide (Mo_3P). In past work, Mo_3P had already demonstrated potential as an electrocatalyst, with the advantages of low overpotentials and the ability to selectively produce multicarbon products.

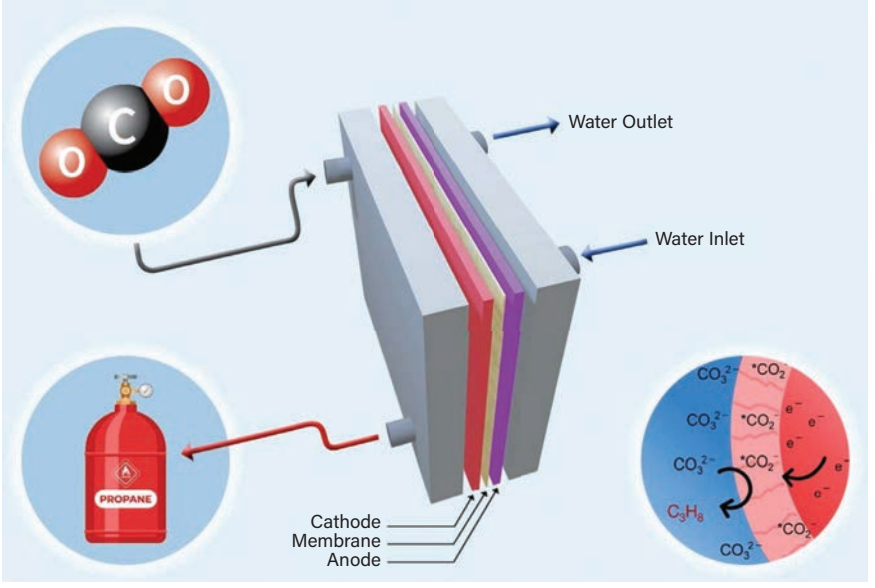
To maximize Mo_3P's performance, though, the researchers went a step further. They modified its surface by applying a layer of imidazolium-based ionic liquids, which are known to enhance CO_2 reduction reaction performance. Additionally, they coated it with an anion-exchange ionomer layer.

The resulting material, known as an ImF-Mo_3P catalyst, converted CO_2 to propane more efficiently and selectively compared to pure Mo_3P, achieving an unparalleled Faradaic efficiency of 91%. (This signifies that 91% of the current went into propane production as opposed to other intermediates.)

To gain a deeper understanding of the ImF-Mo_3P catalyst, the team employed a combination of experimental and computational tests, illuminating the crucial elements that influenced the catalyst's reaction activity, selectivity, and stability. For example, the researchers discovered that the ionic liquid layer strengthened the adherence of carbon intermediates to the Mo sites located on the catalyst's surface. This is key to producing C3+ products, according to Asadi. "We modified the electronic properties at the surface of the catalyst, as well as improved the absorption energy of the carbon intermediates," explains Asadi. "It brings three of the CO_2 molecules close enough to make three bonds, enhancing C-C-C trimerization."

Researchers also found that the ionomer coating layer played a critical role in stabilizing the ImF-Mo_3P catalyst over the long term. During a 100-hour continuous test of the electrochemical reduction of CO_2, results showed that the ionomer-coated ImF-Mo_3P electrode performed consistently, with a high propane production rate and minimal structural degradation over time.

Going forward, the researchers will focus on optimizing and scaling up their complex reactor design, a task that requires rigorous study and analysis, according to Asadi. If accomplished, an electrolyzer with the ability to transform CO_2 into propane with high purity has the potential to serve as a pathway to sustainable and economically viable fuel production.



▲ A new electrolyzer system converts carbon dioxide to propane. The system, engineered by researchers at the Illinois Institute of Technology, hinges on a catalyst known as tri-molybdenum phosphide. Image courtesy of the Illinois Institute of Technology.

"As we move forward to decarbonize the economy, a lot of companies are working on carbon capture technologies," says Asadi. "At some point, they're going to have to decide what to do with that carbon dioxide. That's the level in which we kick in. We can take that carbon dioxide and, using renewable energy, make something valuable out of it."

Esmaeilirad, M., *et al.,* "Imidazolium-Functionalized Mo_3P Nanoparticles with an Ionomer Coating for Electrocatalytic Reduction of CO_2 to Propane," *Nature Energy,* doi: 10.1038/s41560-023-01314-8 (Aug. 17, 2023).

Business Update

DuPont just sold its POM business

American specialty chemicals company, DuPont, agreed to sell its polyoxymethylene (POM) business, better known as Delrin, to The Jordan Company (TJC), a private equity firm, for $1.8 billion.

The background you need. The DuPont we know today is very different from the DuPont we knew five years ago. Following the Dow DuPont merger (2017) and de-merger (2019), the company has been shedding its "commodity" businesses (like the $11 billion sale of its mobility and materials business to Celanese) and leaning into high-growth specialties. Selling off Delrin is just a continuation of that trend.

What is POM? POM is produced by polymerizing formaldehyde, which is made by the oxidation of methanol. The formaldehyde-based polymer is most well-known for its high crystallinity, strength, dimensional stability, and resistance to many solvents and automotive fuels. That makes it great for things like fuel pump components and gears.

Bigger picture. TJC acquired a plastics converter that specializes in engineering plastics (including, but not limited to, POM) a few years ago, so perhaps there is some interest in merging those entities. On the other side of the equation, DuPont seems to be more interested in growth markets like electronic materials.

Mitsui's acrylamide biocatalyst plans

Japanese chemical companies Mitsui Chemicals and Kasano Kosan announced that their 90:10 joint venture, Polaris Chemicals, started up a new acrylamide biocatalyst plant in Wakayama, Japan.

Acrylamide biocatalyst? Acrylamide is produced by hydrating acrylonitrile. That hydration can be catalyzed in a few ways: with sulfuric acid, with copper, or with an enzyme like nitrile hydratase. The enzymatic route, discovered in 1981, seems to be the most popular way of going about it, and that's the route that Polaris is enabling.

What is acrylamide used for? Acrylamide is mostly used to make polyacrylamide (PAM), which is typically used to flocculate solids in a liquid, so the polymer often finds itself in water treatment processes removing solid particles. Mitsui also cites applications as an agent in paper strengthening and crude oil recovery.

Bigger picture. Since this biocatalyst plant is being built on Kasano's premises, and since Kasano makes PAM, the announcement will probably be followed by a PAM expansion. Either that or the company plans on selling all of the biocatalyst they are making, which is less likely.

A permanent pyridine plant shutdown

Indianapolis-based specialty chemical producer, Aurorium, announced plans to close its pyridines plant in Indianapolis by October.

Some context. Aurorium has been around for quite some time. Peter Celestine Reilly transformed a small coal tar distillery business into the Reilly Tar & Chemical Company, and then invented a way to produce pyridine synthetically in the late 1940s. The Reilly family eventually sold the company in 2005 to a private equity firm, which merged it with Rutherford Chemicals in 2006 to form Vertellus. Vertellus changed its name to Aurorium after acquiring Centauri earlier this year.

So, a plant closure? The plant that is slated to close produces some 40,000 tons per year of pyridine and picolines (methyl-substituted pyridines), and is both the largest plant of its kind in the world and the only one of its kind in the western hemisphere.

Bigger picture. The world doesn't consume copious amounts of pyridines and picolines, but chemicals like 2-vinylpyridine, 3-aminopyridine, and 3,5-lutidine are precursors to pharmaceuticals, and zinc pyrithione (the active ingredient in dandruff shampoo) traces its roots back to pyridines. Ultimately, the plant shutdown just boils down to a simple fact: it's cheaper and easier to produce these chemicals overseas. CEP

— Darius Mortazavi

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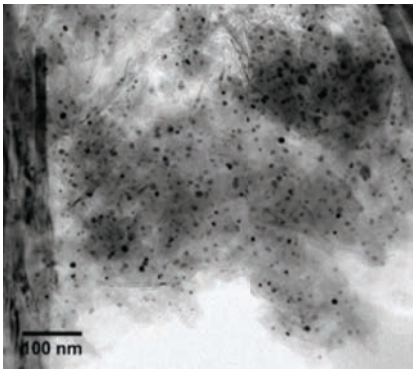
Recoverable and Cost-Effective Platinum Catalysts for Hydrosilylation Applications

Since the hydrosilylation reaction was first reported in 1947, it has become a key process for the organosilicon industry. Metal-catalyzed hydrosilylation is recognized as one of the most important commercial applications of platinum in homogeneous catalysis.

With an estimated market value of $18 billion, hydrosilylation products are used in road construction, bridges, pipelines, and other commercial applications, and they are expected to have a major role in emerging applications such as electric vehicles, health, and personal care. However, the organosilicon industry's reliance on depletable platinum-based catalyst systems has necessitated the development of increasingly efficient and cost-effective platinum catalysts. In addition, commercial cost constraints require that catalytic reactions be carried out without solvents and with a high degree of selectivity to lessen the need for additional product purification.

Homogeneous platinum catalysts used in hydrosilylation reactions often account for up to 30% of the final cost of a product *(1, 2)*. However, in most instances, high product viscosity prohibits the recovery of the platinum and the purification of the product. This affects not only the cost of product preparation but also the shelf life of the product itself due to the presence of the catalyst. Thus, the development of a heterogeneous catalyst, which uses a support, would avoid precious metal loss in the product stream through easy separation of the catalyst and product streams in batch and continuous operations, providing a more cost-effective approach that would facilitate platinum recovery while increasing product quality.



▲ This transmission electron microscope (TEM) image shows platinum graphene nanoplate (Pt-GNP) catalysts. Pt particle size ranges from 4 nm to 8 nm. The high catalytic activity has been attributed to the surface interaction between Pt and graphene that facilitates electron transfer.

The Center for Rational Catalyst Synthesis (CeRCaS) — an Industry-University Cooperative Research Center (IUCRC) funded by the U.S. National Science Foundation (NSF) involving Virginia Commonwealth Univ., the Univ. of South Carolina, the Univ. of California, Davis, and the Univ. of California, Berkeley — has focused on developing and expanding a new method of synthesizing highly active heterogeneous catalysts. One of the methods that CeRCaS employs combines the use of strong electrostatic adsorption techniques with solventless microwave irradiation (SEA-MW) to produce platinum catalysts supported by graphene nanoplates (GNP).

CeRCaS has previously demonstrated that graphene can serve as a semiconductor. The SEA step in the SEA-MW method provides a rational, controllable, and uniform uptake of $PtCl_4^{2-}$ metal precursor onto the surface of the GNP support. The sample is then treated with solventless microwave irradiation to facilitate the simultaneous reduction of $PtCl_4^{2-}$ to form small, well-dispersed Pt nanoparticles and graphene defects or holes that strongly anchor the Pt nanoparticles.

To test the catalyst, CeRCaS's initial evaluations began with the solvent-free hydrosilylation of 1,1,1,3,5,5,5-heptamethyltrisiloxane (MD'M) on 1-octene. Under these conditions with low Pt loading (0.00125 mol%), their catalyst was able to produce quantitative conversion to the desired isomer in only 30 min at 40°C and with a catalyst turnover frequency (TOF) of 4.8×10^6/hr.

CeRCaS found that their catalyst performed with comparative efficiency to the homogeneous industrial benchmark, Karstedt catalyst, which has a TOF of 5.2×10^6/hr. Furthermore, they found the Pt-GNP catalyst to be effective with a broad range of olefin and siloxane substrates.

Most recently, the CeRCaS collaboration has focused on the attachment of Pt-GNP catalyst to conventional supports such as alumina and silica spheres in order to improve the ease of recovery and facilitate their use in packed bed reactor manufacturing platforms as well as batch reactor systems. They are currently working with manufacturing partners to demonstrate the use of these catalysts on a commercial scale. CEP

This research was supported by the Industry-University Cooperative Research Center (IUCRC) program of the NSF.

1. **Schuster, C. H., *et al.,*** "Bench-Stable, Substrate-Activated Cobalt Carboxylate Pre-Catalysts for Alkene Hydrosilylation with Tertiary Silanes," *ACS Catalysis,* **6** (4), pp. 2632–2636 (2016).

2. **Cui, X., *et al.,*** "Synthesis of Single Atom Based Heterogeneous Platinum Catalysts: High Selectivity and Activity for Hydrosilylation Reactions," *ACS Central Science,* **3** (6), pp. 580–585 (2017).

This article was prepared by the National Science Foundation in partnership with *CEP*.

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Bringing Meso-Scale Insights to Continuum-Level Modeling of Aggregating Suspensions

The progress in understanding and modeling the mechanical behavior of aggregating suspensions pales in comparison to their importance and ubiquity in daily life and industrial processes. Some of the common examples include paint, cement, ink, mud, and biological materials like blood. These materials are made of particles suspended in a liquid formulation (which itself may be a complex fluid) and exhibit distinctive mechanical behavior as a result.

It is safe to say that aggregating suspensions are complex materials — their mechanical response is predominantly viscoelastic, and their rheological behavior (*e.g.,* viscosity, modulus) depends not only on how fast they are being deformed but also on how they were deformed in the past (flow history). Their micro- and meso-scale structures underlie much of their complex mechanical and flow behavior. When allowed to sit for a long time, suspensions of aggregating particles tend to form fractal structures that can grow into networks and break when subjected to flow. In many instances, these fractal structures give rise to a yield stress that must be overcome by breaking the agglomerates mechanically before the material can flow.

Aggregation in such suspensions occurs as a result of weak interactions between the particles (or clusters of particles), facilitated by relative motion between them due to Brownian motion or shear itself. Breakage can occur via several mechanisms, such as attrition, fracture, or collision, but it is caused by an external input of mechanical force, for instance, when the material is sheared. The aggregation and breakage kinetics are responsible for the time and flow-history dependence of the rheological properties of these suspensions. This behavior is commonly referred to as thixotropy and is typically defined as a time-dependent decrease observed in the macroscopic viscosity when such a material is subjected to flow. In the case of aggregating suspensions, this behavior has an inextricable link to the micro- and meso-scale morphology of the fractal structures.

In the October *AIChE Journal* article, "A Polydisperse Model for Thixotropic Elasto-Viscoplastic Suspensions of Aggregating Particles Using Population Balances," Soham Jariwala, Norman J. Wagner, and Antony N. Beris (Univ. of Deleware) *et al.* describe how to define these aggregation and breakage kinetics with more rigor using population balance modeling to better understand the flow behavior of aggregated suspensions.

Population balance modeling has been around for over a century and is still finding new applications. Early pioneer Marian Smoluchowski laid the foundation for population balance modeling in the form of the coagulation equation that describes the aggregation processes, which made the esoteric science (at the time) of statistical physics into a very useful and broadly applicable population balance equation that goes far beyond coagulation. It has found a home among chemical engineers, who regularly use it to describe disparate phenomena in process modeling, biological systems, and pharmaceuticals. In this article, population balance modeling plays a key role in connecting the particle-level aggregation and breakage phenomena occurring at nanometer to micron length scales and the macroscopic flow behavior.

The authors start with an idealized view of fractal aggregates, assuming that they don't densify and change in morphology (*i.e.,* spherical symmetry and no preferential alignment in flow direction). The authors then use rate kernels for aggregation and breakage to determine the kinetics. The integro-differential nature of the population balance equation requires a closure rule (*i.e.,* a kind of assumption to enable the solution of the equation itself). The solution methodology and closure rule in this work, called the method of moments with interpolative closure (MOMIC), can handle polydisperse agglomerates while making no *a priori* assumption about their size distribution.

Combining these ideas with the established correlations and theoretical models for the modulus and viscosity of the aggregating suspensions, the authors can generate a multiscale model that connects the micro- and meso-scale dynamics of aggregation and breakage at the particle level to the macroscopic rheological behavior. This modeling methodology worked well for a variety of 'ideal' thixotropic elasto-viscoplastic (TEVP) suspensions of aggregating particles, namely, fumed silica suspensions and carbon black dispersions in mineral oil. Furthermore, the approach offers additional insights into the time evolution of the structure (in terms of the change in mean size, polydispersity, and size distribution) under various dynamic rheometric tests, such as oscillatory experiments, ramps, flow reversals, and step changes in shear rate.

This model advances the field by connecting, for the first time, the morphology of the aggregating suspension to the rheological dynamics in a way that can be implemented in computational fluid dynamics solvers for simulating these complex materials. The added benefit of thermodynamic consistency ensures that the model predictions obey the constraints posed by the first and second laws of thermodynamics and Onsager reciprocal relationships, even when the system dynamics are far from equilibrium. CEP

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Keep the Manway Tightly Closed

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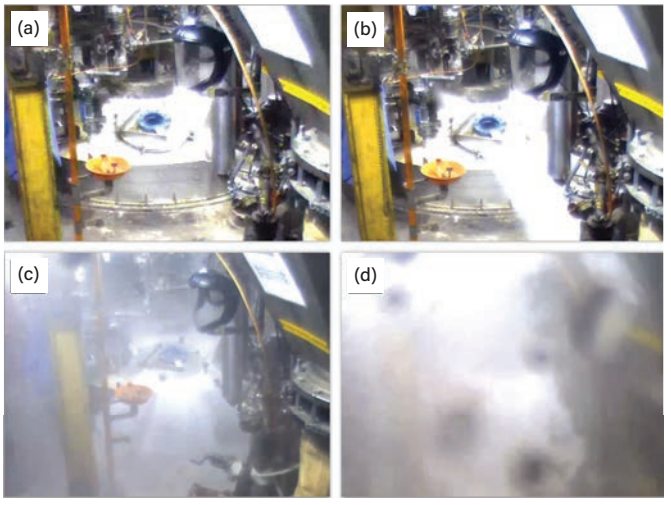

▲ Naphtha released through a manway quickly formed a flammable vapor cloud. These images show the first six seconds of the release. Read the U.S. Chemical Safety and Hazard Investigation (CSB) report No. 2021-04-I-O for more information.

On April 8, 2021, a mixture of flammable naphtha vapors and resin liquid became pressurized and released through the manway of an operating reactor at a resin plant in Columbus, OH. The naphtha vapor spread through the enclosed building and formed a flammable vapor cloud both inside and outside the building. The operator tried to hit the emergency stop button, but he could not see through the white vapor and had difficulty breathing. The operator had also been sprayed with hot resin during the release, but he was able to evacuate the building. Approximately two minutes later, the flammable vapor cloud ignited, causing an explosion and fire.

One employee was fatally injured, and eight others were transported to area hospitals for injuries. The blast shook neighboring buildings, and at least one nearby business sustained damage. The resin plant was severely damaged and demolished afterwards.

Did You Know?

- An incorrect number of clamps or bolts or improper tightening can cause manways and other covers to leak below the design pressure.
- Gaskets are another key part of sealing hatches. They must be properly rated, correctly positioned, and in good condition to provide a good seal.
- Another incident occurred when a manway started leaking before the relief device could open. See the March 2021 Beacon for more detail.
- Adding a volatile material or solvent to a process above the solvent's boiling point can produce rapid boiling, also known as flashing, which can quickly increase the vessel pressure.
- All connections need to be properly tightened so that any overpressure will vent through the relief system to a safe location.

What Can You Do?

- Know the correct way to secure vessel hatches. Details such as how many bolts or clamps and torque requirements are important to preventing leaks.
- Operating procedures should provide the correct way to secure hatches and manways. The correct gasket type, material, and rating should also be specified in the procedure for securing openings. If these details are missing, notify the supervisor to add them.
- Leaking flanges often "whistle" or "hiss" as material leaks out. When you hear this sound, leave the area and ask the area supervisor for guidance.

Tight makes right — especially for hatches and manways!

Environmental Justice and Chemical Engineers

Mary Ellen Ternes ▪ Earth & Water Law, LLC

Chemical engineers should understand the term environmental justice (EJ), its legal implications and impacts on operations, design, siting, business strategies, and project implementation. The U.S. Environmental Protection Agency (EPA) defines EJ as the fair treatment of all people regardless of race, color, national origin, or income with respect to the development and enforcement of environmental laws, regulations, and policies *(1)*. Fair treatment implies that no population should be forced to shoulder a disproportionate share of exposure to the negative effects of pollution due to lack of political or economic strength.

The U.S. has addressed EJ through law and executive action under multiple administrations to protect "overburdened communities," defined as: minority, low-income, tribal, and indigenous populations or communities in the U.S. that potentially experience disproportionate environmental harms and risks due to exposures, cumulative impacts, or greater vulnerability to environmental hazards.

As recognized by agency authorities, this increased vulnerability may result from negative environmental, health, economic, or social conditions such as generational financial stress that limits mobility, poorly supported schools that limit employment opportunities, and food deserts that contribute to poor health. When manufacturing centers and waste management sites grow up around overburdened communities, residents often can't afford relocating or leaving their extended families. Also, they are generally not equipped to engage in public participation opportunities built into the environmental permitting process for individual industrial facilities.

The U.S. 1964 Civil Rights Act (CRA) provided the initial legal framework for U.S. EJ actions. The CRA prohibits discrimination on the basis of race, color, and national origin when programs and activities receive federal financing, codifying President John F. Kennedy's assertion that "simple justice requires that public funds, to which all taxpayers of all races contribute, not be spent in any fashion which encourages, entrenches, subsidizes, or results in racial discrimination."

The U.S. government provides significant public funds to individual states, particularly in delegated implementation of federal environmental laws such as the Clean Air Act (CAA), the Clean Water Act (CWA), and the Resource Conservation and Recovery Act (RCRA). Two key agencies with respect to EJ are thus the EPA and the U.S. Dept. of Justice.

U.S. Executive Branch policies on EJ have been established mainly through Executive Orders (EOs) and interpretive guidance. In 1994, President Clinton signed EO 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." President Biden has also taken action on EJ, issuing EO 14008, "Tackling the Climate Crisis at Home and Abroad" in 2021, which announced the Justice40 initiative mandating that at least 40% of the benefits of certain federal investments flow to disadvantaged communities. In addition, EO 14096, "Revitalizing Our Nation's Commitment to Environmental Justice for All" was issued in 2023, requiring that all federal agencies develop EJ Scorecards to track progress toward Justice40 goals, thereby instituting accountability mechanisms supporting environmental and civil rights protections. EPA also developed EJScreen, a mapping and screening tool for use in program implementation, which tracks permitting, enforcement, and compliance.

EJ is impacting both federal and state actions. In April 2022, EPA initiated an EJ investigation regarding whether Louisiana's environmental agencies discriminated against Black residents in permitting existing and proposed facilities between New Orleans and Baton Rouge. In recently closing the matter, EPA reached enforcement agreements with Denka Performance Elastomers in St. John the Baptist Parish to mitigate chloroprene pollution pursuant to the CAA and RCRA, and proposed a new CAA regulation further limiting chloroprene emissions nationally, along with other measures.

In September 2022, Louisiana's proposed CAA permits for a new $7.9 billion Formosa Plastics complex in St. James Parish were vacated by a district judge (currently on appeal) based in part on EJ concerns as well as CAA failures. In April 2023, EPA issued its draft National Plastics Recycling Strategy specifically requesting comments regarding EJ implications of plastic recycling. Recently, in August 2023, EPA proposed to deny Alabama's coal combustion residual RCRA permit program, finding that its failures to protect the environment posed particular risk to low-income communities of color.

Chemical engineers should consider potential EJ issues in their decision-making, especially regarding siting, compliance, enforcement, reporting violations, proposed enforcement resolutions, and environmental review. They should also maintain good relationships with communities surrounding their facilities and engage thoughtfully in the public participation process. Learn more at Refs. 1–3. CEP

1. **U.S. Environmental Protection Agency,** "Learn About Environmental Justice," EPA, https://www.epa.gov/environmentaljustice/learn-about-environmental-justice (accessed Aug. 24, 2023).
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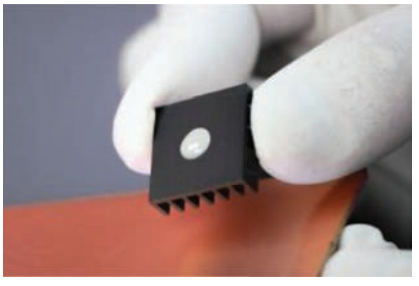

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Pepperl+Fuchs
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ION Science
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OPERATIONS AND MAINTENANCE

Infrared Camera Helps Thermally Locate Hazards

The forward-looking infrared (FLIR) E8 Pro camera is the newest addition to the Pro series. It features a 3.5-in. touchscreen display with FLIR Ignite Cloud connectivity. Like previous models, the camera is handheld with a pistol-grip form factor. It pairs a 5-megapixel digital camera with a thermal camera via multi-spectral dynamic imaging capability. Captured images can be shared over Wi-Fi and accessed on a mobile device, web browser, or desktop computer. The infrared camera has built-in lens protection and offers up to four hours of continuous operation on one battery.
Teledyne
www.flir.com

Walking Stackers Can Replace Forklifts

The CB30 and CB35 Walkie Counterbalance Stackers are walking stackers that are a safer alternative to forklifts. The CB30 and CB35 models have a maximum capacity of 3,000 lb and

3,500 lb, respectively. These stackers were designed for low-speed travel in areas where pedestrian safety is a concern. With updated controls and a compact chassis design, these stackers provide good maneuverability and load-handling capabilities. Each walking stacker includes power steering and features a 180-deg. steer arc.
Big Joe Forklifts
www.bigjoeforklifts.com

The Billion-Dollar Design

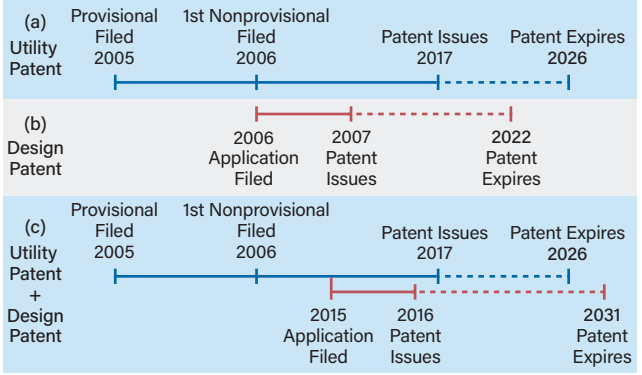
Jason Balich ▪ Wolf Greenfield

When most people think of patents, they naturally think of utility patents. Utility patents claim novel and non-obvious products and processes in words, occasionally using chemical formulas to protect an invention. Sometimes, however, customers will select a product with a more stylish design over the competition, particularly when the utilitarian features are similar among the available options. That's where design patents come in — to protect a product's novel ornamental design rather than its utilitarian features.

A common question is, "Why bother filing a design patent application when the product is protected by a utility patent or a utility patent application has been filed?" For one, utility and design patents protect different aspects of a product. Design patents are not intended to protect anything that is primarily utilitarian, instead they protect the purely aesthetic features of a product. More importantly, perhaps, is that the remedy available for infringement of a design patent can be different from infringement of a utility patent — in at least one case, a billion dollars different.

Damages for utility patents are typically limited to a reasonable royalty, although they can be equal to the patent owner's lost profits. Damages for design patents, however, can be the infringer's entire profit for a product found to infringe a design patent. The difference between those two measures of damages can be quite substantial. For example, in the long-running smartphone litigation between Apple and Samsung, a California jury in 2018 awarded Apple $5 million for Samsung's alleged infringement of two of Apple's utility patents. In contrast, a different California jury in 2012 awarded Apple more than $1 billion for Samsung's alleged infringement of Apple's design patents. While both verdicts were ultimately vacated and the cases settled, the comparison demonstrates the value of design patents and why they should be considered for any intellectual property (IP) strategy.

Design patents have another difference: their term of protection — 15 years — is tied to their date of issuance, not the 20 years from the filing date of the earliest non-provisional application to which the patent claims priority, as is the nominal term for utility patents. While 15 years may not seem as long of a term as 20 years, integrating protection from both utility and design patents in an IP protection plan makes a difference in when that clock begins ticking. The following example illustrates this point by looking at three hypothetical cases: using a utility patent alone, using a design patent alone, and using both types of patent protection.



▲ **Figure 1.** These examples show timelines of (a) utility patent protection, (b) design patent protection, and (c) both utility and design patent protection.

• *Utility patent protection.* The first hypothetical assumes that an inventor filed a provisional application in 2005 and a non-provisional utility application a year later in 2006. Next, after significant prosecution and filing several continuation and divisional applications, a utility patent issues in 2017. Because a utility patent's term is tied to the filing date of the earliest non-provisional application (*e.g.,* 2006), the utility patent would nominally expire in 2026 (Figure 1a), just nine years after the patent was issued.

• *Design patent protection.* The next hypothetical assumes only a design patent is filed on the same date as the first nonprovisional utility application in the above example, *i.e.,* 2006. Prosecution for design applications takes less time on average than utility applications, so this example assumes the design patent issues just a year later in 2007. The design patent would then nominally expire in 2022 (Figure 1b).

• *Integrated strategy.* The third hypothetical assumes that the design patent application is filed in 2015, claiming priority to one of the pending utility applications. The design patent could issue in 2016 and then expire in 2031 — five years after the utility patent expires in 2026 (Figure 1c).

This last hypothetical thus achieves a longer overall term of protection and a later date for that protection to end than any one individual type of protection alone.

Finally, design patents can be less expensive to obtain in the first place. The American Intellectual Property Law Association's 2021 Report of the Economic Survey reported that the average cost to prepare a design patent application was $2,100 and the average cost to prepare a utility patent application in the chemical arts was $11,657. While this may be an oversimplification as each patented invention is different and the time to prepare an application varies depending on its complexity, it illustrates that design patent protection can both cost less in the first place, and result in higher monetary recovery at the same time. So, if your company is not pursuing an integrated patent strategy that includes design patents, perhaps you should ask your IP counsel, "Why not?" CEP

Jason Balich is a trial and appellate lawyer at the law firm Wolf Greenfield, where he protects clients' technology and defends their freedom to use it. He has a BSE in chemical engineering from Princeton Univ., an MBA from Bentley Univ., and a JD from Quinnipiac Univ. School of Law.

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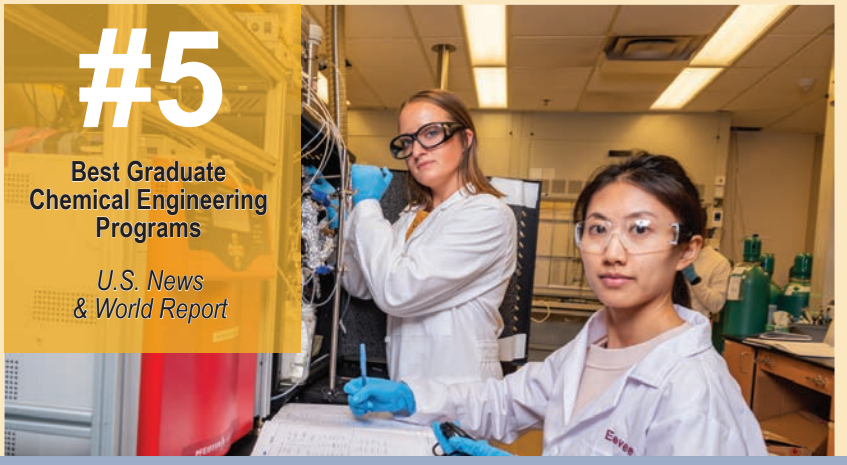

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Flip Your Job Search Strategy — Target Companies, Not Jobs

Kate Williamson ▪ Scientech Résumés

How do you approach the job search process? Many people, especially when faced with an unwelcome situation, such as a sudden job loss or pending layoff, take a reactive approach. Generally, this approach involves applying online to dozens — sometimes hundreds — of jobs with as many employers as possible.

Have you heard a friend or family member say that the job search is a numbers game? Perhaps you have said it to yourself or someone else at some point. If you are solely using the approach mentioned above, then yes — you are treating the job search as a numbers game.

The reality? Online applications are one of the least effective job search strategies. Today, anyone with access to a computer and the internet can apply for any advertised position, leading to market oversaturation. Most people spend less than two minutes reading a single posting. As a result, employers have to sort through hundreds, sometimes thousands, of résumés from applicants, many of whom are unqualified. This method leaves you with a false sense of productivity and increases the risk of losing sight of your goals. Even the best résumés typically receive less than a 7% response rate. Therefore, if you were to submit 100 online applications, you might hear back from only seven companies.

So, what is the best approach? Landing the right job is about strategy over statistics. The most successful job seekers use diverse strategies, investing more time in approaches with a higher return on investment (ROI), like LinkedIn networking. Targeting companies instead of jobs will help you set the foundation of your job search efforts and save you time, energy, and frustration by creating a focused, organized job search that aligns with your goals and values.

The first step in targeting companies instead of jobs involves creating a list of 40 companies for your job search. That might seem like a lot, but a larger list will help you look beyond more well-established companies. You can refine this list later. To put this in perspective, over 98% of U.S. companies employ fewer than 100 people. However, the largest 1–2% garner the most attention from job seekers, with many receiving an average of 250 résumés or more for one advertised position. I share this statistic to highlight the vastness of your employment options.

Let's get started. This exercise will likely be easier for those with a specific industry in mind. You can start with "Best of" lists or "Top Chemical Engineering Companies" to build your initial momentum. You can also get specific. For example, if you are a working parent, you could search "Top 100 Companies for Working Parents," or if you are transitioning from military service, a search for "Best Employers for Veterans" could be fruitful.

Once you have spent two to three minutes brainstorming, you can use LinkedIn to expand your list. A great strategy is to look up each company's LinkedIn page and look on the right-hand side for a separate menu titled "pages people also viewed," where you will see similar companies in that field that you may not have considered. While LinkedIn will only show you the top three in that menu, you can click "show all pages" to expand it and see more companies.

Another underutilized tool is your alumni network, found on your university's website, which is designed to support you at any career stage. They can be particularly useful if you are uncertain about your career stage, need a more open-ended search, or are shy about approaching people for networking. Many will have an online career portal where you can browse open jobs, access career resources, network with other alumni, and attend virtual and in-person events. Some networks will even partner with companies that use the platform for recruitment.

If you are struggling to build your list, you can use online search engines like Indeed, LinkedIn, or Glassdoor to look up companies currently hiring. For instance, Indeed asks for two inputs, "what" and "where." You can use a target job title, a keyword related to your career goal or desired industry (*i.e.,* chemical engineering), or even a company name. The "where" field lets you input a city, state, or zip code, which can be handy if you are geographically constrained. Finally, look up start-ups headquartered in your local area or area(s) of interest if you are considering relocation. This method will give you an idea of emerging or trending employers.

The takeaway. Your target list of companies offers several advantages in the job search process. First, it is a critical step in helping you set the boundaries of your job search, allowing you to use your time intentionally, especially with online applications. By applying to companies that align with your goals and values, your motivation and enthusiasm in the job search will be more sustainable, and your likelihood of greater job satisfaction, fulfillment, and long-term career success will increase. Your list will also serve as the foundation for your networking efforts, particularly on LinkedIn, to research and follow these companies and build connections with people who need to know you. CEP

Kate Williamson is a former R&D technician and product development engineer with a master's degree in applied chemistry. In 2016, she established Scientech Résumés, a highly specialized career management firm that works exclusively with STEM professionals. Learn more at www.scientechresumes.com.

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AIChE Institute Lecturer Leads the Study of Microneedle Drug Application

Since publishing his first article in 1998, Mark Prausnitz has been at the forefront of pharmaceutical technology innovation, developing novel methods of drug delivery using microneedles, lasers, and other microdevices. His work as a researcher and industry leader has dramatically increased the viability and visibility of this technology. Prausnitz is a member of the U.S. National Academy of Engineering (NAE), and he is Regents' Professor, Regents' Entrepreneur, and the J. Erskine Love, Jr., Chair in Chemical and Biomolecular Engineering at the Georgia Institute of Technology (Georgia Tech), where he has completed the majority of his research. It is for this work, both in academia and in industry, that he has been chosen by AIChE to deliver the John M. Prausnitz AIChE Institute Lecture at the 2023 AIChE Annual Meeting in Orlando, FL, on Nov. 8. His lecture, "Translation of Biomedical Microtechnologies From the Lab to the Clinic," will discuss his experience advancing biotechnological innovations from the lab to successful start-ups. This lecture, coincidentally, was named after his father.

"I think my father was surprised when he learned I was choosing chemical engineering as a major," Prausnitz says, recalling his early interest in science. "But it was a science-oriented home." Prausnitz's father was an accomplished chemical engineer who made advancements in the study of the thermodynamics of phase equilibria. Although he hesitates to draw a direct correlation between his father's work and his own career path, his talent for chemistry showed itself in high school, and this guided his path to university. "I especially enjoy using basic science to solve problems, and that led me to chemical engineering."

Prausnitz's work today centers on novel methods of drug delivery that go beyond the traditional hypodermic needle. By using microneedle patches that deliver pharmaceuticals transdermally with little-to-no irritation, the technology reconciles user comfort and convenience, easier distribution and storage, and a variety of unique functional capabilities (Figure 1). "When I got started on this, my first thought was: needles that don't hurt," he says. Still, he recognized that simply reducing consumer irritation would not be enough to get large pharmaceutical companies on board. As the technology developed, the benefits of using microneedles went beyond a lack of discomfort.

The microneedle patches Prausnitz and his team have developed are compact, they use a dry formulation, and they can be made to be thermostable, avoiding the infrastructure necessary to store and transport certain vaccines that need to be kept at extremely cold temperatures. These barriers have been historical roadblocks to getting life-saving pharmaceuticals to remote or impoverished communities.

In addition, the microneedles are able to better target a specific desired area on the body and have the ability to skirt the body's natural defenses. "When you swallow something, you have to deal with the regulated process where the body decides what goes in and what doesn't go in. That limits you. You can't swallow your insulin. With skin, if you can overcome that barrier (the stratum corneum layer is only 10–20 μm thick), you have this straightforward interface to put things in, and, in some of the work we do, take things out."

Prausnitz hopes that this technology will help widen the reach of vaccines. "I think patches can help more people get vaccinated, but that comes in a variety of flavors. Sometimes, people don't have access to the healthcare infrastructure to get vaccinated. For other people, they'd like to get their vaccine, but it's just not convenient. If it could be mailed to their home, maybe they would." The ease of the patch's administration, combined with the increase in global interest in vaccines that came with the COVID-19 pandemic, could help accelerate the adoption of this drug delivery technology.

Prausnitz's work in novel drug application mechanisms began early in his career. After he graduated with a

▲ **Figure 1.** Arrays of microneedles in patches can be designed to slowly release various pharmaceuticals, including this contraceptive hormone, dyed red for visualization. Each microneedle is 600 μm tall. Photo courtesy of Wei Li, Georgia Institute of Technology.

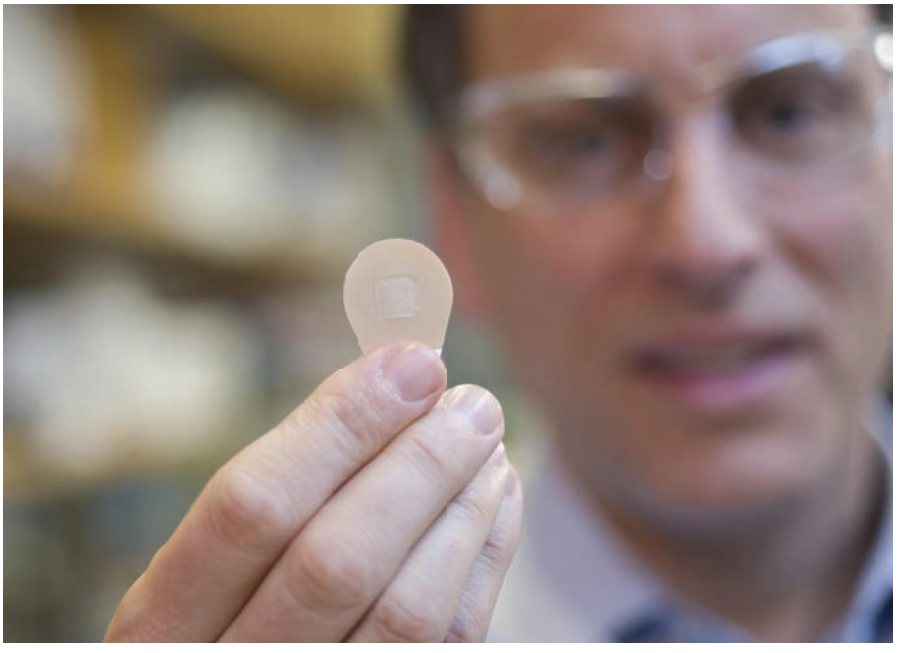
bachelor's degree in chemical engineering from Stanford Univ., he began work at a Palo Alto-based pharmaceutical technology start-up where he used electric fields to facilitate drug delivery by making skin more permeable. Although this initial opportunity piqued his interest in transdermal drug delivery, his research into the subject began in earnest after he received his PhD from the Massachusetts Institute of Technology (MIT). Deficiencies inherent to using electric fields had given Prausnitz the idea of using microneedles as a simple way to localize drug application.

"When I first came to Georgia Tech and interviewed, that was the first time I pitched the idea, the first time I told anyone about it." After assuming his role as a professor and researcher, he teamed up with another researcher who specialized in microfabrication and who was able to help create the first microneedle models (Figure 2). Since beginning his research more than 20 years ago, Prausnitz has worked on transdermal, ocular, oral, and sustained-release drug delivery systems.

Although he has done much to promote and advance microneedle technology, Prausnitz points to a few technical milestones that still need to be achieved before the technology can reach its full potential. He notes that passing pharmaceuticals through the skin barrier remains difficult. The drugs commonly applied in patch form today share similar characteristics: they are oil-soluble, highly potent, and have a low molecular weight. The necessity of these characteristics for suitability with patch technology limits the variety of pharmaceuticals that can be applied using a patch. In addition to diversifying the types of pharmaceuticals suitable to patches, researchers are studying different physical mechanisms for increasing the skin's permeability, including electrophoresis, heat, and ultrasound, as well as microneedles. "That is the way to realize this potential: by making the skin very permeable, but doing it in a way that doesn't have adverse side effects," he says.

As the founder or cofounder of eight biotechnology companies, Prausnitz sees entrepreneurship as the logical extension of his research. Like other researchers in academia, he shares the goal of creating educational content for his students and producing quality research that will move the field forward. "But I do have an additional filter," he says. "That is, if we're successful, I can see a way that someday it will get used in medicine and benefit patients. That is always the criteria." By implementing this entrepreneurial philosophy, Prausnitz has become adept at investing in new, promising technologies that large pharmaceutical companies deem too risky and then selling that finished technology for a premium. It is this experience combining years of research with business acumen that he will share at his 2023 AIChE Annual Meeting lecture.

"When I heard that I was selected to give the lecture, I was excited about the opportunity to tell the community about the work we're doing," he says. "But of course, it is so much more due to my father's name being on it." He is proud to be chosen to give the 75th John M. Prausnitz AIChE Institute Lecture, in the same way that he is proud to carry on a legacy of chemical engineering innovation. As new frontiers in pharmaceutical technology are explored, Prausnitz's work will continue to have a substantial impact on the field of drug delivery and translational medicine. CEP



◀ **Figure 2.** The pharmaceutical patches pioneered by Mark Prausnitz implement tiny needles that dissolve into the skin, carrying a drug. By reducing the discomfort associated with hypodermic needles and simplifying the application process, the microneedle patch could play a significant role in widening the reach of vaccination efforts. Photo courtesy of Christopher Moore, Georgia Institute of Technology.

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What Do Hiring Managers Look For in Chemical Engineers?

Evan Pfab ▪ *CEP*

In this article, hiring managers share tips and advice for chemical engineers navigating the hiring process.

Chemical engineers are widely sought after for roles in a variety of different industries. In any role, having the right qualifications and experience is only one piece of the puzzle — being able to secure the job is a whole other feat. The application and interviewing process is one of the main hurdles standing between you and a new job. In order to stand out and fully showcase your potential as a future employee, acing this stage of the hiring process is crucial, regardless of your qualifications.

Knowing how to apply for roles and secure the job in interviews is a skill in and of itself. In this question-and-answer (Q&A) article, hiring managers share insight into what they are looking for when hiring chemical engineers, and offer advice regarding applications, common mistakes to avoid, and interviewing. The Q&A helps clear up confusion about résumés, cover letters, and follow-up emails. Four hiring managers from different companies within the chemical process industries (CPI) participated in the Q&A: Cynthia Murphy-Ortega (Chevron), Ryan Morrison (Evonik), Adel Boussadia (SLB New Energy), and Andrea Wight (ExxonMobil).

Whether you are a new chemical engineering graduate or a seasoned professional looking to change jobs, read on for tips and advice on how to ace the hiring process.

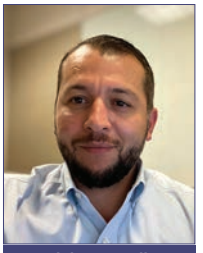
What is an underrated skill you look for in chemical engineers?


Cynthia Murphy-Ortega

Murphy-Ortega: Process safety fundamentals and process control skills are two focus areas that are not consistently developed but are of paramount importance to chemical engineers. Experience working with various process simulation and digital tools (such as Aspen HYSYS, MATLAB, PI Asset Framework, and process workbooks) is essential to partnering across teams and delivering value.

Morrison: The ability to identify and understand the value of various chemical engineering tasks is such an important skill in industry. Being able to properly justify the benefits of a capital project, process optimization study, or data analysis can lead to much higher rates of success. Coursework typically emphasizes the theory (and rightfully so); however, applying that theory in practice is only half the work.


Ryan Morrison


Adel Boussadia


Andrea Wight

Boussadia: We, SLB, are a technology company working to solve the world's energy challenges. Our engineers require critical thinking to be successful in their roles. It is not only about the solution, but the path, the journey, and the continuous lessons learned throughout the process.

Wight: With the large amounts of data and information available to us constantly increasing, understanding how to apply tools like statistics, data visualization, and machine learning techniques is more important than ever in a rapidly evolving technology landscape.

How do you value graduate education in your overall hiring process, regardless of position? Are there newer graduate degrees you look for now that were not on your radar five years ago?

Murphy-Ortega: Chevron values graduate education in a variety of ways. While the majority of our entry-level chemical engineering positions target candidates with BS degrees, we also hire candidates with MS degrees for those positions, laddering the higher level of technical education to a higher starting compensation. Chevron has a select group of positions that target PhD-level chemical engineering candidates, typically organized around research activities. These positions are also recognized with a higher starting compensation commensurate with the candidate's educational background.

Chevron typically does not select MBA candidates for entry-level engineering positions; however, engineering graduates with an MBA may find a variety of career opportunities as their careers progress. We do have targeted development programs for candidates pursuing MBAs, but these are not specific to candidates with engineering backgrounds.

There are several emerging areas that Chevron is focusing on in recruiting. These include renewable energy, carbon capture, digital tools, and systems engineering skillsets. Whether candidates have specialized degrees in these areas or are developing these capabilities as part of their general engineering studies, we value these emerging capabilities.

Morrison: In my role, I hire both BS graduates as well as MS and PhD graduates. Our organization benefits from a diverse range of educational levels. I do not prioritize one over the other, but rather have different expectations of the candidates because they have had different experiences. Having been to graduate school myself, I've felt that most advanced degreed students tend to graduate with two additional skills: very focused knowledge and expertise in a specific technical topic, and the ability to independently drive a complex problem from start to finish. I would expect an advanced degreed hire to be more capable of tackling harder problems with less oversight.

Boussadia: We do value graduate education, especially for our technology roles. As SLB has taken on the challenge of decarbonizing the energy industry and is committed to innovation in the new energy space, we look more specifically to the master's degrees and PhDs related to the business areas we are growing, such as carbon capture and storage, geothermal and geoenergy, critical minerals (lithium), stationary energy storage, and hydrogen. SLB has a diverse portfolio where chemical engineers can find multiple opportunities, especially if their graduate studies and research are relevant.

Wight: Graduate work of any kind can enhance the knowledge and experience the candidate can bring to their professional work, although typical entry-level chemical engineer positions will not require education beyond a BS. Graduate programs improve one's ability to use critical thinking and be more strategic in one's thought process. This is valuable in today's world of technology development and deployment.

What are some non-traditional courses or skills and experiences you like to see from candidates?

Murphy-Ortega: Some skills we look for include data analytics — *e.g.,* the ability to transform a mountain of random data into artwork that tells a story; foundational coding skills, such as Python, that empower analytics and enable better decision-making; and financial acumen to better understand the financial and business impact of technical decisions.

Morrison: Numerous candidates have internship or co-op experiences these days, and those are exceptionally important as they offer opportunities to practice chemical engineering. I particularly like to see clear identification with the value of the work they were performing. What I also like to see is leadership in extracurricular activities (clubs, sports, organizations, volunteering, etc.). Those types of experiences show that you want to get involved in many things and want to influence them through a leadership role.

Boussadia: We like to see digital expertise and data processing skills since they are present in all of our technology areas. Courses, certificates, and experiences related to programming languages and large data processing tools are desirable.

Wight: Commitment to service is a value we seek out. In addition to the typical qualities or technical and leadership skills expected of a professional chemical engineer, seeing a visible demonstration of service to one's community and the well-being of others is an important element in judging a person's character. It shows empathy and an ability to connect to a group or larger purpose. Through service, we

gain a perspective of what another person might experience differently than ourselves. It can make an employee a more compassionate team member and ultimately, a more effective leader who understands and can motivate their team.

Which soft skills are you mainly looking for in a chemical engineer, regardless of position?

Murphy-Ortega: Communication skills and the ability to influence others are very important skills that we look for in engineers. Internally, we call this "storytelling," and we rate candidates in this skill based on observations from interviewing and engaging with them. Good storytelling also shows that a candidate understands how to address an audience. Storytelling is a critical skill to be effective at Chevron since we are continuously aligning partnerships to innovate and work as a team.

Morrison: Some important soft skills that I look for include active listening, self-reflection, and a learn-do-teach mentality. Active listening is a great skill that demonstrates a desire to thoroughly understand a conversation. Self-reflection shows that you can learn from the past and adapt for the future. Lastly, a learn-do-teach mentality shows an interest in learning, applying learnings, and teaching others.

Boussadia: The list of soft skills for a chemical engineer can be exhaustive, so I will focus on the three that I find the most critical:

- integrity: at SLB we act with integrity to achieve our success
- teamwork: we innovate together and use the strength of our diversity to learn and grow
- communication: clear and effective communication allows us to focus on what matters to be the most successful.

Wight: I can't stress enough the importance of communication, in all its forms. Written communication, which is observed in the résumé and email communication with a recruiter, indicates the thoroughness and quality of the work that an individual will produce. Verbal communication, which is observed during the interview process, is critical for an employee to participate in team discussions and articulate results and the impact of their work. Nonverbal communication, like body posture and style of voice (not volume), indicates confidence and maturity. This is an indicator of the ability of the candidate to influence others effectively in the workplace. Career centers at universities can offer much support in this area, which students often do not take enough time to utilize.

How important is a well-written cover letter in the job search process?

Murphy-Ortega: Cover letters are a good way to give a more detailed explanation of your experience and interests. However, they are not required for university talent unless otherwise stated. A cover letter is seldom the difference between being chosen to be interviewed or hired. A well-written résumé that provides specific examples of a candidate's key accomplishments and learnings in each activity listed is far more important than a cover letter.

Morrison: I do not consider cover letters to be as important unless I know the person already. To me, a cover letter is more impactful when it is delivered directly to an individual, as it can be more personalized (*e.g.,* direct email to a hiring manager). Too many times I see a general cover letter that is just a paragraph description of a candidate's résumé, and it ends up not having much value. When using a cover letter, it is more important that a candidate genuinely communicates what they are seeking in a role.

Boussadia: The cover letter is the vehicle for potential candidates to stand out and shine during the application process. It is important to take the opportunity to highlight the skills and achievements that are not reflected in the résumé but are relevant to the position applied for.

Wight: A cover letter is a useful form of introduction, particularly when one is not utilizing career fairs or other in-person opportunities for networking. It helps capture a brief summary of the skills the candidate brings to a specific position, or something unique and memorable about the candidate's experience that brings value to that position. To serve its purpose, it should be well-formatted, organized clearly, and no more than one page.

How can a candidate stand out in interviews, especially in virtual ones?

Murphy-Ortega: Candidates that stand out in interviews generally exhibit one or more of the following characteristics:

- They exhibit strong communication skills by maintaining good eye contact, speaking clearly, and demonstrating good body posture.
- They listen to the questions asked and provide thoughtful responses that answer the question with an appropriate amount of detail, citing examples from their past.
- They demonstrate a genuine interest in the company that they are interviewing with, clearly articulating why they are interested in the company and coming prepared with questions specific to that company and their industry.

Morrison: The strongest candidates are those who know their experiences inside and out. They know what they have and have not accomplished, and can clearly articulate their experiences. Candidates also stand out by being authentic and sincere with their answers, or in other words, not being robotic and overly scripted with their answers. A heavily scripted answer makes an interviewer question whether the answer is real or not. We also appreciate candidates that are able to reflect on and communicate what their experiences have meant to them or provided them. We are much less

interested in a detailed explanation of the tasks they have experienced. Candidates can also stand out by having a clear view of what they would like to do in the first steps of their career.

Boussadia: Virtual interviews should be handled similarly to in-person interviews. Selecting a quiet and well-lit space, having a stable internet connection, being on time, and avoiding distractions during the interview are recommended. Another advantage of a virtual interview is the ability to research your audience and prepare adequately.

Wight: Ultimately, I am looking for a candidate who shows me something about who they are and what they love to do. I need to see evidence of technical skill (how well you can explain a project or task you completed), leadership (what you did to move a team or group forward), and service (the ability to recognize and support something beyond yourself and your own interests). But when the examples used to display those things also intersect with something you truly love and have passion for, there's a sparkle in the eye, an enthusiasm in the voice, or a subtle shift in body posture to lean forward. Those convey to me who you truly are and what you love to do. It is definitely harder to do that in a virtual interview, so practice by recording yourself or having someone you trust observe you in a mock virtual session. Is your unique personality and style coming across the way you hoped? During the actual interview, ensure good internet connection, microphone volume, and lighting. And be sure to limit background noise to help overcome distractions.

What is one of your favorite questions that applicants ask during an interview?

Murphy-Ortega: My favorite question from candidates is, "What keeps you at Chevron?" It gives me an opportunity to talk about the wonderful culture of openness and support we have here. It's something you don't always see from the outside looking in.

Morrison: I had one candidate ask me, "What question would you ask in my shoes and what is the answer?" That question has been so memorable for me as it made me think about what might be important for them to know, and it honestly took me a second to answer. I ended up hiring the candidate, but not just because of that great question.

Boussadia: Two good questions are "What is different about SLB?" or "Why did you choose to work for SLB?"

Wight: I like to see candidates ask meaningful questions about career development and long-term opportunities available. This shows a well-thought-out interest in their own continued growth, which helps them gain skills and the ability to apply those skills as they grow into higher levels of responsibility. It also suggests the candidate is looking for a good long-term employment fit for themselves, consistent with our own hiring objectives.

Are there any questions you recommend that a candidate avoid asking during an interview?

Murphy-Ortega: No, any question is fair game in my opinion. We want candidates to feel comfortable asking the questions they have. We believe the most creative solutions emerge in an environment where diverse voices are heard, ideas are considered, bold thinking is valued, and people can grow into their fullest potential.

Morrison: Avoid asking questions like "What does your company do?" This shows you've not done any research into the company. Also avoid questions about compensation or benefits, as those are better suited if you receive an offer.

Boussadia: Candidates should target questions that allow them to collect information about the company's culture, the role, the work environment, and the objectives to be achieved. At SLB, we value transparency and aim to give candidates enough information to make educated decisions.

Wight: Recruiters have an expectation of respect for their own time and effort in the interviewing process. If a candidate asks questions about easily available public information about that company (*e.g.,* What does your company do/make?), that suggests the candidate does not have real interest in the position. It can make a candidate come off as unprepared or careless in preparing for an interview.

Questions about job expectations (travel, hours, training, relocation, etc.) or company culture are absolutely appropriate to ask if it is important to the candidate. A job interview is like a first date — we are both deciding if we are a good mutual fit for a future working relationship. If something is important to you in your employment decision, you should ask about it.

How can you tell if someone will be able to fit into your company culture?

Murphy-Ortega: When a candidate exhibits good self-awareness and mindfulness. We work on many teams and part of working with others is not only understanding your teammates, but also understanding yourself.

Morrison: We assess candidates on our core company values during the interview. When we see strong answers that align well with our company values, then we expect they will fit into our company culture.

Boussadia: SLB values are at the center of our identity and our culture:

- people: because our exceptional and diverse people are the pulse and spirit of who we are
- technology: because our passion for exploring enables us to solve the world's energy challenges
- performance: because together we deliver outstanding results to build a sustainable future.

During the interview process, we usually present the candidates with situational questions that will allow us to assess

their behaviors and their alignment with our values.

Wight: Company culture is challenging to define and it's constantly evolving. It's often subjective. It isn't really about style, philosophy, or demographics. When I think about whether a candidate is a match for my company, I reflect on aptitude and willingness. For aptitude, I evaluate whether the skill and experience of the candidate match what I need for this position today, as well as the longer-term growth in employee competency. For willingness, I evaluate what the candidate has conveyed to me about what inspires them, the work they enjoy doing, and the career aspirations they have for themselves. If their desires are not going to be met with the job expectations, geographic locations, career development planning, or future work needed by my company, then we are not the right fit for that person. If we don't consider whether our job position and career path can meet the candidate's personal and career goals, we are doing a disservice to the candidate's future career growth.

What are some key mistakes you commonly see engineers make during the job search and interview process?

Murphy-Ortega: A common mistake I see is candidates being too high level or generic when answering questions. An interview is a way to show your experience, so don't be afraid to dive into the details. This goes back to the storytelling skill. A candidate should give enough detail to be understood, but not get bogged down in the minutia or be so high level that the answer has no substance behind it. It's a balance and takes lots of practice to be good at distilling down experiences to address a specific question from an interviewer.

Morrison: Some common mistakes I've come across during the application process include cover letters with another company's name, poor descriptions of one's experiences in a résumé, and leaving off significant details from a résumé (GPA, graduation date, contact information). During the interview process, the biggest mistake I've seen is a candidate coming with a lack of knowledge about the company. If you seriously want a job with that company, then you should do some research into the company.

Boussadia: A common mistake is adopting a mass application strategy without fully reading the job description or the qualification requirements. I recommend a strategic application approach of thoroughly reading and understanding the job posting so that you can properly highlight your relevant skills and experiences in the résumé. It is always an advantage to research the company and have an interest in their projects and missions before attending the interviews.

Wight: Lack of preparation is the biggest mistake I see that hurts an interview assessment. This can be tardiness to an interview, attire inappropriate with the interview environment, poor or nonexistent résumé material, lack of easily available knowledge of the company, or not having any questions to ask of the interviewer during the interview. Here again, career centers at universities offer much support to help in preparation, mock interviews, and researching companies in advance for knowledge and ideas on appropriate questions.

What is the best way to follow up after an interview?

Morrison: A personalized thank you note/email is a very nice touch and leaves an impression. I've seen some candidates send emails to everyone that interviewed them with a personalized element to each email. It says that the candidate really listened to the interviewers and got to know each of them.

Boussadia: During the interview, ask how long the candidate selection process will take and when feedback is expected. It is also important to identify the stakeholder giving feedback and their preferred way to communicate.

Wight: When I was in the interviewing process two decades ago, it was important to follow up with a formal thank you letter. These days, email has mostly replaced the physical paper mechanism of a thank you communication, but a candidate who sends any kind of thank you note shows gratitude for the interviewer's time and high interest in the position. It also gives the candidate an opportunity to re-summarize the most important skills and experience they have for the position. The follow-up establishes a continued interaction with the recruiter, which will be helpful for any additional questions on decision timing or future opportunities.

What advice would you give to someone who has all the qualifications but does not hear back from recruiters?

Murphy-Ortega: My advice is to please be patient. Recruiters and hiring supervisors are usually quite busy trying to fill multiple jobs. In many cases, the recruiter doesn't have authority to make a hiring decision and is waiting to hear back from a hiring supervisor or other person who can make the decision. If you do have questions, you can always contact the recruiter.

Morrison: Some recruiters are great with feedback and some are awful, and you will unfortunately experience both. Before you finish an interview, it's recommended to understand the timeline for next steps so that you level your expectations. It is important to understand that hiring decisions can be difficult and may require some patience. If you have competing timelines, then it is very important to communicate that at the same time. That way, you can reach out for an update when you don't hear back within a communicated timeframe. Unfortunately, a continued no reply most likely means you are not being considered further.

Article continues on next page

Boussadia: Companies are typically looking for defined education, skillset, and experience per role. Reading and understanding the requirements and putting the skills that are relevant to the position at the forefront of the résumé and the cover letter will allow the candidate to stand out and be contacted. I also recommend being visible on professional talent platforms and at conferences to expand their talent network.

Wight: Candidates should ask about the decision timeline, and they should feel free to reach out to ask for a status update on their application consistent with that timeline. Again, job interviewing is like dating, and sometimes the answer is no, this is not the best fit for both of us at this time. Recruiters are trying to find the right match, ideally for a long-term working relationship, and qualifications of technical skill are only one thing that's being evaluated. More intangible items like cultural fit, soft skills, and long-term career aspirations are also factors that help determine mutual good fit. If the answer from a recruiter comes back as no, do not give up. Continue to broaden your job search to other positions and other companies as well. There are many opportunities out there, some of which can be found in unexpected ways and places. Ultimately, you are striving to find the job and career that is right for you.

In closing

While there is no secret recipe for landing a new role through the grueling job-search process, there are certainly ways you can improve your chances and better showcase your skills and qualifications. Put some of these tips from hiring managers to use when applying or interviewing for your next chemical engineering role. CEP

CYNTHIA MURPHY-ORTEGA is the Manager of University Partnerships and Association Relations at Chevron Corp. Her organization manages Chevron's relationships with universities, professional societies, and institutes throughout the world. She joined Chevron in 1991 as an engineer with the Richmond Refinery in the San Francisco Bay Area and has held various engineering, maintenance, operations, financial, business planning, and process safety management positions. Murphy-Ortega later developed and managed Chevron's technical competency development programs for new hires in refining and exploration and production roles. She also worked in the Process Planning Group and performed process modeling on large-scale projects. As the Organizational Capability Manager with the Process, Analytical, and Catalysis Dept., she supported technical competency management, staffing/recruitment, new hire and competency development, and business planning. She participates on various boards at universities and associations across the U.S. with an emphasis on STEM education and diversity, equity, and inclusion. She has also been active in AIChE through the years and currently serves on the Corporate and Industry Leaders Council and the Societal Impact Operating Council (SIOC). Murphy-Ortega has a BS in chemical engineering from the Univ. of California, Davis.

RYAN MORRISON, PhD, is an engineering manager at Evonik, where he works in their Process Technology and Engineering business line. He leads an early career development program for engineers called the Engineering Talent Acquisition & Development (ETAD) program and is based out of Mobile, AL. Morrison is responsible for his business line's recruiting and branding activities in the U.S., as well as ongoing training and development activities for the ETAD program participants. He previously has held other process engineering and management roles within Evonik. He has a BS in chemical engineering from Georgia Institute of Technology (2005) and a PhD in chemical engineering from the Univ. of Texas at Austin (2010).

ADEL BOUSSADIA is a talent acquisition manager at SLB New Energy, where he leads talent acquisition efforts in the new energy sector across the globe. He is an engineer turned recruiter with 15 years of industry experience. His diverse career path with SLB has included roles ranging from field engineer to operations management across various locations in the U.S., Canada, and Brazil. In 2018, he expanded into the recruitment arena, managing numerous roles in full-cycle recruiting and a diverse portfolio from mid-career recruiting and contingent labor to university relations. In 2022, he transitioned to the SLB New Energy division to foster growth within the clean energy sector, inspired by a brief hiatus in 2017 where he pursued his passion for renewable energy by studying Renewable Energy Systems at the Ecole de Technologie Superieure (ETS) in Canada. Boussadia aims to leverage his experience and knowledge to drive energy innovation for a balanced planet. He has a BS in electrical engineering from the National Polytechnic School, Algeria.

ANDREA WIGHT, PhD, is a senior principal engineer with ExxonMobil, responsible for technology development and deployment in chemicals processes. During her 19 years with ExxonMobil, she has worked in many different aspects of the recruitment and hiring process, including coordinating phone (and now Zoom) interviews, onsite interviewing for campus and experienced hires, and serving as a hiring manager and site recruiting lead. She currently leads recruiting efforts and ExxonMobil student interactions at the AIChE Annual Student Conference. Wight has a BS in chemical engineering from Tulane Univ. (1997) and an MS/PhD in chemical engineering from the California Institute of Technology (2004).

Improving Team Effectiveness Through Psychological Safety

Dennis W. Hess ▪ Georgia Institute of Technology

Team leaders strive to establish work environments that enhance team creativity, inclusivity, and retention, all critical elements of psychological safety. It is important that leaders be familiar with the actions that promote psychological safety and those that destroy it.

Since the early 1950s, engineers have undertaken extensive efforts to improve process safety in plants worldwide. Approaches involve hazard identification, prevention, and elimination to reduce the risks associated with materials, chemicals, and process technology. Continual attention to the need for such safety measures at all organizational levels has paid significant dividends *(1)*.

In addition to physical safety, the effective and productive operation of any organization requires psychological safety. A psychologically safe workspace fosters collaboration, inclusion, learning, creativity, productivity, job retention and satisfaction, engagement, accountability, and mental wellness *(2–5)*. Plant and workplace safety also rely on personal behavior and mindset.

A survey by the Society for Human Resource Management *(6)* indicated that 84% of American workers feel that poorly trained managers create unnecessary work and stress; 50% of American workers feel that their performance would improve if their direct supervisor received additional training in people management. According to the survey, the top five skills where manager improvement is needed are effective communication, development and training of the team, time management and delegation, cultivation of a positive and inclusive team culture, and management of team performance.

Since the early 2000s, recognition of the importance of psychological safety to enhance job satisfaction, engagement, and performance has increased, and the concept is now well-entrenched in the lexicon of leadership methodologies. Captain Scott Kelly, the astronaut, engineer, and naval aviator, drew a connection between physical and psychological safety when he remarked, "Safety has to be everyone's responsibility… everyone needs to know that they are empowered to speak up if there is an issue *(7)*."

This article defines psychological safety and how it fits into the context of industrial process safety programs. This

article also outlines actions that promote psychological safety and describes common behaviors that erode psychological safety in the workplace.

What is psychological safety?

The concept of psychological safety was initiated by Schein and Bennis in 1965 in their book *Personal and Organizational Change Through Group Methods (2)*. Building on this foundation, the concept of psychological safety has been extensively developed and promoted by Professor Amy Edmondson *(3, 4)*, who defines psychological safety as "a culture wherein people are comfortable being themselves, will express their true opinions and ideas, and take risks because no negative consequences will result." In such an environment, people are candid about their needs, goals, concerns, and failures. When an organization has a strong culture of psychological safety, individuals feel they:

- will be given the benefit of the doubt
- belong and are accepted, included, and not marginalized
- can display trust and give others the benefit of the doubt
- can be open and honest
- can ask others for help
- can rely on team members
- can address conflict effectively
- can take risks and learn from their mistakes.

These beliefs create a constructive, productive, and enjoyable environment where respect for and openness to others is dominant, and members feel they belong. Furthermore, psychological safety allows difficult conversations to be had and candid feedback to be given. Integrity and interdependence are promoted in this type of atmosphere, leading to accountability and trust.

To assess the level of psychological safety in a team, leaders and managers should obtain input from team members to determine if the members feel that the eight items listed earlier describe their current experiences. This feedback can be collected anonymously through surveys, small group assessment reports, or from direct face-to-face interactions. Managers must determine the most effective and insightful manner by which accurate information can be gathered. When feedback indicates that any of these items are lacking, leadership should request specific examples and take subsequent action to address or discuss them.

In 2016, Google published an extensive study that identified the primary characteristics of the perfect team *(8)*. Their assessment recognized six attributes: high average emotional intelligence, dependability, communication and clarity of expectations, purpose, impact, and psychological safety. Among these characteristics, the most important for effective team functioning and performance was deemed to be psychological safety. It should be noted that emotional intelligence is a key factor in ensuring psychological safety since this concept includes awareness of self and social settings, as well as management of oneself and relationships *(9, 10)*. Specifically, individuals always remember the way someone makes them feel, which represents a human connection.

Four aspects of psychological safety, as defined by T. R. Clark in his book *The Four Stages of Psychological Safety (11)*, are shown in Figure 1, where characteristic actions and sentiments are noted for each stage. Clark categorized the four necessary aspects of psychological safety as inclusion, learning, challenging, and contributing. He stressed that the feelings of inclusion and belonging are foundational for psychological safety. Leadership needs to establish certain mindsets that must be ingrained if team members are to feel safe within their team.

When each team member feels their input is essential and welcome in discussions, decisions, and team directions, they are more apt to be learners and contributors despite the possibility of mistakes (and thus offer new avenues for discovery). When members feel included and heard, they also have a shared identity and are willing to take risks.

Teams must ensure that they consider as many possibilities as are feasible when making decisions. To uncover novel approaches and ideas, team members must feel safe to engage and debate with colleagues and managers in an unconstrained manner. They must feel safe to ask questions and give and receive feedback, allowing them to feel comfortable being learners. Related to making decisions when uncertainty is prevalent, it is critical that team members feel

▲ **Figure 1.** The primary aspects of psychological safety can be sorted into the four broad categories of inclusion, learning, challenging, and contributing. The categories are not mutually exclusive, as a psychologically safe workplace will allow someone to act as a learner, a challenger, and a contributor, all while maintaining a sense of inclusion. Source: Adapted from *(10, 11)*.

safe to be challengers in that they can be candid in challenging the status quo and their colleagues, knowing that they will be respected. Creativity and new directions typically result from establishing learner and challenger safety, while job enjoyment, retention, and interdependence generally result from collaborator safety and inclusion.

The actions described in each quadrant of Figure 1 are crucial to promoting and ensuring open and fruitful discussions, meaningful personal and professional interactions, accountability among team members, and team/organization progress. Every member thrives when a psychologically safe environment exists within a team or organization, since diverse opinions, views, and interpretations are expressed and debated.

When a psychologically safe environment is absent, members do not feel respected, mental wellness is diminished, members suffer emotionally and feel isolated, and fears cause individual inaction, which inhibits creativity, decision quality, and process/product improvements. Our defensive response to feeling unsafe is a "fight or flight" approach, and neither of these reactions is productive. Either unpleasant personal exchanges take place, as fights often lead to toxic behavior, or critical information pertinent to the issue is lost or unstated as members disengage.

Before describing how managers and leaders create psychologically unsafe environments and how safe environments can be established, it's important to understand what psychological safety is not. Being nice to others is important to personal interactions and team satisfaction but does not constitute psychological safety. Likewise, psychological safety is not an invitation to say anything that comes to mind that can insult or harm others. Finally, feeling comfortable emotionally with inappropriate behavior is not a characteristic of psychological safety.

Bias and behaviors that destroy psychological safety

The engineering mindset and culture are often antithetical to psychological safety. For instance, we extol the difficulties we face and endure. We neglect discussing belonging and feelings. We are typically perfectionists and do not frequently discuss how to deal with failure, nor that it is a natural result of risk-taking and progress. We seek specific answers to questions about leadership and management, which is impossible since each individual approaches situations differently and their preferences vary. We feel that seeking help is a sign of weakness rather than courage, confidence, and interdependence. Leaders and team members must be aware of and work to overcome such biases.

Psychological safety can be eroded within a team by simple acts and statements whose intent may not have necessarily been destructive. For instance, managers may not request feedback or input that identifies concerns or complaints, or they may not engage in active listening, thereby giving the impression that members' opinions are unimportant or not wanted. Equally problematic is accepting feedback but not acting on it, or explaining why the input is wrong. Not explaining why certain actions were taken can also erode trust between leaders and team members. Such behavior suggests that input is not wanted, but the manager is "going through the motions" to convince members that they care about alternative opinions.

Acting defensively to member suggestions or concerns gives the impression that a manager is seeking agreement rather than being open to alternative views. In addition, when a team leader responds with "we've always done it that way" or explains why a new approach will never work, it discourages positive discussion and change. Unclear or unstated expectations frequently result in frustration, which inhibits comments and discussion since team members feel they will be judged for asking "stupid" questions. Sarcastic responses or judgmental comments to suggestions or opinions indicate that the leader does not take the opinions of team members seriously or feels they are foolish. When inappropriate behavior like bullying, incivility, microaggression, shaming, discrimination, harassment, or blame placing is tolerated or not addressed, the team concludes that such conduct is acceptable. In such cases, the manager is clearly neglecting their duties, diminishing the collegiality and respect within the team.

A leader who lacks control of their emotional state also significantly harms psychological safety. When plans go awry or unanticipated results surface, the manager may react negatively, act aggressively, and appear to be out of control. The outcome of such events is that team members feel they need to hide concerns and problems rather than address pertinent issues.

Behavior that promotes psychological safety

Since psychological safety is a critical attribute of effective teams and is an important component of diversity, equity, and inclusion efforts, leaders and managers must identify, display, and integrate approaches that incorporate and maintain psychological safety. Several of these behaviors are described briefly below.

Communication regarding expectations, goals, and responsibilities must be clear to avoid wasted effort and frustration. Possible approaches include team meetings to define team goals and how each person's contributions are essential, or focus groups addressing specific issues. Clear communication ensures that a team has a shared purpose and definition of what success looks like for the team and each member. Focus should be on the specific vision and the importance and coordination of individual roles or assign-

ments that will achieve an overall goal.

Interdependence must be stressed to ensure cooperation and collegiality. A team-oriented mentality helps establish trust and accountability. Virtual meetings make this effort more difficult, so it is especially important to incorporate time for virtual team member interaction and discussion of personal and professional activities and accomplishments into the meeting agenda to promote interactions and trust. Mentorship should be encouraged to guide the development of all team members. Mentorship is a two-way street in that both the mentor and the mentee should gain insight and perspective as a result of their discussions.

Demonstrating that each team member is appreciated and respected is critical. Specific reference to commendable or outstanding contributions, preferably at a team meeting, shows that the leader or manager cares for the success and development of each person. Celebration of individual and team successes builds comradery and team spirit. When criticism or correction is warranted, this discussion should be held privately with a focus on professional development, learning, and improvement.

Humility and vulnerability are traits that promote interdependence. When leaders, managers, or team members recognize they do not have all the answers, the team should acknowledge that many viewpoints are essential to arriving at the best decision or direction possible. Confidence is the result of not being afraid of being wrong, and having your team acknowledge that a multitude of opinions is the best path to success removes this fear. An effective way to show humility is to admit when a mistake has been made and apologize, as this builds credibility and trust.

Everyone must be able to candidly offer and accept feedback to improve and adapt to changing circumstances. The leader should show vulnerability by opening up to others about their perspective and the struggles they often hide. Such characteristics and behavior demonstrate authenticity and empathy.

Although displays of emotion (*e.g.,* increased voice volume, change in tone, hand gestures, facial expressions) can indicate motivation and passion for the project or discussion, emotions should be directed toward the issues at hand rather than at people. That is, emotional reactions to issues raised should be critiqued and discussed, but emotional references to people (*e.g.,* "you always take that attitude" or "I can't believe you said that") should be avoided. When people or their priorities, beliefs, or values are referred to when disagreeing with a proposal or statement, collegiality and cooperation are typically lost and egos dominate.

Leaders and team members must encourage risk-taking because significant progress generally results from stepping into the unknown and taking a calculated risk despite the possibility of failure. In this context, mistakes — provided they are due to a lack of full understanding rather than a lack of effort — offer insight and new information. Such an approach also demonstrates trust in team members' ability to define new directions and approaches and to do the right thing. Empowerment is the result of this attitude. Gordon Moore, co-founder and Chairman Emeritus of Intel Corporation, had the appropriate view of mistakes: "One thing a leader does is to remove the stigma of mistakes *(12)*."

Problem-solving, disagreement, and debate should be encouraged to evaluate numerous potential solutions, directions, and compromises. Through team meetings, smaller focus group meetings, or in-house or external retreats, pros and cons of issues can be identified and then further discussed. These detailed discussions among team members will help address complicated issues and enhance performance, and a culture of learning and agility is the result. Psychological safety in this environment can only be achieved when active listening, respect, and interdependence are present so that each team member puts the successes and accomplishments of the team ahead of their own. Similarly, teams and individuals must be open to having difficult conversations, whether those conversations are about interpersonal conflict,

What Happens When Psychological Safety is Absent?

At one point in my career, I observed a team of scientists and engineers that was tasked with developing new processes to circumvent existing limitations. All members were similar in age and experience, but one individual was chosen by the organization to be the leader. The leader called frequent meetings to brainstorm ideas to overcome current problems. After asking everyone for their opinions and suggestions, the leader would offer another point of view and indicate why his way was the best way forward. He frequently countered each alternative suggestion to display its drawbacks, and had the final word on every decision.

After several months of this dynamic, a confrontational attitude permeated the team since they felt that they had to "save face" with the leader and other team members. Most team members disengaged and lost interest in the process. They either resigned themselves to accepting the leader's direction, engaged in a heated battle of words in an attempt to prove the leader wrong, or left the team. Psychological safety was nonexistent at this point.

The environment within the team became so toxic that it was difficult to attract new members. Team success fell sharply, and the organization put a new administration in place. In retrospect, I suspect that the leader felt that he had to prove to team members — not to mention himself — that he deserved to be the team leader. This was his mistake, and it could have been avoided if he had shown vulnerability and established a safe atmosphere to interact and debate.

elimination of certain programs or efforts, or alteration in operating procedures. These discussions have great utility and benefits, but all parties must engage and contribute so that effective changes are made and accepted. When difficult conversations and conflicts are avoided, emotions take over, and anger and resentment build. This situation leads to a hostile, unpleasant, and unproductive culture.

Establishing a questioning culture encourages an improved understanding of technical and social issues and demonstrates that the team is willing to consider alternative views and opinions *(13)*. This culture encourages positive disagreement and debate and promotes diversity, equity, and inclusion, ensuring that all voices are welcomed and heard. Leaders should recognize that different team members may have different ways of expressing their thoughts and ideas. Some individuals may prefer one-on-one discussions with the leader rather than larger group interactions. Other individuals might have no qualms about expressing their opinions in a public forum. These preferences should be accommodated. The leader or manager also demonstrates humility and vulnerability by asking questions of team members who show a willingness to improve. For example, "What do we as a team or organization do well and what needs improvement?", "What about your job and the organization is most frustrating to you?", "What can be done to enhance your professional and personal development?", and "How can I help you?" are all valuable questions to ask. An effective manager or leader must practice active listening when responses are offered. That is, they have to accept the viewpoints expressed as authentic and genuine, and they must focus on understanding the issues raised rather than on judging the comments. Asking questions to obtain further details and incite additional discussion demonstrates interest in and respect for the views presented and shows that the leader or manager sincerely welcomes alternative ideas and directions.

DENNIS W. HESS, PhD, is the Thomas C. DeLoach Jr. Emeritus Professor of chemical and biomolecular engineering at the Georgia Institute of Technology, where his research focused on films, surfaces, interfaces, and plasma processing. He was previously a research staff member and supervisor of process development at Fairchild Semiconductor, a professor of chemical engineering at the Univ. of California, Berkeley, and Chair of the Chemical Engineering Dept. at Lehigh Univ. Hess has served as associate editor of *Chemistry of Materials* and editor of *Electrochemical and Solid State Letters* and *ECS Journal of Solid State Science and Technology*. He was President of the Electrochemical Society (1996–1997), and is a Fellow of AIChE, the American Chemical Society, the American Association for the Advancement of Science, and the Electrochemical Society. Hess received a BS in chemistry from Albright College, and MS and PhD degrees in physical chemistry from Lehigh Univ.

In conclusion

Like physical and chemical safety, psychological safety is a critical attribute of effective technical teams. Specifically, establishing psychological safety promotes team member belonging, willingness to raise difficult issues or questions, and the ability to feel safe disagreeing with consensus viewpoints. Psychological safety encourages creativity, resilience, mental wellness, empathy, job engagement, and job satisfaction/retention. Leaders must advocate and display behavior that promotes psychological safety by:

- seeking input and acting on it when appropriate
- establishing trust and empathy among team members
- tolerating or even encouraging mistakes while learning
- giving and accepting candid feedback
- encouraging productive discussion, debate, and disagreement
- demonstrating appreciation for each person's contributions and successes.

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Is a Process Safety Journey in Your Future?

Jennifer Bitz ▪ Bruce K. Vaughen ▪ CCPS

Process safety focuses on efforts to reduce safety risks associated with processes that involve hazardous materials and energies. It is a disciplined framework for managing the integrity of operating systems and processes by applying good design principles, engineering, and operating practices.

This article, written from the perspective of two process safety professionals, discusses why process safety is so important and provides guidance for engineers new to process safety and for those who are interested in pursuing a career in process safety.


Jennifer Bitz

Jennifer Bitz, CCPSC, is a Lead Process Safety Engineer and Project Manager at the Center for Chemical Process Safety (CCPS). She has 25 years of process safety experience, including engineering and management positions at NCTI and Nouryon, and consulting experiences at ABS, PSRG, and aeSolutions. She has over six years of experience managing site health, safety, and environmental (HSE) programs. Her roles have included building and improving process safety management (PSM) programs, conducting process safety information gap analyses, training employees, communicating with communities and regulators, and leading process hazards analyses (PHAs), layer of protection analyses (LOPA), and audit studies. She holds a BS in mechanical engineering from Rice Univ. and is a CCPS Certified Process Safety Professional (CCPSC).

Jennifer Bitz's reflection. My process safety journey began with a degree in mechanical engineering. This degree led me to work as a mechanical engineer in an operating plant. At the site, I participated in many hazard identification and risk analysis (HIRA) studies, and eventually I started leading them.

But process safety is not just one area of work. The CCPS Risk Based Process Safety (RBPS) program includes 20 elements that cover a broad range of working styles and skillsets *(1)*. HIRA studies, auditing, incident investigation, and workforce involvement have allowed me to combine my engineering knowledge, problem-solving skills, and desire to help people and improve the safety of our workplace. As a people person, I have thrived in roles that included group interaction.

Influencing process safety culture, identifying competencies, and training have allowed me to help others grow in their careers. The RBPS elements such as process knowledge management (which includes process safety information), compliance with standards, and measurement and metrics are a great fit for detail-oriented people.

Mechanical engineers and chemical engineers offer different perspectives during process safety studies. Both skillsets contribute to the competencies needed in a successful PSM program.

Many of my fellow mechanical engineers, as well as electrical engineers, have built careers managing asset integrity, whereas my chemical engineering colleagues enjoy coordinating process knowledge and managing change. We have all spent many hours in HIRA studies and audits.

Those who enjoy spending their day walking through the worksite will do well with workforce involvement, evaluating and improving the conduct of operations, and verifying equipment for startup with operational readiness.

As my career has evolved, the elements of process safety have been a key piece of my professional development.


Bruce K. Vaughen

Bruce K. Vaughen, PhD, P.E., CCPSC, is the Lead Process Safety Subject Matter Expert at CCPS. He has more than three decades of process safety experience, including engineering, research, teaching, and consulting experience in DuPont, DuPont Teijin Films, Cabot Corp., and BakerRisk, and as a visiting assistant professor at Rose-Hulman Institute of Technology. His roles have included leading global PSM efforts, updating and developing corporate PSM standards, and developing PSM training and workshops. He is a coauthor of the book *Process Safety: Key Concepts and Practical Approaches*, and is the principal author of three CCPS guideline books, *Siting and Layout of Facilities*; *Integrating Management Systems and Metrics to Improve Process Safety Performance*; and *Process Safety During Transient Operations.* In addition, he has developed training modules for AIChE's Safety and Chemical Engineering Education (SAChE) program. He holds a BS in chemical engineering from the Univ. of Michigan, and an MS and PhD in chemical engineering from Vanderbilt Univ. He is a registered professional engineer and a CCPSC.

Bruce Vaughen's reflection. My process safety journey began before the term "process safety" was widely recognized. Little did I know when I completed my doctorate in chemical engineering that process safety would become the core of my career. The roads I traveled included research, engineering, teaching, and consulting. Like Jennifer's, and all process safety professionals, my journey continues to evolve.

When I entered the industrial workforce, I did not

imagine how much I would network with and learn from colleagues who shared the same quest. My colleagues and I established that process safety risks have two major components for an event: "How often might it happen?" and "How bad could it be?" These two components can be distilled into a simplified risk formula, where the risk is a function of the product of an event's frequency and its consequence divided by the organization's operational discipline *(2)*.

My process safety colleagues and I have worked together to design, identify, assess, evaluate, operate, maintain, change, improve, manage, and sustain our process safety systems. We have developed methods to safely respond to emergencies and then investigate them. We have learned how best to evaluate and monitor our process safety systems.

I believe that a major tenet in my process safety journey can be shown with the balances in Figure 1 *(3, 4)*. When an incident occurs, one or more of these balances may be adversely affected. Although it may be possible to obtain more raw materials or to generate more energy, injuries to people and fatalities are unacceptable outcomes for the third balance.

Over the decades, process safety professionals have learned that leadership and safety culture set the group's direction, that process safety systems are essential to help manage the risks, and that robust operational discipline by everyone helps to ensure that the systems are sustained. These three foundations — leadership and safety culture, process safety systems, and operational discipline — help reduce the likelihood and severity of incidents.

In 2017, after more than seven years of writing, I finished coauthoring my first process safety book (see Ref. 2). The year this book was published was the same year I joined CCPS. As I began a new road in my process safety journey, I composed a poem to capture why I continued to work in the process safety field (Figure 2) *(2)*. As described in more detail in my book, my reflection integrated all 20 RBPS Elements through the lens of the three foundations, with operational discipline playing a key role *(1, 2)*. As I write this article six years after my book's publication, I do not see any significant changes from what I penned earlier.

Why place process safety in your future? Process safety efforts strive to prevent harm. Keep in mind that your job's risks will either affect or be affected by your decisions, whether you are in academia or industry, and whether you are focused on process safety or not. Process safety efforts help prevent loss of containment incidents — events with severe consequences. When something happens, process safety efforts help by not letting things get worse.

Many of my experienced colleagues have made a big impact on me, including retired plant manager Richard Knowles, who had over 35 years of safety, management, and leadership experience during his career. He strongly believes in people first, with safety being a significant discipline where everyone can agree. Something that Knowles said that really resonated with me was: "It is not okay for me to make my living where it is okay for you to get hurt" *(5)*. CEP

Mass	Raw Materials In = ∑ Converted Materials Out
Energy	Useful Energy In = ∑ Consumed Energy Out
People	Healthy People In = Healthy People Out

▲ **Figure 1.** A major tenet in Bruce Vaughen's process safety journey can be summarized with these three equations.

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Why process safety?
To prevent hazardous materials and energies from causing harm to people, the environment, and the business.

Why do we design safe processes?
To control the hazardous materials and energies.

Why do we identify and assess process hazards?
To understand and evaluate their risks.

Why do we evaluate and manage process risks?
To identify safeguards for the equipment design.

Why do we operate safe processes?
To control the process hazards and risks.

Why do we maintain process integrity and reliability?
To control the process hazards and risks.

Why do we manage process changes?
To control the process hazards and risks.

Why do we manage incident response and investigation?
To safely respond to and learn from incidents.

Why do we monitor process safety program effectiveness?
To control the hazardous materials and energies.

Why process safety?
Because.

▲ **Figure 2.** This poem demonstrates why someone may choose a career in process safety.

AIChE® 35 UNDER 35

This Year's Young Trailblazers

The AIChE 35 Under 35 Award honors 35 chemical engineering professionals under the age of 35 who have made great contributions to the field, as well as to AIChE. These young individuals will pave the way for future generations, serving as role models and innovators. The recipients of the awards were selected for their achievements and contributions in one of seven different categories:

- bioengineering (6 winners)
- chemicals and materials (9 winners)
- education and outreach (2 winners)
- energy and environment (6 winners)
- innovation and entrepreneurship (3 winners)
- leadership (7 winners)
- safety (2 winners).

These award winners embody what it is to be an accomplished chemical engineer. From graduate students, researchers, entrepreneurs, professors, and industry professionals, these individuals are career-driven, but also lead interesting lives outside of their work (Figure 1). This article introduces this year's young trailblazers and gives you a glimpse of their work, research, and personal interests.

All winners will be formally recognized and celebrated during an awards reception at the 2023 AIChE Annual Meeting in Orlando, FL (Nov. 5–10, 2023). In addition, each awardee will receive a cash prize of $500, have their profiles highlighted throughout AIChE and the chemical engineering community, and receive complimentary AIChE membership for 2024. For more details about the award and to get to know some of the past winners, please visit www.aiche.org/35under35.

▲ **Figure 1.** From left to right: Christina Bailey-Hytholt, Michelle Calabrese (above), Alex Abramson (below), Mariah L. Arral, Sasha Ebrahimi (above), Chang Dou (below), and Michele L. Sarazen.

Omar Abdelrahman, 33
Assistant Professor
Univ. of Massachusetts Amherst

Abdelrahman's research expertise focuses on catalysis and reaction engineering. His lab develops and disseminates experimental designs using custom scientific equipment that he builds in-house to help lower the barrier to entry in catalysis research. Growing up in the Middle East influenced his decision to become a chemical engineer. Abdelrahman hopes that his research will help speed the energy transition of the chemical production sector toward a more sustainable future. If he wasn't a chemical engineer, he would have been a historian or economist.

Christina Bailey-Hytholt, 29
Assistant Professor
Worcester Polytechnic Institute

Bailey-Hytholt researches biomaterials and drug delivery, particularly for women's health and prenatal patients. For example, she developed placental models and lipid-based drug- and gene-delivery systems to help treat pregnancy-related complications. She is passionate about her research and plans to develop new *in vitro* models of the maternal-fetal interface, as well as new therapeutics for prenatal care in the future. Bailey-Hytholt enjoys kayaking, hiking, crocheting, and gardening during her free time. Her favorite place that she has gone kayaking is Kauai, HI.

Alex Abramson, 30
Assistant Professor
Georgia Institute of Technology

Abramson's research focuses on drug delivery and bioelectronic therapeutics. His team developed a capsule capable of delivering macromolecule drugs — such as insulin, monoclonal antibodies, and mRNA nanoparticles — with a comparable bioavailability and pharmacokinetic profile to a subcutaneous injection; this capsule has entered clinical trials. His goal is to develop a network of wearable sensors and implantable devices that can help maintain homeostasis by first engineering an artificial nervous system capable of communicating changes to the wearables. He has been recognized on *Forbes'* 30 Under 30 List, and he is an *MIT Technology Review* Innovator Under 35. He enjoys watching movies and has hiked in more than 20 national parks.

Michelle Calabrese, 33
Assistant Professor
Univ. of Minnesota

Calabrese's research group employs rheology, soft matter physics, and polymer and nanoparticle synthesis to address a range of fundamental and applied problems in polymer and soft materials engineering. During her undergraduate education, she switched majors from bioengineering to chemical engineering, as the latter allowed her to focus on addressing more wide-ranging problems, from therapeutic delivery to green energy. She hopes that her research group will be recognized both for their scientific contributions and their efforts to improve diversity, equity, and inclusion in science, technology, engineering, and mathematics (STEM). In her free time, Calabrese likes to listen to live music and enjoys playing soccer weekly.

Mariah L. Arral, 27
NIH National Research Service Award Fellow and PhD Candidate
Carnegie Mellon Univ.

Arral aims to lead her own research program as a tenure-track professor, focusing on drug delivery challenges for understudied groups such as the elderly and pregnant people. Her research focuses on developing new materials for lipid nanoparticles and understanding the relationship between materials, delivery, and immunogenicity. She also conducts engineering education research related to neurodiversity. Having experienced prejudice in the past due to her disability, she advocates for others with disabilities by educating the community. She strongly believes that disabilities do not hinder success and can instead improve teamwork and problem-solving skills, leading to better outcomes. Arral has traveled to 12 countries.

Christopher Cogswell, 33
Global Engineering and Customer Consultant
Elsevier

As a subject matter expert on climate change, carbon capture and utilization, and sustainability, Cogswell consults with major government, academic, and corporate clients throughout the world on issues relating to the digital transformation of their workforce, creating sustainable and safe engineering practices, and developing solutions to meet their needs. He wants to continue growing his knowledge of the sustainability industry and make a positive impact on the way engineering problems are solved. Cogswell hosts a podcast called "The Mad Scientist Podcast," where he discusses the philosophy and history of science and pseudoscience. The podcast has over 1.5 million total downloads.

Matthew Crane, 34
Assistant Professor
Colorado School of Mines

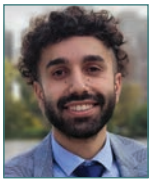
Crane's research focuses on developing design rules and manufacturing methods for the application of optoelectronic nanomaterials in energy and computing. A goal of his is to realize different technologies that can be enabled by colloidal nanomaterials and bridge the gap between the synthesis of these materials and their application in new devices. He co-founded a start-up, BlueDot Photonics, which is innovating solar technologies and materials that will help mitigate climate change. Crane and his partner have two cats, one of which is named in honor of David Bowie. He also recorded an album with his band, Better off Ed, the week before defending his PhD thesis.

Helen E. Durand, 34
Associate Professor
Wayne State Univ.

Durand is most proud of the achievements of her students; in fact, her first PhD student recently graduated. Her research group focuses on utilizing control theory, physics, and math to mitigate cybersecurity hazards for industrial control systems. She loves to challenge herself to learn new things, both in and outside of work. For example, when she was an undergraduate student, she joined the color guard team and had to learn several choreographed dances, as well as the intricacies of marching routines. Outside of work, Durand is working on a screenplay and is proud of her progress moving it toward a complete draft.

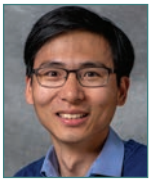
Gözde S. Demirer, 31
Assistant Professor
California Institute of Technology

Demirer's lab focuses on the engineering of plants and the rhizosphere for food security, sustainability, and climate change resiliency using novel nanotechnology and synthetic biology approaches. She hopes that her team's research will contribute to the sustainable production of crops and food. Demirer was born and raised in Istanbul, Turkey. She was inspired to pursue chemical engineering by her mother, who worked in research and development (R&D) at a cosmetics company and was also a chemical engineer. Demirer enjoys dancing and listening to music.



Sasha Ebrahimi, 28
Principal Scientist and Associate Fellow
GSK

At work, Ebrahimi researches molecular-level design rules for engineering protein-based medicines with appropriate developability profiles for clinical and commercial use. He hopes that his career will see the development of many new life-changing drugs. His scientific interests lie in engineering materials to solve fundamental challenges in medicine. He considers mentoring to be one of the most important aspects of being a scientist and hopes to continue mentoring those going into the field of healthcare and medicine. Ebrahimi loves to run and claims to be the biggest Shawn Mendes fan.



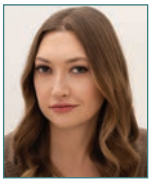
Chang Dou, 34
Senior Engineer
Lawrence Berkeley National Laboratory

Working in the Advanced Biofuels and Bioproducts Process Development Unit, Dou leads process analytics R&D to bridge lab innovation and commercial success in advanced biomanufacturing. He aspires to further drive the convergence of sustainable technologies into viable commercial products, especially within the industrial biotechnology field. Dou loves the outdoors. In 2011, he traveled to Lhasa, Tibet, with a friend to hike and hitchhike more than 1,300 miles along the China G318 route (approximately the distance between New York and Miami).

▲ **Figure 2.** Outside of work, Courtney Flood is a wine enthusiast. For three months, she has blind-tasted over 15 wines daily while studying for her Wine & Spirit Education Trust (WSET) diploma.

Jeremy T. Feaster, 32
Principal Investigator and Research Staff Scientist
Lawrence Livermore National Laboratory

Feaster and his team create 3D-printed electrochemical reactors to transform air into fertilizer and convert CO_2 into fuels and chemicals. His research focuses on using advanced manufacturing and chemical engineering to build a sustainable world. He leads the Jeremy T. Feaster Foundation, a nonprofit organization that, over the past 11 years, has awarded over $20,000 in scholarships to Black and underrepresented students around the nation. Feaster enjoys winemaking with his friend and has partnered with local vineyards and wineries to increase their production of several varietals. He has practiced mixed martial arts for more than 11 years.



Courtney Flood, 29
Vice President – Marketing and Business Development
LBB Specialties

Working as a commercial strategist, Flood is the youngest operating executive in the U.S. specialty chemical distribution industry. She started her career early, beginning college at the age of 14. She specializes in business-to-business distribution, organizational design, corporate partnerships/joint ventures, and sales and marketing team development. Flood has mentored local New York City chemical engineering students to pursue their first internships and careers. She is a hobby genealogist, researching and building family trees for others for over ten years. She is also studying for her Wine & Spirit Education Trust (WSET) diploma and has been blind-tasting over 15 wines daily in preparation (Figure 2). Flood is currently training for a triathlon.

Ankur Gupta, 33
Assistant Professor
Univ. of Colorado, Boulder

Gupta's research group studies interfacial phenomena, including electrochemical interfaces, colloidal motion, and microhydrodynamics for applications in energy storage, desalination, and lab-on-a-chip technologies. He and his group aspire to delve into the design of porous electrodes using electrolyte transport phenomena, with the goal of advancing energy storage technologies. Gupta is an avid chess fan and follows the game every day. He enjoys playing bullet chess and solving various chess puzzles in his free time. He has watched the series "The Office" numerous times and hopes to write a research paper that combines his academic pursuits with his love for the show.

Article continues on next page

Deeksha Jain, 31
Senior Research Specialist
Dow

Jain is involved in the discovery, development, and scale-up of catalysts for Dow's ethylene oxide technology. She values mentorship and would like to give back to the chemical engineering community by mentoring early-career professionals. Her goal is to lead and drive impactful research in catalysis and related fields to create a net positive impact on society. She hopes her work will aid in solving challenges such as climate change and natural resource depletion. Jain enjoys spending time with family and friends, as well as traveling. Thus far, she has visited 26 U.S. states and hopes to visit the remaining ones in the next decade.

Aditi Khadilkar, 34
Process Technology Development Manager
Intel Corp.

Khadilkar's teams focus on developments in lithography to find novel patterning solutions and equipment development. Her research interests span across energy, materials, semiconductors, and data and their integration. She hopes to initiate a research institute to drive toward integrated energy solutions using smart materials and devices. Khadilkar loves to read and always ends up getting a new book when visiting a bookstore or library. She also enjoys astrophysics, neuroscience, classical music, and hiking.

Jovan Kamcev, 33
Assistant Professor
Univ. of Michigan

Kamcev's research group focuses on developing structure/property relationships to guide the design of next-generation polymeric materials for water treatment, energy generation, and energy storage applications. Whenever he encounters challenges in research, he is excited to see unexpected results as it indicates that there is something new to be learned. He is looking forward to navigating the tenure process, graduating his first PhD student, and hopefully becoming a leader in the field of membrane science. Kamcev was the captain of his high school's basketball and volleyball teams. He knows the lyrics of nearly every song by the Beatles.

Sophie (Sun Hye) Kim, 30
Associate Research Scientist
Dow

As a data scientist, Kim has worked on various projects related to data visualization, forward and inverse formulation modeling, natural language processing, and user-interface development. Due to her interdisciplinary background in chemical engineering and computational science, she hopes to stay on top of recent technological developments and employ cutting-edge methods to address complex challenges in the material science and chemical industries. In her career, she hopes to serve as the bridge between traditional engineers and data scientists. If she weren't a chemical engineer, Kim would have been a travel blogger. She would have also liked to be a dog trainer since she enjoys spending time with dogs.

Pranav Karanjkar, 34
Associate Research Scientist
Dow

Karanjkar develops new processes to convert lignocellulosic biomass to value-added chemicals. He has investigated alternative catalysts and reactor designs that could provide a step change in process technology, as well as a competitive cost advantage. His career goal is to continue gaining experience in reaction engineering. He met his wife, who is also a chemical engineer, while pursuing research interests. In his free time, Karanjkar enjoys wildlife photography and traveling around the world with his wife (Figure 3). His current favorite fiction book is "Project Hail Mary" by Andy Weir.

▲ **Figure 3.** Pranav Karanjkar loves to travel around the world with his wife and take photos of the wildlife that are present.

Yuzhang Li, 32
Assistant Professor
Univ. of California, Los Angeles

Li's research group focuses on inventing new tools and materials that can accelerate next-generation renewable energy solutions, such as leveraging cryogenic electron microscopy to address challenges in sustainability. One challenge he faced was starting his faculty career during the pandemic, which he overcame by focusing on the things he could control. This allowed him to stay present and accomplish the task at hand. Outside of work, Li enjoys staying active by playing basketball and weightlifting. The highlight of his basketball career was when he scored a basket on Jeremy Lin in high school. Li one day hopes to participate in the Los Angeles marathon.

Christopher Lowe, 34
Senior Staff Engineer
Takeda

Lowe is responsible for developing manufacturing processes for protein therapeutics at the lab scale and shepherding those processes through scale-up and transfer for clinical and commercial manufacturing. His primary expertise is in mammalian cell culture. Recently, he has also focused on expanding bioreactor automation capabilities in Takeda's process development labs. As an active member of the Young Professionals Committee, he helped launch AIChE's Beer Brewing Competition, which takes place at the Annual Meeting every year. Lowe enjoys brewing classic German lagers.

Shelby Mills, 31
Scientist
Glycosyn, LLC

As a scientist, Mills performs a core analytical role operating and maintaining two high-performance liquid chromatography (HPLC) instruments and determining all of the precursor and product titers in the experimental fermentation runs. She also contributes to strain engineering work. Her goal is to become a senior scientist and eventually pursue a management role, either in project management or leading a team of younger scientists. A personal goal of hers is to raise a loving family with her husband. Mills is regularly involved with her faith and church community. Her birthday is on February 29th — leap day.

Article continues on next page

Nitish Mittal, 34
Staff Research Engineer
ExxonMobil

Mittal leads and supports process systems engineering and technoeconomic analysis of chemical reaction and separation processes. His work thus far has led to three patents. He comes from a family of engineers, with his father being a mechanical engineer and his older brother being an electrical engineer. Recognizing that mentorship has played an important role in his career development, he plans to pay it forward by mentoring students and young professionals. He is the Communications Chair for the AIChE South Texas Section. Mittal has traveled to four of the six habitable continents and plans to visit the remaining two soon.

Ashley Pennington, 33
Senior Chemical Engineer and Resilience Specialist
Cybersecurity and Infrastructure Security Agency (CISA)

As a resilience specialist, Pennington provides technical expertise on the chemical sector supply chain, security, and climate resilience. Her goal is to continue to make knowledge of science safety more available to the public, as well as to bring awareness of the importance of safety and resilience of the chemical industry to lawmakers, regulators, people working with chemicals, and others. Pennington is the oldest of seven children. In her free time, she enjoys volunteering at the Virginia Renaissance Festival. She also enjoys camping and backpacking in the woods.

Victoria Muir, 27
Presidential Postdoctoral Research Fellow
Princeton Univ.

Muir's current research focuses on microbe-virus interactions in porous media. She is an incoming tenure-track assistant professor at the Univ. of Delaware for 2024. Her research lab will focus on designing soft materials for 3D bioprinting, injectable tissue repair, and microbiome research. Muir has been a Zumba instructor for more than eight years and has also taught barre and high-intensity interval training (HIIT). She is a big fan of all things Star Wars and named her dog after Ahsoka Tano.

Zhe Qiang, 31
Assistant Professor
Univ. of Southern Mississippi

Qiang's group currently researches materials and manufacturing of polymers and their derived functional materials, including pioneering the additive manufacturing of functional carbons using plastic waste materials. His goals focus on the sustainable development and decarbonization of the chemical industry through research. He hopes to educate the next generation of engineers and scientists, as well as promote a diverse workforce. Qiang enjoys listening to hip hop music. He also likes to travel and explore different parts of the U.S.

Joel Paulson, 33
Assistant Professor
Ohio State Univ.

Paulson's research interests are in data-driven optimization, physics-informed machine learning, and model predictive control. He won the National Science Foundation (NSF) CAREER Award in 2023, which allowed his research group to develop data-driven optimization algorithms for solving problems related to sustainable energy storage and management. He plans on developing open-source software for data-driven optimization and interpretable machine learning so that algorithms developed by his research group are accessible to many people. Paulson is a huge basketball fan and loves playing first-person shooter (FPS) video games. He was once a highly ranked online Halo 3 player.

▲ **Figure 4.** Joaquin Resasco leads an active lifestyle. As shown above, he enjoys climbing mountains and hopes to climb all peaks taller than 14,000 ft in the U.S.

Sreekanth Rajagopalan, 33
Associate Research Scientist
Dow

Rajagopalan develops end-to-end advanced analytics solutions for manufacturing operations, supply chain management, and commercial functions. His work focuses on process systems engineering and operations research, a mix of math and computational science, which he enjoys. He wants to make decision science and related toolkits equitable and approachable, as well as apply his background in systems thinking for social good. Rajagopalan loves listening to Carnatic music (a type of Indian classical music). He is currently learning how to fly a glider/sailplane and hopes to do it solo.

Joaquin Resasco, 33
Assistant Professor
Univ. of Texas at Austin

Resasco was inspired to pursue chemical engineering because his father was a professor in the field, specifically in the field of catalysis. He followed in his father's footsteps, and today, Resasco's research group focuses on understanding and designing next-generation catalysts that can enable sustainable technologies. He is proud of having had a positive impact on his students, whether it be through teaching or mentoring. Resasco hopes to climb all peaks taller than 14,000 ft in the U.S. (Figure 4). His two most prized possessions are his wok and his snowboard.

Julie Rorrer, 30
Assistant Professor
Univ. of Washington

Rorrer's research group develops catalytic processes to convert plastic waste and sustainably derived materials, such as bio-derived molecules, into higher-value chemicals and renewable fuels. She led the creation of the coloring book series ColorMePhD, which explains research papers to a broad audience using coloring pages. Since its launch in 2018, over 30,000 free coloring books have been downloaded around the world. Rorrer has played the violin since she was four years old. She also loves science fiction books and television, and she sometimes writes her own science fiction short stories.

Article continues on next page

Michele L. Sarazen, 34
Assistant Professor
Princeton Univ.

Sarazen hopes to advance catalytic active site engineering for efficient energy manufacturing transformations. Her work involves making cognizant design decisions concerning sustainable catalyst synthesis. Sarazen's research group couples synthetic, kinetic, and theoretical investigations of porous crystalline materials as catalysts and adsorbents for sustainable fuel and chemical production with an emphasis on reaction and deactivation mechanisms. She enjoys traveling and experiencing new cultures through their food and history. If she wasn't a chemical engineer, Sarazen would have pursued a degree in history.

Michelle Teplensky, 30
Assistant Professor
Boston Univ.

Teplensky's research focuses on engineering immunology through nanomaterial control over biomolecular architecture. Through this control, her research group can impact cancer treatment and protect against infectious diseases, which require an interdisciplinary approach to advance current strategies. She hopes that the students trained in her lab enter their careers feeling inspired. Teplensky loves to shop at Stew Leonard's, and she has become an avid fan of Boston Univ.'s hockey team. Her family has a tradition of buying and completing a puzzle on every vacation.

Kayla G. Sprenger, 33
Assistant Professor
Univ. of Colorado Boulder

Sprenger's lab focuses on multi-scale computational approaches to design immunotherapeutics against a wide variety of infectious and neurological diseases. She hopes to publish and establish her lab's research in the areas of computational immunology and machine learning-driven vaccine design. She is proud of her lab's diverse and inclusive environment, the majority of which are female engineers, including one first-generation college student. During her spare time, Sprenger enjoys walking, hiking, and biking with her partner and son (Figure 5). She has played soccer since she was five and loves to play the violin and sing.

Haotian Wang, 33
Associate Professor
Rice Univ.

Wang became a chemical engineer to pursue his dream of building a clean factory that is based on classical electrochemistry. Thus, it is fitting that his research group focuses on developing novel nanomaterials for energy and environmental applications, including energy storage, chemical/fuel generation, and water treatment. His goal is to be able to contribute to lowering the chemical process industry's global carbon footprint. Wang enjoys playing mahjong and has spent a lot of time playing the game. CEP

William Tarpeh, 33
Assistant Professor
Stanford Univ.

Tarpeh's research group develops and evaluates selective separations of wastewater at several synergistic scales: molecular mechanisms of chemical transport and transformation; novel unit processes that increase resource efficiency; and systems-level assessments that identify optimization opportunities. One of his goals is to realize the vision of reimagining wastewater as a source for valuable products. As a child, Tarpeh first aspired to be a paleontologist. If he wasn't a chemical engineer, he would have studied history.

▲ **Figure 5.** Kayla Sprenger enjoys spending time with her son, whether that means playing with him in a ball pit, walking, hiking, or biking.

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2023 AIChE ANNUAL MEETING

November 5 – 10, 2023
Hyatt Regency Orlando • Orlando, FL

LEADING THE WAY TO A SUSTAINABLE FUTURE

You're invited to attend the **2023 AIChE® Annual Meeting**, the premier educational forum for chemical engineers interested in innovation and professional growth. This year's theme, "Leading the Way to a Sustainable Future," will highlight the many sectors in which chemical engineering leadership and expertise is helping to ensure a sustainable and equitable future. Celebrate reconnecting with your chemical engineering colleagues in Orlando, FL!

Industry and academic experts will cover a broad range of topics relevant to cutting-edge research, new technologies, and emerging growth areas in chemical engineering. This year's Meeting is offering you more can't-miss events than ever before.

We are excited to share our plans with you for the featured panels that we have organized on leading the way to a sustainable future. Hear from and ask questions of leaders in the panel sessions:

- **Sustainability and the Circular Economy Panel Discussion**

  Featured Panelists include:
  - Michael Goltzman, The Coca-Cola Company
  - Ramani Narayan, Michigan State University
  - Meltem Urgun-Demirtas, Argonne National Laboratory

- **IDEAL Featured Session: A Conversation on Equity, Diversity, and Inclusion**

  Featured Panelists include:
  - Charlie Dickson, ExxonMobil
  - Lola Eniola-Adefeso, University of Michigan
  - Luke Landherr, Northeastern University
  - Carlos Rinaldi-Ramos, University of Florida
  - Jean Tom, Bristol Myers Squibb

The Annual Meeting will take place November 5-10 at the Hyatt Regency Orlando. Your registration grants you access to an agenda full of exciting sessions and events:

- The full technical program, including lectures from leaders representing acclaimed universities and corporations from around the globe
- Sponsors and exhibitors showcasing cutting-edge technology
- Networking events to connect (and reconnect!) with chemical engineering peers
- Permanent access to the online proceedings

Take advantage of this year's meeting to unite with an array of like-minded peers, catch up with a former colleague, or network to make new connections and friends. **Reserve your spot by October 23 to save on your registration at aiche.org/annual!**

Let's get together to lead the way with our fellow engineers and scientists. We look forward to your participation!

Sincerely,

Yu Shi
Meeting Program Chair
Vice President,
Technical, Innovation & Supply Chain
Japan & Korea OU
The Coca-Cola Company

Martha Grover
Meeting Program Chair
Professor and Associate Chair for
Graduate Studies School of Chemical and
Biomolecular Engineering
Georgia Institute of Technology

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2023 AIChE® ANNUAL MEETING: FEATURED LECTURES, AWARDS & EVENTS

The 2023 AIChE® Annual Meeting will bring together top academic and industry thinkers to discuss how chemical engineers are powering the future by solving societal and global problems to create and ensure a sustainable and equitable future.

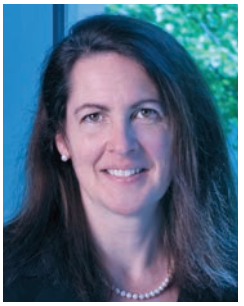
This is just a sneak peek of the exciting conference lineup; check out the latest events on the website!

2023 Andreas Acrivos Award for Professional Progress in Chemical Engineering Lecture ■

Rachel A. Segalman
Edward Noble Kramer Professor of Chemical Engineering, Chemistry and Biochemistry, and Materials & Warren G. and Katherine S. Schlinger Department Chair of Chemical Engineering
University of California, Santa Barbara

John M. Prausnitz AIChE Institute Lecture ■

Mark R. Prausnitz
Regents' Professor, Regents' Entrepreneur and J. Erskine Love, Jr. Chair in Chemical & Biomolecular Engineering
Georgia Institute of Technology



William R. Schowalter Lecture ■

Kathleen J. Stebe
Goodwin Professor of Applied Science and Engineering, Professor of Chemical and Biomolecular Engineering
University of Pennsylvania

SBE's James E. Bailey Award Lecture

Gregory Stephanopoulos
Willard Henry Dow Professor in Chemical Engineering
Massachusetts Institute of Technology

D.I.C. Wang Award Lecture ■

Huimin Zhao
Steven L. Miller Chair of Chemical and Biomolecular Engineering
University of Illinois at Urbana-Champaign

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FEATURED TOPICAL CONFERENCES

Explore trending topics, emerging technologies, and original core programming plus key areas of engineering science and fundamentals while connecting with colleagues throughout the Meeting.

- Bridging the Skills Gap in Chemical Engineering
- Decarbonization of the Chemical Industry through Electrification
- Engineering for Inclusion
- Innovations in Process Engineering
- Material Interfaces as Energy Solutions
- Next-Gen Manufacturing
- Sensors for Sustainability
- Sustainable Pathways Toward Hydrogen and Synthetic Fuels
- Waste Plastics

DIVISIONS, FORUMS & COMMUNITIES

Explore original core programming plus key areas of engineering science and fundamentals.

DIVISIONS AND FORUMS

- Catalysis and Reaction Engineering Division (CRE)
- Computing & Systems Technology Division (CAST)
- Education Division (EdDiv)
- Environmental Division (ENV)
- Food, Pharmaceutical & Bioengineering Division (FP&BE)
- Forest Bioproducts Division (FBP)
- Fuels & Petrochemicals Division (F&P)
- Management Division (MGT)
- Materials Engineering & Sciences Division (MESD)
- Nuclear Engineering Division (NE)
- Process Development Division (PD)
- Separations Division (SEP)
- Transport and Energy Processes Division (TEP)
- Chemical Engineering & the Law Forum (ChE&L)
- Computational Molecular Science & Engineering Forum (CoMSEF)
- Nanoscale Science & Engineering Forum (NSEF)
- North American Mixing Forum (NAMF)
- Particle Technology Forum (PTF)
- Pharmaceutical Discovery, Development and Manufacturing Forum (PD_2M)
- Sustainable Engineering Forum (SEF)

ENGINEERING SCIENCE AND FUNDAMENTALS

- Thermodynamics and Transport Properties (1A)
- Interfacial Phenomena (1C)
- Transport Processes (1D)
- Electrochemical Fundamentals (1E)
- High Pressure (1F)
- Fluid Mechanics (1J)

COMMUNITIES

- Disabilities OutReach & Inclusion Community (DORIC)
- LGBTQ+ and Allies Community
- Minority Affairs Community (MAC)
- Public Affairs and Information Committee (PAIC)
- Publication Committee
- Women in Chemical Engineering (WIC)
- Early Career Community (ECC)

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- **Meet** global leaders and changemakers
- **Grow** professionally

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EXCLUSIVE PROFESSIONAL + SOCIAL NETWORKING EVENTS

This year's Meeting will host exclusive networking events and opportunities throughout the week. Continue to explore meeting topics, make new contacts, and have some fun while connecting with your colleagues.

University Receptions where students, faculty, and alumni from around the world can catch up, share stories, and make new connections!

Networking Events where you will have a chance to explore a variety of both technically driven and fun social topics and themes in a relaxed setting.

Committee Meetings and Events where you can actively engage with peers in focused events hosted by the technical divisions, forums, and other AIChE communities.

WHAT'S YOUR INTEREST?

The Meeting offers extensive, engaging programming dedicated to various disciplines and topics across chemical engineering. Check out the areas below that are of most interest to you.

Bioengineering *(aiche.org/annual/bioengineering)*

Catalysis + Reaction Engineering *(aiche.org/annual/cre)*

Energy + Sustainability *(aiche.org/annual/energy)*

Materials & Engineering Sciences *(aiche.org/annual/materials)*

Pharmaceuticals *(aiche.org/annual/pharma)*

Industry *(aiche.org/annual/industry)*

CHEER ON YOUR PEERS AT OUR 2023 COMPETITIONS!

AIChE BEER BREWING COMPETITION

AIChE teams brew their most creative and delicious beer to be judged by YOU in the Fan Favorite Tasting Competition, as well as by judges from the Beer Judge Certification Program.

AIChE K-12 STEM SHOWCASE & OUTREACH COMPETITION OPEN HOUSE

Swing by the AIChE K-12 STEM Showcase & Outreach Competition Open House. Don't miss this opportunity to interact with AIChE member-led STEM demos and get ideas for how to begin or enhance your own outreach with your local K-12 community. Leave with lesson plans for the demos that you want to put into practice.

AIChE'S ANNUAL Chem-E-Car COMPETITION®

A highlight of the Annual Student Conference, undergraduate student teams from around the world will be racing their chemically powered vehicles. Come and cheer for your favorite team as they compete for the international title!

ChemE Cube™ COMPETITION PRESENTED BY RAPID

ChemE Cube invites undergraduate university teams to design, build, and demonstrate a 1-cubic-foot plant that produces a defined chemistry. Teams compete on cube performance via a head-to-head duel and promote their technology through a 1-minute ad, poster, and 20-minute 'Shark Tank' style pitch to a panel of mock investors.

UNDERGRADUATE STUDENT POSTER COMPETITION

Join us to check out best-in-class undergraduate research on a wide variety of ChemE topics. With 400+ student presenters and almost 100 judges, the Undergraduate Student Poster Competition is the largest forum for Chemical Engineering undergraduates to present their research activity to the professional community at large.

ASC23
AIChE Annual Student Conference

Interested in seeing all the competitions and events at the 2023 Annual Student Conference? Visit: aiche.org/asc/featuredevents

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MEETING INCLUSION + SECURITY GUIDELINES

Your security is our primary concern. The 2023 AIChE Annual Meeting and Annual Student Conference in Orlando will include enhanced security and inclusion measures.

For more information on this and other safety protocols being implemented, consult the Meeting FAQ: **aiche.org/annual/faq**

AIChE Volunteer and Meeting Attendee Conduct Guidelines:
Read our Code of Conduct at: **aiche.org/conductcode**

IDEAL
An AIChE Commitment

IDEAL Statement: AIChE believes that all who wish to be a part of the chemical engineering community should have equal opportunity to pursue and achieve success. It also proposes an IDEAL Path for progress in an environment characterized by inclusion, diversity, equity, anti-racism, and learning. Read our statement at: **aiche.org/edi/statement**
#DiversityInSTEM

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- **Navigate** the conference venues with the Locate Me function.
- **View exhibitor PDFs:** Designed to enhance the conference experience and provide valuable information.
- **Filter** sessions by division, forum, area, and/or committee. Control your meeting experience and see only exactly what you want to see.
- **Explore:** The explore page is your home for finding important Meeting information, upcoming events, and links to all things #AIChEAnnual. The explore page will be updated regularly, so be sure to check the explore screen throughout the week for the latest Annual Meeting news.

Let us know how we're doing. Your feedback is important! Fill out a quick and easy survey for the Meeting.

Refresh your app daily by clicking the update icon in the top right to get the latest Meeting updates. Before building your schedule, be sure to log in/register in the scheduler to save your schedule. This login will be used to sync your schedule across platforms from your browser to the app.

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Download the AIChEvents App to stay up-to-date on the Meeting program, highlights, networking, and more.

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Need help securing your attendance at the Meeting? Check out resources to aid in your business justification and make sure that you are maximizing your time and money, such as:

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- **Quantifying** The Benefits
- **Present** A Justification Letter To Your Supervisor
- **Calculate** Projected Expenses

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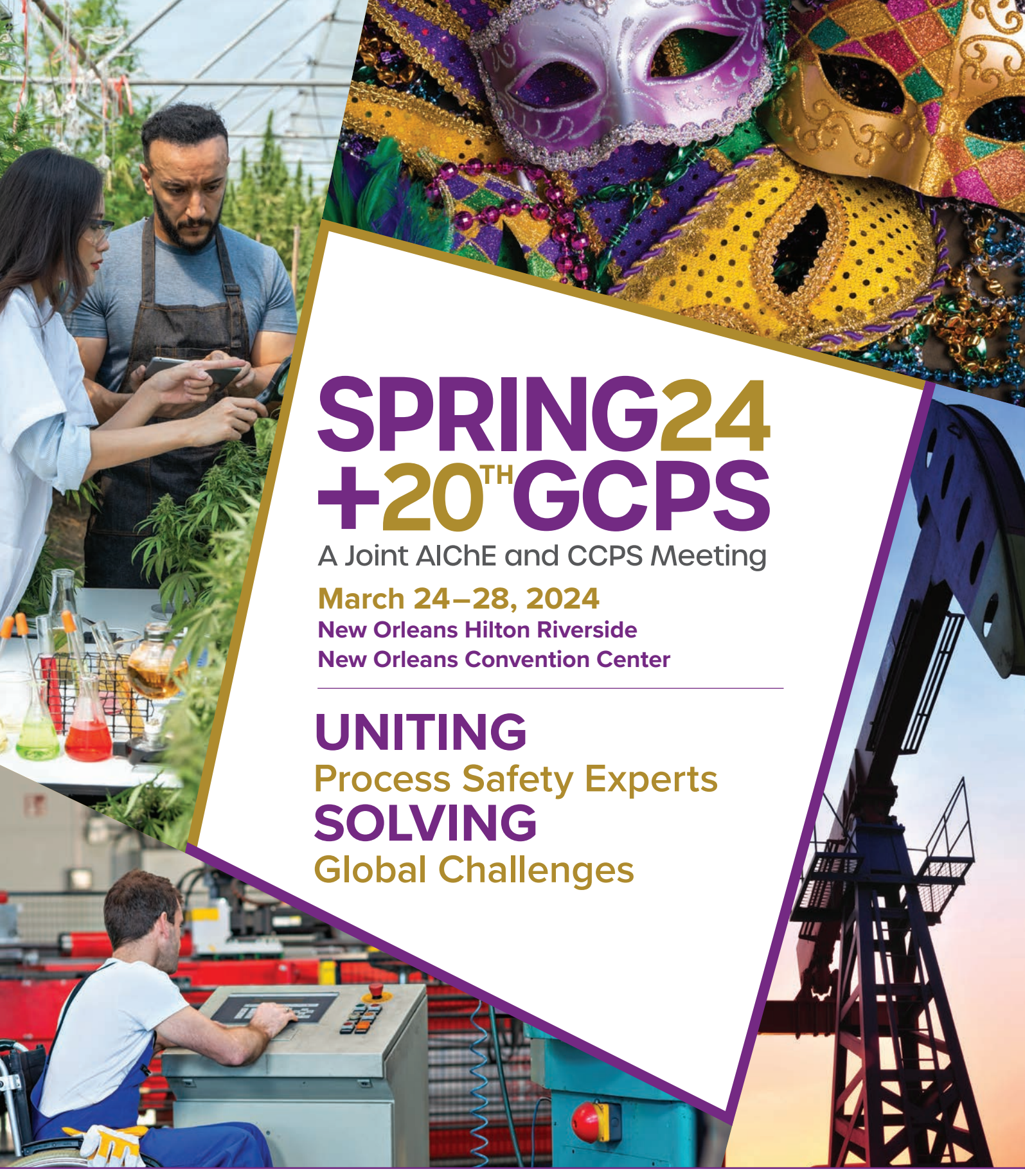

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ABSTRACT DEADLINE: **OCTOBER 25, 2023**

For more information and instructions on how to submit an abstract, please visit **aiche.org/spring** or **aiche.org/gcps**

AIChE Annual Meeting Will Showcase Technical Innovations for a Sustainable Future, Nov. 5–10 in Orlando


▲ Keung


▲ Prausnitz


▲ Segalman


▲ Stebe


▲ Stephanopoulos


▲ Zhao

AIChE will spotlight the roles that chemical engineers play in fulfilling the needs of society and industry during the organization's 2023 Annual Meeting, taking place Nov. 5–10 in Orlando, FL.

At the conference, chemical engineering researchers, practitioners, entrepreneurs, and business leaders will explore the field's growth areas and the many ways in which chemical engineers are leading the charge to a sustainable future.

In addition to sessions devoted to chemical engineering fundamentals, the conference will examine new areas of research and application — including a new topical conference that addresses decarbonization efforts in the chemical industries. Other sessions explore chemical engineering's influence on sustainable pathways toward hydrogen-based and synthetic fuels, and the use of new materials as energy solutions. Along another program track, AIChE's Regenerative Engineering Society will feature the inaugural Cato T. Laurencin Regenerative Engineering Founder's Award Lecture — named for that society's organizer. Sessions are also being devoted to building a more equitable and inclusive engineering profession.

Additional topical conferences cover the challenges involved in managing waste plastics, innovations in process engineering, and the use of sensors in various applications. The Next-Generation Manufacturing conference incorporates topics such as 3D printing, cybersecurity, Industry 4.0, smart manufacturing, and process intensification. These topics and others will be examined at more than 700 technical sessions.

An associated Annual Student Conference (Nov. 3–6) will offer career development opportunities — including workshops, scholarly competitions, research poster sessions, and networking activities — for nearly 2,000 chemical engineering undergraduates. Highlights include a welcome keynote talk by Lori Ryerkerk, Chairman, Chief Executive Officer, and President of Celanese Corp.; a graduate recruitment fair; and the 25th running of AIChE's Chem-E-Car Competition. Also, at the K-12 STEM Showcase, chemical engineering undergraduates will exhibit chemical engineering principles to an audience of local K-12 students.

With its emphasis on technical innovation and the professional growth of chemical engineers, AIChE's Annual Meeting is the foremost educational forum for chemical engineers working in research and development. Programmers expect 5,000 engineers, scientists, and affiliated stakeholders to participate in the meeting. Those who attend will gain insight into the field's latest developments and connect with other professionals.

Featured events and meeting highlights

• On Sunday, Nov. 5, an Honors Ceremony will celebrate the accomplishments of AIChE's Institute and Board of Directors' award recipients for 2023. These high honors recognize eminent achievements across a spectrum of chemical engineering endeavors.

• The Meet the Faculty and Post-Doc Candidates poster session (Nov. 5) permits academic leaders to interact with graduate students and postdoctoral researchers who are seeking faculty positions. This concept has been extended to a Meet the Industry Candidates session (Tuesday, Nov. 7), where grad students will showcase their research to industrial attendees and talent scouts.

• Setting the stage for the week's technical program — and emphasizing a key theme of the meeting — a panel discussion devoted to Sustainability and the Circular Economy is slated for Monday, Nov. 6. Panelists from industry, academia, and government agencies will reflect on emerging opportunities for chemical engineers to create sustainable solutions for global problems. At another session on Nov. 6, meeting attendees will engage in "A Conversation on Equity, Diversity, and Inclusion." Thought leaders will discuss the values underlying AIChE's IDEAL path — characterized by inclusion, diversity, equity, anti-racism, and learning.

• Also on Nov. 6, AIChE's Public Affairs and Information Committee leads a town hall discussion that will inform future iterations of the Institute's climate solutions policy.

• The Langer Prize for Innovation and Entrepreneurial Excellence Lecture (Nov. 6) will be presented by 2023 fellowship recipient Albert J. Keung, Associate Professor

2023 AIChE ANNUAL MEETING

and University Faculty Scholar at North Carolina State Univ. Keung will discuss his research on the data-storage potential of modified DNA. (See article below.)

• The Andreas Acrivos Award for Professional Progress in Chemical Engineering Lecture (Tuesday, Nov. 7) will be delivered by AIChE's 2022 Acrivos Award recipient Rachel A. Segalman, the Edward Noble Kramer Professor of Materials and the Warren G. and Katherine S. Schlinger Chair of the Dept. of Chemical Engineering at the Univ. of California, Santa Barbara. Segalman will discuss her research on superionic conductivity for use in lithium-ion batteries and other applications.

• Also on Nov. 7, AIChE's Society for Biological Engineering (SBE) presents its Daniel I. C. Wang Award for Excellence in Biochemical Engineering. An associated lecture will be given by the Wang Award recipient Huimin Zhao, the Steven L. Miller Chair of Chemical and Biomolecular Engineering at the Univ. of Illinois at Urbana-Champaign. Zhao will discuss his research in his lecture, "Synthetic Biology 2.0: the Dawn of a New Era."

• The James E. Bailey Award Lecture (Wednesday, Nov. 8), also sponsored by SBE, will be delivered by Gregory Stephanopoulos, the Willard Henry Dow Professor of Chemical Engineering at the Massachusetts Institute of Technology. His lecture is entitled "Can Biotechnology Deliver Cost-Effective Fuels with a Reduced Carbon Footprint?"

• The John M. Prausnitz AIChE Institute Lecture (Nov. 8) is named for the pioneer of engineering-oriented molecular thermodynamics, and will be presented by Mark R. Prausnitz, Regents' Professor, Regents' Entrepreneur, and the J. Erskine Love Jr. Chair in Chemical and Biomolecular Engineering at the Georgia Institute of Technology. AIChE's 75th Institute Lecturer, Mark Prausnitz, will discuss his research on biomedical microtechnologies that can selectively cross tissue barriers to improve drug delivery, among other medical applications. (See article on pp. 26–27.)

• The William R. Schowalter Lecture (Nov. 8) is named for fluid mechanics pioneer William Schowalter of Princeton Univ. This year's lecture will be given by Kathleen J. Stebe, the Goodwin Professor of Applied Science and Engineering and Professor of Chemical and Biomolecular Engineering at the Univ. of Pennsylvania. Stebe's lecture is entitled "Active Surface Agents: Active Colloids at Fluid-Fluid Interfaces."

For a complete schedule of events and information about conference registration, visit www.aiche.org/annual.

Albert Keung of NC State is the 2023 Langer Prize Fellowship Recipient

Albert J. Keung, Associate Professor of Chemical and Biomolecular Engineering and University Faculty Scholar at North Carolina State Univ., has been chosen by AIChE to receive the 2023 Langer Prize for Innovation and Entrepreneurial Excellence. The fellowship is named for biomedical pioneer Robert Langer of the Massachusetts Institute of Technology (MIT), and provides an unrestricted grant of up to $100,000 to enable creative researchers and engineering entrepreneurs in their early careers to pursue potentially game-changing innovations.

Keung, who is studying the use of modified DNA as a substrate for data storage, will receive the Langer Prize and present an associated lecture on Nov. 6 at the 2023 AIChE Annual Meeting, taking place Nov. 5–10 in Orlando, FL.

Kristi Anseth, Tisone Distinguished Professor at the Univ. of Colorado and Chair of the Langer Prize selection committee, said "We were impressed by Dr. Keung's exceptional record of achievements and his creative approaches to solving important problems. The proposed technology is innovative and should help unlock the storage potential of DNA."

In acknowledging the honor, Keung said "I am thankful for this fellowship and for its camaraderie and resources, to help accelerate innovation and entrepreneurship. I am also thankful for the trainees in my group and the collaborators that have led us to this point in developing technologies. I'm also excited about how the fellowship can help move forward their legacies and involvement in entrepreneurship as well."

Keung's research group is studying how information is stored and accessed in biological systems. The team focuses on the engineering of DNA, which is already being used as the information substrate in engineering molecular diagnostics, as well as for the production of biofuels, cancer immunotherapies, and vaccines. Keung's team sees potential beyond these applications, including the use of DNA to address challenges in data storage and computation, programmable materials, and climate mitigation. To that end, Keung co-founded DNAli Data Technologies, Inc., with a mission to drive the expansion of a DNA-based economy. Among the technologies that Keung has licensed to DNAli Data Technologies, a key technology is the modification of DNA oligos created through sustainable enzymatic synthesis.

Keung is a chemical engineering alumnus of Stanford Univ. and the Univ. of California, Berkeley, and he was a postdoctoral fellow in biomedical engineering at MIT.

Information about the Langer Prize fellowship is available at www.aiche.org/langerprizes. The deadline for 2024 fellowship applications is Feb. 15, 2024.

New Membership Tier Introduces AIChE to Explorers

In Fall 2023, AIChE unveils a new, introductory tier of Institute membership for chemical engineering professionals who are joining AIChE for the first time, as well as for chemical-industry-adjacent professionals who would like to explore the opportunities available to AIChE members.

The new AIChE Explorer membership grade will introduce engineering professionals to AIChE, its technical offerings, and the activities of the Institute's many communities. Established AIChE member professionals will receive the new designation "Pro Member," and will maintain full professional member benefits and services.

AIChE Explorer members — who will join at a reduced rate — will be able to participate in many of AIChE's member communities and technical forums, and will receive access to select member benefits including professional development resources, CareerEngineer job listings, the Career Discovery opportunities offered through AIChE's Institute for Learning and Innovation, and discounted insurance plans. AIChE Explorers will pay non-member rates for AIChE conferences, publications, and most AIChE Academy offerings.

The AIChE Explorer membership grade is now in effect, and Explorers will have the opportunity to upgrade their membership to become Pro Members in future AIChE dues cycles. AIChE Pro Members and prospective AIChE Explorer members alike can learn more at www.aiche.org/membership/explorer.

AIChE's Safety and Health Div. Announces New Name

Leaders of AIChE's Safety and Health Div. have voted to change the name of the long-established technical division to the Process Safety Div. The renaming of the AIChE entity reflects the increasing emphasis placed on process safety by the chemical industries, as well as the prominent role that process safety plays in the endeavors of modern chemical engineers and AIChE members. The name change was approved in August 2023, and the newly rebranded community will formally unveil its programs and activities at the next AIChE Spring Meeting and Global Congress on Process Safety, Mar. 24–28, 2024, in New Orleans, LA.

In establishing a mission for the Process Safety Div., leaders took into account comments solicited from stakeholders — to identify how the Division can best serve members and to align the Division's activities with those of other AIChE entities. Organizers say that the Process Safety Div. — like the Safety and Health Div. before it — remains steadfast in advancing AIChE's objectives of providing expert guidance, resources, and knowledge exchange on process safety topics. Leaders anticipate that, with fresh perspectives from new participants and the Division's renewed emphasis on process safety, members will gain even greater access to safety resources, networking opportunities, and expert insights.

Since 1979, AIChE's Safety and Health Div. has been at the forefront of safety education and programs that promote safety in chemical engineering practice. The Division preceded the establishment of the Institute's Center for Chemical Process Safety (CCPS), which formed in 1985. CCPS will continue to identify and address process safety needs in industry for member companies, while the Process Safety Div. will identify and address individual engineers' process safety needs and technical development.

AIChE members — including existing members of the Safety and Health Div. — as well as new stakeholders are encouraged to join the Process Safety Div. and to help continue the safety community's progress. For more information about the AIChE Process Safety Div., its initiatives, and how to join, visit www.aiche.org/psd.

WISE ChE Students Complete DC Assignments

This past summer, four chemical engineering undergraduates interacted with public-policy officials and learned firsthand how engineers can work with legislators to solve societal problems as AIChE-sponsored participants in the Washington Internships for Students of Engineering (WISE) program.

Courtney Cochran (Mississippi State Univ.), Evan Erickson (Univ. of Wisconsin-Madison), and Aicha Sama (Brown Univ.) were selected by AIChE to spend two months in Washington, DC, where they prepared papers on public policy topics of their choice. In addition to those students, chemical engineering student Ryan Alimento (Univ. of Southern California) received sponsorship from the American Society of Testing and Materials.

Cochran's research delved into regulatory issues related to the electricity grid in the Southeastern U.S. Erickson's paper discussed strategies and sustainable

Article continues on p. 67.

WISE ChE Students (continued from p. 66)

technologies for chemical recycling and the management of waste plastics. Sama's work focused on technologies to mitigate carbon emissions. Alimento's paper considered challenges facing the future electric grid.

On Aug. 3, AIChE's WISE interns, along with interns sponsored by other engineering societies, presented their research to the U.S. House Science and Technology Committee on Capitol Hill. Videos of the presentations are available online and the papers will be published in the 2023 edition of the *WISE Journal of Engineering and Public Policy*, available at www.wise-intern.org/journal.

AIChE's WISE interns are scheduled to present their papers on Nov. 6 during the AIChE Annual Meeting and Annual Student Conference in Orlando, FL.

The annual WISE program selects engineering undergraduates to conduct research on public policy topics in Washington, DC. The students learn about the interactions between the engineering community and policymakers, and contribute to discussions related to technological matters that affect society. The application deadline for 2024 WISE internships is Jan. 15, 2024. For details, visit www.wise-intern.org.

▲ On Aug. 3, ChE undergraduates presented their public policy research to the U.S. House Science and Technology Committee. From left: Ryan Alimento (Univ. of Southern California), Aicha Sama (Brown Univ.), Courtney Cochran (Mississippi State Univ.), and Evan Erickson (Univ. of Wisconsin-Madison). Photo courtesy of Heather Yeungling.

ACADEMIC OPENINGS

TENURE-TRACK FACULTY POSITION CHEMICAL AND BIOMOLECULAR ENGINEERING, OHIO UNIVERSITY

The Department of Chemical & Biomolecular Engineering at Ohio University seeks a colleague with a passion for mentoring students and with research interests that complement our strengths in Energy & the Environment, Materials, and/or Bioengineering. An assistant professor is targeted, but exceptional candidates at the Associate level will be considered. The successful candidate will involve PhD, MS, and BS Chemical Engineering students in high-quality externally-funded research, and will teach chemical engineering core and elective courses at the undergraduate and graduate levels. Candidates interested in mentoring and teaching in our MS Biomedical Engineering program are also invited. Requirements include a (1) doctoral degree in chemical engineering or closely allied field; (2) commitment to mentoring students at all degree levels; (3) capacity to develop a high-quality externally-funded research program; and (4) commitment to professional service. Ohio University, the oldest university in Ohio, has recently gained status as a Carnegie R1 research university, one of 142 schools nationwide. The successful candidate will be one of ten full-time tenured or tenure-track faculty in the department. We value innovation, student engagement, and interdisciplinary collaboration. Faculty have extensive collaborations across departments and colleges. The Institute for Sustainable Energy and the Environment (www.ohio.edu/engineering/ISEE) applies electrochemistry, catalysis, and supercritical fluids to address problems in alternative energy, battery technology and sustainability. The Institute for Corrosion and Multiphase Technology (www.ohio.edu/engineering/corrosion), one of the largest research centers of its kind in the world, approaches problems in the prediction and prevention of corrosion through electrochemistry, fluid dynamics, and microbiology. Our faculty address critical topics in the detection and treatment of cancer and inflammatory disease through biochemistry, biophysics, and cellular biology. Annual departmental research expenditures are $300–500K per faculty member, from a balance of federal and industry sources. The department has 30–40 PhD students and 20–25 students each in our thesis-based chemical engineering and biomedical engineering MS programs. We have about 140 undergraduate students; by graduation, 45% of them participate in research, 35% in a design competition, and 60% in a co-op or internship. The Russ College will open a new 80,000 square foot research facility in 2023 and benefits greatly from the $120 million Russ gift to the college, which supports engineering research and education. Athens is a quintessential college town in the Appalachian foothills of southeastern Ohio, offering university opportunities and small-town life in a single package. **To apply, visit http://www.ohiouniversityjobs.com/postings/47063.** Review of applications will continue until the position is filled; applications received by December 15th, 2023 will receive full consideration. Rank and salary will be commensurate with qualifications. To learn more about the position and the department, contact Dr. Darin Ridgway, Chair (ridgway@ohio.edu). Ohio University is committed to creating a respectful and inclusive educational and workplace environment. Ohio University is an equal access/equal opportunity and affirmative action employer with a strong commitment to building and maintaining a diverse workforce. Women, persons of color, persons with disabilities, and veterans are encouraged to apply. Ohio University is a member of the OH/Western PA/WV Higher Education Recruitment Consortium www.ohwpawvherc.org.

Statement of Ownership, Management and Circulation of October 1, 2023 for CEP, Publication No. 101-920, issued monthly, for an annual subscription price of $246 from 120 Wall Street Fl 23, New York, NY 10005, which is the location of its publication and business offices. The name and address of the Publisher is Michelle Bryner, American Institute of Chemical Engineers, 120 Wall Street Fl 23, New York, NY 10005. The name and address of the Editor-in-Chief is Emily Petruzzelli, American Institute of Chemical Engineers, 120 Wall Street Fl 23, New York, NY 10005. The name and address of the Managing Editor is: None. The owner is the American Institute of Chemical Engineers, 120 Wall Street Fl 23, New York, NY 10005. The following figures describe the nature and extent of the circulation of the September 2023 issue. In each category, the first number (in italics) is the average number of copies of each issue during the preceding 12 months. The number next to it, within parentheses ( ), is the actual number of copies of the single issue published nearest to the filing date. Total number of copies (net press run): *17,053* (16,757). Paid circulation (by mail and outside the mail): 1. Mailed outside-county paid subscriptions stated on PS Form 3541: *14,683* (14,420). 2. Mailed in-county paid subscriptions stated on PS Form 3541: *none* (none). 3. Paid distribution outside the mails including sales through dealers and carriers, street vendors, counter sales, and other paid distribution outside USPS: *1,062* (1,039). 4. Paid distribution by other classes of mail through the USPS: *28* (25). Total paid distribution: *15,773* (15,484). Free or nominal rate distribution (by mail and outside the mail): 1. Free or nominal rate outside-county copies included on PS Form 3541: *220* (100). 2. Free or nominal rate in-county copies included on PS Form 3541: *none* (none). 3. Free or nominal rate copies mailed at other classes through the USPS: *2* (2). 4. Free or nominal rate distribution outside the mail: *137* (202). Total free or nominal rate distribution: *359* (304). Total distribution: *16,132* (15,788). Copies not distributed: *921* (969). Total: *17,053* (16,757). Percent paid: *98%* (98%). I certify that the statements made by me are correct and complete. Karen Simpson, Production Manager.

EQUIPMENT

ADVERTISERS' INDEX

ADVERTISING AND RECRUITMENT

Tania Babiuk

Email: tanib@aiche.org

Tel: 646-495-1386

IN THE NEXT ISSUE

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This special section will focus on up-and-coming developments in the field of bioengineering. Articles will review biological information storage, genetically engineered probiotics, and next-generation cancer detection methodologies.

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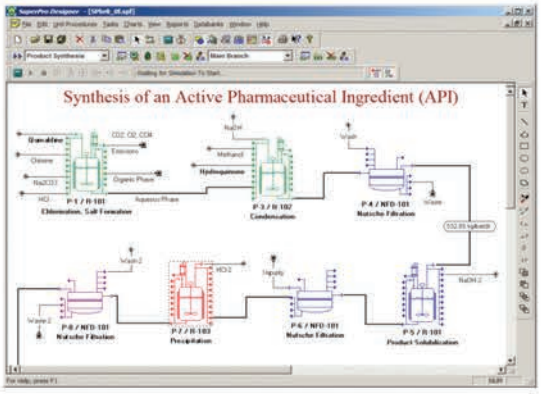

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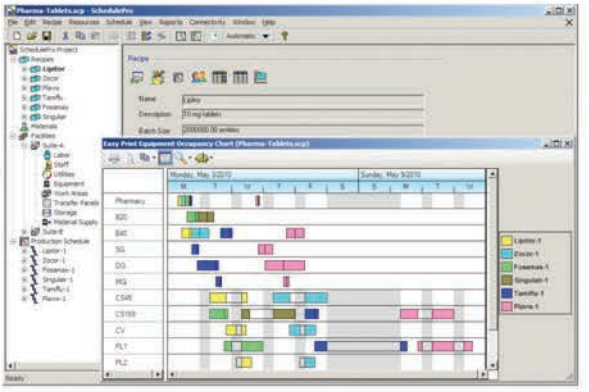

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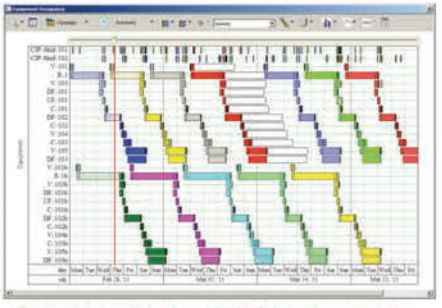

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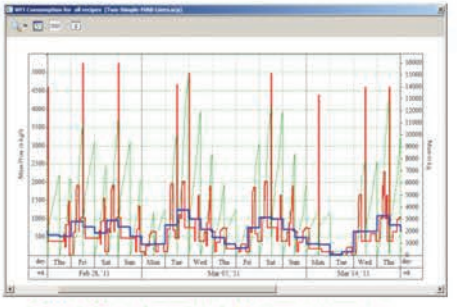
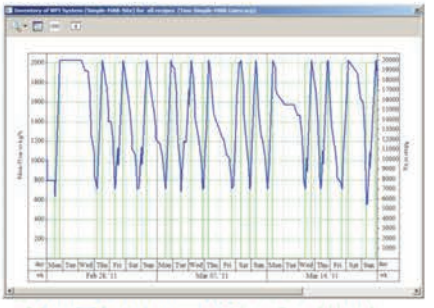


Tracking demand for resources (e.g., labor, materials, utilities, etc.)



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SuperPro Designer is a comprehensive process simulator that facilitates modeling, cost analysis, debottlenecking, cycle time reduction, and environmental impact assessment of integrated biochemical, bio-fuel, fine chemical, pharmaceutical (bulk & fine), food, consumer product, mineral processing, water purification, wastewater treatment, and related processes. Its development was initiated at the Massachusetts Institute of Technology (MIT). SuperPro is already in use at more than 500 companies and 900 universities around the globe (including 18 of the top 20 pharmaceutical companies and 9 of the top 10 biopharmaceutical companies).

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AIChE MEETINGS

For information and registration details, visit www.aiche.org/conferences or call Customer Service at 1-800-242-4363 or 1-203-702-7660 (outside the U.S.).

Oct. 3–4, 2023 · Advanced Manufacturing & Processing Conference/Industry 4.0 Digital Transformation Conference
Hyatt Lodge Oak Brook • Oak Brook, IL

Oct. 17–18, 2023 · Ethylene Middle East Technology Conference
Grand Hyatt Al Khobar • Kingdom of Saudi Arabia

Oct. 17–19, 2023 · International Conference on CRISPR Technologies
Revere Hotel Boston Common • Boston, MA

Oct. 18, 2023 · CCPS and DNV Present Process Safety in Africa
Virtual Visit www.aiche.org/ccps/conferences-events

Oct. 19, 2023 · CCPS Latin America Meeting
Cartagena, Colombia

Oct. 22–24, 2023 · AfroBiotech Conference
Hyatt Centric Midtown Atlanta • Atlanta, GA

Oct. 24–25, 2023 · Diversity & Equity Accelerator Through Learning for Startups (DEALS)
Hyatt Centric Midtown Atlanta • Atlanta, GA

Oct. 24–25, 2023 · Global Conference on Process Safety & Big Data
DECHEMA House • Frankfurt am Main, Germany

Oct. 24–26, 2023 · Offshore Technology Conference — Brazil
Expo Mag • Rio de Janeiro, Brazil

Nov. 3–6, 2023 · AIChE Annual Student Conference
Hyatt Regency Orlando • Orlando, FL

Nov. 5–10, 2023 · AIChE Annual Meeting
Hyatt Regency Orlando • Orlando, FL

Nov. 14–15, 2023 · Chevron Sponsored Virtual CCPS Process Safety Faculty Workshop
Virtual Visit www.aiche.org/ccps/conferences-events

Nov. 15–17, 2023 · Battery & Energy Storage Conference
Argonne National Laboratory • Lemont, IL

Nov. 15–17, 2023 · Cell Free Systems Conference
DoubleTree by Hilton Austin • Austin, TX

Nov. 27–29, 2023 · CCPS Global Summit on Process Safety
Himeji Culture & Convention Center • Himeji City Hyogo Prefecture, Japan

Nov. 28–30, 2023 · The ChemE & Process Engineering Tradeshow (ChemE Show)
Moody Gardens Convention Center • Galveston, TX

Dec. 2, 2023 · CCPS India Regional Meeting
Vadodara, Gujarat, India

Dec. 7, 2023 · AIChE Gala
Pierre Hotel • New York, NY

Dec. 8–10, 2023 · International Conference on Microbiome Engineering
Univ. of California, Berkeley • Berkeley, CA

Mar. 11–12, 2024 · Renewable Hydrogen Storage & Transport
Univ. of Southern California • Los Angeles, CA

Mar. 24–28, 2024 · AIChE Spring Meeting & 20th Global Congress on Process Safety
Ernest N. Morial Convention Center • New Orleans, LA

Apr. 21–24, 2024 · mRNA Technology Conference
Revere Hotel Boston Common • Boston, MA

May 6–8, 2024 · Middle East Process Engineering Conference
Dhahran Expo Center • Saudi Arabia

May 6–9, 2024 · Offshore Technology Conference
NRG Park • Houston, TX

June 24–27, 2024 · Synthetic Biology: Engineering, Evolution & Design (SEED) Conference
Signia Hilton • Atlanta, GA

July 14–18, 2024 · Foundations of Computer-Aided Process Design (FOCAPD) Conference
Beaver Run • Breckenridge, CO

July 28–Aug. 1, 2024 · Foundations of Molecular Modeling and Simulation (FOMMS) Conference
Snowbird, UT

AIChE ACADEMY
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For more information, and to register, visit www.aiche.org/academy.

Oct. 17–19, 2023 • Houston, TX
Combo Course: Flow of Solids AND Pneumatic Conveying (CH032 & CH033)
Course # CH757 • Instructor: TBA

Virtual **Oct. 19–20, 2023 • AIChE Career Discovery Workshop**
Course # CHCRDVTL • Instructor: V. Patrick

Oct. 23–26, 2023 • Houston, TX
Process Safety Boot Camp
Course # CH900 • Presented by CCPS

Oct. 30–31, 2023 • Houston, TX
Crystallization Operations
Course # CH110 • Instructor: W. Genck

Nov. 1–3, 2023 • Houston, TX
SuperChems™ for DIERS Software User Training
Course # CH174 • Instructor: E. Kumpinsky

Nov. 6–9, 2023 • Combo Course: Project Evaluation: Operating Cost Estimating (CH139 & CH140)
Course # CH758 • Instructor: TBA

Virtual **Nov. 13–17, 2023 • Process Safety Boot Camp**
Course # CH900VTL • Presented by CCPS

Virtual **Nov. 27–Dec. 1, 2023 • Basic Emergency Relief System Design**
Course # CH172VTL • Presented by DIERS

Virtual **Dec. 4–7, 2023 • Hazard Identification for Operations and Maintenance Workers**
Course # CH166VTL • Presented by CCPS

Virtual **Dec. 4–8, 2023 • Combo Course: HAZOP Studies AND Advanced Concepts for Process Hazard Analysis (CH157VTL & CH754VTL)**
Course # CH759VTL • Presented by CCPS

Virtual **Dec. 5–7, 2023 • Combo Course: Spreadsheet Problem-Solving AND VBA Programming (CH764VTL & CH766VTL)**
Course # CH768VTL • Instructor: D. Clough

Virtual **Dec. 11–15, 2023 • Process Safety Boot Camp**
Course # CH900VTL • Presented by CCPS

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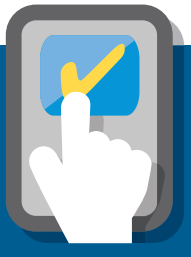

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