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Better Chemistry Through…Chemistry

UC Santa Barbara organic chemistry professor Bruce Lipshutz is pleased and grateful to have been selected to receive the 2017 H. C. Brown Award for Creative Research in Synthetic Methods. The national award from the American Chemical Society (ACS) is in recognition of “outstanding and creative contributions to research in synthetic methods.”

“It’s a great honor to be in this club,” Lipshutz said of the commendation from the society, which comes on the heels of his 2016 Organic Letters Outstanding Publication of the Year Lectureship Award, also from the ACS.

But, if you ask Lipshutz what he *really* wants to discuss, it is the need for better, greener chemistry that minimizes the ongoing growth in the global stockpiling of organic solvent-containing waste. It’s waste generated not only by industrial chemical production, but also academic organic chemistry labs all over the world.

“Organic chemists are doing great things for society; we’re synthesizing, as examples, crucial pharmaceuticals and agrochemicals, making good use of a very sophisticated science,” he said. “But what about all the organic waste being created?”

Lipshutz claims, based on estimates in the literature, that about 85 percent of the organic waste the world produces through chemistry consists of organic solvents.

These carbon-containing substances — which are used to dissolve a variety of other organic substances — function in the production process of, among other things, pesticides heavy duty cleaning chemicals, drugs and polymers. Many commonly used solvents are toxic, flammable, and recognized as potential carcinogens, among other health hazards.

About a century and a half ago, when modern organic chemistry was in its infancy, concern over the environmental and health impacts of organic solvents and the processes that use them was nonexistent, said Lipshutz. Pollution and costs of using these chemicals were not issues for chemists back then. But as the discipline grew, so did their use. This was especially significant because organic solvents allowed for solubilization of otherwise water-insoluble materials, and suddenly made it possible for chemistry to be done in solution.

“We certainly cannot fault those who became traditional organic chemists for their discoveries that relied on the use of organic solvents; imagine the excitement at the time that their newly found dissolution properties brought to the field,” said Lipshutz. “It is such a shame, however, that these pioneers, these brilliant minds of the time, did not choose to follow the perfect model — nature — and develop chemistry in water.”

In fact, Lipshutz himself received his postdoctoral training from renowned organic chemist E.J. Corey, who won the 1990 Nobel Prize in Chemistry for his work in organic synthesis. “I’m as hardcore and traditionally trained in organic synthesis as they come,” said Lipshutz, who came to UCSB in 1979, having received his doctorate from Yale University.

But after decades spent doing traditional organic synthesis at UCSB, he said, he couldn’t ignore the growing volume of organic waste being generated — solvents that were just the medium being used to create the product, and then disposed of, furthering a practice that is not sustainable. While the processes themselves would use relatively small amounts of organic solvents, additional handling — for instance, dilution of the reaction mixture with water — would in turn lead to huge volumes of contaminated water, thereby greatly increasing the volume of waste.

“Depending on the process, there may be some recycling of solvents depending upon where the chemistry is being done,” Lipshutz said. “Alternatively, much is being burned, which is not good for the ozone, and probably most is just buried.

Let’s just hope that in the future, the oceans of solvents underground do not threaten the water supply.”

So it’s no surprise, then, that about 10 years ago Lipshutz turned his attention toward more sustainable, more environmentally friendly chemistry, working to develop greener versions of processes that generate the same results, but without the waste.

“Let’s follow nature’s lead,” he said. So far he and his group have developed alternatives to the use of organic solvents for two of the most commonly utilized reactions in modern organic chemistry, and eliminated the need for energy to be invested in such reactions beyond that available at room temperature. Most recently, they have developed reagents that enable precious metals, such as palladium, to be used as reaction catalysts in far lower concentrations than are typically used in conventional processes.

This new chemistry has been applied to the Nobel Prize-winning and palladium-catalyzed Suzuki-Miyaura couplings — which should eliminate concerns for palladium, an element classified by the ACS as “endangered,” with limited availability. The Lipshutz group also has developed an alternative to the Nucleophilic Aromatic Substitution (SNAr) reaction using water in place of several particularly egregious organic solvents. This is the breakthrough for which Lipshutz was recognized with the ACS 2016 Outstanding Publication award.

“Now that we have provided solutions for two of the three most heavily used reactions in organic synthesis (Suzuki-Miyaura coupling and SNAr reactions), we’re going for the one at the top of the list — catalyzed amide/peptide bond couplings,” said Lipshutz. “It’s a very tough problem, but I’m confident we have a good shot at doing it.”

Green chemistry still has a long way to go before it becomes universally accepted, Lipshutz noted. He and his group are the only scientists in academia discovering the new rules associated with running reactions in water, he said, and more than a century’s worth of traditional learning and industrial applications must be overcome to convince the community that green organic chemistry can be both effective and economical. At least one major drug company, Swiss-based Novartis, has embraced the challenge, and has been integrating this emerging green technology in its research and development for a couple years now — an exciting development for

Lipshutz and also, perhaps a sign of things to come.

“The students here, they get it immediately; they see how much waste is being created and where it is going, and what the implications are,” Lipshutz said. “The students know this is *their* world that’s being polluted, and that it is *their* future that is very much at risk.”

About UC Santa Barbara

The University of California, Santa Barbara is a leading research institution that also provides a comprehensive liberal arts learning experience. Our academic community of faculty, students, and staff is characterized by a culture of interdisciplinary collaboration that is responsive to the needs of our multicultural and global society. All of this takes place within a living and learning environment like no other, as we draw inspiration from the beauty and resources of our extraordinary location at the edge of the Pacific Ocean.