Chemistry That Could Save the World

Summer Undergraduate Research Project Seeks to Convert Atmospheric Carbon into Cheap Fuel

By Mary Price

The work of two cadets doing research in VMI's chemistry labs could someday change how the world powers its automobiles and heats its homes.

Under the tutelage of Maj. Dan Harrison '05, assistant professor of chemistry, McKenzie Raber '18 and Sam Shepherd '18 worked this summer to find a cost-efficient way to convert carbon dioxide into a usable fuel source.

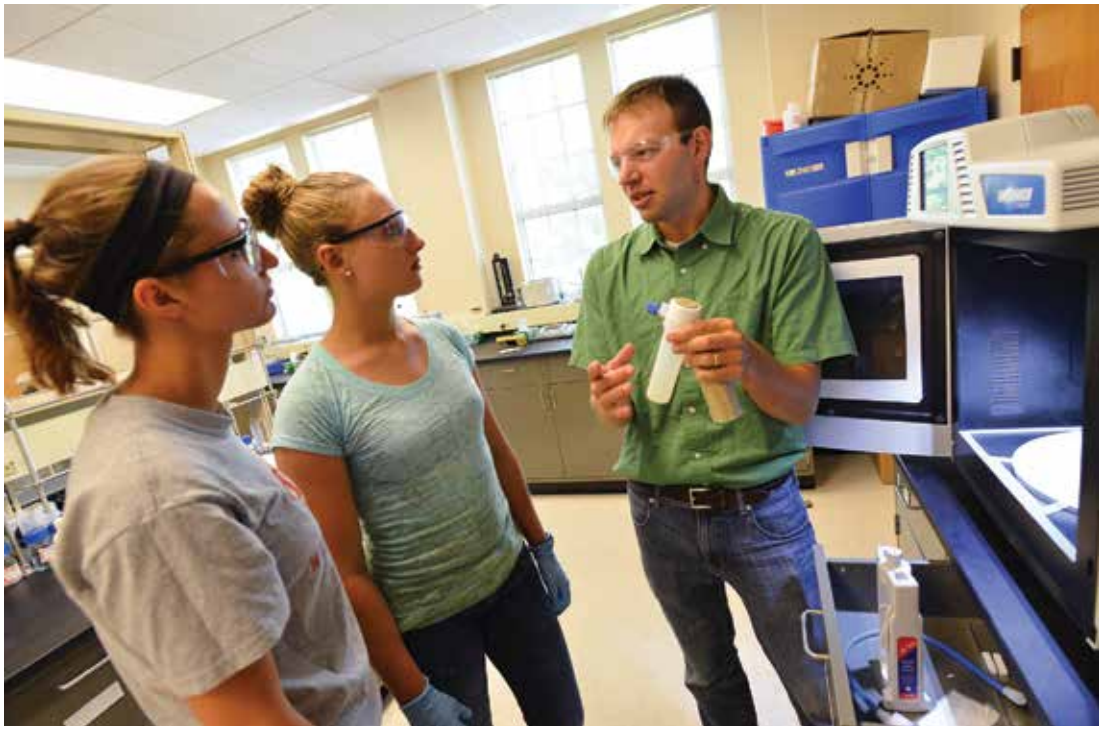
Raber's portion of the work involved creating three ligands – molecular fragments that serve as the core structural framework of larger, more complex molecules – that will each impart different properties once attached to ruthenium atoms. In doing so, she was creating a catalyst that will hopefully lower the activation energy required to convert carbon dioxide into fuel.

Shepherd, meanwhile, worked to find a polymer – a large molecule composed of many repeating subunits – that would provide an effective pathway for the transfer of electrons to reduce carbon dioxide into a combustible fuel such as methane.

"Really, if we can just take the carbon dioxide out of the air and turn that into clean energy, that will reduce the effects of greenhouse gases in the atmosphere as well as creating an energy source," Shepherd noted.

Funding for the projects came from the Summer Undergraduate Research Institute and the chemistry department's Summer Undergraduate Research Program. Chemicals and other supplies were purchased with money from the Jackson-Hope Fund.

While both cadets have had much success in their work, they've also encountered the occasional snag and frustration.



Samantha Shepherd '18 (left) and McKenzie Raber '18 undergo training with Maj. Dan Harrison on the Microwave Assisted Reaction System (MARS 6), which uses microwaves and high-pressure vessels to heat up reactions beyond their normal boiling points and induce reactions that do not occur under normal conditions. – *VMI Photo by John Robertson IV.*

Raber noted that while her work was enjoyable, it was also painstakingly slow, because she not only had to synthesize each ligand separately but also make its precursors.

"There's not one fixed way to do a reaction," said Raber. "There's multiple ways you can get to the same end product. It's all about finding the way that works best, that will give you the cleanest end product."

Identifying the subtle differences was a real challenge. At times, she said, "My reactions feel like they're all the same, and I get confused as to which one is which."

Harrison, though, explained that work such as this develops the kinds of skills a chemist needs to be successful in the lab.

"In class you have a lot of linear or serial thinking, but in a lab you have to be able to parallel think or you won't make any progress," he said.

Now in his third year teaching at his alma mater, Harrison became interested in alternative fuels while completing a post-doctoral fellowship in 2011 at the University of North Carolina at Chapel Hill. At UNC's Energy Frontier Research Center, he investigated a process that would mimic photosynthesis.

Harrison explained that plants make energy by taking in water and carbon dioxide to make oxygen. He and other scientists investigating alternative fuels hope to find a way to replicate that process in a lab, with a clean-burning combustible fuel as the end product.

"Plants do [photosynthesis] naturally, and they've had a really long time to figure it out," noted Harrison. "We don't. We have 50 years or so to solve this problem of allowing us to consume a lot of energy but not produce a lot of waste."

Raber added, "Right now it's not feasible to convert carbon dioxide because of the high cost. By making these catalysts, ideally, we'll be able to get to a monetary value that's affordable and sustainable."

Raber explained that the availability of undergraduate research opportunities such as these were a powerful draw in her decision to attend VMI – as was the NCAA swim team, where she's among the Keydets' top female distance swimmers.

"VMI is known for its undergraduate research in the STEM majors, so I hoped to do research, but I didn't think it would be this soon or this kind of work," she noted.

She continued, "I'm very appreciative of this opportunity, because I feel like that at a lot of larger schools this is not something you could even think about coming out of your freshman year."

Shepherd, a defender with the NCAA soccer team, said she'd been a bit timid about jumping into research, but she's quite glad she made the leap. "You get to do things, and make things," she said. "We're doing a project that could save the world. How is that not great?"

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