New Way to 'Fix' Nitrogen Discovered

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University of Oregon chemists have produced ammonia from nitrogen at room temperature under normal atmospheric pressure, marking a significant step toward achieving one of chemistry's coveted goals.

A scientific article describing the method, which uses a simple compound of iron and hydrogen as the electron source in the "fixing" reaction, will be published in the July 27 issue of the *Journal of the American Chemical Society*.

The process devised by University of Oregon chemistry professor David Tyler and two graduate students, John Gilbertson and Nate Szymczak, was carried out in ether solutions. However, all steps but one also have been shown to work in water.

In the atmosphere, nitrogen gas is inert. However when nitrogen is converted to ammonia, it becomes available as a nitrogen source for plant growth - and as such is the fertilizer that drives the world's food supply. Industry produces ammonia using the century-old Haber-Bosch process, which directly combines nitrogen from the air with hydrogen under extremely high pressures and temperatures.

"For the first time, we've been able to use hydrogen as the source of electrons in the laboratory fixation of nitrogen," Tyler said. "Until now people have had to use other sources of electrons that are not relevant to the Haber-Bosch process. The only other case in which hydrogen was used successfully required higher temperature and exotic materials."

"In the eyes of chemists, the conversion of nitrogen to ammonia in water, using simple hydrogen at room temperature and pressure is the holy grail of nitrogen fixation," Tyler said. "The next challenge is figuring out how to carry out the complete cycle in water."

The University of Oregon method parallels the Haber-Bosch process very closely by using the electrons in the hydrogen molecule as the source of electrons required in the fixing reaction. "This is simpler than any other solution put forward to date," Tyler said. "Other procedures involve the use of relatively exotic electron sources or they require elevated temperatures to complete the synthesis."

And, while the new method "provides one solution to a fascinating, fundamental scientific challenge," Tyler emphasized that it could be decades - if ever - before it will bridge from the bench to cost-effective industry use.

Tyler said the new approach to synthesizing ammonia took five years to achieve and was inspired by earlier advances made by his graduate students, who found ways to make complexes soluble in water. He pointed out that Gilbertson and Szymczak both are funded by the university's National Science Foundation grant establishing research positions in Materials Science through the IGERT (Integrative Graduate Education and Research Traineeship) program.

"Solving problems of this magnitude takes a lot of student power and research dollars," Tyler said. "We're building on advances achieved during the last 20 years. A lot of hard thought went into this, not only by me and my students, but by other researchers who came before us."

Students chosen for the IGERT program receive opportunities to pursue interdisciplinary research, teach at other campuses, and do internships at National Labs and private companies. Gilbertson, who will complete his doctorate in chemistry in August, will begin a teaching postdoctoral position at Trinity University in San Antonio, Texas this fall. Szymczak currently has an internship at Pacific Northwest National Laboratories.

Source: University of Oregon

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