IONIC LIQUIDS: THE GREEN SUPER-SOLVENTS

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WHEN IT COMES TO SOLVENTS, IONIC LIQUIDS are in a class by themselves. Compared to other solvents in wide commercial use, they're environmentally friendly — in a word, green. They're nonflammable and nonvolatile, releasing no harmful vapors into the atmosphere. Amazingly versatile, their properties can be fine-tuned for applications in fields as varied as pharmaceuticals, fine chemicals, medical science, nanotechnology and environmental remediation.

Ionic liquids are exceptionally potent as well. Research to date indicates that these solvents can be customized with the chemical muscle to dissolve almost any material, including metals, plastics and even rock. And that's not all of their virtues. One especially useful type of ionic liquid can be made from a very renewable natural resource — pine trees.

"The potential of such agents is immense," says Sanjay V. Malhotra, assistant professor in the Department of Chemistry and Environmental Science at NJIT. "Properly formulated ionic liquids could be a safe and effective way to dissolve and recover dangerous chemicals that have been spilled on the ground. They might be used for mining, and for refining petroleum. The list goes on and on."

Given their qualities, it's easy to understand why ionic liquids comprise one of the most intriguing areas of research for investigators like Malhotra, who has already participated in major grant-funded studies of these compounds. More work is on the horizon with funding from sources that include the National Institutes of Health and the U.S. Department of Energy.

Ionic liquids are organic salts that can be kept in a liquid state at room temperature, a breakthrough achieved only recently. Imidazolium and pyridinium derivatives are typical examples. However, as a laboratory curiosity liquefied at higher temperature, the unique characteristics of these compounds have been known for over 50 years. There is even evidence that related compounds were used by Bronze Age weavers to fix the dyes in their fabrics.

But in the twenty-first century, Malhotra explains, ionic liquids are a groundbreaking green alternative to highly toxic solvents capable of causing significant environmental harm. Such solvents are basic constituents of products as commonplace as paint remover, and they are critical in many complex industrial processes. When employed as media for promoting organic synthesis or catalytic reactions, ionic liquids offer other substantial advantages as alternatives to conventional solvents. They can be safely reused, along with making product recovery easier and allowing catalysts to be recycled.

Reflective of the current widespread interest in ionic liquids, Malhotra points to the eight papers on the subject presented at an August 2004 meeting of the American Chemical Society (ACS) by members of his research team. A feature article on the potential of ionic liquids for organic synthesis, which gives prominent mention to the work at NJIT, followed the Philadelphia ACS gathering in the November 8 issue of *Chemical & Engineering News*.

To promote investigation of the many applications for ionic liquids, Malhotra and his colleagues have spearheaded the formation of the New York Regional

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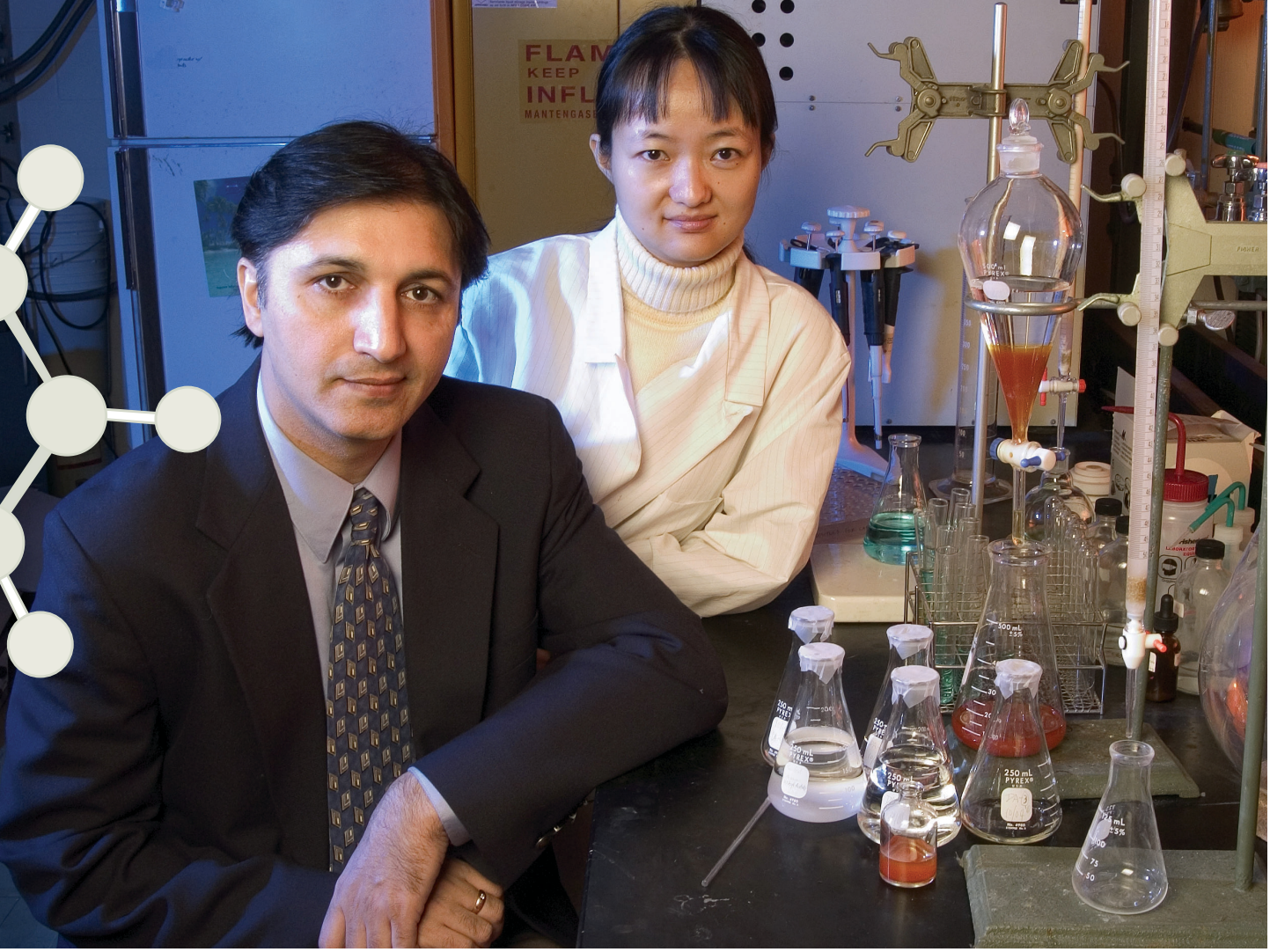

Assistant professor Sanjay V. Malhotra and PhD student Chengdong Zhang were cited by *Chemical & Engineering News* for their paper on the potential of ionic liquids to detect chemical warfare agents.

Alliance for Ionic Liquid Studies, or NYRAILS. Malhotra says that this research consortium, which includes Rutgers University, The City University of New York, The State University of New York at Binghamton and Brookhaven National Laboratory, is the only organization of its kind in North America dedicated to researching ionic liquids.

In addition to exploring the industrial utility of ionic liquids, Malhotra and his colleagues will be looking at how they can help to protect people against one of this century's disturbing realities — chemical warfare. Reporting on the more than 7,000 papers given in Philadelphia last August, the September 13 issue of *Chemical & Engineering News* also singled out the discussion by Malhotra and PhD student Chengdong Zhang regarding the use of ionic liquids as a superior assay medium to test for the presence of organophosphates. These compounds, common in many insecticides and pesticides, are also a key ingredient of less benign chemical warfare agents.

But Malhotra is quick to emphasize how ionic liquids can open new paths to better health as well affording greater security against chemical attacks. This is the province of research focused on a special class of ionic liquids known as chiral ionic liquids. NJIT has one of the few labs in the world dedicated to organic synthesis involving this type of ionic liquids.

In simple terms, chirality means that some compounds can have either a "left-handed" or "right-handed" molecular structure, as discovered by Louis Pasteur. Such mirror-image forms can have very different properties. What is a poison on the one hand, can be a medicine on the other. Chirality, Malhotra says, is the heart and soul of pharmaceutical development and production. Accordingly, because it's possible to synthesize chiral forms of ionic liquids, they hold great promise for advancing basic biomedical research as well as facilitating the manufacture of pharmaceuticals. ■

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