Pollution Solution? Nano Research Leads to Happy Accident

Expert discusses ionic liquid solvents and how they might clean up industrial processes

Dr. Scott Flanagan, senior project scientist with nGimat
By Joy LePree

Nanomaterial manufacturer nGimat may have accidentally found a solution to some of industry's biggest environmental problems. The company's ionic liquid solvents, stumbled upon during non-related precursor work, are now being developed to make industrial processes run cleaner and consume less energy. "Because volatile organic solvents are a source of hazardous emissions and air pollution and are implicated in ozone depletion and global warming, nGimat recognized the opportunity for the development of products designed to eliminate emissions from industrial processes," says Dr. Scott Flanagan, senior project scientist with the firm. "The process to manufacturer terephthalic acid, which is used to make PET, a polymer used to make textile fibers and soft drink bottles, requires the application of high heat and pressure and uses the organic solvent acetic acid, which generates emissions. We decided to focus initial demonstrations of our ionic liquids capabilities on this application." Flanagan continues to say that the discovery has a bright future as government agencies tighten regulations governing the use of solvents classified as hazardous air pollutants or volatile organic compounds. "We are pleased with our initial results and will continue to develop new environmentally friendly ionic liquid solvents for companies that manufacture pharmaceuticals, intermediates, performance chemicals, organic solvents, or related products."

Q: What exactly are the ionic liquid solvents that your company stumbled upon?

A: nGimat's new series of ionic liquid solvents are derived from 2-ethylhexanoic acid and have essentially no vapor pressure and should therefore have significantly reduced emissions. Several of the new salts are liquids at room temperature and fall into a relatively rare category known as room temperature ionic liquids (RTILs), which are prized over other ionic liquids for their ease of use. Initial experiments have demonstrated significant reduction in the pressure required to manufacture terephthalic acids, which has the potential to dramatically reduce the energy requirements for this process while at the same time reducing harmful emissions.

Q: How did a nanotechnology company come up with this development? And was it really an accident?

A: Yes. I have been doing precursor chemistry for nGimat and we work on a process called combustion chemical vapor deposition, which was the original invention the company was started upon. This process takes a flammable organic solvent and dissolves precursors in it. Typically, they are metal compounds and you can take the solution and tailor the composition just by changing the concentration of precursors you dissolve in it. You atomize it into a spray, and the spray is combusted, and the flame can be directed at the surface to deposit a thin film, or you can condense powder out of the flame and get oxides out of the metals that you dissolved in the organic solvents. Ionic liquid work grew out of this, but it's not exactly what one would imagine. Some of the compounds used as precursors are metal salts, which are used because they are very soluble. Studying these compounds in relation to precursor work, I came to discover that even in pure form and even though they are salts, some of them are liquids at room temperature, which opens up the possibility of using them as solvents. But because they are salts, due to the strong attractions between oppositely charged ions, there's no evaporation we can measure. This may eliminate the typical hazards encountered with this type of chemistry such as exposure to fumes when using organic solvents that are toxic. But because the ionic liquid solvents aren't volatile, they eliminate the pathways for trouble.

Q: Are the substances used to replace hazardous solvents in a process, or is it the process that makes the solvents less hazardous?

A: That's a difficult question to answer right now. To evaluate a product as a replacement for another substance that you think is hazardous, you need to do a lifecycle analysis on both processes, and then you have to compare the two analyses. You might replace something that has a high toxic emission with something more toxic but with a lower emission and come out with a better lifecycle. We are at such an early stage that we haven't developed any processes yet, much less performed any lifecycle analysis.

Q: What is the first application nGimat is considering?

A: We've looked at oxidation of p-xylene used when making terephthalic acid, which is used when making PET. This is a huge industrial process that the EPA has looked at extensively. It uses acetic acid as a solvent in the oxidation process, which is a reasonably volatile solvent, so one of the big areas of concern is emission control because of the acetic acid and some of the volatile byproducts. So, we tried the oxidation of p-xylene in one of our ionic liquids. Normally, this would be done in a plant that was designed for this reaction. The oxidation is done with air so that the oxygen in the air acts as the oxidant. It is generally done at 200 to 300 psi pressure and at elevated temperatures. The industrial process forces the air through the mixture. We didn't have that kind of high-pressure flow equipment, so we used statically pressurized vessels. What we found was when we tried to do it with acetic acid as a solvent, under our conditions we didn't get any yield, but using our ionic liquid solvents, we could get up to 80 percent yield. It was an experiment, and we didn't try to optimize the process, so we are fairly optimistic about it.

Joy LePree is a contributing writer for CHEM.INFO magazine. She has worked as a journalist for 14 years. CHEM.INFO accepts suggestions for Q&A interviews. Tell us who you would like to see interviewed in our monthly Q&As by sending an e-mail to Lisa Arrigo, editor in chief, at lisa.arrigo@advantagemedia.com.