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SCIENCE DESK

## With a Splash of Salt, Industry May Reap Environmental Advantages

By KENNETH CHANG (NYT) 927 words

Substances with chemical structures similar to table salt -- but which look and flow like water -- may one day become environmentally friendly replacements for some of the noxious solvents used by industry.

The so-called ionic liquids -- essentially salts with low melting temperatures -- were first invented in the 1940's but remained mainly novelties.

"They look terribly ordinary," said Dr. Kenneth R. Seddon, a professor of chemistry at Queen's College in Belfast, Northern Ireland. "They look like water."

Only in the past few years have chemists started thinking of them as a medium for performing chemical reactions. Although still years away from widespread industrial use, ionic liquids are attracting the interest of Exxon Mobil, BP Amoco and other companies.

"It's just a new way of thinking about them," said Dr. Robin D. Rogers, director of the Center for Green Manufacturing at the University of Alabama.

More than 200 scientists crowded into 80 talks about ionic fluids at the American Chemical Society meeting in San Diego this month.

"It is a very exciting and promising young field," said Dr. Robert Morland, a senior scientist at BP Amoco Chemicals. "It's just beginning to emerge."

The most evident advantage of ionic liquids is environmental. Chemical reactions producing

materials ranging from polyester to pharmaceuticals generally employ organic solvents -- a commonplace example of one is paint thinner -- but their fumes are often dangerous if inhaled and can contribute to the formation of smog.

Most ionic liquids emit hardly any fumes, and they can usually be easily recycled and reused, eliminating many of the problems and costs of disposing of solvents.

"If, in fact, that turns out to be true, it may create an economic advantage," Dr. Morland said.

The resemblance of ionic liquids to table salt is in their chemical bonds.

Sodium chloride, the chemical name of table salt, consists of equal parts of sodium and chloride. Because of how the laws of quantum mechanics place electrons around a nucleus of an atom, a sodium atom has a loose hold on its outermost electron. (Think of the electrons filling seats in an auditorium.

A sodium atom has, in essence, a single atom sitting alone in the upper balcony.)

By contrast, the top level of electrons in a chlorine atom is full save for one spot (just one empty seat in the balcony). A chlorine atom will readily yank the loose electron away from a nearby sodium atom. That electron shift leaves the sodium positively charged and the chlorine negatively charged, and the two are pulled together like socks with static cling. The sodium and chlorine pairs then neatly stack up into a crystal of salt.

Heated, the atoms in salt crystal start vibrating. Heated to 1,474 degrees Fahrenheit, the vibrations become so strong that the salt crystal melts into a liquid.

Hot molten sodium chloride is of little use, but in an ionic liquid, a molecule with a similar loose electron takes the place of sodium and a second molecule is inserted for electron-grabbing chlorine.

Because the molecules are larger than sodium and chlorine atoms, they do not stack as neatly. The molecules are not held together as tightly, and the compound melts at much lower temperatures. Some ionic liquids are still liquids at temperatures as cold as -130 degrees Fahrenheit.

Because the liquid is made of ions rather than molecules, the chemical properties are different from those of conventional organic solvents. "It's not surprising everything we see is brand new chemistry," Dr. Seddon said.

By switching the molecules used in the ionic liquids, chemists will be able to design custom properties in their solvents. Dr. Seddon estimates one trillion possible combinations. "You've got this incredible flexibility for getting the system right," he said. Ionic liquids can be mixed together to tweak their properties further.

Dr. James Davis, a professor of chemistry at the University of South Alabama, gives the example of designing an ionic liquid that is able to bind with heavy metal pollutants like mercury and cadmium.

Shaking contaminated water with the ionic liquid will enable the ionic liquid molecules to

pull the heavy metals out of the water. The ionic liquid and water will then separate, and the clean water can be poured off.

"The salt and water don't mix," Dr. Davis said, "just like if you have oil and vinegar in a salad dressing."

In addition to the environmental advantage, ionic liquids are often better than traditional solvents and can enable some new chemical reactions.

Ionic liquids are likely first to find applications in high-cost products like pharmaceuticals, with large-scale industrial applications following years later.

But chemists still lack fundamental understanding of how ionic liquids work, even simple properties like the melting temperature. That makes for years of fertile research to come.

"It's just something so unexpected to have a salt that's a liquid," Dr. Davis said. "That looks like an orchard I'm never going to finish picking fruit from."

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