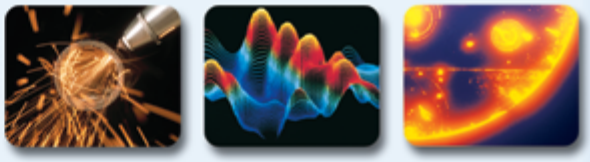
Chemistry in Action



Ultrasonic Toxic-Waste Destroyer

Paints, pesticides, solvents, and sulfides are just a few components of the 3 million tons of toxic waste that flow out of U.S. factories every year. Some of this waste ends up in groundwater and contaminates our streams and drinking water.

Eliminating hazardous waste is a constant challenge. Unfortunately, today's disposal methods often damage the environment as much as they help it. Incinerators burning certain waste, for example, produce dioxins, one of the most dangerous class of toxins known to man.

Finding new methods to destroy toxic waste is a puzzle. Michael Hoffmann, a professor of environmental chemistry at the California Institute of Technology, thinks that part of the solution lies in sound-wave technology.

According to Hoffmann, cavitation is the key to eliminating certain chemical wastes from polluted water. Cavitation occurs when the pressure in water is made to fluctuate from slightly above to slightly below normal, causing bubbles. The bubbles are unstable and collapse, creating tiny areas of extremely high pressure and heat. The pressure inside a collapsing bubble can be 1000 times greater than normal, and the temperature reaches about 5000°C—just a bit cooler than the surface of the sun. These conditions are harsh enough to combust most toxic-waste compounds in the water, breaking them down into harmless components.

Hoffmann has employed a device that uses ultrasound—sound waves at frequencies just above the range of human hearing—to create cavitation in polluted water. As water flows between two panels that generate ultrasound at different frequencies, the ultrasonic waves generated by one panel form cavitation bubbles. An instant later, the ultrasound produced by the other panel collapses the bubbles. The intense pressure and heat generated break down toxic compounds into innocuous substances, such as carbon dioxide, chloride ions, and hydrogen ions.

"With ultrasound," says Hoffmann, "we can harness frequencies . . . of about 16 kilohertz up to 1 megahertz, and different . . . compounds are destroyed more readily at one frequency versus another . . . applying a particular frequency range, we can destroy a very broad range of chemical compounds."

The device destroys simple toxins in a few minutes and other toxins in several hours. To be destroyed completely, some compounds must form intermediate chemicals first and then be treated again. To be sure the waste is totally removed, scientists use sophisticated tracking methods to trace what happens to every single molecule of the toxin.

The ultrasound toxic-waste destroyer treats about 10% of all types of waste, eliminating both organic and inorganic compounds, such as hydrogen cyanide, TNT, and many pesticides. While the device cannot destroy complex mixtures of compounds, such as those found in raw sewage, it does have many advantages over current technologies. Aside from having no harmful environmental side effects, ultrasonic waste destruction is cheaper and simpler than the process of combustion.

Questions

1. How does Dr. Hoffmann's ultrasound device benefit society?
2. Briefly explain why the bulk temperature of the water remains low (at room temperature).

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