Fallout From a Chemical Catastrophe

Methyl isocyanate, the deadly gas that last week leaked from a Union Carbide pesticide factory in Bhopal, India, killing more than 2,000 people, is one of the most dangerous chemicals regularly used in industry, according to the Occupational Safety and Health Administration (OSHA). At the same time, little is known about its long-term effects on human health and precisely how the substance causes its toxic effects.

The lack of data on methyl isocyanate reflects the fact that it's very potent and difficult to control, says Meryl H. Karol of the University of Pittsburgh's Graduate School of Public Health. Although nominally a liquid at room temperature, methyl isocyanate evaporates so quickly from an open container that it easily turns into a colorless, odorless, highly flammable and reactive gas. "I would hesitate having it in the laboratory," Karol says.

The OSHA standard for exposure to methyl isocyanate during an eight-hour day is 0.02 parts per million in air, far lower than what many Bhopal residents were subjected to. This standard is five times more stringent than that for phosgene gas, which was used as a chemical weapon during World War I and is still used in various industrial processes.

For the last 10 years, Karol and her colleague Yves Alarie have been studying how low doses of isocyanates, the family of compounds to which methyl isocyanate belongs, irritate the lungs and, over an extended time, cause allergies. Isocyanates are widely used not only, as in the case of methyl isocyanate, for making a series of compounds called carbamates (a popular class of pesticides that attack the nervous systems of insects) but also in other forms for making plastics like polyurethane foam. Thousands of workers potentially face occasional exposure to isocyanates.

"There are differences in potency among the isocyanates," says Karol, "but they generally have the same effects." At low levels, isocyanates cause eyes to water and damage to the cornea. At higher concentrations, muscles constrict, blocking the nasal and bronchial passages in something comparable to a severe asthma attack. This was responsible for most of the deaths in India. Isocyanates are easily absorbed through the skin and quickly enter the bloodstream. They react readily with proteins, disrupting membranes and killing cells. They may also affect the nervous system by inhibiting an enzyme called cholinesterase.

"One of our goals is to find the target molecules in the biological system that the isocyanate goes to [to produce] the physiological effects that we're seeing," says biochemist William E. Brown of Pittsburgh's Carnegie-Mellon University. The researchers are finding surprising evidence that despite their great reactivity, isocyanates that enter a biological system seem to have an affinity only for a few, specific proteins.

Ironically, the tragedy in India may allow the Pittsburgh group to check some of their results obtained from experiments performed on guinea pigs. "We would like to know if the protein that we're finding in guinea pigs is the same one that is affected in humans," says Brown. If this turns out to be the case, then a blood test — an "early-warning detection system" — can be developed for screening workers who may have been exposed to isocyanates. "A lot of the effects that you see are reversible," says Brown. "If you could see the danger level early enough, you could do

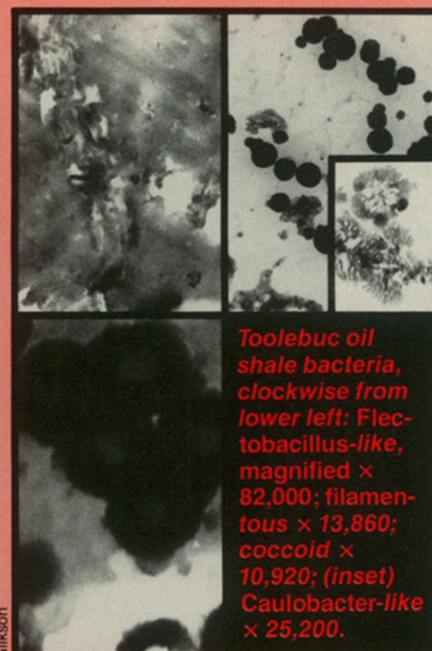
Viewing fossil fuels' bacterial sources

Conventional wisdom used to hold that fossil fuels originated mainly from marine plankton and higher plants, crushed and heated over the eons. But that ignored bacteria's role. Today, work on two fronts suggests that bacteria which dine on those plankton and plants are a dominant biochemical force in the creation of most petroleum and natural gas.

In Strasbourg, Pierre Albrecht of CNRS, the French national research organization, and co-workers recently established the presence of bacteria in fossil fuels. Although they never saw any bacteria, they uncovered a rich legacy of hopanoids — characteristic chemical fossils derived from the hopane molecule — that the bacteria left behind in petroleum. Photographic confirmation of bacteria's role was left to Australian geologist Miryam Glikson.

At Australian National University in Canberra, Glikson has used transmission electron microscopy to produce the first images of bacteria from fossil-fuel source rock. The technique requires first concentrating the organic matter by dissolving the rock. Then the organic matter is dried, embedded in resin and shaved into 0.05-micron slices with a handmade glass knife.

Though identification of the bacteria is difficult, Glikson says several types appear to resemble forms currently found in marine environments. Lacy, fan-shaped clumps suggest the living genus *Caulobacter,* she says, while a doughnut-shaped type appears similar to *Flectobacillus marinus,* a bacterium that degrades algae in the Florida Keys. In Australia's Toolebuc oil shales deriving from 120 million years ago, Glikson says "the bulk of the organic matter is made up of either filamentous bacteria or organic matter that has the same characteristics and consistency" but has lost its structure through compression. However, occasionally she identified in the shales a structure that she finds "reminiscent of the cyanobacteria" that



Glikson

Toolebuc oil shale bacteria, clockwise from lower left: Flectobacillus-like, magnified × 82,000; filamentous × 13,860; coccoid × 10,920; (inset) Caulobacter-like × 25,200.

form mats in the oxygen-poor zone at the seafloor (SN: 4/22/82, p. 284).

Shales formed from freshwater environments showed few if any bacterial remains. Glikson suspects this is due both to the type of bacteria-resistant planktons that likely served as a source of organic matter and to the highly alkaline — and therefore hostile to bacteria — nature of the initial environment.

Glikson's micrographs may generate more than academic interest, according to J. M. Moldowan of Chevron Oil Field Research Co. in Richmond, Calif. "One thing that all petroleums seem to have in common is bacterial reworking of organic matter," he says. Knowing more about the bacteria involved, he suggests, could help oil exploration teams gauge the potential yield of petroleum source rocks and the value of the oil they form.

Reports of Glikson's work are due out in the next issues of ORGANIC GEOCHEMISTRY and CHEMICAL GEOLOGY.

— *J. Raloff*