The Crusade Against Chlorine

As environmentalists broaden an unprecedented campaign to banish an entire element from industrial chemistry, industry and scientists ready their counterattack

Until this spring, Brad Lienhart worked in the Dow Chemical Co.'s Midland, Michigan, headquarters, where for 10 years he had been responsible for the production of elemental chlorine. That's no small job at Dow. The company produces nearly 5 million tons of the pale green gas each year—at least 10% of the world's chlorine production—by passing electricity through salt water. Dow uses it to make millions of tons of products, among them pesticides, ingredients for the high-volume plastic polyvinyl chloride (PVC), and chemicals for the pharmaceutical industry. When it comes to chlorine, "I live and breathe the stuff," Lienhart says.

Now Lienhart is in Washington, D.C., with what he says is a far bigger, more pressing job to do. He's poised to fend off something unprecedented in the history of environmentalism: an effort to ban an element completely as a feedstock in industrial chemistry. The basic chemistry of chlorine and the club of apparently innocuous chlorine compounds—from DDT to PCBs—that have turned out to be hazardous make the entire class of chlorine containing compounds suspect, say the antichlorine forces. And with industry turning out at least 10,000 chlorine compounds, no regulatory body is capable of studying and regulating them one by one. Since viable alternatives are available for at least some chlorine-containing products and processes (see sidebar), why not play it safe and simply banish the element from industry? "If no chlorine goes in, none comes out" into the environment, says Joe Thornton, a leading antichlorine voice at the environmental advocacy organization Greenpeace.

Sounds crazy? Not to the chlorine-dependent industry, which is taking this threat very seriously. The antichlorine campaign has already had practical effects: the elimination of chlorine gas as a bleach in Europe's pulp and paper industry and cutbacks in the use of PVC plastic in some public construction projects. Now the campaign is broadening. Conservative regional commissions such as the International Joint Commission on the Great Lakes region have recommended broad chlorine phaseouts. To industry's alarm, the idea is even making inroads at the highest levels of government. Norway, for example, commissioned researchers at the Massachusetts Institute of Technology (MIT) last year to study the policy implications of a total chlorine ban.

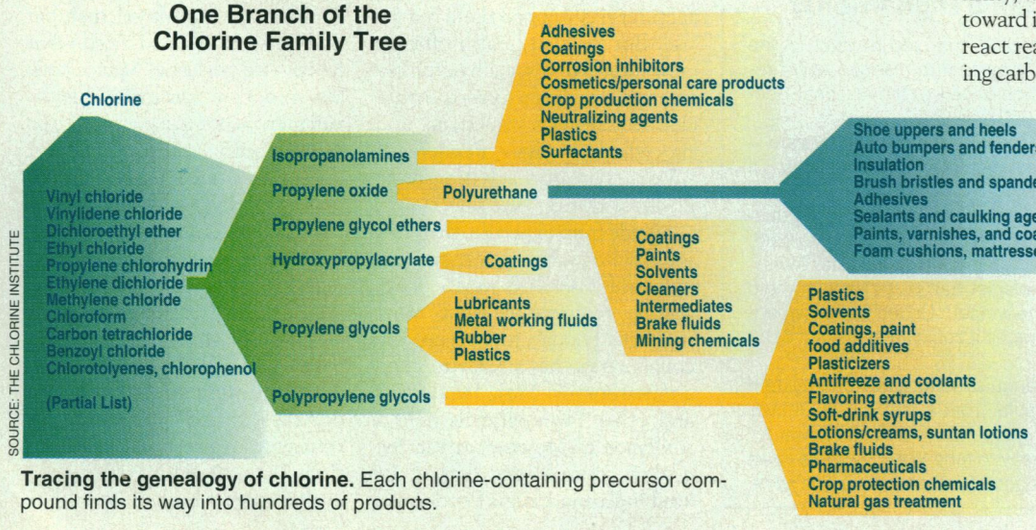
The chemical industry is so concerned about these political developments that it is organizing a counteroffensive, with Lienhart as its general. "We want to be part of the public debate," he says. With a bankroll approaching $5 million from members of the giant Chemical Manufacturers Association and support from smaller industry organizations such as the Chlorine Institute and the Vinyl Institute, Lienhart is now orchestrating a long-term pro-chlorine campaign. Through the newly formed Chlorine Coordinating Council, which Lienhart chairs, Dow and other chemical manufacturers hope to counter what they view as antichlorine prejudice, fueled more by public relations than hard science and sober risk assessment. Chlorine compounds, they say, ought to be regulated like other compounds—based on determinations of their individual risks and benefits, not on the mere presence of chlorine atoms in their molecular anatomies.

The battle is already resembling other struggles over environmental hazards, from Alar to electromagnetic fields. Both sides in the dispute admit that little is known about potential health and environmental effects of most chlorinated compounds. To industry and many scientists, there's no scientific basis for a blanket condemnation of chlorine compounds. Says Philippe Shubik, a cancer researcher and toxicologist at Oxford University, "Any scientifically based toxicologist finds that kind of general approach abhorrent." To environmentalists and their growing ranks of allies, though, circumstantial evidence of harm and the long wait for scientific certainty point to the need for broad action. Ellen Silbergeld, chief toxicologist for the Environmental Defense Fund and an epidemiologist and toxicologist at the University of Maryland Medical School in Baltimore, believes that the onus should be on industry to show that its various uses of chlorine yield more benefit than risk.

How many chlorovillains?

Chlorine's two-faced role as darling of the chemical industry and environmentalist bugaboo is rooted in its chemistry. Industrial chemists delight in the element's high electron affinity, which means it tends to draw electrons toward it. As a result, chlorine atoms generally react readily with electron-rich atoms including carbon, making carbon and chlorine one of the century's most versatile combinations for synthesizing molecular structures. The result is a vast menagerie of chlorinated organic chemicals that have found their way into virtually every industrial nook and cranny.

But chlorine also can endow compounds with troublesome properties. Chlorine's electron affinity stabilizes some chemical structures so that once the chemicals end up in the environment they don't break down. That's what goes wrong with CFCs, or chlorofluorocarbons, used



Tracing the genealogy of chlorine. Each chlorine-containing precursor compound finds its way into hundreds of products.

as refrigerants and industrial solvents. Chlorine's stabilizing influence makes these chemicals inert, nontoxic—and able to survive in the atmosphere until they are swept up into the stratosphere. There ultraviolet light helps to break them into molecular fragments that destroy ozone. Other chlorine compounds combine persistence with a tendency to accumulate in oily locations like fat tissue, where they can build up to toxic levels. Those properties were the Achilles' heel of DDT, an insecticide so effective against disease vectors, such as malaria-carrying mosquitoes, that the World Health Organization once regarded shortages of the chemical as threats to public health. A similar combination of stability and toxicity has consigned PCBs, or polychlorinated biphenyls—compounds used to insulate electrical equipment—to the ranks of the chlorovillains.

Even chlorine compounds that do not themselves persist in the environment, and presumably pose little long-term risk on their own, can break down into harmful molecules that do stick around. Take the elemental chlorine used to whiten paper and the volatile chemicals used to make PVC, two of the largest chlorine consuming activities. When these break down in the environment, they can spawn polychlorinated dibenzodioxins and polychlorinated dibenzofurans (PCDDs and PCDFs), which are suspected human carcinogens.

The antichlorine forces believe these hazards are the tip of the iceberg. Little is known about the health effects of thousands of other compounds, they point out. But they argue that parallels between the stable, fat-soluble chlorine compounds known to cause harm and the many hundreds of others with similar chemical properties warrant a precautionary stance. "There are no uses of chlorine that we regard as safe," remarks Thornton. Silbergeld, though she can't see banning chlorine entirely, has "a sympathetic view of the [inferential] argument," noting that plenty of untested compounds chemically resemble ones known to be hazardous. (The naturally occurring chloride ions in salt are not on the list of suspects.)

Even if the scientific case against chlorine is incomplete, say advocates of a ban, the regulatory track record suggests that an across-the-board ban is the only failsafe strategy for ridding the world of hazards still unknown. "You can't look at one compound at a time, because you end up being on a treadmill," says Rick Hind, legislative director for Greenpeace's Toxics Campaign. Bringing around the Environmental Protection Agency (EPA) won't be easy, though. The agency is considering common regulations for clusters of chemicals that emanate from the same industrial process, says Denise Keehner, deputy director of EPA's chemical control division. But Keehner adds that any generic regulatory action as broad as a blanket ban of chlorine is unlikely.

The activists at Greenpeace and elsewhere who view the thousands of chlorine-containing compounds in commercial use as a single class of chemicals non grata don't expect to achieve their aim with a single global ban. They are taking a piecemeal approach, hoping to move country by country and category by category. The antichlorine forces are delighted, for example, with a bill expected to be introduced in Congress this month by Representative Bill Richardson (D–NM). A draft of the bill would have required pulp and

To Switch or Not to Switch

The environmentalists and their allies who want to eliminate chlorine from industrial chemistry base much of their case on the hazards, known or suspected, of a few chlorine compounds (see main text). When their critics cite the key role chlorine-containing compounds play in industrial society, the antichlorine forces unveil another part of their case: the availability of what they say are workable, economical substitutes.

TOM HOLLYMAN/PHOTO RESEARCHERS

Troubled waters. Effluent from a paper mill.

To the defenders of chlorine, however, a chlorine-free world would be much more expensive, and not necessarily safer or cleaner. "You can substitute for anything, but why should you?" asks Fran Brown, an analyst with Charles River Associates (CRA), which produced an industry-commissioned report on the economics of chlorine.

Take polyvinyl chloride (PVC) plastics, which consume roughly one-quarter of the world's chlorine supply and serve as flooring, sidings, pipes, wire casings, and bottles. The antichlorine forces at Greenpeace and other organizations such as the International Joint Commission (a U.S.-Canadian body that recommends policy for the Great Lakes) argue that wood, metal, and chlorine-free polymers such as polyethylene terephthalate (PET) can take the place of PVC for most uses. That would eliminate health risks posed by carcinogenic chlorinated precursors and breakdown products of PVC. Sure, the switch is possible, say chlorine supporters, but the substitutes are often more expensive, less workable or durable, and have their own environmental baggage—the high energy cost of smelting metals, for example.

There's less argument about substitutes in the pulp and paper industry, which has traditionally bleached paper mostly with elemental chlorine. The industry is on the way to replacing straight chlorine with chlorine dioxide, which whitens less efficiently but also reduces the quantity of worrisome organochlorine compounds such as chlorinated dioxins and furans in mill effluent. A few companies, including Louisiana Pacific of Portland, Oregon, are moving to totally chlorine-free processes that rely on oxygen, ozone, and peroxide.

Another feasible swap, industry concedes, is that of ozone for the elemental chlorine bubbled through municipal water supplies to disinfect them. Ozone is a workable substitute for chlorine, which leaves behind chlorinated disinfection products such as chloroform, and it already disinfects about 1% of the U.S. water supply, says the CRA report. But the report claims it is somewhat less effective: It breaks down very rapidly and thus does not guard against recontamination. Moreover, the report claims that a general switch to ozone for treating drinking water and waste water would cost $6 billion per year.

Even if some substitutions are possible, says industry, other key chlorine-based materials—including more than half of the pharmaceuticals on the market—would be dauntingly hard to replace. And a broad effort to replace chlorine would be overwhelmingly expensive; the CRA report puts the price at $91 billion per year to United States' consumers alone. Environmentalist forces write off the CRA price figure as exaggerated. Meanwhile, they are trying to rally consumers to buy chlorine-free products. Market forces can push the chlorine phaseout, says Rick Hind, legislative director for Greenpeace's Toxics Campaign. "That's the most dynamic thing about capitalism."

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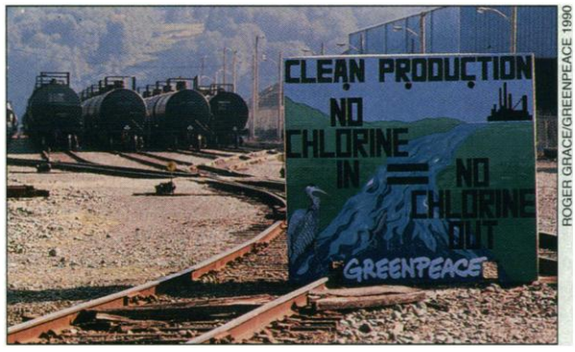
paper companies to phase out chlorine-based bleaching methods. Although industry is already on its way to doing so in response to the dioxin scare of the mid-1980s, the bill, if passed, would establish a precedent that chlorine could be banned for specific uses in the United States. Coming on the heels of the Montreal protocol, the international agreement to phase out CFCs, even talk of such a bill convinces the antichlorine camp that its cause is gaining momentum. "Next, we'll go after plastic and solvents," says Thornton of Greenpeace.

Industry might dismiss that as environmentalist bravado, were it not for the equally strong antichlorine position adopted last year by a government commission—the International Joint Commission (IJC), a treaty organization established by the U.S. and Canadian governments for the sound management of waters in the Great Lakes region. In its latest report, the IJC recommended that its member governments "develop timetables to sunset [phase out] the use of chlorine and chlorine-containing compounds as industrial feedstocks."

Behind the recommendation was a broad acceptance of the reasoning that, until now, has been advanced largely by environmental advocates. Gordon Durnil, one of the IJC's six commissioners, explains that the body's scientific panels and advisors convinced him and fellow commissioners that toxic chlorinated compounds are persistent enough in the Great Lakes region that a recommendation to phase them out is prudent. Half of 362 synthetic chemicals identified in the water, sediment, and/or biota of the region by the IJC's Water Quality Board several years ago, notes the recent report, were synthetic chlorinated organic substances. "Even though many of these substances have not been proven to be individually toxic, it is likely that many of these chemicals—because of their chemical characteristics—will be identified as persistent toxics," the report says.

"We could have made a recommendation that more study be done, as government advisory boards always do," remarks Durnil. "But we wanted to make sure that our recommendation would elicit action." The IJC's formal recommendation, which will be up for reconsideration by the commissioners this October, has served as a credibility windfall for the antichlorine movement. Although some of the IJC's advisers belong to environmentalist groups, the commissioners "are all [politically] conservative with a predisposed inclination toward industry," says Durnil. "The IJC lit up our life," admits Hind of Greenpeace.

The antichlorine movement is also gathering momentum abroad. In a report commissioned by the Norwegian Ministry of Environment and a few Norwegian industries, for example, John Ehrenfeld of MIT's Center for Technology, Policy, and Industrial Development and his colleagues list more than a dozen policy-making and advisory bodies in Europe that have either discussed or enacted antichlorine positions. The latest event to cement the political reality of the issue was the 19 April *Chemical & Engineering News*, which sported a cover with chlorine's chemical symbol, Cl, inside a circle with a slash running across it like a no-smoking sign. Inside, a 10-page article described the growing chlorine controversy and the correlations between organochlorine compounds and health problems.



Gas attack. Greenpeace blocks railway tracks carrying chlorine-filled tank cars into a factory.

The counteroffensive

Lienhart hopes to convince officials and the public that banning chlorine would be a disaster. One shot in the industry counteroffensive has already been fired by the Chlorine Institute. In April it released a report prepared by the Charles River Associates, a Boston-based consulting firm, that portrays chlorine's ubiquitous presence in industry, from purifying water to bleaching pulp and paper to making polymers, pharmaceuticals, inks, flame retardants, herbicides, and hundreds of other products. Substitutes for these products and processes, says the report, would place an enormous economic burden on consumers and industry, while providing no guarantees that the substitutes, if available, would be less risky to health and the environment (see sidebar). Also at risk, the report claims, would be many of the 1.4 million jobs in chlorine-related industries in the United States and Canada, and the $33 billion of collective wages these jobs represent.

What's more, another Chlorine Institute-sponsored report argues, the demonstrated hazards simply don't justify the expense and disruption that a generic chlorine ban would entail. The report, referred to as the "scientific principles report," is a summary of a much larger study prepared by CanTox Inc., a Canadian toxicology consulting firm. The report cites chlorine compounds that don't share the chemical characteristics of substances proven hazardous—they don't persist in the environment—and therefore are unlikely to pose serious problems. It also argues that chemicals of any kind become hazardous only when exposures rise above some threshold, which is different in each case. In the face of all this diversity, the CanTox report says, a blanket ban is scientifically unfounded.

Scientists, even ones who have studied the effects of environmentally hazardous chlorinated compounds, often echo that view. Mario Molina, an atmospheric chemist at MIT who, with Sherwood Rowland of the University of California, Irvine, first pointed out the CFC-ozone-depletion link in the early 1970s, agrees that a call for a total ban is going too far. "It isn't taken seriously from a scientific point of view," he says. The chlorine compounds that persist and accumulate in tissues or form harmful breakdown products make up "a small subset," he says.

Molina fears a total ban could backfire by depriving society of chlorine's benefits. "The underlying need for all of this is to make reasonable assessments of risk, and then tackle the problems that matter" on an individual basis. Otherwise, he says, "you could simultaneously tackle insignificant risks with large ones." Steve Safe, a Texas A&M toxicologist, agrees. Given how important many chlorinated compounds are, Safe adds, "calling for a ban of chlorine chemistry is irresponsible. It would be throwing the baby out with the bathwater."

Environmentalists admit that their scientific case against chlorine isn't airtight. "Little conclusive research is available on the effects of Great Lakes organochlorines on humans," wrote Thornton in a Greenpeace publication, *The Product Is the Poison.* To him and his fellows, however, the risk of delay—and of overlooking the risks of a future DDT or CFC—is too high to wait for certainty. Theo Colburn, senior fellow at the WorldWatch Institute, for example, argues that extra caution is in order because the environment is already so loaded with toxic substances. "We have reached the point where we should be concerned about releasing more," she says.

Whether both sides can cross this philosophical gulf toward a middle ground could become clear in September, when many of the players will be gathering in Washington for a Chlorine Forum, coordinated by the nonprofit Toxicology Forum. There, specific data on how much chlorine is where, what effects the organochlorine compounds have on the environment and living creatures, and critical analyses of those studies and their implications may help both camps of the chlorine controversy find some common ground. But Lienhart, for one, doesn't expect to be returning to Midland any time soon.

–Ivan Amato