Reuther/EHP

HOW DANGER

One afternoon last year, Karen Preul of Scottsdale, Arizona, was scooping wood chips from the pile in her backyard to put under her young children's play set. Such wood chips are made from recycled wood and in Arizona often serve as a cushioning barrier over the state's unforgiving soil. While shoveling she noticed a partially shredded rubberized plastic label sticking out of the pile. She pulled out the scrap of label and read the words printed on it: "WARNING: This wood contains chemicals known to the [text illegible] cause cancer, birth defects or other reproductive—" The rest of the warning had been ripped away.

In a panic, she called her husband, Mark, a physician who is the director of neurosurgery research at the Barrow Neurological Institute of St. Joseph's Hospital and Medical Center in Phoenix. He in turn contacted the Bakersfield, California, manufacturer that was listed on the mangled tag, who told him that the chemical mentioned on the label was chromated copper arsenate (CCA), a wood preservative. "A company representative told me that to shred this wood and have children playing on it is probably not a very good thing," Mark Preul says. "I was pretty mad about this, because my kids had played intimately on this wood."

That news started Preul on a trip through a gauntlet of scientists, federal and state regulators, and businesses including the wood preserver that originally treated the wood, the recycler, the company that chipped and packaged the used wood, and the play set manufacturer, which sells wood chips as an accessory. Ultimately two of the companies voluntarily removed the Preuls' wood chips and, at the urging of a state toxicologist, paid to have the top two inches of soil removed as well.

Mark Preul

"My problem has been solved, I hope," Mark Preul says. "Hopefully my children won't suffer any long-term problems from this. The real problem is for all these people out here who have play sets and, unlike myself, don't know that they may be manufactured from CCA-laced wood or come with ground cover made from shredded CCA-treated wood. These play sets have been around for a long time, and they are continuing to install them. What if you'd had a kid playing in direct contact with CCA-treated wood for years?"

The Preuls' predicament raises many of the questions surrounding the use of CCA-treated wood, particularly on playground equipment: Is it safe to use as designed? Should special precautions be taken for children who play near it? In normal use does it contaminate sites in which it is installed? And what are the risks of disposing of CCA-treated wood?

The Growth of CCA

Without some sort of chemical protection, most types of wood that are exposed to the elements will soon fall victim to persistent insects and microbial pests. During most of the twentieth century, creosote was the dominant wood preservative. But creosote has a strong odor, leaves an oily residue, and is toxic to humans. In 1986, the U.S. Environmental Protection Agency (EPA) declared it a restricted-use pesticide. Currently it is used almost exclusively to treat railroad ties and utility poles. A second oil-borne preservative, pentachlorophenol (or penta), is also used for demanding outdoor applications such as bridge timbers and livestock pens. Penta also contains toxicants, including dioxins.

The disadvantages and regulation of these earlier preservatives eventually resulted in CCA becoming the most commonly used wood preservative worldwide. But although CCA was developed in the 1930s, it wasn't until the 1970s that it gained widespread use with the popularity of decks, boardwalks, shelters, fences, and the substitution of wood for metal in children's play sets. For regions that have particularly invasive wood-eating insects such as termites, CCA-treated wood is also used for framing residential and commercial structures. In 1970, less than 1 million cubic meters (m^3) of CCA-treated wood was produced in the United States. By 1985 that number had increased to about 8 million m^3, and by 1995 to 14 million m^3. By 1993 more than

OUS IS CCA?

80% of treated wood was saturated with waterborne preservatives, and virtually all of that was CCA, according to a paper published in the *Proceedings of the 4th International Wood Preservation Symposium* by Carol Clausen, a microbiologist at the U.S. Department of Agriculture Forest Service's Forest Products Laboratory in Madison, Wisconsin, and Robert L. Smith, an extension specialist in forest products marketing at Virginia Polytechnic Institute and State University in Blacksburg.

CCA is by most accounts a safer and more aesthetically pleasing treatment than earlier chemicals. But it still a potentially hazardous material that must be applied under carefully controlled conditions. In production, as much as 250 liters/m^3 of CCA–water solution is forced into wood (usually Southern pine) under high pressure. This results in concentrations between 7,800 and 78,000 milligrams per kilogram. The arsenic repels insects, and the copper kills fungi. The chromium—which is hexavalent chromium when applied but converts to the more benign form, trivalent chromium, in the wood—fixes the copper and arsenic.

Fixation is a series of chemical reactions that starts when hexavalent chromium is reduced to trivalent chromium as the CCA solution is forced into the wood. The reduction of the hexavalent chromium results in precipitation and adsorption binding the copper, chromium, and arsenic to the wood. The degree to which the chemicals are fixed depends on the heat at which the wood is treated, how long it is treated, and the type of wood. "It takes some time for the chemicals to react with the wood, depending on the temperature," explains Paul Cooper, an associate professor of forestry at the University of Toronto. "And there's concern that if the material is not completely fixed, if the stuff is made in the winter when it takes a long time for these conversions to take place, it's conceivable that it could contaminate the yard or even get further afield into retail yards or to the home builder."

Trick or treat? Although dermal contact with the metals that leach from CCA-treated wood does not cause fatal illness, hand-to-mouth transfer can result in ingestion of carcinogenic chemicals.

Restricted Use

Arsenic and chromium can be toxic to humans, and all three metals can cause environmental damage. Of the top 275 hazardous substances listed by the Agency for Toxic Substances and Disease Registry as being present at EPA Superfund sites based on frequency, toxicity, and human exposure, arsenic was ranked first and hexavalent chromium sixteenth in 1997. As a result of contamination from CCA solution used at treatment plants, there are 51 wood preservation sites on the EPA Superfund National Priorities List.

Based on its potential health hazards, CCA is regulated as a restricted-use pesticide by the EPA Office of Pesticide Programs. (This office is currently conducting a regularly scheduled review of CCA that is expected to be finalized in 2003.) But because CCA is presumably fixed in treated wood, the treated products themselves are not regulated. Some industry professionals warn, however, that the chemicals are neither harmless nor fixed in the wood permanently. "Heavy metals are forever," says Duane Duncanson, a specialist with the Minnesota Pollution Control Agency in St. Paul. "Year after year all these pounds of arsenic come [into Minnesota], and they're either in use, have leached out of the product into the soil and water, or are in a landfill as waste wood. But it's not leaving."

Copper, except in extremely high doses, is considered nontoxic to humans. The other two metals are more problematic, with arsenic getting most of the attention from environmentalists and health professionals. If ingested, a small dose of inorganic arsenic (70–170 milligrams) is fatal to humans. Although a small amount of ingested arsenic can be fatal, the amounts of arsenic found on the surface of CCA-treated wood are a thousand times less than a potentially fatal dose. Still, inorganic arsenic—a result of elemental arsenic combining with oxygen, chlorine, and sulfur—is classified as a known human carcinogen by the National Toxicology Program and other federal agencies. Arsenic has been a suspected carcinogen since the late 1800s, when unusual numbers of skin tumors developed in patients who were treated with arsenicals. More recent studies link it to bladder, kidney,

Image Ideas

nasal, liver, prostate, lung, and skin cancers. Noncancer repercussions of ingesting arsenic include cardiovascular, pulmonary, immunologic, neurologic, and endocrine disruption effects.

Hexavalent chromium has been classified as a known human carcinogen, but considerably less attention is paid to the chromium in CCA because the treatment process converts it to the more benign trivalent chromium. Hexavalent chromium from CCA is sometimes released to the environment, however; if during the pressure-treating process the hexavalent chromium isn't fixed completely and converted to the more benign trivalent form, it can leach out of the wood in its original form.

Workers in the pressure-treated wood industry can potentially contact or inhale hexavalent chromium, but studies specific to the industry thus far have not demonstrated elevated risks. A 1981 study funded by the American Wood Preservers Institute (AWPI) of Fairfax, Virginia, the lobbying arm of the pressure-treated wood industry, found "no adverse health effects or increased incidence of mortality" in a group of industry workers in Hawaii. And a 1995 study published in the *Proceedings of the 3rd International Wood Preservation Symposium* and conducted over a 20-year period found no increased risk of cancer in Scandinavian wood preservation workers.

Even if virtually all of the chromium is fixed, however, the metal can revert to the hexavalent form. Research published by Cooper and colleagues in the February 2001 issue of the *Forest Products Journal* demonstrates that certain deck-brightening washes both leach metals from CCA-treated wood and oxidize the trivalent chromium back into the hexavalent form. Other projects have shown that hexavalent chromium leaches from CCA-treated wood, including a 1990 study by scientists from the University of Guelph in Ontario, published in volume 9 of *Environmental Toxicology and Chemistry*, that showed that leaching of chromium increased as the pH of a deck-washing solution was lowered. "You can liberate the trivalent chromium," Cooper explains. "You can oxidize it to hexavalent chromium if you treat the wood with an aggressive oxidizing agent like a bleach, which is a component of some of the deck washes and deck brighteners."

The past decade or so has seen a marked increase in research on the potential effects of CCA-treated wood on human health and the environment. "We have found through the research that has been done that we're finding problems in four broad areas," says Bill Hinkley, chief of the Florida Department of Environmental Protection's Bureau of Solid and Hazardous Waste. "We're finding problems with the ash. We're finding problems with mulching. We're finding problems with the disposal of CCA, particularly in unlined construction/demolition landfills. And lastly we're finding that arsenic leaches out of CCA-treated wood into the environment at levels that are higher than most people realize and are resulting in contamination of the soil under decks."

Much of this research, Hinkley says, was spurred by projections of a virtual flood of used CCA-treated wood that soon will enter the waste stream. Widespread CCA use started about 30 years ago and, according to some estimates, CCA wood has an expected service life of 20–50 years. The result is that CCA just recently began to enter the waste stream in significant quantities. Some researchers, including Rodney DeGroot, a research plant pathologist at the Forest Products Laboratory, estimate that by 2020, 19 million m^3 of treated wood—most of it CCA-treated—will have to be either disposed of or recycled.

Other industry professionals, however, believe that the expected service life is much shorter, although they disagree about the implications of an abbreviated life cycle. Mel Pine, communications manager for the AWPI, says that although CCA-treated wood can last 50 years or more, its practical life is probably less than a decade. That's because, he says, people remodel frequently. And sometimes CCA-treated wood—which is brittle and prone to cracking and splintering—is replaced for purely aesthetic reasons. As a result, Pine says, significant quantities of CCA-treated wood began entering the waste stream 20 years ago. However, he believes that the amount of CCA-treated wood entering the waste stream is about to peak and that there will not be a significant increase in the future. "We think that we are much closer to the top of the bump than [other researchers] do," he says. But Clausen says that a shorter practical life simply means more wood entering the waste stream, which leads to a bigger bulge even sooner than projections that depend on a 30-year life.

Leaking in Landfills

Virtually all discarded CCA-treated wood ends up in landfills, where it's likely to leach chemicals into the landfill and possibly beyond, says Tim Townsend, an assistant professor of environmental engineering sciences at the University of Florida in Gainesville. "There is good reason to think that it might be a problem in unlined landfills," he warns. When the wood decomposes, whether in a landfill or on site, the component chemicals are released. Laboratory and field research has demonstrated that new and aged (but not rotting) CCA-treated wood can leach significant quantities of metal. David Stilwell, a chemist with the Connecticut Agricultural Experiment Station in New Haven, has tested the soil beneath decks and highway sound barriers. "We found elevation of copper, chromium, and arsenic," he says. The arsenic concentrations under six out of seven tested decks exceeded state limits, and four exceeded the stricter EPA regulatory cleanup guidelines. Stilwell's data, published in 1997 in volume 58, issue 1, of the *Bulletin of Environmental Contamination and Toxicology*, indicate that the amounts of chemicals found under decks tend to increase with the age of the deck.

Some industry representatives, including Pine, say that a large portion of the chemicals found under CCA-treated decks originates not from the structures themselves, but from sawdust and other debris generated during construction. But, Stilwell says, the chemicals found under structures in the field appear in proportions that reflect the rate at which they leach. "If [the chemicals] were from sawdust that had degraded, you would expect the ratio to be the same as the ratio that is in the wood," he says. Laboratory studies by Stilwell, Stan Lebow, a forest products technologist with the Forest Service, and Townsend—all working independently—have also demonstrated similar amounts of leaching under a variety of conditions. And in Florida, Townsend says, the same concentrations that are occurring beneath decks are greater than those to which some industries are being forced to clean up their sites.

Of particular concern, Townsend says, are laboratory data indicating that leached metals could contaminate groundwater and eventually drinking water. And Hinkley worries in particular about the quality of Florida drinking water, which in some areas is drawn from private wells drilled as shallowly as 20 feet into sandy soil. Florida relies heavily on groundwater as a source of drinking water. In fact, over 90% of the state's drinking water comes out of the ground.

Some types of arsenic do not move readily through most soils. Arsenate binds strongly with iron oxyhydroxides and so is relatively immobile in soil that is rich in iron. Arsenite binds less strongly and is more mobile. But in soils that are not rich in iron, such as sand or some landfill environments, arsenic can pass into the groundwater rather than bind to the soil. Trivalent chromium also binds to soil, says Cooper. But if the trivalent chromium converts back to the more mobile and more toxic hexavalent form, "some [of it] will move at the speed of the groundwater," Cooper says.

According to Pine, it's a leap to assume that any of these materials—particularly those in landfills—will ever reach groundwater. "We don't see evidence from what's been studied so

Under the boardwalk. University of Florida students measure arsenic under CCA-treated wood structures to gauge the extent to which the metal leaches from treated lumber. Although the chemicals in CCA are largely fixed in treated wood, problems arise when the lumber degrades or is burned at the end of its usefulness. The length of the service life of CCA-treated wood is debated, but most experts agree that an influx of the material will soon hit the waste stream.

Helena Solo-Gabriele

Jon M. Fletcher/*The Gainesville Sun*

Cancerous kid stuff? Higher-than-background concentrations of arsenic were found in the soil under this Gainesville play area, which was then razed.

far," he says, "that the arsenic is leaching out of landfills and getting into water tables or anything like that." Townsend, however, warns that current practices are likely to lead to a tainted water supply over the long term. "My guess is that there will be a number of landfills [where], if they were to continue to accept treated wood even at the current levels and not necessarily the growing future levels, you'll see some contamination [of groundwater]," he says. "We're going to need 10 years' worth of monitoring data to begin to see whether or not the laboratory holds true. And the question is, do we really want to wait around that long?"

Regulating CCA

When CCA leaches, some of the arsenic stays on the wood's surface, where it can cause a variety of health problems if touched. Touching this arsenic can cause skin lesions, skin ulcers, and, if transferred to the eyes, conjunctivitis, according to the EPA Material Safety Data Sheet for CCA. But the amount of arsenic at the wood's surface can vary widely. In wipe tests, Stilwell found that arsenic that dislodged from new CCA-treated planks onto nylon wipes ranged from 7 to 122 micrograms per square centimeter (μg/cm^2) and averaged 35 μg/cm^2, while children's playscape surfaces ranged from 2 to 45 μg/cm^2 and averaged 8.8 μg/cm^2. Stilwell also measured dislodgeable arsenic from vertical playscape surfaces (poles) by direct hand contact and found the amounts removed ranged from 5 to 632 μg/cm^2, with averages of 105 μg/cm^2. (These findings were also published in the 1997 *Bulletin of Environmental Contamination and Toxicology* article.) Although dermal contact with arsenic or chromium isn't thought to cause cancer or other fatal illnesses, health experts caution that hand-to-mouth transfer, which is especially common among young children, can result in ingestion of the carcinogenic chemicals.

With this possibility in mind, 10 years ago the Consumer Product Safety Commission (CPSC) conducted a series of tests to gauge the risks to children of contact with CCA-treated play sets and published the results in the 1990 report *Estimate of Risk of Skin Cancer from Dislodgeable Arsenic on Pressure Treated Wood Playground Equipment*. The CPSC found that the risk of skin cancer through ingestion of arsenic dislodged from playground equipment ranged from less than one in a million to nine in a million. The samples associated with the highest risks were the ones purchased at retail stores, suggesting that "a possible hazard might be created when playground equipment is built with unfinished pressure-treated wood from retail sources." As the popularity of CCA-treated materials has increased, so has media coverage of the potential health hazards and with it a growing concern by advocacy groups and citizens.

Two years ago in Gainesville, for example, Kidspace, a CCA-treated structure at Terwilliger Elementary School, was scrapped in part because of concerns about higher-than-background concentrations (0–7 parts per million) of arsenic detected in the ground beneath it. According to a 25 March 2001 article in *The Gainesville Sun*, Scott Ramminger, president of the AWPI, said that the cleanup was not necessary. "Background levels of arsenic in soil average around five parts per million nationwide," Ramminger said. "Background levels of fifteen to twenty parts per million are not unusual." And the Walt Disney Company elected to use a less toxic alternative wood treatment for its Disney World Animal Kingdom theme park out of concern that the animals might be harmed by chewing on CCA-treated wood.

On 23 May 2001, the public interest groups Healthy Building Network and Environmental Working Group petitioned the CPSC to ban arsenic-treated wood in playground equipment and to review its safety in other consumer items. Concurrent with the request, the groups released a report titled *Poisoned Playgrounds: Arsenic in Pressure Treated Wood*. Citing findings of the

report, Environmental Working Group analyst Renee Sharp says, "In less than two weeks, an average five-year-old playing on an arsenic-treated play set would exceed the lifetime cancer risk acceptable under federal pesticide law."

In fact, there are few limitations on how CCA-treated wood can be used in the United States. During the 1980s, the EPA concluded that CCA-treated wood did not pose unreasonable risks, based on studies that demonstrated that the materials in CCA are not readily absorbed through the skin. Federal rules exclude the arsenic and chromium in CCA from leaching tests and limits—called the toxicity characteristic leaching procedure—that apply to other similar toxic substances. Because of this exclusion, CCA-treated wood is not classified as hazardous waste under the Resource Conservation and Recovery Act, and users are not required to dispose of scrap wood in any special way. CCA-treated wood can be used anywhere out-of-doors and in interiors, except in areas where it would be likely to contaminate food. Recognizing that there were potential risks to workers and end users, in 1985 wood treatment industry representatives and the EPA agreed that consumer information sheets would be provided to anyone who purchases CCA-treated wood.

But according to industry and consumer advocates alike, more often than not the strongly worded sheets—containing warnings of potential health effects including death—don't reach the consumer. Recently, the AWPI proposed implementing new consumer awareness measures on CCA-treated wood including placement of individual tags with specific safe handling information on each piece of CCA-treated lumber before it is sold. The proposal also describes measures such as displaying information stickers and signs in stores and establishing a consumer toll-free hotline to provide consumers with information on CCA.

Industry is not the only one taking steps to respond to the recent outcry against CCA-treated wood in playgrounds. The EPA is currently conducting a comprehensive assessment of CCA-treated wood including an expedited assessment of children's exposure to CCA-treated wood in playgrounds. This peer-reviewed evaluation will consider all available scientific data. The EPA expects to complete its draft children's exposure assessment by the end of the summer.

Over the years several states and municipalities have introduced legislation ranging from outright bans on CCA-treated wood to limits on usage in specific environments. The *Gainesville Sun* article describes how in 1999 in the town of Eastham on Cape Cod, for example, residents concerned with the effect of the copper in CCA on marine life voted to require that all new docks be made with non-CCA-treated wood. In Minnesota a bill has been introduced that would ban the use and sale of CCA in the state. A second Minnesota bill would require that schools that use CCA-treated products seal the wood every two years. The state of California prohibits the use of state funds to purchase CCA-treated wood playground or recreational equipment unless the materials have been sealed. According to Stilwell, such coatings are in fact effective. His research demonstrated that sealants such as acrylic, polyurethane, and spar varnish can reduce the amount of arsenic that leaches by as much as 95%.

Although few rules govern CCA-treated wood directly, some federal rules have an indirect but profound effect on the way CCA is used. For example many states, such as Florida, match their groundwater limits for arsenic to the federal limits for arsenic in drinking water.

The current federal level of 50 parts per billion (ppb) for arsenic in drinking water was first set by the U.S. Public Health Service in 1942 and then reconfirmed in 1962. Effective in 1977, the EPA set the same standard as a National Interim Primary Drinking Water Regulation. In 1996, Congress directed the EPA to propose a new standard by 1 January 2000 and to issue a final standard no more than a year later. Relying primarily on research collected by the National Academy of Sciences, the EPA initially proposed a new standard of 5 ppb before settling on a final standard of 10 ppb, which would have become effective 22 June 2001. Soon after the standard was published, however, the AWPI, concerned that the standard would cripple the wood treatment industry, filed a legal action to petition the EPA to return to the previous standard. Three weeks later, on 20 March 2001, EPA administrator Christie Whitman, at the direction of President George W. Bush, announced that the EPA would propose withdrawing the new standard. During the delay of implementation of the standard, the EPA plans to pursue independent reviews of the science behind the standard and of the estimates of its financial impacts on communities most affected by it.

According to Allan Smith, a professor of epidemiology and director of the arsenic research program at the University of California at Berkeley, these regulatory interconnections often spur companies to attack drinking water standards rather than more appropriate targets. "They should say that the laws that govern them having to meet the drinking water standards are the problem," Smith says. "I find it a little ludicrous what the companies are doing. Instead of opposing that they have to meet the drinking water standards, they oppose the actual drinking water standard, and they oppose the scientists who do the work on which it's based."

Even the state of Florida, which produces its own pressure-treated wood for such applications as highway guardrails and until now has relied on CCA, is considering alternatives. Responding to increasing public concern over reports of arsenic leaching from wood, Florida governor Jeb Bush vowed in March of 2001 to switch the state's treatment plant to a formula that doesn't rely on arsenic.

Problems with Disposal

One key to keeping arsenic and hexavalent chromium out of soil and groundwater is to keep CCA materials out of landfills in the first place, says Hinkley. And for CCA-treated lumber that is already in service, that means recycling or incineration. But numerous problems are associated with burning the wood.

Incineration does generate energy and reduce the volume of material that must be disposed of, but the resulting ash is rich in arsenic and chromium. A 12-foot length of 2-by-6 lumber treated with CCA contains about an ounce of arsenic, m ost of which, when burned, is concentrated in the ash. A typical power pole contains about 40 pounds of arsenic. If a batch of incinerated wood includes more than 3–6% CCA-treated materials (depending on the concentration of metals in the wood), the resulting ash will fail the Supreme Court–mandated toxicity characteristic leaching procedure test for arsenic and must be treated as hazardous waste. Burning also releases arsenic in its dangerous gaseous form as it creates particles that are so small—less than 1 micrometer in diameter—that they slip by conventional pollution controls. To incinerate CCA-treated wood properly requires very expensive and sophisticated pollution control systems to treat these smokestack gases.

Avoiding CCA-treated wood, whether at a landfill entry or municipal incinerator, can be exceedingly difficult, says University of Miami assistant professor of civil and environmental engineering Helena Solo-Gabriele. Although heavily treated new wood is strikingly green, woods treated at lower levels are less distinctive. And as the wood ages, the green color fades, making it difficult to distinguish treated from untreated wood. "The problem is that most of the wood that gets disposed of as lumber and timber is the lower retention levels," Solo-Gabriele says. "And especially if the wood

PhotoDisc

Reaching for alternatives. New disposal methods and alternative treatment products may be the solution to problems associated with CCA-treated wood.

has been soiled and is dirty, it is difficult to see whether it has a green tinge to it."

At research facilities such as the University of Miami, the University of Florida, and the Forest Products Laboratory, scientists are investigating a multitude of recycling strategies for CCA-treated wood [see "Special Treatment: Disposing of CCA-Treated Wood, p. A274 this issue]. But currently the most common technique is decidedly low-tech and, says Townsend, high-risk. In Florida, which uses 15% of the nation's CCA-treated lumber, discarded CCA-treated wood is chopped and dyed to resemble cedar chips or tree bark, and then sold as a decorative mulch. Like construction debris or sawdust, mulch has much more exposed surface area than intact lumber and so is more prone to leaching metals. "It causes the soil underneath to exceed currently available risk levels for what we consider clean soil that is fit for anybody's use," Townsend says. "It exceeds Florida's [standards] by over an order of magnitude." This mulch also often finds its way into hobby gardens—a potential risk, says Stilwell. Romaine lettuce grown in arsenic-rich soil, for example, will store 4–10 µg of arsenic per serving, which, he says, "could equal what one would already be consuming in the diet otherwise."

Alternatives to CCA

"One way to address disposal problems is to go back to the source of the problem and look at ways to substitute CCA with other materials," says Solo-Gabriele. In other countries—such as Japan, Indonesia, Denmark, Germany, and Switzerland—that have banned CCA or have restricted it severely, alternatives have filled the need for preserved wood. These waterborne alternatives, which do not rely on arsenic or hexavalent chromium, include ammoniacal copper quaternary (ACQ-A and ACQ-D), amine copper quaternary (ACQ-B), alkyl ammonium compound (AAC), ammoniacal copper citrate (CC), copper dimethlydithiocarbamate (CDDC), and inorganic boron (SBX). Each of the three major CCA manufacturers in the United States offers a nonarsenical waterborne alternative.

According to Huck DeVenzio, marketing director for Arch Wood Protection of Smyrna, Georgia, CCA-free countries have readily accepted Arch's patented formulation of copper azole in which copper is the principal active insecticide, organic azole is the fungicide, and boron provides supplemental protection. Similarly, Osmose of Buffalo, New York, sells disodium octaborate tetrahydrate, and Chemical Specialties of Charlotte, North Carolina, sells ACQ-D, which can replace CCA in almost any application. The catch, though, is that in the United States, finding wood treated with any of these products is difficult. Just 2 of the hundreds of the country's wood treatment facilities use copper azole, and just 10 use ACQ-D. According to DeVenzio, because all of the alternatives add 10–15% to the cost of treated wood, CCA will continue as the primary treatment chemical in the United States until government regulations force a change or other market forces, such as concerns over safety, increase demand for alternatives.

In some areas, demand for alternatives is indeed growing, according to Patrick Bischel, president of Northern Crossarm Company of Chippewa Falls, Wisconsin, a pressure-treated wood producer. Concerned about the health of his employees and the environment, seven years ago Bischel converted one of his plants from CCA to ACQ and four years ago converted his remaining plant. "As the business developed we found that the consumer was not opposed to paying a slightly higher price for the product," he says.

According to Townsend, within the next decade the United States will follow the lead of other countries that now depend on alternatives. "I think that ultimately we're not going to use arsenic-treated wood," he says. "It's not a sustainable practice. We as a society have got a lot of things to remove as hazardous materials. We stopped using lead-based paint in residential construction. We stopped using lead in gasoline. We stopped using mercury in our batteries for the most part. All of these things are steps to reduce the emissions to the environment of these chemicals that we know are bad."

Scott Fields