Green Chemistry at Work 2

California Businesses Making Products Safe from the Start

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California Businesses Making Products Safe from the Start

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Executive Summary

Leading California businesses are showing that consumer products don't have to contain toxic chemicals, threaten public health, or produce large amounts of waste. Safer alternatives exist, and they work. Companies that design their products to be safe from the start are seizing new business opportunities, gaining access to new markets, improving efficiency, and saving money—all of which gives them an edge over their competitors. These businesses are also building momentum for a new green chemistry industry in California.

This report highlights seven Golden State businesses that are identifying unnecessary hazards in their facilities, in their manufacturing processes and in the products they sell—and acting to eliminate them. They join many other businesses (including 12 profiled in Environment California Research & Policy Center's 2010 report, *Green Chemistry at Work*) that are making Californians healthier and succeeding in the marketplace by following the principles of green chemistry.

However, the use of safer alternatives to toxic chemicals in commerce remains the exception, rather than the rule. California can protect public health, safeguard our environment, help companies remain competitive in the global marketplace, and set an example for the rest of the nation by finalizing the Safer Consumer Products Regulations, a key part of the state's Green Chemistry Initiative.

When California businesses and institutions think seriously about how they design, manufacture or use products, they find opportunities to use safer alternatives—reducing hazards to workers and public health, preventing pollution, saving money,

and creating markets for new and innovative products. For example:

- **Johnson & Johnson**, a worldwide family of companies including Los Angeles-based skin care company **Neutrogena**, pledged in 2012 to remove a host of problematic chemicals from its consumer products by the end of 2015. For example, the company plans to remove phthalates—toxic chemicals linked to reproductive and developmental damage—from hair spray, and to remove ingredients that may expose consumers to carcinogens such as formaldehyde or 1,4-dioxane. The company plans to develop alternatives and test them to ensure they are safer, positioning itself for future market advantage.
- **Sherwin-Williams** developed a paint using soybeans, winning a Presidential Green Chemistry Challenge award from the U.S. Environmental Protection Agency in 2011. The paint produces less air pollution during and after application, helping California to prevent unhealthy smog, and enabling businesses across the state to meet air quality management district regulations.
- **IBM,** which has a major research center in San Jose, eliminated two toxic perfluorinated chemicals from its semiconductor manufacturing process in 2010. The chemicals do not break down in the environment and accumulate in the food chain, where they may contribute to developmental health problems, including premature birth.
- Green chemistry isn't just creating opportunities for manufacturers, but it has also sparked new types of businesses that can help eliminate hazardous chemicals in California's broader economy. **Chemical Safety Software**, based in Emeryville, developed technology to help researchers, chemists, product manufacturers and facilities managers identify substances of concern in every stage of the supply chain, from production to disposal, and replace them with safer alternatives.
- Many **Trader Joe's**-brand canned food items come in cans that are free from bisphenol A, a chemical linked to a wide variety of harms, including obesity, low sperm count, miscarriage, diabetes and cancer.

There are major challenges for companies seeking to create safer products. California needs strong Green Chemistry Initiative policies to promote widespread adoption of safer alternatives to toxic chemicals. Existing state and federal chemical policies have key weaknesses—termed the "data gap," the "safety gap" and the "technology gap" by experts at the University of California, Berkeley.

- **The data gap:** Existing chemical policies allow manufacturers to sell a chemical or product without studying or sharing information about its potential health or environmental hazards. As a result, consumers and businesses have difficulty knowing what ingredients are in a product, whether those ingredients are safe—or even knowing whether an alternative to a hazardous chemical is actually safer.
- **The safety gap:** Additionally, under existing policy, state regulators are unable to take effective action to address known hazards. As a result, California businesses may be allowed to sell products made with

toxic ingredients banned in other countries.

- **The technology gap:** Finally, existing policy fails to promote adequate investment in green chemistry research, development, education and technical assistance.

California's Green Chemistry Initiative is a great first step toward addressing some of these weaknesses. The initiative created the Safer Consumer Products Regulations, which will require manufacturers to seek out safer ingredients for their products. These regulations will help level the playing field for companies that are already working to do the right thing.

- The Department of Toxic Substances Control (DTSC) should finalize the Safer Consumer Products Regulations immediately and move quickly to expand its analysis and regulation beyond the five initial product-chemical combinations slated for analysis in the first years of the program to comprehensively address the thousands of additional chemical hazards used in California.

Policymakers must do more to protect consumers from chemical hazards in California's marketplace, both now and in the long term. In addition to finalizing and strengthening the Green Chemistry Initiative, policymakers should:

- Support green chemistry research, development and technical support to help develop a supply of safer, green chemistry alternatives.
- Require chemical manufacturers to demonstrate that a chemical is safe before allowing it on the market. This will help break the cycle of replacing one toxic substance with another and ensure that safer alternatives are actually safer.
  - Regulators should require companies to provide comprehensive data on the intrinsic hazards of chemicals that they produce or import into California.
  - Chemical testing should include specific consideration of potential impacts on infants, children and pregnant women; potential impacts of low-dose exposures; and potential interactions with other toxic chemicals.
  - The reliability and adequacy of the information should be validated by government scientists and/or an independent third party free of conflicts of interest.
  - Allowances for ingredient secrecy based on claims of "confidential business information" should be limited.
  - Where there is uncertainty in the evidence, regulators should err on the side of protecting health and the environment by not allowing the product on the market.
- Ensure public access to information on chemicals and their uses.
  - The public has a right to know about chemicals currently on the market, including their specific uses, potential hazards to health and the environment, and potential routes of exposure. When finalized, the California's Toxics

Information Clearinghouse, created by legislation in 2008, should be an easily understandable database of all chemicals currently in use. This tool should enable businesses and consumers to compare the safety of chemicals, identify missing data, and create demand for safer alternatives.

- Until health and safety data are available for a particular chemical, there should be mandatory labeling for consumer products indicating the presence of a chemical that has not been tested for its impact on human health.

"By changing chemicals policy to help create demand for safer chemicals, the Green Chemistry Initiative can help develop a new green chemistry industry in the state…"

If effectively implemented, California's Green Chemistry Initiative can help ensure that consumers have access to safer products. By changing chemicals policy to help create demand for safer chemicals, the Green Chemistry Initiative can help develop a new green chemistry industry in the state, driving investment and employment in developing safer ways of doing business and helping California companies to remain competitive across the globe.

Introduction

In August 2003, California passed legislation banning the sale of two forms of a toxic flame retardant commonly used in furniture and plastics found in every California home, illustrating the dilemma society faces when it comes to the use of toxic chemicals in commerce.

On one hand, the ban represented the triumph of a basic principle of government: individual states have a duty to protect the health and well-being of their residents.

On the other hand, this action revealed a profound failure. By the time the evidence of harm was strong enough to motivate action, exposure had already become widespread. Flame retardants are still pervasive in most homes. In fact, these chemicals are widely distributed across the planet, from the blubber of Arctic seals to the breast milk of mothers in California. The levels of the chemicals found in some mothers and fetuses have reached levels shown to impair learning and behavior in laboratory experiments with animals.[1]

State legislatures in about a dozen states, including California, have passed bans on polybrominated diphenyl ethers (PBDEs), toxic chemicals used as flame retardants.[2] By the time these bans were put in place, however, product manufacturers had grown accustomed to using these chemicals, and the chemical industry profited from their sale. The industry has therefore spent millions of dollars on lobbying and campaign contributions to block other attempts to regulate flame retardant chemicals, including attempts to ban "deca"-PBDE, which remains legal in most of the United States.[3] In California alone,

flame retardant manufacturers spent $23 million between 2006 and 2011 to defeat the legislature's last five attempts to regulate these chemicals.[4]

The case of toxic flame retardants in California reveals a pattern of widespread exposure before regulatory action, a pattern that could be played out repeatedly with dozens, if not hundreds, of chemicals commonly used in consumer products. Flame retardants are just one class of roughly 83,000 industrial chemicals in EPA's Toxic Substance Control Act inventory, the bulk of which were already on the market before the first toxics regulations in the 1970s; at least 62,000 remain on the market today.[5] The health effects of almost half of the major industrial chemicals have not been studied at all.[6] Of those that have been studied, approximately 1,400 chemicals with known or probable links to cancer, birth defects, reproductive impacts and other health problems are still in use today.[7]

Manufacturers can reduce their use of these chemicals through smarter product design and by using safer ingredients. Green chemistry is a design philosophy that emphasizes the design of chemicals, processes and goods that cause little or no harm to public health or the environment during manufacturing, use or disposal. This helps eliminate chemicals that persist in the environment, accumulate in the food chain, have toxic properties, or pose a threat to workers or public health.

In 2008, California took a major step to encourage green chemistry. Assemblymember Mike Feuer saw the need for a comprehensive approach to address Californians' over-exposure to toxic chemicals. He introduced and passed—with bi-partisan support—the state's landmark Green Chemistry Initiative. The legislation provides a regulatory framework to encourage the widespread adoption of green chemistry practices throughout the state's economy and to discourage manufacturers and retailers from acting without considering the risks posed by their products.

In its 2010 *Green Chemistry at Work* report, Environment California Research & Policy Center highlighted 12 Golden State businesses that demonstrate that green chemistry works. Safer alternatives or manufacturing approaches exist. This report profiles more companies that integrate these approaches and seize opportunities to simultaneously improve human health and their bottom line.

It is time to implement the Green Chemistry Initiative in a way that can help more companies doing business in California protect consumers' health and well-being from toxic chemicals, all while growing their businesses and strengthening the state's economy.

The Case for Green Chemistry

Historically, product manufacturers and chemical suppliers have designed their products based strictly on functionality and cost, often with little regard to public health, environmental concerns, or worker health or safety. This approach has led to a wide array of problems, from the proliferation of toxic chemicals that can now be found in practically every human being, to pollution that contaminates our environment, to lead paint in homes. Compounding the problem, chemical regulatory policy in the United States has failed to give regulators enough tools to address obvious problems in a timely fashion—or, in many cases, to even address them at all.

Fortunately, a new design and business philosophy aimed at making products and manufacturing processes safe from the start has begun to take root in California. This philosophy, known as green chemistry, is penetrating the business world, changing the way California companies think about designing and manufacturing products. It is also beginning to transform the state's approach to regulating toxic chemicals, through the state's pioneering Green Chemistry Initiative.

Toxic Chemicals Threaten Our Health and Our Environment

From plastics to pesticides, the world contains potentially hazardous synthetic substances in far greater amounts today than at any time in human history. There are tens of thousands of industrial chemicals on the market in the United States, but almost half of these chemicals have

never been studied for their health effects.[8] Of those that have been studied, approximately 1,400 chemicals with known or probable links to cancer, birth defects, reproductive impacts and other health problems are still in use today.[9]

The Disease Burden Is Rising

Although it is usually impossible to show that a single chemical is the cause of a broad health trend, the evidence continues to mount that toxic chemicals have a significant impact on the health of both children and adults:

- In children, the National Academy of Sciences estimates that toxic exposures play a role in at least one in four cases of developmental disorders.[13]
- More than 2 million adults (7.6 percent) and more than 800,000 children (8.6 percent) in California have asthma.[14] Nearly one-fourth of all deaths in California are caused by cancer.[15] Both cancer and asthma have strong links to a variety of chemical exposures in outdoor air in cities and the air inside homes.
- Across the U.S., scientists estimate that occupational hazards, such as exposure to toxic chemicals or pollution, lead to more than 800,000 new cases of cancer, cardiovascular disease or lung disease annually—costing the economy more than $25 billion a year.[16]

State and Federal Chemical Policies Are Inadequate to Protect Californians

Regulators have few effective tools to protect public health from chemical hazards or address the broad impacts of the way companies design and manufacture goods.

When Congress passed the Toxic Substances Control Act in response to the PCB crisis 30 years ago, the chemical

The Home as a Toxic Environment

Not all toxic chemicals enter the environment dripping from a factory waste pipe, leaking from a hazardous waste dump at the edge of town, or billowing into the air from an incinerator smokestack.

Many times more chemicals are shipped from factories to homes, contained within consumer products, than are spilled or dumped into the environment. Massachusetts, one of the few states where companies are required to report the amounts of chemicals they use and ship in products, provides a good illustration. In Massachusetts in 2009, for every pound of chemicals produced as a byproduct or released into the environment, eight pounds were distributed in manufactured products.[10]

In addition, most upholstered furniture made before 2005 contains toxic flame retardants (PBDEs), and these chemicals are still used in electronics today.[11] These chemicals can contaminate household dust, which is the primary vehicle of PBDE ingestion, especially among young children because of their hand-to-mouth behavior.[12]

Regulations are needed not only to reduce the discharge of toxic chemicals into the environment, but also to prevent toxic chemicals from ending up in our homes.

industry succeeded in making sure there were no new testing requirements placed on the tens of thousands of chemicals already in use. For new chemicals, the law required only a rapid pre-manufacture screening based on existing information, and generally did not require toxicity testing for health effects. As a result, the burden of demonstrating that a chemical is unsafe fell on the EPA and the scientific community.

The current approach to chemical regulation is far less stringent than the process for approving drugs, where the U.S. Food and Drug Administration requires manufacturers to demonstrate safety and effectiveness before a new drug can be placed on the market.

As a result, U.S. chemical regulation stumbles blindly, using an "innocent until proven guilty" model, allowing widespread exposure to toxic chemicals before they have been tested for safety. Moreover, where significant evidence of harm to public health already exists, inadequate resources and legal authority often prevent regulatory agencies from taking protective action.

Green Chemistry Seeks to Make Products Safe from the Start

Green chemistry is a design and business philosophy that seeks to address the problems associated with the production, use and disposal of chemicals by making products and processes safe from the start. Many businesses that sell products in California have voluntarily begun to adopt green chemistry design principles, helping protect consumers in the absence of strong chemicals policies at the state and national levels. In 1998, Paul Anastas and John Warner, pioneers in the field, developed a set of guiding principles for green chemistry, including:[18]

- Prevention: "It is better to prevent waste than to treat or clean up waste after it has been created." Chemists

Weaknesses in Chemical Regulation

Chemical policy experts at UC Berkeley and UCLA have identified three key weaknesses in federal and state chemical regulatory policies:[17]

- **The Data Gap**: Existing chemical policies allow manufacturers to sell a chemical or product without studying or sharing information about its potential health or environmental hazards. As a result, consumers and businesses have difficulty knowing what ingredients are in a product and whether those ingredients are safe—or even knowing whether an alternative to a hazardous chemical is actually safer.
- **The Safety Gap**: Additionally, under existing policy, state regulators are unable to take effective action to address known hazards. As a result, California businesses may be allowed to sell products made with toxic ingredients banned in other countries.
- **The Technology Gap**: Finally, existing policy fails to promote adequate investment in green chemistry research, development, education and technical assistance.

should minimize the potential for accidents.

- Safer Chemicals: "Wherever practicable," chemists should use substances that pose little or no threat to human health and the environment and design products to be effective while minimizing toxicity.
- Design for Degradation: Chemists should design products "so that at the end of their function they break down into innocuous degradation products and do not persist in the environment."
- Efficiency: As much of the material used in a chemical process should end up in the final product as possible. Moreover, chemists should minimize energy use.
- Use Renewable Materials: Chemists should use renewable materials "whenever technically and economically practicable."

Implementing these principles, starting at the earliest steps of product design, can reduce or eliminate the use of chemicals that:

- Persist in the environment,
- Accumulate in the food chain,
- Have toxic properties, or
- Pose a threat to workers or public health.

At the same time, green chemistry can reduce energy use, lower global warming emissions, and reduce or eliminate waste—all of which can improve a company's bottom line.

In fact, successful adoption by the marketplace is a key criterion for an innovation to "truly be green chemistry," since the primary goal of green chemistry is the reduction of overall pollution.[19] Similarly, green chemistry products must also meet environmental "performance" criteria—the extent to which it minimizes impacts on human health and the environment.[20] These elements are not traditionally considered when evaluating product performance, but green chemistry is "the science of pushing these into the criteria for molecular, materials, and product development," according to a report in *New Solutions: A Journal of Environmental and Occupational Health Policy*.[21] If an innovation fails to meet any of these criteria, green chemistry dictates a return to the lab for a product redesign.

Public policy can help encourage the spread of green chemistry practices in the marketplace by speeding the removal of dangerous chemicals from the marketplace, encouraging companies to design safer alternatives, creating cost incentives to use safer alternatives, and ensuring public access to information about the chemicals in consumer products.

The Green Chemistry Initiative: Advancing Green Chemistry Through Policy

The Green Chemistry Initiative, launched in April 2007, is California's groundbreaking effort to encourage adoption of green chemistry practices in commerce across the state.[22]

Two facets of the Green Chemistry Initiative were enacted into law in 2008. One is the Toxics Information Clearinghouse, an online database of thousands of chemicals used in California. The other grants authority to the Department of Toxic Substances Control (DTSC) to identify "chemicals of concern" and adopt regulations requiring the evaluation of safer alternatives. Based on those evaluations, the DTSC can then require further research into the product, require the company to label its product

regarding the presence of the chemical, or even to phase out the chemical within a designated time frame. These policy changes will help decision-makers reform chemicals policy to encourage adoption of green chemistry principles among product developers and manufacturers.

DTSC has been working on the Safer Consumer Product Regulations, which would establish the prioritized list of chemicals as well as which products to analyze, for several years. It has issued many drafts for public comment, but its efforts to finalize the regulations have been delayed by special interests that have opposed the regulations.[23] The final regulations are expected to be adopted in 2013.

If California gets the Green Chemistry Initiative right, we can begin to offer parents new assurance that everyday consumer products are safe to bring home from the store and to use in caring for their families. California workers will be healthier and more productive because they will have less exposure to toxic chemicals. California can also give birth to a new industry and new ways of doing business—benefiting the people of California and setting an example for the nation as a whole.

Green Chemistry Can Protect Our Health and Our Environment while Creating New Business Opportunities

The case studies that follow highlight seven pioneering businesses and institutions in California that are using the principles of green chemistry, helping to reduce our exposure to toxic chemicals while creating new business opportunities. Not all of these companies have fully embraced green chemistry, but all have taken steps that show the potential benefits of green chemistry for public health, the environment and the economy in California.

Substituting Problematic Ingredients with Safer Alternatives: Johnson & Johnson

Johnson & Johnson is a Fortune 500 company that manufactures a wide range of personal care products, including sunscreens, cosmetics, soaps, shampoos, lotions and anti-wrinkle creams, that are sold worldwide. The company, originally founded in New Jersey in 1886, is particularly well-known for its baby care products, although it has created or acquired several other popular drug store beauty brands such as Aveeno, Lubriderm, RoC, Clean & Clear and Los Angeles-based Neutrogena (acquired in 1994).[24]

Thanks in part to the work of organizations like the Campaign for Safe Cosmetics, a national coalition of more than 175 non-profit organizations, consumers are becoming increasingly aware of the fact that personal care products can contain hazardous substances—either as direct ingredients, as trace contaminants, or as byproducts of reactions that can happen inside the product bottles. For example:

- Colognes, hairsprays and perfumes can contain diethyl phthalate (DEP), a chemical linked to defects in reproductive development and to attention and behavior problems.[25]

- Nail polish manufacturers have used dibutyl phthlate (DBP) as an ingredient to impart coating flexibility. Scientists have linked exposure to DBP with reduced sperm quality in adult men, softening and weakening bone tissue, attention deficit disorder in children, feminized behavior in boys, and genital defects in rats.[26]
- Body washes and shampoos can contain trace contaminants such as formaldehyde and 1,4-dioxane. Exposure to these chemicals at is associated with increased cancer risk.[27] Formaldehyde exposure can also cause or aggravate allergies and asthma in children.[28]
- Over the counter dandruff shampoos, such as Neutrogena T-Gel Shampoo, can contain coal tar. The European Union has banned this ingredient in cosmetics because it is a known carcinogen.[29]
- Antibacterial soaps and related products can contain triclosan, a chemical that is being studied for potential interference with important hormone systems in the human body.[30]

Johnson & Johnson's Naturals line has been formulated without any of the chemicals that the company now plans to remove from all its baby products. Photo: Johnson & Johnson

In 2011, Johnson & Johnson pledged to reduce or eliminate two hazardous chemicals from its baby products by 2013: 1,4-dioxane, a likely carcinogen, and quaternium-15, a preservative that releases small amounts of methylene glycol, the liquid form of formaldehyde.[31]

While the company maintains that its baby products have never contained unsafe amounts of either of these chemicals, it nevertheless recognized the need to respond to consumer concerns. According to Susan Nettesheim, who oversees product integrity and toxicology at Johnson & Johnson:[32]

> Over the past few years, some interest groups have raised questions about the ingredients in personal care products used widely around the world, and they've put particular focus on our baby products. At first we were disappointed, because we know that all our products are safe by scientific standards and meet or exceed government regulations. Over time, though, we've come to realize that sometimes safety alone isn't enough.

In August 2012, the company expanded its commitment to reduce or remove 1,4-dioxane and quaternium-15 from its adult personal care products. By 2015, the company also plans to remove or reduce several other problematic chemicals, including parabens, phthalates and triclosan from all of its products, making it the first company of its kind to make such a broad commitment, according to the *New York Times*.[33] These changes have yet to take place, since the company still needs to develop alternatives and test them to ensure they are demonstrably safer. Still, Johnson & Johnson's commitment is a strong step toward implementing the green chemistry principle of using ingredients that do not harm human health or the environment.

By removing these substances from their product line worldwide, Johnson & Johnson has positioned itself to succeed in the future in California and in marketplaces across the world. This change, for example, will ensure that the company can continue to access markets in Europe, which has policies designed to keep many harmful substances out of consumer products. At the same time, however, Johnson & Johnson should ensure that it is not substituting an untested—and potentially toxic chemical—for a known toxin.

Johnson & Johnson's subsidiaries in California, such as Neutrogena, will also be able to respond nimbly to California's forthcoming Green Chemistry Initiative policies, while using the company's commitment to customer health as an effective marketing tool.

Cleaning California's Dirty Air: Sherwin Williams and Soy-Based Paint

Smog is one of California's most familiar public health hazards. Since the 1950s, the state's metropolitan areas, and the Los Angeles region in particular, have struggled to reduce the number of unhealthy air days residents have to deal with each year. One piece of this effort has been restrictions on volatile organic compounds, or VOCs.

Smog results from the interaction of two kinds of pollutants, oxides of nitrogen (or NO_x) and VOCs, in the presence of sunlight. Power plants, automobile tailpipes and other combustion sources are the major sources of NO_x. Evaporating chemicals from gasoline, solvents, paints and other chemical products are a major source of VOCs. When these two compounds combine in the presence of sunlight, they form ozone, a powerful oxidizing pollutant and a major component of the smog problem in Los Angeles and the Central Valley. Ozone "burns" the lungs, causing difficulty breathing. Children, adults who are active outdoors, and people with existing respiratory system ailments suffer most from ozone's effects. Repeated exposure to ozone can cause permanent lung damage, and can even kill.[34]

VOCs are also a health hazard in their own right, posing a threat of cancer or respiratory harm in both outdoor and indoor air. The effects of immediate exposure to VOCs include headaches; eye, nose, and throat irritation; nausea; and loss of coordination. Long-term exposure can contribute to kidney, liver and central nervous system damage, as well as increased risk of cancer.[35] Exposure to VOCs while using solvents or paint products can reach up to 1,000 times background outdoor levels.[36]

Air quality management districts in California—government entities charged with reducing levels of unhealthy air pollution—set regulations on the use of VOCs in paints and other consumer products as one tool to clean up the air.[37] These regulations have helped push paint manufacturers to find alternative chemicals that do not create air pollution—but not without a fight.[38]

In 2003, a national paint manufacturer's association sued the South Coast Air Quality Management District, claiming that the regulations limiting the use of VOCs in paint were too strict to be feasibly achievable.[39] However, the California Supreme Court upheld the decision, and today many leading paint manufacturers have successfully introduced high-performance, low-VOC paints into California's market, proving the association wrong.

In 2011, for instance, paint company Sherwin Williams won a Presidential Green Chemistry Challenge Award for inventing a new line of greener paints made from soybean oil and recycled plastic bottles.[40] The new paint is a water-based acrylic alkyd paint that performs as well as traditional oil-based alkyd paints, but with a 60 percent reduction in VOC content.[41]

"[S]ometimes green products need a little kick from a regulation to overcome the barrier to change."

– Colin Gouveia, marketing director at building products company Rohm and Haas, speaking to the *Los Angeles Times*.[43]

According to the company, the new paint eliminated the use of 800,000 pounds of VOC solvents in 2010.[42]

Expansion of the new technology could eliminate millions more pounds of VOC emissions each year, particularly in California, where the company has 133 stores for household paint and 20 stores for commercial and industrial coatings.

According to Mike Conway, director of corporate communications and investor relations at Sherwin-Williams, the new paint has helped grow sales, revenue and profits.

"We've always been a technological and environmental leader," he said. "The two things that drive our company are our staff and our research and development efforts, which have allowed us to maintain a leading edge in getting solvents out of our paints," he said.

The company has also recently become the nation's first manufacturer of a full "color cast" without VOCs, according to Conway. The color cast is the assortment of highly concentrated colors that are mixed into white base paint to develop Sherwin-Williams's palette.

The case of Sherwin-Williams illustrates that strong regulations that prompt companies to invest in research and development can lead to the discovery of new green chemical alternatives that outperform their hazardous predecessors across the board.

Reducing Toxic Chemicals in Semiconductor Manufacturing: IBM

In the highly innovative and highly competitive technology industry, materials and components are made from complex—and sometimes toxic—substances. For example, the production of many devices requires the use of perfluorinated chemicals known as PFOA or PFOS. These chemicals do not readily degrade in the environment and they concentrate in the food chain (or bioaccumulate). Scientists studying nearly 300 newborns in Baltimore found these chemicals in just about every baby they tested—indicating that children are exposed to these chemicals while in the womb.[44] Levels in U.S. adults tend to be higher than levels in residents of other countries, with more industrialized nations likely to show more contamination.[45]

Scientists have also linked PFOA and PFOS exposure to toxic effects, including:

- The increasing prevalence of premature birth and low birth weight,[46]
- Problems with brain development leading to behavioral defects,[47]
- Immune system problems,[48] and
- Damaged sperm in adult males.[49]

Persistent, bioaccumulative and toxic chemicals like PFOA and PFOS are obvious targets for replacement with safer alternatives that do not have these properties.

In recent years, electronics companies such as IBM have used green chemistry principles to eliminate PFOA and PFOS from their manufacturing processes.

IBM is a globally integrated technology and consulting corporation that specializes in computer hardware, software and services. It is the second-largest

employer in the United States, with just over 430,000 employees.[50] IBM can claim credit for an extensive list of innovations in its 100-year history, including the automated teller machine (ATM), laser scanners at grocery stores, UPC barcodes, magnetic strips for credit cards, and computerized airline reservation systems.[51]

IBM has had a strong presence in California's Silicon Valley for decades. "Silicon Valley" refers to San Jose and the region south of the San Francisco Bay, where a large number of silicon chip developers and manufacturers earned the region its moniker. The term now refers to all of the high-tech and innovative start-up companies in the area, as well. IBM established one of its 10 global research labs in San Jose in 1945.[52] By 2011, IBM employees in California accounted for almost 10 percent of the total number of patents filed by the company that year.[53]

In the early 2000s, regulatory agencies in the U.S. and Europe were examining the use of various toxic chemicals in electronics. The European Union passed a directive limiting the use of some chemicals.[54] In the U.S., the Environmental Protection Agency restricted new uses of PFOS compounds because of concerns that the chemical accumulated in the food chain. However, EPA allowed the chemical to continue to be used in semiconductor manufacturing, where there were no obvious replacements ready at hand.

Starting in 2005, IBM proactively decided to find alternatives to PFOS and PFOA in its semiconductor manufacturing processes, based on a corporate policy to use development and manufacturing processes that are more protective of the environment. Semiconductors are used in products and electronic components such as transistors, LED lights, diodes and integrated circuits.

The company prohibited the use of PFOS and PFOA in new materials in 2005 and from new manufacturing operations in 2007. The company also began the extensive development and process redesign work necessary to eliminate them from existing manufacturing applications. Solutions for replacing PFOS and PFOA ranged from changes in processes to eliminate the need for these chemicals to finding new chemicals or chemical mixtures that could be substituted for PFOS and PFOA.

Replacing the use of PFOS in hundreds of semiconductor manufacturing processes was a significant challenge. After several years of testing to find a suitable replacement for PFOS in these processes, IBM successfully replaced it in 2010 with another chemical, perfluorobutane sulfonate (PFBS), which is less harmful to human health and the environment, according to the EPA.[55]

In contrast to PFOA and PFOS, PFBS doesn't bioaccumulate and has a much lower toxicity.[56] However, PFBS doesn't degrade and tends to persist in the environment, particularly in water. Increased

IBM has ended the use of PFOS and PFOA in its manufacturing processes for semiconductors. Photo: IBM

use of PFBS could therefore cause large build-ups of the chemical in aquatic environments, the effect of which has yet to be studied.[57] In addition, many of IBM's electronic products still contain other toxic ingredients, such as flame retardants. Therefore, IBM's achievement of removing PFOS is only a first step toward green chemistry, but one worthy of praise. The company achieved the conversion to PFBS without increasing the costs of any chemicals except one, without decreasing product yield, and without increasing the volume of chemicals needed for production.[58] IBM has tremendous potential to completely integrate green chemistry design principles to further reduce the total amount of toxic chemicals used in production as well as to remove specific chemicals from its products, including toxic flame retardants.

According to Michael Cadigan, general manager for micro electronics at IBM, developing alternatives to PFOS and PFOA was "an ambitious technological challenge."[59] In a company statement, he said, "The transition to the new formulations had to be implemented and qualified across a large array of processes without impacting customer product delivery commitments." He added that several of IBM's technology partners in at least five countries now also have access to the technology to make the switch.[60]

In the same statement, Wayne Balta, IBM's vice president of corporate environmental affairs and product safety, said, "This achievement is another in a long line of significant initiatives and innovation at IBM that supports the company's longstanding commitment to environmental leadership. In this case, it demonstrates IBM's proactive approach in identifying, developing and utilizing environmentally preferable materials."[61]

Apart from PFOA and PFOS, other hazardous chemicals in electronics include chlorinated or brominated chemicals, typically added to plastics and resins to make them fire resistant. Compounds containing these chemicals can persist in the environment, bioaccumulate, and, when combined with organic matter, can form dioxin, a known human carcinogen that is toxic even in small amounts.[62]

Seagate, based in Scotts Valley, is the world's largest manufacturer of disk drives, and it has eliminated all chlorine- and bromine-based ingredients from its products.[63] The company didn't stop there, however; Seagate adopted an entire set of safety protocols in 2005 with the goal of meeting or exceeding global requirements for the environmental safety of its products.[64] These protocols required Seagate's suppliers to disclose all chemicals and concentrations in every component or raw material bought by Seagate. Evaluating the possible risks of these chemicals, Seagate restricted the use of more than 200 problematic chemicals conventionally used in disk drives.[65] These restricted chemicals include any compound containing PFOS, as well as antimony trioxide, lead, mercury, hexavalent chromium and cadmium.[66]

Because of Seagate's disclosure protocol, the company has a comprehensive list of all chemicals in its supply chain and can work toward comprehensively removing problem chemicals, rather than removing them piecemeal from its products as new restrictions form in its markets all over the world. This approach has dramatically cut Seagate's cost of compliance with chemical restrictions, helping the company stay ahead of its competition. For example, when the European Commission implemented its new approach to chemical regulation, REACH (Registration, Evaluation, Authorization and Restriction of Chemical substances), Seagate spent sixty percent less than its competitors retrofitting its hard drives to meet REACH regulations.[67]

Companies that look for alternatives to hazardous chemicals can find them. Silicon Valley offers good examples that others can follow.

Helping Companies Make Smart Decisions: Chemical Safety Software

Green chemistry is not only creating opportunities for manufacturers to protect their customers and increase their bottom line; it is also sparking new kinds of businesses. Implementing green chemistry practices throughout the entire economy will open doors for new businesses at every point in the supply chain, beyond manufacture to distribution, sales, and even disposal and cleanup.

Because information about green chemistry practices and safer chemical alternatives is not yet widely available, there are also unique opportunities for information systems specialists. Manufacturers and retailers seeking to participate in the growing market for green consumer goods need accurate information about the relative toxicity of different product ingredients in order to make good decisions. Making the right decisions can help companies market their

Sunlight for Disinfectants: Clorox Discloses Product Ingredients in U.S. and Canadian Cleaning Products

Lack of public information about chemical use and toxicity is a major obstacle to the expansion of green chemistry practices. Consumers and manufacturers only begin searching for safer alternatives once they become aware that a particular substance poses a health threat.

Traditionally, household cleaners have contained chemicals that can irritate skin and respiratory tissues, are linked to asthma, or even lead to reproductive harm. These products can also include phosphates, which contribute to water pollution, and disinfectant chemicals that can contribute to the problem of antibiotic resistant bacteria and to human health problems including breast cancer and asthma.[68]

That is why the decision by **The Clorox Company,** based in Oakland, to disclose the ingredients in all of its U.S. and Canadian cleaning products comes as good news. Clorox has gradually been increasing transparency about its products. In 2008, Clorox provided information to consumers about the active ingredients in its "Green Works" line of cleaning products.[69] In 2009, the company expanded that initiative to include disclosure of active ingredients in all its products, making it the first in the industry to offer such transparency.[70] The information isn't printed on each product's label, but is available through the company's website.[71]

Clorox's announcement that it will disclose all of its product ingredients will enable researchers, consumers, and public health advocates to know what is in their products, increasing pressure on other companies to do the same. This will increase the likelihood that more manufacturers of cleaning supplies will put less-toxic ingredients in their products.

products, improve their good reputations and attract new customers.

Chemical Safety, based out of Emeryville, has developed computer software, EMS (Environmental Management Systems), that will help researchers, chemists, manufacturers and facility managers reduce the amount of harmful chemicals they purchase in the first place, ultimately reducing the use and disposal of these chemicals, as well.

The software includes a database and inventory tracking system. The database includes a list of green chemical alternatives recommended by the EPA, universities and other leading institutions.[72] In the EMS system, when clients elect to purchase potentially hazardous chemicals from their suppliers, the database prompts them to select a safer alternative. In addition, the inventory tracking system allows clients to easily track chemical containers from the point materials are purchased, delivered, used, stored, and ultimately disposed of or destroyed.[73]

According to the company, "These steps reduce unnecessary chemical purchasing, reduce the footprints of hazardous chemicals at facilities, and decrease the generation and disposal of chemical waste."[74]

Chemical Safety's EMS tool will also help boost the market for safer products, as more manufacturers learn about alternatives. Chemical Safety already has a broad array of clients using the software, including the Department of Energy's Stanford Linear Accelerator, Novartis Vaccines and Diagnostics, E&J Gallo, the L'Oreal Group, and EPA Region 9 laboratories.[75]

Removing Toxic Bisphenol A from Canned Food: Trader Joe's

When California grocery chain Trader Joe's opened in Pasadena in 1967, it was meant to be a different kind of grocery store—one with "innovative, hard-to-find" food products that were rapidly replaced if they weren't selling. According to the Trader Joe's website, the company was "still trying to find [itself]" by 1973, when customers could go into their local Trader Joe's and find anything from a butcher shop to nuts in barrels to magazines and pantyhose—which were sold until 1978.

One thing that did stick, however, were Trader Joe's-branded products, first introduced in 1972. Private labels such as Trader José, Trader Giotto and Trader Ming allowed the company to cut costs, according to the website. These private label products now make up the majority of items in Trader Joe's stores, which now number 270 in California and nearly 100 in 31 other states.[76]

These private-label products have also helped the company protect the health of their customers and the environment by eliminating harmful chemicals from its food products, particularly from canned food items.

Resin coatings are commonly used in can linings to create a barrier between the metal of the can and the food inside, which helps protect the flavor of the food and prevent bacterial contamination.[77] Unfortunately, these resin coatings are typically made with bisphenol A, a toxic chemical, which leaches into the food and introduces the chemical into our diets.[78]

Bisphenol A does not accumulate in the body, but people are continuously exposed to it. The chemical is so ubiquitous in society that scientists almost always

find it in the blood, tissues and urine of adults and children across the United States. Scientists at the U.S. Centers for Disease Control and Prevention found bisphenol A in more than 90 percent of people tested, with exposure remaining relatively steady over the past decade.[79]

In the body, bisphenol A mimics the human hormone estrogen. Scientists first learned that bisphenol A could act as a synthetic substitute for estrogen in the 1930s.[80] However, in 1953, chemists discovered that bisphenol A could be made into polycarbonate plastic. Despite the fact that bisphenol A was known to be active in the human body, it became commonplace in the manufacture of a variety of materials not meant to be drugs, including canned food liners.

Researchers have linked bisphenol A exposure in laboratory studies to a wide variety of developmental harms, including:

- low sperm count,[81]
- defects in the development of the reproductive system,[82]
- miscarriage,[83]
- brain development and behavioral changes such as hyperactivity and impaired memory,[84]
- obesity and diabetes,[85] and
- increased susceptibility to breast and prostate cancer.[86]

Trader Joe's has eliminated bisphenol A from many of its private-label canned products. These products include Trader Joe's canned corn, tomatoes and pumpkin; canned beans (except baked beans); canned fruit (except mandarins); and canned vegetables (except artichokes). It also includes canned poultry, beef and fish, such as tuna and anchovies.[87] However, other canned products, such as Trader Joe's sardines, crab, cherrystone clams and oysters, and Hatch chiles still contain bisphenol A in their can linings.[88]

Unfortunately, Trader Joe's has not disclosed what material it is using to replace BPA in its can linings. There are safer alternatives to BPA liners currently in use, but these have limited applicability or tend to increase costs.[89] For example, Japanese can manufacturers now use a polyester coating in can linings, only using BPA when needed as an adhesive underneath.[90] The polyester reduces BPA leaching by up to 95 percent.[91] Can liners can also be made from natural oil and resins. One oil and resin mixture, known as oleoresin, is used by Eden Foods in its bean products.[92]

There are still relatively few safe alternatives to BPA in can linings, and because of weaknesses in state and federal chemical regulatory policies, there is no guarantee that all alternative, substitute chemicals that go into today's "BPA-free" cans are actually safer. For example, companies can legally use polyvinyl chloride (PVC) as a packaging additive, though vinyl chloride is a known human carcinogen.[93] Bisphenol S (BPS) is another alternative, but it is still relatively untested for human health impacts. Further research and development into green chemistry alternatives could give companies such as Trader Joe's access to the solutions they need to ensure that the materials used to line their food cans are safe for consumers.

Food retailers such as Trader Joe's that work to eliminate dangerous chemicals from their products are taking steps to protect the health of consumers, ahead of regulatory action curve and positioning their businesses for the future.

Policy Recommendations

As the case studies in this report show, green chemistry offers many potential opportunities for California businesses to succeed. Green chemistry can help companies innovate, create new business opportunities, capture new markets, make their products more competitive in the global marketplace, improve manufacturing efficiency, reduce waste, cut the costs of dealing with hazardous waste, improve workplace safety, and reduce liability.

California needs to find new ways to encourage businesses to adopt and implement green chemistry. Businesses that wish to reduce their impacts on the environment and public health need a helping hand—in the form of reliable information on toxic chemicals, safer alternatives, and new ways of doing business—to ensure that they are maximizing the potential of green chemistry to improve the environment and their bottom line.

The initiative has already created the Toxics Information Clearinghouse, which arms consumers and manufacturers with information about the chemical hazards in California's marketplace. The pending Safer Consumer Products Regulations are another critical step in making the lofty vision of the Green Chemistry Initiative a reality.

The Department of Toxic Substances Control (DTSC) should finalize the Safer Consumer Products Regulations. DTSC should move quickly to expand beyond the five initial product-chemical combinations

slated for analysis in the first several years of the program to comprehensively address the many other products and chemicals in the marketplace with impacts on the environment and public health. Policymakers should grant the department the authority to charge a fee to companies that use toxic substances, providing funding for analysis of chemicals and products and supporting research into alternatives.

California's Green Chemistry Initiative can play an important role in encouraging more businesses to follow the lead of those profiled in this report in reducing their impacts on the environment and public health. However, businesses that are laggards in adopting these principles need a firm push from state officials to re-examine their products and practices and develop alternatives that are safer from the start. Policymakers should strengthen California's chemicals policy to better protect consumers from chemical hazards, both now and in the long term.

In addition to finalizing and strengthening the Green Chemistry Initiative, policymakers should:

- Support green chemistry research, development and technical support to help develop a supply of safer, green chemistry alternatives.
- Require chemical manufacturers to demonstrate that a chemical is safe before allowing it on the market. This will help break the cycle of replacing one toxic substance with another and ensure that safer alternatives are actually safer.
    - Regulators should require companies to provide comprehensive data on the intrinsic hazards of chemicals that they produce or import into California.
    - Chemical testing should include specific consideration of potential impacts on infants, children and pregnant women; potential impacts of low-dose exposures; and potential interactions with other toxic chemicals.
    - The reliability and adequacy of the information should be validated by government scientists and/or an independent third party free of conflicts of interest.
    - Allowances for ingredient secrecy based on claims of "confidential business information" should be limited.
    - Where there is uncertainty in the evidence, regulators should err on the side of protecting health and the environment by not allowing the product on the market.
- Ensure public access to information on chemicals and their uses.
    - The public has a right to know about chemicals currently on the market, including their specific uses, potential hazards to health and the environment, and potential routes of exposure. When finalized, the California's Toxics Information Clearinghouse, created by legislation in 2008, should be an easily understandable database of all chemicals currently in use. This tool should enable businesses and consumers to compare the safety of chemicals, identify missing data, and create demand for safer alternatives.
- Until health and safety data are available for a particular chemical, there should be mandatory labeling for consumer products indicating the presence of a chemical that has not been tested for its impact on human health.

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