



Green Chemistry at Work

Leading California Businesses Demonstrate
How to Make 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 in order to work. These businesses are making California healthier and wealthier by designing products to be safe from the start, following the principles of green chemistry.

This report highlights 12 Golden State businesses or institutions that are identifying unnecessary hazards in their facilities, in their manufacturing processes and in the products they sell – and acting to eliminate them. In the process, these pioneers are demonstrating how a strong state-wide green chemistry policy can give birth to a new way of doing business – benefiting the people of California and setting an example for the nation as a whole.

Green chemistry is a design and business philosophy that seeks to make products safe from the start and prevent pollution at its source.

- Traditionally, designers have failed to comprehensively consider the risks posed by their products, such as the potential ill-effects of hazardous ingredients brought inside our kitchens, offices and living rooms. In contrast, green chemistry 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. Green chemistry also has the potential to reduce energy use, lower global warming emissions, and reduce or eliminate waste – all of which offer opportunities to simultaneously improve human health and a company's bottom line.

- California's Green Chemistry Initiative is a groundbreaking effort to apply green chemistry principles to state chemical regulatory policy. This initiative aims to 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, in favor of safer alternatives.

While protecting public health and the environment, green chemistry can also be an effective business strategy. For example:

- Oakland-based **Kaiser Permanente** offers a more comprehensive view of health care than its competitors. The organization has been working to eliminate the use of IV bags and tubing containing phthalates, a class of chemicals that interferes with healthy development and reproduction, in all of its neonatal intensive care units. Kaiser Permanente's new hospital in Modesto, which opened in 2008, also features a new kind of phthalate-free carpet invented specifically because of Kaiser Permanente's purchasing power – a carpet now being marketed to other health care facilities nationwide.
- Cupertino-based **Apple Computer, Inc.** and Palo Alto-based **Hewlett Packard** have improved their products, expanded their market share, and ensured access to the global marketplace while eliminating a broad range of toxic chemicals from their products. Apple chose to phase out any chemical made with chlorine or bromine in its electronics. These two elements are commonly found in hazardous substances – for example, in PCBs and PBDEs, chemicals which accumulate in the food chain and can



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interfere with healthy development in children. Apple's approach made it simple and cost-effective to ensure that the components it receives from suppliers do not contain PBDEs or related hazards by testing for a just few elements, rather than for large numbers of individual compounds. HP also requires its suppliers to avoid a list of restricted substances, and to voluntarily report on 240 additional ingredients of concern. As a result, Apple's and HP's products meet standards for sale in all markets worldwide, and the companies are prepared to rapidly respond to new evidence of potential hazards.

- The South Coast Air Quality Management District issues regulations to reduce smog and toxic air pollution in Southern California. In response, **BASF, Inc.**, one of the world's largest chemical companies, developed a new kind of paint primer which does not contain organic solvents and therefore contributes

to cleaner, healthier air and a safer workplace. Moreover, the innovative primer performs even better than traditional products, opening the door to new business opportunities.

- Chico-based **Klean Kanteen** and Los Angeles-based **Green-to-Grow** manufacture water bottles and baby bottles without the use of bisphenol-A – a widely used chemical that scientists have linked to cancer, heart disease, thyroid disease, and developmental disorders. Both companies were well-positioned to capitalize on the emerging market for safer containers as concern over bisphenol-A exploded during the last decade. In fact, after stories about bisphenol-A proliferated in the mainstream media, Klean Kanteen's business grew by more than 1,000 percent from 2007 to 2008 and the company grew from six to 36 employees.
- San Francisco-based **Method Products** manufactures and sells home and personal cleaning products using non-toxic and biodegradable ingredients. **CleanWell**, another San Francisco-based company, designed a natural, biodegradable disinfectant to replace toxic triclosan in hand cleaners and surface cleaners sold by Seventh Generation. Even the Oakland-based **Clorox Company**, one of the nation's largest cleaning product companies, has developed a line of cleaning products made from naturally-derived ingredients, with every ingredient listed on the bottle for all to see. These companies are creating and expanding new business opportunities. The market for cleaning products designed with green chemistry in mind is currently estimated at more than \$100 million per year, and growing rapidly.
- Los Angeles-based **Nubar** manufactures nail polish without using formaldehyde, toluene or dibutyl phthalate, all chemicals listed as hazards under California's Proposition 65 labeling policy. Eliminating these hazards has given Nubar an excellent marketing tool, while enabling the company to sell its products in markets worldwide, including the European Union, where dibutyl phthalate is banned in cosmetics.
- **Pfizer**, one of the nation's largest pharmaceutical companies, with more than 1,000 scientists based in La Jolla, used green chemistry principles to streamline and reduce the toxicity of the manufacturing process for the antidepressant drug Zoloft. The new process reduced solvent use by 90 percent and eliminated hundreds of tons of waste laced with hydrochloric acid. New companies, like Redwood City's **Codexis**, are springing up to help pharmaceutical companies apply green chemistry innovations. Codexis, for example, developed three customized enzymes for Pfizer to use in the synthesis of Lipitor, a widely-used cholesterol management drug. The enzymes reduced the need for fossil fuels and harsh chemicals during the reaction process, reducing waste and energy use – and earned Codexis a 2006 Presidential Green Chemistry Challenge award from the U.S. EPA. These green chemistry strategies reduce waste, cut costs, and improve manufacturing efficiency – all of which improve the bottom line.

These case studies demonstrate that green chemistry can benefit public health and the environment – and create new business opportunities, too. When California businesses and institutions think seriously about how they design, manufacture, or use products, they find opportunities to use less hazardous ingredients and safer designs – reducing hazards to workers and public health, preventing pollution, saving money, and creating markets for new and innovative products.

However, existing state and federal chemical regulatory policies are not doing enough to promote widespread adoption of green chemistry practices. Existing policies have key weaknesses – termed the “data gap,” the “safety gap” and the “technology gap” by chemical policy experts at the University of California.

- **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 better.
- **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 has the potential to address the weaknesses in existing chemical policy and to help make the application of green chemistry principles widespread. In order to be most effective, the state’s Green Chemistry Initiative should:

- Require chemical manufacturers to prove that each chemical they market is safe;
- Empower regulatory agencies to restrict or ban the manufacture and use of chemicals that pose potential dangers; and
- Ensure public access to information on chemicals and their potential hazards through mandatory reporting requirements, including product ingredient disclosure.

If effectively implemented, California’s Green Chemistry Initiative can 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 in the global marketplace.

Introduction

In the 1880s, the Johns Manville company began manufacturing building insulation using a mineral known as asbestos. Asbestos had a remarkable ability to trap heat and resist fire, making it an ideal substance to use in making buildings more comfortable. Builders installed asbestos-containing insulation in millions of American homes and businesses over a span of multiple decades. By the 1970s, businesses were marketing more than 3,000 consumer and industrial products that contained asbestos.²

The only problem was, inhalation of even tiny amounts of asbestos can cause lung disease and cancer, leading to disability and death.³ On the order of 10,000 Americans now die every year due to asbestos-related illness.⁴

In the 1980s, documents uncovered by litigation brought by sick workers uncovered evidence that Johns Manville medical staff and leadership knew about the risks of asbestos exposure as early as 1934.⁵ However, instead of looking for alternative ways to make insulation and other asbestos-containing products,

Johns Manville executives chose to hide the dangers of asbestos from workers and the public while continuing to use it in products for more than 50 years.⁶

To resolve its liability, Johns Manville filed for reorganization under Chapter 11 bankruptcy law in 1982. The reorganization created a trust that provided hundreds of millions in compensation to injured workers, but also shielded the company from future asbestos claims.⁷

By any measure, the way the asbestos industry handled the knowledge of the risks of asbestos exposure was a disaster for public health. It was also a financial and public relations disaster for Johns Manville – even if the company managed to evade full responsibility for compensating every worker and customer sickened by its products.

Johns Manville learned an important lesson from this experience, namely that “an ounce of prevention is worth a pound of cure.”⁸ In other words, good business strategy involves anticipating and planning to avoid problems from the start.

Johns Manville has since put this lesson to work. For example, the company de-

cided to stop using formaldehyde in its building insulation products in 2002.⁹ As scientists gathered increasingly powerful evidence that formaldehyde is a toxic chemical linked to allergies and asthma in children, as well as cancer, Johns Manville engineers searched for an alternative chemical to use in the binding of its insulation products.¹⁰ The company switched to an alternative acrylic compound in place of formaldehyde – protecting its workers and the public from harm. The company became the first to produce formaldehyde-free insulation, breaking ahead of its competition and preparing the company to respond nimbly to indoor air quality regulations and capitalize on a new market.

A growing number of businesses and institutions across California have learned this same lesson. They are taking advantage of the emerging opportunity of **green chemistry** – a new way to minimize and prevent hazards with products or manufacturing processes. These pioneers have found that helping to solve the problem of toxic chemical exposure can also be an economic opportunity.

This report tells the story of 12 leading businesses and institutions in the Golden State that have taken the time to think carefully about their products and services, designing new ways to deliver the quality that consumers expect – while phasing out ingredients that could harm public health or the environment during manufacture, use, or disposal. In so doing, these companies have helped to create safer working conditions, safeguard our health, save energy and resources, reduce pollution, and discover new opportunities to succeed.

Companies such as Clorox have found that green chemistry can help businesses innovate, create new business opportunities and capture new markets. Clorox's new line of green cleaning products

“Green chemistry is not a theory. It’s being demonstrated by companies over and over again.”

– Paul Anastas, the “father of green chemistry,” professor at Yale University, now assistant administrator of the U.S. EPA Office of Research and Development under the Obama administration, speaking to the *Los Angeles Times* in 2008.¹

has introduced many people to the idea that cleaning products can be less toxic, contributing to the rapid growth in the green cleaning market. Companies such as Klean Kanteen, Green to Grow and Method have launched specifically to take advantage of a growing consumer desire for products that do not pose dangers to their health or the environment.

Companies such as Apple have discovered that green chemistry can help California businesses become more competitive in the global marketplace. Guided in part by new regulations on toxic chemicals in electronic products in the European Union, Apple made changes to its product design that resulted in a better product that can be sold in any marketplace in the world.

Companies such as Pfizer and Codexis have discovered that green chemistry can improve manufacturing efficiency, reduce waste and cut the costs of dealing with hazardous waste – directly improving the bottom line.

While a green chemistry approach offers great dividends for businesses, for the health of all Californians, and for the global environment, business as usual poses a large barrier to change. Moreover, existing chemical policies at the state and

“Green Chemistry is going to create more jobs in California than the Internet.”

– Maziar Movassaghi, acting director of the California Department of Toxic Substance Control, July 27, 2009.¹¹



Photo: RodolfoClix

federal level allow businesses to market chemicals and products without disclosing information about potential hazards while giving too little authority for regulators to act to reduce our exposure to known hazards.

California's pioneering Green Chemistry Initiative – an important effort to codify the principles of green chemistry into the state's chemicals policy – has the potential to improve how our society deals with the problem of toxic chemical exposures. If strongly implemented, this initiative can help overcome barriers to change and help all California businesses, and businesses across the country, to take advantage of the opportunities of green chemistry and help make California cleaner, safer, and more prosperous in the years to come.

The Case for Green Chemistry

Historically, product manufacturers and chemical suppliers have designed their products based strictly on performance and cost, often with little regard to public health, environmental concerns, or threats to worker health or safety. This approach has led to a wide array of social problems, from the proliferation of toxic chemicals that can now be found in practically every human being, to pollution that contaminates water supplies or contributes to global warming. 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 problems at all.

Green chemistry seeks to correct these problems. Green chemistry is a design and business philosophy aimed at making products and manufacturing processes safe from the start. In California, this philosophy is beginning to penetrate the business world, changing the way

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 Public Health and the Environment

Children in California today grow up surrounded by synthetic chemicals. Their food containers are made with plastic, from reusable bowls to throwaway wrapping. Their homes and yards are treated with pesticides. Their families use cosmetics and personal-care products that contain hundreds of manufactured additives. The furniture and electronics in their homes contain flame retardant chemicals. Testing products on California store shelves, the state's Department of Toxic Substances Control found a child's

necklace containing enough lead to be classified as hazardous waste, while a lunchbox contained both lead and cadmium in toxic amounts.¹²

Toxic chemicals often do not remain securely contained within factory waste ponds or in consumer goods. Toxic substances are leaking into the groundwater at more than 70 percent of the state's largest hazardous waste sites.¹³ In addition, many chemicals escape from consumer products and end up in household dust and in household air.¹⁴ (See "The Home as a Toxic Environment" on page 13.) These chemicals have become such a close part of our lives that scientists can find more than 100 industrial chemicals and pollutants in the bodies of every mother and child.¹⁵

From plastics to pesticides, the modern world contains potentially hazardous substances in far greater amounts than at any time in human history. Since World War II, annual chemical production in the United States has grown more than 20-fold.¹⁶ Today, U.S. companies are the world's largest chemical producers, generating more than 1.2 billion tons of chemicals each year.¹⁷ The chemical industry has introduced tens of thousands of new products – substances that did not exist anywhere on Earth before the industrial revolution.

Photo: Jurga R., www.sxc.hu



There are now more than 83,000 industrial chemicals on the market in the United States.¹⁸ While these chemicals have had many undeniable benefits for society, from improved medical care to increases in economic productivity made possible by electronics, the benefits have come with unintended side effects.

Very little is known about most chemicals in commerce. The health effects of almost half of the major industrial chemicals have not been studied at all.¹⁹ 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.²⁰

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.

The risks begin at conception. The National Academy of Sciences estimates that nearly half of all pregnancies in the U.S. end with the loss of the baby, or with a child born with a birth defect or chronic health problem. Moreover, the National Academy estimates that toxic exposures play a role in at least one in four cases of developmental disorders.²³

The developing brain is particularly vulnerable to disruptions that lead to disorders such as autism, attention deficit disorder, mental retardation and cerebral palsy.²⁴ Industrial chemicals, including lead, methylmercury, PCBs, arsenic and toluene, are known causes of these disorders. Although no comprehensive testing has been done, more than 200 additional chemicals are likely to interfere with early brain development.²⁵

Health risks continue through adolescence and adulthood. More than 2

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. Products containing hazardous materials are made in factories and shipped to our homes and offices, serving as a chemical conduit into our daily lives.

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 2007, for every pound of chemicals produced as a byproduct or released into the environment, three pounds were distributed in manufactured products.²¹ Companies shipped thousands of times more of certain toxic chemicals—especially ingredients in plastics and personal care products—than they released into the environment.²²

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.



million adults (7.6 percent) and more than 800,000 children (8.6 percent) in California have asthma.²⁶ Cancer is the second-leading cause of death in California, accounting for about one-fourth of deaths – with about 150,000 new cases diagnosed each year.²⁷ Both of these diseases have strong scientific links to a variety of chemical exposures in the everyday environment, from the outdoor air in cities to the air inside our homes.

Toxic hazards at places of employment also put workers at risk. 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.²⁸

According to the Berkeley Center for Green Chemistry, health care costs from chemical and pollution-related diseases for California's children and workers exceed \$2 billion per year.²⁹

Chemicals and Manufacturing Processes Can Harm the Environment

From the environmental crisis of global warming to the fiscal impacts of managing waste, the way we manufacture and use products can have a wide range of impacts beyond harm to public health. For example:

- Energy use in product manufacturing creates carbon dioxide pollution

Photo: Kenn Kiser



and contributes to global warming. The damaging impacts of warming – from the acidification of the world’s oceans to melting glaciers and rising sea levels – are happening even faster than the most eye-opening predictions made by the United Nations’ Intergovernmental Panel on Climate Change just two years ago.³⁰ Scientists are becoming increasingly concerned that critical thresholds are a matter of years or a few decades away – beyond which lay dramatic and irreversible changes to our world and our way of life.³¹

- Industrial facilities continue to dump millions of pounds of toxic chemicals into America’s rivers, streams, lakes and ocean waters each year – threatening both the environment and human health.³² According to the EPA, pollution from industrial facilities is responsible for threatening or fouling water quality in more than 10,000 miles of rivers and more than 200,000 acres of lakes, ponds and estuaries nationwide.³³
- Wastewater from homes, businesses and agriculture contaminates streams

and rivers across the country with low levels of drugs, nutrients, and other chemicals – some with the potential to disrupt animal development or the overall balance of the ecosystem.³⁴

- Plastic particles – which do not biodegrade – outweigh plankton by 600 percent in the Great Garbage Patch – a swirling mass of persistent trash the size of Texas in the North Pacific Ocean.³⁵
- Local governments are struggling to figure out what to do with almost 9 billion pounds of plastic and electronic waste each year.³⁶ Inefficient management of materials increases waste management costs for local governments and their taxpayers, while also contributing to global warming and other forms of pollution.³⁷

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 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-market screening based on existing information, and did not require toxicity testing for health effects. As a result, the burden of proving that a chemical is unsafe fell on the EPA and the scientific community.

And the burden of proof is impossibly high. Even in the case of asbestos, EPA

was unable to successfully ban the use of the substance despite decades of evidence that inhalation of asbestos causes cancer.³⁸ This approach 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.

In September 2009, federal EPA Administrator Lisa Jackson visited San Francisco to make the case for reforming the Toxic Substances Control Act (TSCA).

She acknowledged that “over the years, not only has TSCA fallen behind the industry it’s supposed to regulate – it’s been proven an inadequate tool for providing the protection against chemical risks that the public rightfully expects.”³⁹ Administrator Jackson chose to visit California for her announcement in recognition of the state’s leadership in advancing new ways of managing chemicals in our society, including the state’s pioneering Green Chemistry Initiative.

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 safe from the start.

Weaknesses in Chemical Regulation

Chemical policy experts Michael Wilson and Megan Schwartzmann at the University of California at Berkeley, and their colleagues at UCLA, identified three key weaknesses in federal and state chemical regulatory policies in a comprehensive report for the state legislature titled *Green Chemistry: Cornerstone to a Sustainable California*.⁴⁰ These weaknesses are:

- **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 better.
- **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.

Traditionally, designers have narrowly considered factors such as cost and performance when creating a product. Wider concerns, including potential impacts on public health and the environment, did not enter into the equation.

In contrast, green chemistry encourages a more comprehensive approach, seeking to meet consumer needs for quality and cost-effectiveness while minimizing harmful impacts. Green chemistry starts at the earliest stages of product or process design and follows through all the way to product disposal, emphasizing the use of the safest materials or approaches.

In 1998, Paul Anastas and John Warner, pioneers in the field, developed a set of guiding principles for green chemistry, including:⁴¹

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

The Green Chemistry Initiative—Advancing Green Chemistry Through Policy

The Green Chemistry Initiative, launched by Governor Schwarzenegger and Secretary for Environmental Protection Linda Adams in April 2007, is California’s groundbreaking effort to incorporate the principles of green

Photo: BASF



chemistry into state chemicals policy, and to encourage the widespread practice of green chemistry in commerce across the state.⁴² Maziar Movassaghi, the acting director of the California Department of Toxic Substance Control, calls the Green Chemistry Initiative “a game-changing plan on how we can save the environment and increase our economy.”⁴³

The Green Chemistry Initiative, authorized by enabling legislation AB 1879 and SB 509, emphasizes the need to identify safer, functional and cost-effective alternatives to toxic chemicals in manufacturing processes and consumer products.

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

Photo: Daino 16, www.sxc.hu



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.

California Companies are Showing that Green Chemistry Works

The case studies that follow highlight 12 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. These leaders are showing that green chemistry works. Through design and innovation, we can reduce and eliminate the use of harmful chemicals, maximizing the benefits of commerce and minimizing its hazards. These examples show the potential for strong implementation of the Green Chemistry Initiative to give birth to a new industry here in California, protecting our health while creating jobs.

Kaiser Permanente: Expanding the Definition of Health Care

Kaiser Permanente, based in Oakland, is the nation's largest integrated health

care delivery organization. It serves more than 8.6 million customers nationwide, operates 35 medical centers, and employs 14,600 physicians.⁴⁵ Kaiser Permanente operates based on the Hippocratic Oath: “above all, do no harm.” Following words with action, Kaiser Permanente began to reduce the use of harmful chemicals in its hospitals beginning in the 1990s.⁴⁶

Kaiser Permanente's awareness of the threat posed by toxic chemicals dates back to the 1960s. According to Kathy Gerwig, Kaiser Permanente's Vice President for Workplace Safety and Environmental Stewardship Officer, famed environmentalist Rachel Carson gave one of her final speeches to a group of Kaiser Permanente doctors. The organization listened to Carson's warnings of the danger toxic chemicals posed to human health and the environment, and took action. According to Gerwig, “where there is credible evidence that a material we're using may result in environmental or public health harm, we [...] strive to

Are Alternative Chemicals Safer?

In most of the case studies presented in this report, businesses have proactively identified hazards in products or manufacturing processes and acted to phase them out, replace them altogether, or redesign the way a product is made. These actions are a strong step forward and deserve praise. However, because of weaknesses in state and federal chemical regulatory policies, there is no guarantee that all alternative, substitute chemicals will actually be safer. For example, manufacturers initially introduced toxic PBDE flame retardants to replace chlorinated compounds that showed signs of toxicity, persistence in the environment, and the ability to accumulate in the food chain. Only later did scientists discover that PBDEs posed similar risks. Now, some of the chemicals being used to replace PBDEs are showing up in our bodies.⁴⁴ Very little hazard testing has been done on the chemicals.

A strong green chemistry policy will be necessary to break the cycle of replacing one toxic substance with another and to ensure that safer alternatives are actually safer. Strong policy can give all businesses the tools to make more informed decisions while protecting public health and the environment.

replace it with safer alternatives.”⁴⁷ “We recognize that healthy communities and a healthy environment are critical to the health and wellness of every person.”⁴⁸

Kaiser Permanente has adopted a set of green chemistry principles to guide decisions about chemicals, product purchasing, and its broader public stance on the chemicals issue.⁴⁹ Kaiser Permanente seeks to:

- **Understand product chemistry.** Kaiser Permanente asks product suppliers to transparently disclose ingredients used to manufacture the product.
- **Assess and avoid hazards.** Kaiser Permanente asks suppliers to eliminate hazards wherever possible, to minimize exposure when hazards cannot be prevented, and to redesign products and processes to avoid the use and generation of hazardous chemicals.

Photo: Michael Jeung



Kaiser Permanente is working to phase out the developmental toxicant diethylhexyl phthalate from its neonatal intensive care units, and driving the market for phthalate-free carpeting through its purchasing policies.

- **Commit to continuous improvement.** Kaiser Permanente regularly reviews its progress in creating a safer health care environment, and looks for areas to make further progress.
- **Inform public policies and industry standards.** Kaiser Permanente speaks out in support of policies and standards that expand green chemistry research and education, and advance green chemistry principles in the broader economy.

Kaiser Permanente's use of these principles drives innovation in the larger economy. One of the best examples in this regard is the organization's work to eliminate the use of di(2-ethylhexyl) phthalate (DEHP) – a chemical used to make polyvinyl chloride (PVC) plastic flexible. PVC contains 20 to 40 percent DEHP by weight and makes up about a quarter of all the plastics used in hospitals, including IV bags and medical tubing.⁵⁰

In 2001, Kaiser Permanente staff concluded that there was credible evidence that DEHP may cause reproductive harm. In 2000, Dr. L. Earl Gray and his colleagues at the U.S. EPA reported that three types of commonly used phthalates

(DEHP, BBP and DINP) disrupt sexual development in the male rat.⁵¹ When female rats were fed these phthalates during pregnancy, they gave birth to male pups that weighed less and showed symptoms of malformed urethras, cleft phallus, reduced testes weight, undescended testicles, and other reproductive malformations. DEHP apparently reduced testosterone production in the developing testes, interfering with the signals that direct normal male reproductive development.⁵²

Given the potential risk, Kaiser Permanente chose to begin to phase out the use of DEHP in its neonatal intensive care units. Nursing staff inventoried products that were used in neonatal care, and experts identified those that contained DEHP. Kaiser Permanente then studied potential alternatives, discovering and deploying replacements for three key products.⁵³

As further studies confirmed the evidence that DEHP poses a threat to human health – uncovering links to premature birth, reproductive system birth defects in boys, attention deficit problems, early puberty, endometriosis, and asthma and allergies in children and

Green Chemistry at Catholic Health Care West

San-Francisco-based Catholic Health Care West, the state's largest hospital system, is also a leader in removing phthalates from medical products. In 2005, the organization contracted with German manufacturer B. Braun Medical, Inc. to supply phthalate-free IV bags and tubing to its 41 hospitals in California, Arizona and Nevada – spending \$70 million over five years.⁵⁴

Catholic Healthcare West's Kathryn Kudzia explained the organization's motivation for taking action in a factsheet: "We understand our responsibility to deliver safe, effective care to all who come to us. That we have taken a stand against unnecessary additives that may cause harm is a natural extension of our mission."⁵⁵

adults – Kaiser Permanente took further action, by seeking to eliminate PVCs and phthalates from the carpeting in its medical facilities.⁵⁶

Kaiser Permanente was initially unable to find any carpet manufacturers offering a vinyl-free carpet that met its performance standards.⁵⁷ Instead of giving up, Kaiser Permanente leveraged its market power to encourage carpet manufacturers to design a new product at a price not to exceed that of the current product. Since Kaiser Permanente planned to spend \$28 billion on facility construction and renovation through 2015, several carpet suppliers were willing to bid for Kaiser Permanente's business.⁵⁸

Tandus, a carpet company based in Georgia, invented a new kind of carpet that uses reclaimed laminate from windshield glass for a backing material, instead of PVC. The carpet, called "Ethos," is recyclable, does not contain phthalates, and has very low emissions of indoor air pollutants.⁵⁹ Moreover, the carpet cost less than PVC-backed products.⁶⁰ Tandus was able to win Kaiser's business while developing an innovative new product to market to other customers, moving ahead of the competition. Kaiser Permanente has used the new carpet extensively in its new Modesto Medical Center, a facility that employs more than 1,000 people.⁶¹

However, even with Kaiser Permanente's market power, it has found that eliminating toxic chemicals from its facilities can be difficult. First of all, obtaining full disclosure from its suppliers about chemical ingredients is difficult or impossible in many situations. Sometimes, a supplier won't supply information about the chemicals it uses, either due to lack of knowledge or to protect a trade secret. When a supplier provides information, it is often incomplete or hard to use – largely due to the lack of publicly available safety information for tens of thousands of chemicals in com-

merce today.⁶² Moreover, Kaiser Permanente's experience in finding alternatives to PVC-backed carpet highlights the high level of effort required to identify, test and deploy alternative products.

Not every company has Kaiser Permanente's size and power, but an effective green chemistry policy can effectively bring businesses of all shapes and sizes to work together toward a healthier future. A strong green chemistry policy can make information about chemical ingredients, their hazards, and alternatives available to all companies and people that need it. This information can enable companies or organizations that are looking for greener ways of doing business to do an effective job, and reduce the barriers for other companies to take action.

Moreover, a strong green chemistry policy can enable California to act as an effective driver of innovation, much as Kaiser Permanente motivated Tandus to invent a new product and compete in a new market. Policies that promote the use of safer alternatives in California will prompt companies to invest in developing those alternatives, creating new opportunities for success throughout the economy.

Apple Computer, Inc. and Hewlett-Packard: Eliminating Toxic Flame Retardants While Designing Better Products

Apple Computer, Inc. is one of the nation's leading manufacturers of computers and personal electronic devices. From designing one of the first personal computers in the 1970s to inventing new entertainment and communication devices like the iPod and the iPhone, Apple has built its reputation around innovation.

Photo: Apple Computer



By October 2008, Apple Computer reworked its supply chain to phase out a range of potentially hazardous substances, including toxic PBDE flame retardants.

Apple's innovation in product design extends into the realm of green chemistry. Starting in the 1990s, Apple has grappled with the issue of hazardous chemicals in its batteries and electronics, using the challenge as an opportunity to design better products and increase its competitiveness in the information technology marketplace.

Similarly, Palo Alto-based Hewlett Packard (HP), the world's largest information technology company, has worked to eliminate hazardous chemicals from its computers, printers, and data storage devices since establishing a Design for the Environment program in 1992.⁶³

Apple's and HP's introduction to green chemistry came in no small part from the European Union. A major fraction of these companies' business is in Europe. Thus, regulations passed in Europe have had an important influence over product design strategies at Apple and HP. For example, in 2003, the European Union responded to concerns over the use of a set of toxic chemicals in electronics by passing a directive limiting their use.⁶⁴

The directive affected how electronics companies deal with the challenge

of making their products fire-safe. One class of flame retardant (polybrominated diphenyl ethers, or PBDEs) stood out as a focus of concern. This chemical was not physically bound to plastic in electronic devices, so it could escape from the product during use or after disposal, contaminating the home or the broader environment.⁶⁵

In 1997, European scientists discovered PBDE flame retardants accumulating in the blood and fatty tissues of animals and in human breast milk. In the early 2000s, scientists discovered the chemicals in the breast milk of California women at levels 75 times higher than that of European women.⁶⁶

The discovery triggered a flurry of additional research. Scientists began to uncover the possibility that PBDEs could interfere with the process of healthy brain development in infants.⁶⁷ The situation was eerily reminiscent to the widespread problem of PCBs, chemicals banned in 1976 because they were found to cause immune suppression, altered sexual development, cancer, delayed brain development, lower IQ, and behavioral problems such as hyperactivity in humans.⁶⁸

Faced with a European Union directive limiting the use of PBDEs, and the likelihood of similar action in the U.S. and other countries, Apple took the opportunity to evaluate its entire product line, identify potentially hazardous substances, and proactively eliminate them. In addition to meeting the requirements of the directive years before it went into effect, Apple looked for opportunities to remove other problematic compounds while working to increase product performance and attractiveness and minimizing the cost of ensuring supplier compliance.⁶⁹ For example:

- Apple went above and beyond the European directive on hazardous chemicals, voluntarily phasing out

the use of other dangerous materials, including asbestos, cadmium, hexavalent chromium, organic tin, polychlorinated biphenyls, polychlorinated dibenzodioxins, polychlorinated naphthalene, polychlorinated terphenyls, and chlorinated paraffins.⁷⁰

- In 2006, Apple became the first computer company to switch entirely away from cathode ray tube (CRT) monitors in favor of liquid crystal displays (LCD), largely eliminating the use of lead, a toxic metal linked to birth defects.⁷¹ Two years later, Apple transitioned to light emitting diode (LED) displays, largely eliminating mercury, another toxic metal.⁷²
- In working to eliminate PBDE flame retardants from its products, Apple realized that many substitute chemicals – especially those made with chlorine or bromine – were possible health threats. As a result, Apple chose to eliminate all compounds containing chlorine and bromine from its electronics, including widely used materials like polyvinyl chloride.⁷³ By October 2008, Apple had succeeded in reforming its entire supply chain.⁷⁴

Broadly eliminating all chlorinated and brominated compounds made it simple and far less costly for Apple to confirm that the suppliers it works with are in compliance with company policy. Testing for individual chemical compounds can be difficult and costly – especially when large numbers of chemicals are involved. However, testing for the presence of a pair of elements like chlorine and bromine is relatively simple and cheap. By directing suppliers to avoid chlorine and bromine in components, Apple created an easily verifiable standard that protects its



By working with suppliers to eliminate toxic hazards from product designs, Hewlett-Packard has made its products easier and safer to recycle.

customers from a variety of toxic chemicals all at once.⁷⁵

This action has rippled throughout the consumer electronics industry. For example, California-based Seagate, Inc. – the world's largest manufacturer of disk drives – eliminated chlorine- and bromine-based ingredients from its products in response to Apple's action.⁷⁶

Similarly, HP has restricted a wide range of chemicals of concern from inclusion in its products, including PBDE flame retardants. The company includes a list of these chemicals in every contract with a supplier, covering all components that end up in an HP product or in packaging.⁷⁷ Every two months, a team of HP employees meets to discuss any emerging concerns about chemicals that might be used in the company's products, updating the list of restricted substances annually.⁷⁸ For example, HP is restricting three additional types of phthalates by 2012.⁷⁹

HP also asks suppliers to supply information about 240 chemicals of concern that are not now subject to regulation, but may be restricted in the future. The company has set up a customized Web portal to make it easier for suppliers to respond.⁸⁰ HP is also working to deploy methods to establish that any alternative chemicals are safer than the substances they replace – a key principle of green chemistry. These steps ensure HP's access to markets in Europe and prepare the company to respond to any future concerns about hazardous chemicals in advance of many of its competitors.

Both HP and Apple have continued to grow and succeed while making major green chemistry innovations in the information technology world. Cupertino-based Apple earned more than \$32 billion in revenue worldwide in 2008, and received the top rank on Fortune Magazine's list of "Most Admired Companies" in that year.⁸¹ Similarly, HP is the largest company of its kind, earning almost \$120 billion in revenue in 2008.⁸² These com-

panies' examples show that a thoughtful approach to product design – including green chemistry principles – can be a strong component of business success and delivering customer satisfaction.

A strong green chemistry policy can encourage other companies to follow Apple and HP and use the task of eliminating hazards as an opportunity to design better products and become more competitive in the marketplace.

How BASF Responded to California's Need for Clean Air with a Less-Polluting Paint

Smog is one of California's most familiar public health hazards. Since the 1950s, the state, 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 the use of 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 Los Angeles's smog problem. 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.⁸³

Photo: BASF



BASF scientists, like those pictured here, invented a new kind of paint primer curable with U-V light, reducing emissions of air pollutants that contribute to Southern California's poor air quality.

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 exposure to VOCs include headaches, eye, nose, and throat irritation, nausea, and loss of coordination during immediate exposure, and also long-lasting ill effects such as kidney, liver, and central nervous system damage, as well as increased risk of cancer.⁸⁴ Exposure to VOCs while using solvents or paint products can reach up to 1,000 times background outdoor levels.

The South Coast Air Quality Management District (the District) is one of the governmental entities charged with reducing the threat of smog, VOCs, and other air pollutants in the Los Angeles basin.⁸⁵ In 2003, the District established the nation's strictest regulations on the use of VOCs in paints – regulations that precluded the use of many existing paint technologies at the time. In response, a national paint manufacturers' association sued the District, claiming that the regulations were too strict to be feasibly achievable.⁸⁶

BASF, the world's largest chemical company, proved the claim wrong. As Colin Gouveia, a marketing director at building products company Rohm and Haas put it to the *Los Angeles Times*, "sometimes green products need a little kick from a regulation to overcome the barrier to change."⁸⁷ In many ways, paint innovations at BASF have followed the evolution of District regulations. Since the mid 1990s, BASF has used District regulations as a benchmark for research and new product development.⁸⁸

Responding to the 2003 District regulations required a technological leap to new varieties of automotive primers that no longer relied on VOCs as a principle solvent.⁸⁹ BASF chemists could have chosen to reduce volatile chemical emissions by choosing a water-based primer tech-

nology. However, these products dried too slowly to be convenient for many uses. BASF chemists solved this problem by inventing a product that cures very rapidly under ultraviolet light, creating a durable coat in a very short time.

In addition to reducing VOC content by half to two-thirds below conventional primers, BASF's new primer performed better than traditional products.⁹⁰ The new primer offered a higher quality coat and faster drying time, while reducing the amount of primer required to do a job and reducing the amount of waste product. Moreover, the new product is less hazardous for workers' respiratory health, requiring simpler and less expensive safety equipment – a benefit of particular importance for small businesses.⁹¹ The U.S. Environmental Protection Agency gave BASF a Presidential Green Chemistry Challenge Award in 2005 in recognition of its achievement.⁹²

BASF's response to a standard that rendered many of its existing products obsolete demonstrates the potential for green chemistry policies to drive innovation. 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.

Green to Grow and Klean Kanteen: California Companies Making Bottles without Bisphenol-A

Many water bottles, hard clear plastic food containers, and the linings of metal food cans used in California are made from a synthetic sex hormone known as bisphenol-A, or BPA. The chemical industry produces over 6 billion pounds of BPA annually, largely for use as a

building block of polycarbonate plastic (identifiable by its hard, clear properties, the #7 recycling symbol, and the letters “PC”). Because it is so widespread, BPA can be found in more than 90 percent of American adults, and in the blood of children yet to be born.⁹³

BPA possesses some of the properties of the hormone estrogen in the human body – enabling it to interfere with the proper transmission of information between cells. More than a decade of scientific research has revealed that exposure to even tiny doses of BPA may lead to serious adverse health effects, including breast and prostate cancer, heart disease, thyroid disease, early puberty in girls, attention deficit and hyperactivity disorders, diabetes, and obesity.⁹⁴ In early 2010, the Food and Drug Administration expressed concern over public exposure to this chemical, while stating that it lacked the regulatory authority to take meaningful action.⁹⁵

As consumers have become more aware of this toxic hazard in drinking water bottles, they have begun to demand healthier alternatives. Two California companies are leading the charge to

provide water bottles made from safer materials.

Green to Grow, a Glendale-based baby products company, centers its business around a line of BPA-free baby bottles. Instead of BPA-based polycarbonate plastic, Green to Grow uses an alternative plastic called polyethersulfone (PES).⁹⁶ Green to Grow’s bottles are hard, durable, heat-tolerant, dishwasher-safe, and contain no toxic additives.⁹⁷ The FDA views PES plastic as a safe material for use in storing food and liquids meant for human consumption.⁹⁸

As Michael Ritterbrown, president of Green to Grow, writes on the company Web site, “Our decision to launch Green to Grow with a line of BPA-free plastic baby bottles grew from our alarm as we read reports that highlighted the potential dangers presented by polycarbonate plastic, which contains the hormone disruptor bisphenol-A and from our frustration over the lack of options.”

Chico-based Klean Kanteen is another California company meeting consumer demand for BPA-free products. In the early 2000s, inventor Robert Seals listened to Julia Butterfly Hill, an environmental activist and motivational speaker, talk about the hazards of BPA and polycarbonate plastic, as well as the massive amounts of waste created by the single-use water bottle industry. He was inspired to make a reusable water bottle made from stainless steel, with a BPA-free cap made from polypropylene, a safer plastic.⁹⁹ In 2004, the company introduced the product to market, and has since built a thriving business. As of 2010, the company employs about 40 people.¹⁰⁰

The stainless steel in Klean Kanteen bottles performs better than other types of metal, making a plastic liner unnecessary – a clear contrast from similar companies like Sigg, which used an ep-

Photos: Green to Grow



Green to Grow manufactures and markets baby bottles made from an alternative plastic or from glass, reducing babies’ exposure to the synthetic sex hormone bisphenol-A.

oxy liner containing BPA until August 2008.¹⁰¹ Using stainless steel eliminates the problem of the plastic lining degrading and leaching into the liquid inside the bottle.¹⁰²

Klean Kanteen was well positioned to respond to consumer demand for safer water bottles as awareness of the hazards of BPA began to grow. According to Danielle Cresswell, sustainability officer for Klean Kanteen, when Canada took action to ban polycarbonate in baby bottles, “business went completely through the roof.”¹⁰³

As stories about BPA began to proliferate in the mainstream media, Klean Kanteen’s business grew by 1,000 percent from 2007 to 2008 – reaching on the order of \$18 million in revenue.¹⁰⁴ The company rapidly grew from six employees to 36.¹⁰⁵ Demand has continued to grow – although not as rapidly – even through the economic downturn.¹⁰⁶

As competing BPA-free water bottle products proliferate, Cresswell notes that Klean Kanteen is helping to transform the industry through its attention to detail in helping consumers recognize and access a safer product. “At the end of the day, that’s a huge source of satisfaction for our company,” she said.¹⁰⁷

The founders of Green to Grow and Klean Kanteen both created their companies specifically in response to emerging concerns over the safety of BPA-based polycarbonate and other traditional plastics. The companies applied green chemistry principles to create simple but innovative products designed to be safer to use. As a result, these companies broke out ahead of their competition because they were prepared to capitalize on a growing public demand for alternative products. As awareness of the hazards of BPA grows in the future, these companies are well positioned to achieve even greater success.

Photo: Klean Kanteen



Klean Kanteen manufactures stainless steel beverage containers, including the insulated version pictured here. These bottles help to reduce public exposure to the synthetic sex hormone bisphenol-A, which is the main ingredient in polycarbonate plastic and is often found in the inner lining of canned food.

California Green Cleaning: Method Products, CleanWell and The Clorox Company

Household cleaners – including popular products like Formula 409 or Tide laundry detergent – can contain chemicals that irritate skin and respiratory tissues, are linked to asthma, or even lead to reproductive harm. These problematic ingredients include chemicals like monoethanolamine, quaternary ammonium compounds, glycol ethers, alkyl phenol ethoxylate surfactants, and phthalates.¹⁰⁸ Some products also include ingredients – such as nitromusk fragrances – that could accumulate in the food chain by concentrating in fatty tissues, permanently contaminating our bodies and leading to unknown consequences.¹⁰⁹ Cleaning



Photo: Method Products

Method manufactures and sells home and personal cleaning products using non-toxic and biodegradable ingredients, including the bathroom cleaning kit pictured here.



Photo: CleanWell

CleanWell designed a natural, biodegradable disinfectant based on thyme to replace toxic triclosan in hand cleaners (pictured here) and in surface cleaners marketed by Seventh Generation.

products can also contain phosphates, which contribute to water pollution, and disinfectant chemicals such as triclosan and quaternary ammonium compounds, which could contribute to the problem of antibiotic resistant bacteria and to human

health problems including breast cancer and asthma.¹¹⁰

To address these problems, several leading companies based in California have designed new cleaning products using green chemistry principles – products designed to pose little or no threat to the user or to the environment after disposal. For example, San Francisco-based Method manufactures home and personal cleaning products from biodegradable ingredients, avoiding a set of common cleaning ingredients like phthalates and parabens it considers hazardous.¹¹¹ Another San Francisco company, CleanWell, manufactures a natural oil-based disinfectant for hand sanitizers and industrial cleaners. Even major multinational corporations, such as Oakland-based Clorox Company, have joined the drive to produce and market green cleaning products.

CleanWell founder Sam DeAth launched his company in response to the struggles of his son, born with an immune system disorder. DeAth wanted to keep his home as free of infectious agents as possible to help protect his son, but without exposing him to triclosan and other potentially cancer-causing chemicals. Working with his mother, DeAth “set out to create a formula that could kill germs, while not being a poison itself.”¹¹² Starting with oregano and thyme, and with the help of a team of microbiologists, DeAth developed a natural, biodegradable disinfectant oil used in CleanWell’s own line of hand cleaners, and in products marketed by Seventh Generation.¹¹³

Method Products was founded in 2000 by Adam Lowry, a Stanford-educated chemical engineer, and his partner Eric Ryan.¹¹⁴ The company put green chemistry principles “at the core of [their] business philosophy.”¹¹⁵ Today, Method sells more than 100 non-toxic cleaning and personal care products at major retailers in the United States, the United

Kingdom and Canada, including Target and Costco.¹¹⁶ The company has built a business generating more than \$100 million in revenue annually.¹¹⁷

In addition to using non-toxic formulas for its products, Method requires its suppliers, including fragrance manufacturers, to certify that all ingredients meet the company's health and environmental criteria.¹¹⁸ Lowry is working to transform the cleaning products industry with "a fundamentally different business model, one that generates waves of innovation that will force the largest companies out of their comfort zones."¹¹⁹

Oakland-based Clorox Co. was the first major cleaning products company to respond to the wave of innovation and introduce a line of green products. Dubbed "Green Works," Clorox's green cleaners contain ingredients derived from sources including coconuts and lemons.¹²⁰ The products are biodegradable and the bottle lists every ingredient.¹²¹ While the product isn't perfect (some products contain the potentially problematic sodium laureth sulfate, and some of the natural sources of these chemicals can lead to rainforest habitat destruction or come from corn, which undergoes energy-intensive fertilization

and pesticide applications), the U.S. Environmental Protection Agency has certified the products under the Design for the Environment program.¹²²

In its first year, Green Works generated on the order of \$40 million in revenue, capturing a little more than 40 percent of the \$100 million market for green cleaning products. Significantly, as one stock analyst noted, Clorox increased the size of the market. "People who weren't buying (green cleaning products) are buying them now."¹²³

Other California-based manufacturers of green cleaning products include Pleasanton-based Shaklee Corporation, a social marketing company, and Huntington-beach based Sunshine Makers, which manufactures a "Naturals" line of its well-known "Simple Green" cleaning product using ingredients certified by Green Seal.¹²⁴

The actions of these companies are providing a "wake-up call" to chemical manufacturers that supply ingredients for cleaning products, driving new innovations.¹²⁵ Chemical manufacturers have responded to this new market by designing and producing new types of ingredients that perform in the way consumers expect while posing fewer hazards.¹²⁶ The

Photo: Clorox Company



Clorox Company, one of the nation's largest cleaning product manufacturers, developed this line of cleaning products made from naturally-derived ingredients, greatly expanding the green cleaning market.

need for greener ingredients for cleaning products is already a major driver of activity and innovation for suppliers of specialty chemicals.¹²⁷ For example, Dow chemical company developed a line of surfactants called Ecosurf, based on palm kernel oil.¹²⁸ Other companies are finding new uses for ingredients traditionally marketed to the food industry, such as alginates from seaweed.¹²⁹

Method's Lowry sees green chemistry as the guiding principle for all product manufacturers in the future. "The companies that don't do it will become the dinosaurs," he told the *Los Angeles Times* in 2008.¹³⁰

Using Green Chemistry to Streamline Drug Manufacturing: Pfizer and Codexis

Manufacturing a drug can require dozens of chemical reactions, carried out on a massive scale. Some steps require toxic solvents or hazardous chemicals, which can pose hazards to workers and end up as waste products. Other steps require large energy inputs.

"What initiatives like the Green Chemistry Initiative do is they create requirements and incentives to create more businesses like Method to be born and to compete."

- Adam Lowry, Co-Founder of San Francisco-based Method Products, a manufacturer of green home care products, speaking on KGO-TV news, December 8, 2009. 131

Green chemistry offers the possibility of making pharmaceutical manufacturing cleaner, more efficient and less toxic. Several companies based in California or operating research facilities here – including Pfizer and Codexis – are driving these innovations forward.

Pfizer, one of the world's largest pharmaceutical companies, employs more than 1,000 scientists at a research campus in La Jolla. Pfizer researchers used green chemistry principles to streamline and reduce the toxicity of the manufacturing process for the antidepressant drug Zoloft. The new process reduced solvent use by 90 percent and eliminated hundreds of tons of waste laced with hydrochloric acid.

Zoloft is based on an active ingredient called sertraline. Originally, Pfizer manufactured sertraline using a process that required titanium tetrachloride – a salt that can generate hydrochloric acid – to help push the reactants in and out of solution. The reaction used 60,000 gallons of solvent for every ton of sertraline produced, and every year Pfizer disposed of 150 tons of waste that was composed of 35 percent hydrochloric acid.¹³²

However, in 1998, Pfizer researchers streamlined this reaction, switching to ethanol as a solvent and eliminating titanium tetrachloride, avoiding the generation of hydrochloric acid. Moreover, the researchers reduced solvent use to just 6,000 gallons per ton of sertraline. In addition to requiring less raw materials and producing less waste, the new process offered higher product yields. All of these benefits improved Pfizer's bottom line.

Codexis, based in Redwood City, is a relatively new company started to help large pharmaceutical companies develop and apply green chemistry innovations. According to the company Web site, Codexis develops "enzyme products that make new industrial processes possible, and make existing processes faster, clean-

er and more efficient than conventional methods.”¹³³

For example, Codexis developed three customized enzymes for Pfizer to use in the synthesis of Lipitor, a widely-used cholesterol management drug. The enzymes reduced the need for fossil fuels and harsh chemicals during the reaction process, reducing waste and energy use – and earned Codexis a 2006 Presidential Green Chemistry Challenge award from the U.S. EPA.

Lipitor is the world’s best selling cholesterol-reduction drug, and the first drug to achieve worldwide annual sales of over \$10 billion. Originally, one critical building block of Lipitor was produced through a several-step process that required the use of hydrogen gas derived from fossil fuels, took place partly in potentially dangerous heated alkaline conditions, and produced unnecessary waste products. Codexis reworked the reaction by developing three enzymes that could produce the desired results without using fossil fuels, producing excessive byproducts, or requiring such a harsh reaction environment.¹³⁴ The new process has lower manufacturing costs, and also requires less purifying equipment. Codexis notes that increasing manufacturing efficiency can “reduce production costs and enhance brand value [... which is] not only good for the environment, it’s good for the bottom line.”¹³⁵

Pfizer has learned that green chemistry can help build a stronger business, reducing chemical and energy inputs, improving the safety of working conditions, and reducing the volume and hazard of waste products. And Codexis has learned that green chemistry principles make an effective business foundation – three years after winning the Presidential Green Chemistry Challenge award for its work on Lipitor, the company filed for an initial public offering in December 2009.¹³⁶

A strong green chemistry policy can

Photo: Pfizer



Codexis worked with Pfizer to streamline the reaction used to make the cholesterol-lowering drug Lipitor, reducing the use of hazardous materials, saving energy and reducing waste – and improving the company’s bottom line.

help many different types of California companies improve their manufacturing processes, capture efficiencies, improve their products and achieve business success.

Making Nail Polish Without Prop-65 Listed Carcinogens: Nubar

Noubar Abrahamian is a Los Angeles-based businessman and the founder of Nubar – a manufacturer of nail polish products formulated without chemicals listed as carcinogens under California’s pioneering Proposition 65 labeling law.

When Abrahamian was 33, one of his cousins was diagnosed with cancer. While his cousin was in the hospital undergoing treatment, he brought her some nail polish to cheer her up. Much to his surprise, the hospital staff informed him that his cousin could not use the polish, because it contained potential carcinogens.¹³⁷

Abrahamian gave serious thought to the encounter. He questioned why nail polish would contain ingredients that could make a healthy person sick.¹³⁸ He

decided that he wanted to create a line of nail polish that was carcinogen free for all women.¹³⁹

Nail polish commonly includes ingredients that are likely carcinogens, including dibutyl phthalate (DBP), toluene and formaldehyde. All three of these chemicals are listed under California's Proposition 65 as chemicals known to the state of California as causes of cancer, birth defects, or reproductive harm. Specifically:

- Exposure to formaldehyde vapors can cause and/or aggravate allergies and asthma in children.¹⁴⁰ The chemical can also cause cancer after long-term exposures to very small amounts.¹⁴¹
- Toluene is a solvent often used in paint thinners and related products. Exposure to toluene can cause damage to the nervous system. Pregnant women exposed to toluene may have an increased risk of delivering a child with birth defects.¹⁴²
- Cosmetic product manufacturers regularly use DBP as an ingredient. Scientists commonly find DBP and related chemicals in human urine samples.¹⁴³ 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.¹⁴⁴

Abrahamian felt certain that nail polish did not have to contain these toxic ingredients in order to be beautiful, durable and effective. He founded Nubar Cosmetics, which designed and produced a new nail polish formula without using chemicals on the Proposition 65 list. According to Nubar Marketing Director Jenn Anderson, "We have found that quality is not sacrificed, rather improved upon, by using a carcinogen-free formula."¹⁴⁵

Photo: The Nailphile



Nubar markets nail polish products made without the Proposition 65-listed carcinogens dibutyl phthalate, toluene or formaldehyde.

Nubar holds its ingredients list proprietary. As a result, there remains the possibility that it could contain hazards that have not yet been tested sufficiently to lead to inclusion on the Proposition 65 list – a situation that also applies to practically every other nail polish product available.

However, Nubar's formula reduces its customer's exposure to known hazards. Additionally, because Nubar products do not contain DBP – which has been banned in cosmetic products in the European Union – and other harmful substances, the company is able to access a large international market for its products. The company is also well-positioned to respond nimbly to new chemical regulations in domestic markets, while using its unique green chemistry approach as an effective marketing tool.

According to Anderson, "the nail care industry needed a healthy alternative for beautiful nails, and Nubar fills that need."¹⁴⁶

Another Example of California Regulations Driving Innovation: How Columbia Forest Products is Making Homes with Healthy Air

California is well known for innovation when it comes to addressing hazards to public health. One example is the state's efforts to reduce the levels of the cancer-causing respiratory irritant formaldehyde in the indoor air of many homes.

California formally declared formaldehyde to be a toxic air contaminant in 1992.¹⁴⁷ State law requires the California Air Resources Board (ARB) to take action to reduce public exposure to toxic air contaminants, requiring the use of best available control technology that is technically available and economically feasible. After years of debate, ARB proposed a regulation limiting the emissions of formaldehyde from composite wood boards in 2006. The regulation applies at the level of board manufacturing, reducing allowable emissions from the raw materials later used in furniture and buildings.

As California indicated its intention to regulate formaldehyde, Columbia Forest Products (North America's largest manufacturer of hardwood plywood and hardwood veneer) acted to develop a healthier alternative, applying green chemistry principles to the problem. In 2005, Columbia Forest Products announced its transition to PureBond®, a manufacturing technology that utilizes a natural adhesive composed primarily of soy flour and water.¹⁴⁸ Scientists designed the formula "to mimic the protein that marine mussels use to attach themselves to rocks and other hard surfaces."¹⁴⁹

By March 2008, the company had converted all seven of its manufacturing plants to use this system, producing more than 25 million plywood panels with formaldehyde-free adhesive.¹⁵⁰ The conversion replaced millions of pounds of urea-formaldehyde, reducing emissions of hazardous air pollutants at the plants by up to 90 percent.¹⁵¹

Plywood panels made with PureBond® cost no more than panels made with the standard urea-formaldehyde adhesive.¹⁵² In 2007, U.S. EPA recognized Columbia Forest Products for this achievement with a Presidential Green Chemistry Challenge Award.¹⁵³ Building products retailers across California carry this innovative product.

By following green chemistry principles, Columbia Forest Products was prepared to make the transition to formaldehyde-free technologies well in advance of the stringent new limits on formaldehyde emissions put forward by the California Air Resources Board.¹⁵⁴ As a result, the company positioned itself well to capitalize on a growing market for safer building materials, stimulated by government regulations and consumer desire for healthier places to live – a smart business strategy.

California's Green Chemistry Initiative should ensure that other manufacturers identify and prioritize safer alternatives to many different varieties of toxic chemicals, much as Columbia Forest Products has done with formaldehyde-based adhesives.

Photo: Building Green



Workers stack sheets of Columbia Forest Products' hardwood plywood, a product made with an innovative formaldehyde-free adhesive called PureBond.

Green Chemistry 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.

Despite these many benefits, the green chemistry approach represents a paradigm shift in the way businesses have treated product design, and large barriers to change exist. That is why the California Green Chemistry Initiative is so important.

A strong Green Chemistry Initiative will improve our knowledge of chemicals used in commerce, encourage the use of materials and processes most likely to

be safe, and enable the government to take action to protect public health and the environment from the greatest threats, when warranted. By helping to overcome barriers to change, the Green Chemistry Initiative can give birth to a new industry in California.

Policy Recommendations

In order to be meaningful, California's Green Chemistry Initiative should be more than a voluntary, incentive-based program. The state needs to create the regulatory infrastructure – even if it needs to collect fees from manufacturers – to assess chemical safety and restrict or phase out the use of the most dangerous substances. The Green Chemistry Initiative should:

Require chemical manufacturers to prove that a chemical is safe before allowing it on the market.

- Regulators should require companies to provide comprehensive data on the intrinsic hazards of chemicals that they produce or import into California. Such data should include information on a chemical's ability to persist in the environment, accumulate in living organisms, be metabolized into other hazardous compounds, cause genetic damage, mimic important hormone signals, interfere with human development or reproduction, weaken the immune system, damage the nervous system, cause respiratory disease, or otherwise harm human health.
- 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.

Empower regulatory agencies to restrict or ban the manufacture and use of chemicals that pose potential dangers to human health or the environment.

- Where chemicals show evidence of intrinsic hazard – such as a tendency to persist in the environment, accumulate in living organisms, or cause toxic effects – regulators should restrict or prohibit the use of these chemicals and require the

substitution of safer alternatives, particularly in consumer products or other applications that lead to human exposure. In addition, regulators should consider possible adverse impacts to ecosystems.

- State agencies should lead the effort to identify and prioritize chemicals of concern and direct an appropriate regulatory response, based on a chemical's ability to cause harm.
- Where there is uncertainty in the evidence, regulators should err on the side of protecting health and the environment. In other words, "no data, no 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. California's Toxics Information Clearinghouse, created by legislation signed by Governor Schwarzenegger in 2008, should be an easily understandable database for 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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