



# Safer by Design

Businesses Can Replace Toxic  
Ingredients through Green Chemistry



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# Executive Summary

**T**he widespread use of toxic chemicals – in everything from industrial plants to baby bottles – is threatening our health and environment. But it doesn't have to be that way. Leading American businesses are showing that they can reduce or eliminate the use of toxic chemicals, keeping them out of our air, water, land and food. Through innovation, businesses can design manufacturing processes and products to be safe, following the principles of green chemistry.

This report highlights 14 businesses 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 businesses are creating green jobs and strengthening the economy.

However, because of weaknesses in current chemical regulation, many companies are continuing to depend on dangerous chemicals when safer alternatives exist. Stronger policies can do more to promote the invention and deployment of green chemistry innovations, protecting our

environment and our health while helping U.S. industries to thrive in the 21st century.

**Green chemistry is an approach businesses can use to reduce the use of toxic chemicals, make products safer and prevent pollution.**

- Traditionally, designers have failed to fully consider the risks posed by their products. From leaded gasoline to toxic additives in plastics, many products have ended up causing widespread damage.
- In contrast, green chemistry emphasizes the design of chemicals, processes and goods that cause little or no harm to our health or environment during manufacturing, use or disposal.

**While protecting public health and the environment, green chemistry can also help businesses drive revenues, reduce costs, and avoid risks.**



- By reducing the use of toxic chemicals, green chemistry can help businesses create new markets and new revenue streams; reduce raw material needs, cut waste, drive down energy costs, lower the cost of compliance with environmental regulations, minimize the cost of disposing of hazardous materials, reduce exposure to potential liability, and improve a company's branding and reputation. All of these are important for a company's bottom line.

**Leading companies across America are starting to realize the potential of green chemistry. For example:**

- **True Textiles** manufactures a fabric product made from 100 percent post-consumer recycled polyester and corn. The fabric, called Terratex, is naturally stain resistant and durable without the use of substances that pose health risks, such as toxic stain repellents. In 2006, the company estimated that the Terratex manufacturing process saves on the order of \$300,000 per year compared to conventional fabric manufacturing methods.
- The pharmaceutical company **Pfizer** worked with startup **Codexis** to simplify the process of manufacturing the cholesterol management drug Lipitor. Smarter approaches like this can reduce waste generation in drug manufacturing by as much as 50 to 90 percent, reducing the use of toxic ingredients and potentially saving the pharmaceutical industry billions of dollars on energy, raw materials and waste disposal.
- **SC Johnson** deployed a screening system that enabled it to reduce volatile organic chemical emissions from Windex by 1.8 million pounds per year, while designing a formula that cleans 30 percent better.

- **BASF and Procter & Gamble** each invented technology to reduce the contribution of paint to smog and unhealthy air quality in America's cities, positioning the companies to capture a greater share of the paint market while helping their customers comply with air quality regulations.
- These are not the only companies that have had success in replacing toxic chemicals with safer methods and materials. Other companies as diverse in size and scope as **Apple, Seagate, Hewlett-Packard, Walmart, Johns Manville, and Headwaters Technology Innovation Group** have made important advances, profiled in this report, that will benefit our health and environment.

**However, these examples are still the exception rather than the rule. State and federal governments are not doing enough to promote alternatives to toxic chemicals. Better policies can accelerate the development and deployment of smart green chemistry solutions. Reforms should:**

- **Increase access to information.** By requiring manufacturers to study and share information about the potential health or environmental hazards of chemical ingredients and products, consumers can better

know what ingredients are in a product and evaluate the relative safety of alternative chemicals or product designs – and thus give manufacturers a strong incentive to choose safer designs.

- **Require safer alternatives.** Developing non-toxic alternatives is a capital-intensive enterprise, and under current policy, there is no assurance that manufacturers will elect to use them. A rule requiring the phase-out of toxic chemicals as safer alternatives are established for particular uses would give entrepreneurs and investors the right market assurances spurring a major leap in the development of such alternatives.
- **Ensure that polluters pay.** One of the reasons that toxic chemicals are still widely viewed as “economical” is that manufacturers are never required to bear the full health and environmental costs that toxic chemicals impose. Policies that internalize at least some of these costs – like restoring the polluter pay fee to Superfund – help restore balance to the playing field and allow non-toxic alternatives to compete on equal footing.
- In the absence of comprehensive federal action, states should create their own policies to achieve these objectives, as several states have already begun to do.

# Introduction

Much of the time, businesses make choices out of sheer inertia, following the old adage, “If it ain’t broke, don’t fix it.”

The way many companies have addressed the issue of toxic chemicals is a prime example. Companies have tended to narrowly consider only factors such as short-term cost and product performance when deciding which chemicals to use. Moreover, companies have tended to look only at costs to themselves – not to our wider society.

This approach is broken. It allows toxic chemicals to infiltrate our lives, often without our knowledge or consent. It leads to the pollution of our skies with asthma-inducing smog; to the contamination of water supplies with toxic stain-resistant chemicals dumped from manufacturing plants; and to the contamination of our homes and bodies with toxic flame retardants shedding from furniture and electronics.

Consumers are growing increasingly aware of the environmental and public health hazards posed by the use of toxic chemicals in commerce. After each new

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“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.<sup>3</sup>

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chemical health threat hits the news, consumers are demanding action.

In response, leading American companies are turning to green chemistry – an approach businesses can use to reduce the use of toxic chemicals, make products safer, and prevent pollution. Paul Anastas, a former Yale professor and current official in the U.S. EPA Office of Research and Development under the Obama administration, sees green chemistry as creative, “out-of-box thinking” that can “boost profits and increase productivity while protecting the environment and human health.”<sup>2</sup>



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“There’s an amazing amount of this kind of out-of-box thinking going on now. These remarkable innovations are moving us closer to the day when green chemistry becomes standard and is recognized for what it truly is: A way to boost profits and increase productivity while protecting the environment and human health.”

– Paul Anastas, the “father of green chemistry” and Assistant Administrator of the U.S. EPA Office of Research and Development under the Obama administration.<sup>1</sup>

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Green chemistry innovations are beginning to transform the way some American businesses think about toxic chemicals and product design. As this report shows, when companies think seriously about how they design, manufacture or use products, they find opportunities to use less hazardous ingredients that are better for our environment and our health – and often better for the corporate bottom line, too.

This report tells the story of 14 leading businesses 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 the environment or public health during manufacture, use or disposal. In so doing, these companies have discovered how proactively

dealing with chemical hazards can open new markets and drive new revenue streams; reduce the cost of raw materials or energy; maintain or strengthen a company’s good reputation; and avoid business risks – such as the risk of being caught off-guard by a new regulation or exposed to liability for creating an environmental problem.

While green chemistry offers great dividends for American businesses, for our environment and for public health, large barriers in the marketplace stand in the way of its widespread adoption. Better regulatory policy around chemicals can help overcome these barriers – making it much easier for companies to invest in developing creative green chemistry advances and then to use them to make America cleaner, safer and more prosperous in the years to come.

# The Case for Green Chemistry

**H**istorically, product manufacturers and chemical suppliers have designed their products based strictly on performance and cost, often with little regard for our air, water, food supply or the environment. 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 animal and human being, to pollution that contaminates water supplies or contributes to global warming.

Green chemistry seeks to correct these problems – reducing toxic chemical use and preventing pollution by design. This approach is beginning to penetrate the business world, changing the way companies think about business.

## Toxic Chemicals Threaten Our Environment and Our Health

In the middle of the last century, a chemical revolution took place. Fueled by

the availability of chemicals from petroleum refining, and by the steady march of scientific discovery, manufacturers began to turn to chemistry to provide the raw materials for commerce. From plastic to pesticides, American industry began producing large amounts of many new types of compounds – substances that did not exist anywhere on earth before the industrial revolution.

Since World War II, annual chemical production in the United States has grown more than 20-fold.<sup>4</sup> Today, U.S. companies are the world's largest chemical producers, generating more than 1.2 billion tons of chemicals each year.<sup>5</sup>

Chemical companies have invented more than 83,000 industrial chemicals,<sup>6</sup> most introduced to market without adequate scrutiny of their health and environmental impacts or consideration of safer alternatives. And now we are paying the price.

Toxic chemicals have a significant impact on our environment. For example:

Photo: Jurga R., [www.sxc.hu](http://www.sxc.hu)



function in frogs and fish.<sup>11</sup> The chemical could be a factor behind the worldwide decline in frog populations.<sup>12</sup> Additionally, endangered killer whales in Puget Sound are developing defects in their reproductive and immune systems – effects that could be caused by the overwhelming levels of toxic flame retardants in their blubber, chemicals which have been shown to interfere with normal development.<sup>13</sup>

Chemical exposures also have serious effects on public health. For example:

- Our water, our food and our air are polluted with toxic chemicals, some of which have been banned for decades. Industrial facilities continue to dump more than 200 million pounds of toxic chemicals into America's rivers, streams, lakes and ocean waters each year.<sup>7</sup> Agricultural interests apply more than 700 million pounds of active pesticide ingredients on farm fields across the United States every year – chemicals which can run off into streams or leave toxic residues on food items.<sup>8</sup> In addition, many chemicals escape from consumer products and end up in household dust and in household air, contaminating even the environment of our homes.<sup>9</sup>
- These chemicals make their way from the environment into the bodies of animals and people. Scientists can find more than 100 industrial chemicals in the bodies of every American, including pesticides, flame retardants and plastics.<sup>10</sup>
- Chemicals can have damaging impacts on ecosystems. The widely used weed killer atrazine affects behavior, immune function, and reproductive development and
- 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 – and that toxic exposures play a role in at least one in four cases of developmental disorders.<sup>14</sup>
- The developing brain is particularly vulnerable to disruptions that lead to disorders such as autism, attention deficit disorder, mental retardation and cerebral palsy.<sup>15</sup> Industrial chemicals, including lead, methylmercury, PCBs, arsenic and toluene, are known causes of these disorders.<sup>16</sup> Although no comprehensive testing has been done, more than 200 additional chemicals are likely to interfere with early brain development.<sup>17</sup>
- More than 30 million adults (12 percent) and more than 10 million children (14 percent) in the United States have been diagnosed with asthma at some point in their lives.<sup>18</sup> Asthma has been linked to a variety of chemical exposures in the everyday environment, from smog in city air to formaldehyde and phthalates released from furniture and building

materials in our homes.<sup>19</sup> Additionally, cancer is the second-leading cause of death in America, accounting for about one-fourth of deaths – with about 1.5 million new cases diagnosed each year.<sup>20</sup> Exposure to a wide variety of chemicals in the environment could cause or accelerate the development of cancers.<sup>21</sup>

- 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.<sup>22</sup> Nationwide, the figure is sure to be much higher.

## Green Chemistry Seeks to Make Products Safer by Design

Green chemistry is an approach businesses can use to reduce their use of toxic chemicals, make products safer and prevent pollution.

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 the use of toxic chemicals and reducing harmful impacts. Green chemistry starts at the earliest stages of 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 that lead toward reduced use of toxic chemicals or dangerous approaches. These principles include:<sup>24</sup>

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

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 improve efficiency, reduce energy use, lower global warming emissions, and reduce or eliminate waste – all of which can improve a company's bottom line.

# Green Chemistry Works for Business and the Environment

Leading American businesses are showing that we can reduce and eliminate the use of toxic chemicals, keeping them out of our air, water, land and food. Through innovation, businesses can design products and manufacturing processes to be safe, following the principles of green chemistry.

The case studies that follow highlight 14 businesses 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 businesses are growing the market for green products, driving new revenue streams, reducing the cost of raw materials or energy, strengthening their public reputation, and avoiding business risks.

Applying green chemistry principles on a widespread level will be an important source of green jobs and economic progress as America moves forward in the 21st century.

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“Smart companies seize competitive advantage through strategic management of environmental challenges. [...] [E]nvironmental strategies provide added degrees of freedom to operate, profit and grow.”

– Daniel Esty and Andrew Winston, authors of *Green to Gold: How Smart Companies Use Environmental Strategy to Innovate, Create Value and Build Competitive Advantage*<sup>25</sup>

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**Company:** True Textiles

**Locations:** Headquarters in Grand Rapids, Michigan. Additional facilities in Maine, North Carolina, New York and China

**Innovation:** Terratex Fabrics and TerraCHECK ingredient screening

**Environmental Benefits:** Reduced exposure to persistent, bioaccumulative and toxic stain-resistant chemicals.

**Economic Benefits Profiled:** Reduced costs for raw materials, water and energy in manufacturing – saving a significant amount compared to conventional techniques, pegged at \$300,000 per year by one estimate. Unique product, improving corporate branding and reputation.

## True Textiles: Screening Out Persistent, Bioaccumulative and Toxic Chemicals while Reducing Costs

With operations in Maine, Michigan, North Carolina, New York and China, True Textiles is the world's leading panel fabric producer and a major supplier of fabrics for seating, wall coverings, cubicle curtains, and various other products. In addition to focusing on product quality, True Textiles works to minimize the impact of its business activities on public health and the environment.

True Textiles manufactures Terratex, a collection of fabrics that are naturally stain-resistant, flexible and safer to use, recycle or dispose of than conventional materials. True Textiles also uses an ingredient screening system called TerraCHECK to keep hazardous substances out of the dye ingredients used for different Terratex designs. These innovations have helped the company establish a unique brand identity and drive a revenue stream – while offering reduced manufacturing costs compared to conventional methods.

### The Birth of True Textiles' Corporate Responsibility

True Textiles inherited its ethic of corporate responsibility from its former parent company, Interface.

In 1994, the founder of Interface, Ray Anderson, read Paul Hawken's book *The Ecology of Commerce*. Inspired by the principles of sustainability and the creation of industrial ecosystems described in Hawken's book, Anderson decided to oversee a profound transformation of his own company. Anderson and key leaders in the company set an ambitious goal to eliminate any negative environmental impacts of the company's operations by the year 2020.<sup>26</sup>

The first two benchmarks on the road to sustainability, according to Anderson, are the elimination of waste and the elimination of toxic or hazardous substances from products and manufacturing processes – or in other words, the elimination of “anything that does not provide benefit to the customer.”<sup>27</sup>

When a private investment firm purchased the Interface Fabric unit and its five East Coast fabric mills in 2007, it also acquired Interface's spirit of responsibility.<sup>28</sup> Renamed True Textiles, the company is working to eliminate all waste, all hazardous emissions and all potentially harmful raw materials from its business.<sup>29</sup>

## Toxic Challenges Posed by Conventional Fabrics

Conventional fabric manufacturing can involve a variety of toxic chemicals that pose hazards to our environment and public health. These hazards are among the potential issues True Textiles has worked to avoid.

- Textile manufacturers have used **perfluorinated compounds** to make fabrics resist stains from spills, pets and dirt. For example, 3M used a perfluorinated compound in its Scotchgard and Stainmaster products until 2000, when potential problems associated with two of the chemicals became public and 3M began to phase them out.<sup>30</sup> These perfluorinated chemicals persist indefinitely once released into the environment and have the potential to concentrate in living organisms and accumulate in the food chain. Perfluorinated compounds contaminate food,

water and wildlife in every corner of the globe, including bottlenose dolphins and polar bears.<sup>31</sup> Virtually all Americans tested in the last 10 years have perfluorinated chemicals in their blood.<sup>32</sup> These chemicals have toxic effects on numerous organs in the human body and have been linked to a wide variety of health problems, from birth defects to cancer.<sup>33</sup>

- Since 2002, 3M has used a different perfluorinated chemical in its Scotchguard products. While tests show that this chemical is less bioaccumulative than the original formula, it does not readily degrade, and scientists have found it in rivers and in drinking water wells.<sup>34</sup>

## Terratex and TerraCHECK – Tools to Avoid Toxic Hazards in Textiles

As part of its path to sustainability, True Textiles (back when it was part of Interface) set out to design fabric that was free of these toxic hazards. In the process, the company helped to begin a transformation of the entire textile industry.

In 1995, True Textiles (then Interface Fabric) developed a new group of fabric products, manufactured using a procedure that reduces the need for toxic additives. This procedure follows the green chemistry principles of design for prevention and design for safer chemicals.

The fabrics, called Terratex, are made from pre- and post-consumer recycled polyester, from sources including plastic bottles and non-food grain corn.<sup>35</sup> The resulting fabric is inherently less toxic and naturally fire-, stain- and odor-resistant.<sup>36</sup> Corn-based Terratex fabrics are also compostable and biodegradable.<sup>37</sup>

However, corn-based Terratex has different physical properties than con-

## The Economic Benefits of Green Chemistry

While protecting public health and the environment, green chemistry can also help businesses drive revenues, reduce costs and avoid risks. As illustrated in the case studies of this report, the economic benefits of green chemistry include:

- Creating new markets;
- Reducing raw material needs;
- Cutting costs for energy, waste disposal or compliance with regulations;
- Reducing exposure to potential liability for environmental problems;
- Increasing safety in the workplace;
- Improving corporate branding and reputation;
- Raising opportunities for start-up businesses; and
- Creating green jobs.

ventional fabrics, so True Textiles had to develop new methods to color the fibers. The company used this as an opportunity to ensure that any new dyeing methods excluded hazardous chemicals.

True Textiles asked its dye suppliers to submit a list of ingredients used in dyes – information it was able to obtain in most cases by signing a non-disclosure agreement to protect each supplier’s business.<sup>38</sup> Staff double-checked ingredients against a list of problem chemicals informed by the latest hazard science, including perfluorinated chemicals, lead, mercury, toxic flame retardants, and other chemicals with the potential to persist in the environment, bioaccumulate, or have toxic effects.<sup>39</sup>

At the same time, True Textiles informed suppliers that the company planned on consolidating the number of companies they planned to do business with – reducing the number by as much as 90 percent. In order to improve the odds of being selected, suppliers worked to make their materials as toxic-free as possible.<sup>40</sup> Since suppliers work with many different companies, this created a ripple effect across the entire industry – instead of reacting to a customer approving or rejecting an individual problem substance, suppliers began to proactively develop green alternatives for the entire market.<sup>41</sup>

True Textiles now calls this screening system TerraCHECK and applies it to Terratex fabrics made from 100 percent post-consumer recycled polyester or from corn – with a goal of eventually applying it to all products it makes. (As of 2010, the company offers some products labeled Terratex made from pre-consumer recycled materials that do not go through the TerraCHECK protocol, and may include potentially problematic ingredients such as Scotchgard.)<sup>42</sup>

TerraCHECK involves screening a confidential list of dye and chemical in-



*True Textiles manufactures Terratex, a collection of fabrics that are naturally stain-resistant, flexible and safer to use, recycle or dispose of than conventional materials.*

gredients obtained from suppliers against lists of restricted substances maintained by True Textiles, state, federal or international governmental agencies, and nongovernmental organizations. The ingredients are also evaluated for their potential to harm human health and the environment. Ingredients that fail the screening are not used.

TerraCHECK has been reviewed by the Lowell Center for Sustainable Production at the University of Massachusetts to “ensure that it is comprehensive, systematic, scientifically and technically valid.”<sup>43</sup>

Intuitively, one might expect that developing a new product and dyeing system would have increased True Textile’s costs. However, the opposite proved to be true. Terratex fabrics were comparable to conventional products in appearance, performance and price.<sup>44</sup> Moreover, the process of making the textiles required less fuel and less water – and consolidating suppliers allowed the company to negotiate better prices for raw materials. True Textiles estimates that the Terratex innovations yield significant savings. In 2006, the company estimated that the innovations delivered consistent savings of \$300,000 per year.<sup>45</sup>



## Union Carbide, Procter & Gamble and BASF: Reducing Smog Pollution and Saving Money with Low VOC Paint

Across the nation, nearly 170 million people are exposed to unhealthy levels of a widespread form of air pollution called ground-level ozone.<sup>46</sup> A natural layer of ozone exists high in the atmosphere, absorbing ultraviolet radiation from the sun. However, when pollutants create ozone near the ground, it becomes a threat to public health.

When inhaled, ozone damages lung tissue and causes short-term swelling. With long-term exposure at even low levels, it causes permanent and irrevocable damage, and it can even kill.<sup>47</sup> Children, adults who are active outdoors, and people with existing respiratory system ailments are most vulnerable.

*Photo: BASF*



*BASF scientists, like those pictured here, invented a new kind of paint primer curable with ultraviolet light, reducing emissions of air pollutants that contribute to health-threatening smog pollution.*

Ozone pollution results when oxides of nitrogen (or NO<sub>x</sub>) interact with volatile organic compounds (VOCs) in the presence of sunlight. Power plants, cars and other combustion sources produce NO<sub>x</sub>, while VOCs evaporate into the air from sources including gasoline and solvents, such as those often found in wet paint. Even before contributing to the formation of ozone, VOCs are a health hazard in their own right. The effects of immediate exposure to VOCs include headaches, eye, nose, and throat irritation, nausea and loss of coordination, while long-term exposure can cause ill effects such as kidney, liver and central nervous system damage, as well as increased risk of cancer.<sup>48</sup> Exposure to VOCs while using solvents or paint products can reach up to 1,000 times background outdoor levels.

To control smog and VOC pollution, states like California have established increasingly stringent air quality regulations. As states have tightened rules over the years, businesses have had to innovate and respond, delivering new green chemistry innovations.

Procter & Gamble, BASF and Union Carbide have all introduced products with reduced VOC emissions, which can help to limit public health damage from direct VOC exposure and from ozone pollution. These companies have positioned themselves to capture greater market share while helping their customers cost-effectively comply with new regulations. Each company has taken a different approach to reduce the use of VOCs, but all have resulted in commercial innovations.

**Company:** BASF

**Locations:** Major production facilities in Texas and Louisiana, with other locations in AL, CA, GA, MI, MO, NC, NJ, NY, OH, PA, SC, TN and WI. Headquartered in Germany.

**Innovation:** UV-curable paint primer

**Environmental Benefits:** Reducing VOC content by half to two-thirds below conventional primers, improving air quality.

**Economic Benefits Profiled:** More efficient; performs better than conventional primers – positioning the company to capture greater market share. Also helping customers provide safer workplaces and cost-effectively meet air quality regulations.

## BASF

Southern California's fight against smog has helped to drive innovation in the paint industry.<sup>49</sup> 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."<sup>50</sup>

For example, in 2003, the entity in charge of air quality management in the Los Angeles basin established the nation's strictest regulations on the use of VOCs in paints in order to reduce Southern California's persistent and dangerous smog pollution. These regulations precluded the use of many existing paint technologies at the time. In response, a national paint manufacturers' association sued, claiming that the regulations were too strict to be achievable.<sup>51</sup>

BASF, the world's largest chemical company, proved the claim wrong, inventing a low emission paint technology that actually outperformed traditional products.

Responding to regulations required a technological leap to new varieties of automotive primers that no longer relied on VOCs as a principal solvent.<sup>52</sup> BASF chemists could have chosen to reduce volatile chemical emissions by choosing

a water-based primer technology. 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.<sup>53</sup> 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.<sup>54</sup>

This product kept the door open to a wide market for the company, even as VOC emission limits continued to grow more stringent in cities with serious air quality problems. Moreover, the product's enhanced performance increased the odds that it could increase its market share. More than 50,000 body shops across America use automotive refinishing paints worth more than \$2 billion every year – capturing more of this market could prove lucrative.<sup>55</sup>

**Companies:** Procter & Gamble, Cook Composites and Polymers Company

**Locations:** P&G chemicals division is headquartered in Ohio, Cook Composites is headquartered in Kansas City, MO.

**Innovation:** Sefose, a new solvent that reduces VOC emissions from high-gloss paint.

**Environmental Benefits:** Reduced contribution of high-gloss paint to unhealthy air quality, smog and airborne toxic chemicals. If all high-gloss paint worldwide used this technology, it would cut the equivalent of emissions from 7 million cars.

**Economic Benefits Profiled:** Capturing greater market share with a quality product, helping customers cost-effectively meet air quality regulations.

## Procter & Gamble

Procter & Gamble (P&G) is one of the world's largest consumer product manufacturing companies, responsible for brands and products ranging from Tide laundry detergent to Pringles potato chips.

In 2005, Procter & Gamble's chemicals division, headquartered in Ohio, worked with Cook Composites and Polymers Company, headquartered in Kansas City, Missouri, to invent a new solvent to reduce VOC emissions from durable, high-gloss paints. Conventional formulas used solvents that tended to evaporate, contributing to unsafe workplaces and smog, and making it harder for businesses to comply with air quality rules. Moreover, many low-VOC substitutes either cost too much or didn't perform as well, making them less attractive.<sup>56</sup>

To solve these problems, P&G and Cook Composites invented a new type of oil using sugar and vegetable oil as raw ingredients, calling it "Sefose." The solvent is chemically similar to the food additive Olestra.<sup>57</sup> When used as a solvent for high-gloss paint, the oil reduces VOC emissions by half compared to traditional formulations. By choosing different types of natural oils as ingredients, the companies can impart different properties on the resulting Sefose oil,

leading to wider possible applications.<sup>58</sup> In paint, Sefose is not just a solvent. The oil reacts with other parts of the paint formula and helps to make the coating glossy and tough, which helps to prevent the oil from evaporating into the atmosphere.<sup>59</sup>

According to P&G and Cook Composites, replacing the millions of gallons of high-gloss paints used around the world each year with Sefose-based paint could reduce VOC emissions substantially – by the equivalent of the emissions of 7 million cars annually – curbing ozone pollution. At the same time, such a switch could save nearly 1 million barrels of oil per year.<sup>60</sup> Sefose-based paints have been commercially available since 2008.<sup>61</sup>

Sefose-based paint offers several economic advantages to both its manufacturers and to customers. First, P&G and Cook Composites report that Sefose-based paints are cost-competitive with conventional products, while performing better than other low-VOC alternatives.<sup>62</sup> Using Sefose, painting firms could reduce their emissions and increase compliance with air quality regulations while maintaining product quality. And by offering a product with these capabilities, P&G and Cook Composites position themselves to capture a greater share of the market for high-gloss paint.

## Union Carbide and Using Carbon Dioxide for Green Chemistry

Carbon dioxide, which is emitted from the burning of fossil fuels, causes global warming when humans emit massive amounts of it into the atmosphere. However, in smaller amounts, carbon dioxide can work as a safe and effective solvent, and it has been an important part of many green chemistry innovations.

For example, in the 1990s, Connecticut-based Union Carbide (part of Dow Chemical) invented a technology to apply paint using carbon dioxide rather than solvents that contribute to VOC emissions, toxic workplace air and smog.

The company took advantage of the fact that when heated and compressed, carbon dioxide turns into a “supercritical fluid,” with similar properties to many traditional solvents. By mixing paint components with this type of carbon dioxide, Union Carbide developed a system that could apply an even coat of professional-quality paint. The company called its invention “Unicarb.”

Used in the automotive industry, this innovation was able to reduce the use of VOC-producing solvents by 50 to 85 percent – and in some cases eliminate toxic solvents altogether.<sup>63</sup> It also improved performance, delivering better paint coverage, reducing application steps and enhancing coating quality. These advantages translate into economic advantages for paint shops, including reduced costs for energy, labor, and solid waste disposal. In the 1990s, a Unicarb painting system typically could pay for itself in savings in less than a year.<sup>64</sup> One company using the system was able to increase the number of parts it could paint per gallon of material from nine to 36, saving \$2.5 million over the course of a year.

Scientists have found that careful application of carbon dioxide technology “can result in products (and processes) that are cleaner, less expensive and of higher quality.”<sup>65</sup> Supercritical carbon dioxide has been key to a number of commercially successful green chemistry advances since the 1980s, including:

- Decaffeinating coffee without toxic solvents;
- Producing polyurethane foam, and
- Dry-cleaning clothing without the toxic solvent perchloroethylene.

## The Pharmaceutical Industry and the Economic Opportunities of Green Chemistry

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 end up in the environment, posing hazards to our health and well being. Some manufacturing processes create as much as 100 pounds of waste for every pound of medication.<sup>66</sup> Other steps require large energy inputs.

Green chemistry offers the possibility of making pharmaceutical manufacturing cleaner, more efficient and less toxic. Smarter pharmaceutical synthesis can reduce waste generation by as much as 50 to 90 percent, dramatically reducing waste disposal costs. Speaking to the Toxics Use Reduction Institute in Massachusetts in 2005, Dr. Berkeley Cue, a scientist retired from pharmaceutical giant Pfizer, estimated that the pharmaceutical industry could potentially save billions of dollars annually with effective application of green chemistry principles.<sup>67</sup>

Pfizer, one of the world's largest pharmaceutical companies, has provided some good examples of the potential for green chemistry to revolutionize drug manufacturing. In particular, the company has been working with biotechnology firms to re-design drug synthesis processes

using enzymes – part of the chemical infrastructure of living organisms.

In living cells, enzymes efficiently carry out very specific reactions, driving the functions of life. In a synthetic chemical reaction, enzymes can function the same way – producing very specific products with little energy input and little waste. Using enzymes as catalysts in chemical reactions is an elegant way to apply the principles of green chemistry. One company specializing in enzyme technology, Codexis, based in Redwood City, California, notes that enzymes can “make new industrial processes possible, and make existing processes faster, cleaner and more efficient than conventional methods.”<sup>68</sup>

In the early 2000s, Pfizer worked with Codexis to apply enzyme technology to the synthesis of Lipitor, a widely-used cholesterol management drug. Pfizer's Lipitor is the world's best selling cholesterol-reduction drug, and the first drug to achieve worldwide annual sales of over \$10 billion. Originally, Pfizer produced one critical building block of Lipitor through a several-step process that required hydrogen gas derived from fossil fuels, took place partly

**Company:** Pfizer and Codexis

**Locations:** Pfizer is headquartered in New York City, with major laboratories in MA, CT, MI, and CA, and Codexis is based in Redwood City, CA.

**Innovation:** Re-designing the manufacturing process for Lipitor using custom enzymes

**Environmental Benefits:** Eliminated the use of harsh chemicals, reduced raw material requirements, cut waste and energy use.

**Economic Benefits Profiled:** Lowered manufacturing and waste disposal costs.

in potentially dangerous heated alkaline conditions and generated 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.<sup>69</sup> 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.”<sup>70</sup>

Codexis has learned that green chemistry principles make an effective business foundation. Three years after winning a Presidential Green Chemistry Challenge Award for this invention, in April 2010, the company raised \$78 million from investors in an initial public offering.<sup>71</sup>

Pfizer has continued to deploy enzyme technology to eliminate toxic ingredients or byproducts in its manufacturing processes. In 2006, Pfizer figured out a way to substitute enzymes for a nickel-based catalyst in the process of making a nerve pain drug called Lyrica. The substitution enabled more specific reactions to take place, cutting the number of required steps to four from ten, and reducing waste and energy use by more than 80 percent.<sup>72</sup>

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 [m-dash] and improving the company's bottom line.*

Pfizer has found that green chemistry can help build a stronger business by reducing chemical and energy inputs, improving the safety of working conditions and reducing the volume and hazard of waste products. Green chemistry innovations have the potential to yield similar advantages for the pharmaceutical industry as a whole.

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“Our goal is to make it as easy as possible for our scientists to make better decisions.”

– Dan Lawson, Sustainable Innovation Manager for SC Johnson<sup>86</sup>

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## SC Johnson and Walmart: Screening Hazardous Chemicals Out of the Supply Chain

Daryl Ditz, a senior policy advisor at the Center for International Environmental Law, told *Scientific American* in May 2010, “If no one can distinguish between a green molecule and a toxic molecule, it is almost impossible for safer products to break into the market.”<sup>73</sup>

Consumers are not the only ones facing this problem. 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. And making the right decisions can

help companies market their products, improve their good reputations and attract new customers.

To address this need, SC Johnson Company and Walmart have deployed screening systems designed to single out the least toxic ingredients and product designs, informing how products are made and what products end up on the retail shelf.

## SC Johnson and Greenlist

SC Johnson, headquartered in Racine, WI, designs and manufactures a wide variety of consumer products, from Windex glass cleaner, to Raid pest killer, to food storage products Ziploc bags and Saran Wrap.<sup>74</sup> On its company website, SC Johnson writes, “From the ingredients in our products, to the way we run our factories, we’re committed to working every day to do what’s right for people, the planet and generations to come.”<sup>75</sup> With more than \$8 billion in annual sales, the actions that SC Johnson takes can have a wide impact across the economy.<sup>76</sup>

As a part of the process of doing “what’s right,” SC Johnson has developed a system it calls Greenlist, which provides SC Johnson chemists and product formulators with information on the toxicity of potential ingredients, helping them to identify the best options for manufacturing safer products – going beyond legal

**Company:** SC Johnson

**Locations:** Headquarters in Racine, WI

**Innovation:** Greenlist, a tool to screen product ingredients for environmental attributes

**Environmental Benefits:** Helped SC Johnson scientists eliminate nearly 48 million pounds of toxic chemicals from its products since 2001.

**Economic Benefits Profiled:** Greenlist helped the company invent a less-toxic formula for Windex that cleans 30 percent better, growing the market for green cleaning products and capturing more market share.

requirements.<sup>77</sup> The company began using the system in 2001.

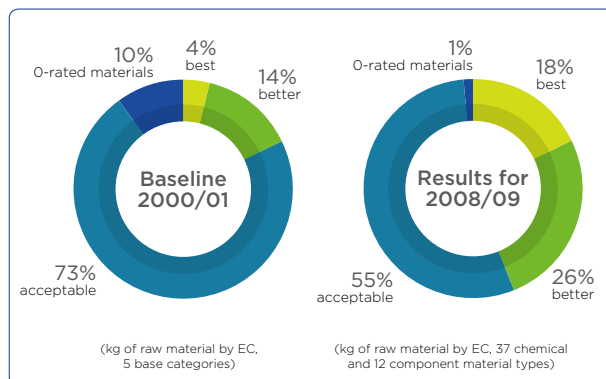
Doing “what’s right” also helps SC Johnson grow the market for green products and capture a larger market share – important strategies to improve business success. As of 2008, the market for green cleaning products alone reached \$100 million and is growing rapidly.<sup>78</sup>

Greenlist grades potential ingredients on a variety of measures, including biodegradability, aquatic toxicity, human toxicity, carcinogenicity and potential for endocrine-disrupting effects. Greenlist also incorporates information published under the European Union’s Registration, Evaluation, Authorization and Restriction of Chemical Substances (REACH) policy.<sup>79</sup> Each potential ingredient receives a score of Best (3), Better (2), Acceptable (1) or Restricted (0). Greenlist includes information for 95 percent of the chemical ingredients SC Johnson uses.<sup>80</sup>

Greenlist provides a standardized way for SC Johnson to measure its progress in creating safer products and an easy way to communicate that progress to its customers. In 2001, only four percent (by mass) of the materials SC Johnson used ranked in the “Best” category, only 14 percent ranked as “Better,” and 10 percent ranked as “Restricted.”<sup>81</sup> The average score of its products was 1.12. By 2009, the latest reporting year, 18 percent of the ingredients the company used ranked in the “Best” category, and 26 percent ranked as “Better.” The company cut the use of “Restricted” materials to 1 percent of overall ingredient weight and increased the overall score of its products to 1.6.<sup>82</sup> (See Figure 1.)

SC Johnson has used Greenlist as a guide to reformulate its products to be less toxic and more effective. For example, Greenlist helped SC Johnson scientists remove a volatile organic compound

**Figure 1: SC Johnson’s Progress in Choosing Better Ingredients through Greenlist<sup>83</sup>**



(VOC) from Windex. According to the company, the new formula cleans 30 percent better while reducing VOC use by 1.8 million pounds per year.<sup>84</sup> Greenlist also helped SC Johnson decide to replace polyvinylidene chloride (a chlorinated chemical with problematic properties) with a substance of less concern, polyethylene, in Saran Wrap.<sup>85</sup>

In 2002, SC Johnson eliminated chlorine-based materials from its packaging, including polyvinyl chloride, in favor of safer alternatives.<sup>87</sup> In 2004 and 2006, the company eliminated the use of two pesticides – DDVP and propoxur – because of risks to human health and persistence in the environment. Greenlist guided SC Johnson to choose safer detergent chemicals, earning the company a Safer Detergents Stewardship Initiative Award from the U.S. Environmental Protection Agency in 2008.<sup>88</sup> And in 2008, the company began eliminating phthalates from the fragrances in its products – a process that it reports will be complete by 2012.<sup>89</sup>

Altogether, SC Johnson reports that it has eliminated more than 45 million pounds of hazardous chemicals from its products since 2001 using Greenlist.<sup>90</sup>



In related moves, SC Johnson has made Greenlist available to other companies without licensing fees.<sup>91</sup> Moreover, the company has created a website, [www.whatsinsidescjohnson.com](http://www.whatsinsidescjohnson.com), which includes ingredient lists for more than 200 air and home cleaning products – with companion sites in French and Spanish. Ingredients are also listed on a product label and available at a 1-800 number.<sup>92</sup>

Greenlist has helped SC Johnson begin to meet consumer demand for greener products and remain a successful company. Among the benefits of the company's approach are:

- **Safer workplaces.** Since the 1990s, the company has cut the rate of days lost to accidents by 80 percent – in part due to working with safer ingredients.
- **Employee loyalty.** SC Johnson's annual workforce turnover is on the order of two percent.<sup>93</sup> A number of factors play into this statistic, including the company's commitment to doing the right thing for society.
- **Less waste.** Since 2000, the company has cut emissions of waste into air, water or landfills by 40 percent – reducing raw material and waste disposal costs.<sup>94</sup>

- **Retaining access to international markets** even as new regulations, like the European Union's REACH policy, are adopted.

## Walmart and GreenWERCS

Walmart is one of the world's largest retail companies. The company employs more than 2 million people and expects to earn more than \$400 billion in revenue in fiscal year 2010.<sup>95</sup> With revenues larger than the annual budgets of many countries, 175 million weekly customers and 61,000 suppliers, the retailer has the power to catalyze changes in consumer buying habits and industry manufacturing processes on a global scale.<sup>96</sup>

The company has been stung over the years by criticism over its labor practices and its effect on communities. In a move to improve its overall reputation, Walmart has set a series of goals to become a more responsible corporate citizen and a force for sustainability. Among the goals articulated by the company in 2006:<sup>97</sup>

- “When we suspect that an ingredient in a product or the product itself is capable of causing harm to human health and the environment, we will act to find better alternatives.”

**Company:** Walmart

**Locations:** Headquarters in Bentonville, AR; retail locations nationwide

**Innovation:** GreenWERCS, a screening system for the environmental attributes of product ingredients

**Environmental Benefits:** Holds the potential to drive green chemistry innovations throughout Walmart's extensive supply chain, catalyzing changes in product design and manufacturing processes worldwide.

**Economic Benefits Profiled:** Helps Walmart capture a greater share of the growing market for green products; helps the company build a stronger reputation.

- “In most cases our principles will require actions beyond compliance with government regulations. [...] At Walmart, we are engaged in an effort to identify chemicals of concern and encourage innovation towards more preferred chemicals that perform and meet consumer needs in a more sustainable way.”

The sheer number of suppliers and products on Walmart shelves poses a daunting challenge for the retailer in meeting these goals. Walmart needs to know what ingredients are in the products it sells – and further, it needs to know what level of hazard these ingredients pose – in order to ask its suppliers to take corrective action.

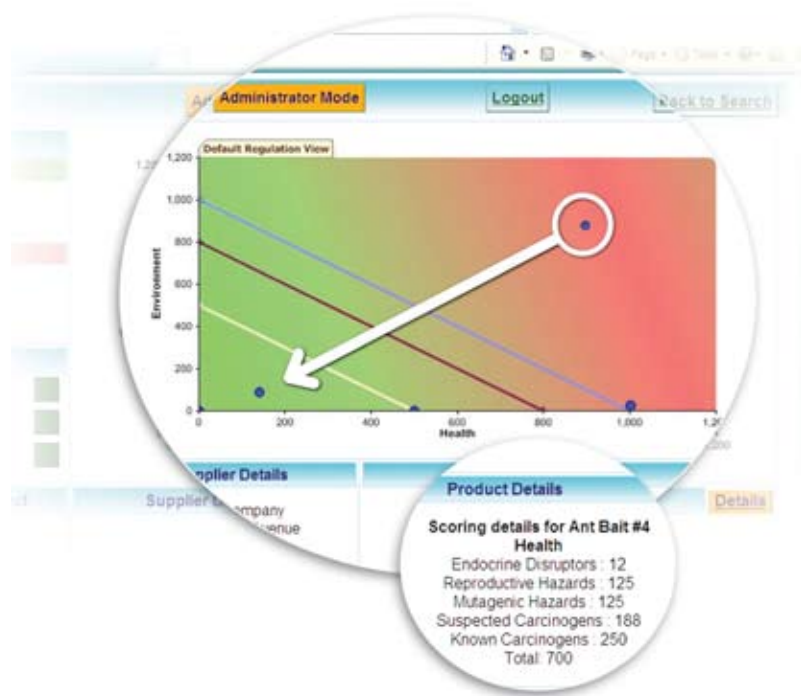
Walmart settled on a tool called GreenWERCS to deliver the necessary information. In the first phase of the project, Walmart asked companies selling chemical-intensive products, including items for home and personal care, to submit a list of all ingredients used in a product to Worldwide Environmental Regulatory Compliance Solutions (WERCS), a company providing assistance to other companies dealing with evolving chemical regulations. Through the WERCSmart Chemical Assessment Review, Walmart obtained information about products on its shelves that were regulated under state or federal laws to ensure they were handled appropriately.<sup>98</sup>

GreenWERCS, launched in May 2009, takes the process one step further.<sup>99</sup> GreenWERCS enables Walmart to evaluate each product based on the risk it poses to human health or the environment – whether the ingredients are regulated or not.<sup>100</sup> With this information, Walmart can identify components of concern and ask its suppliers to reformulate a product using safer alternatives, or choose to sell products

with the smallest hazard profile. (See Figure 2.)

In a press release, Lou DeSorbo, president of the company that developed GreenWERCS, noted that “[b]eing indifferent to green chemistry is no longer an option for chemical manufacturers. They will either have to innovate or risk being pushed aside by government regulations and fed-up consumers. GreenWERCS will help drive the market toward greener chemistry by providing manufacturers with actionable information to improve the health and environmental impact of their products.”<sup>101</sup>

**Figure 2: Identifying Components of Concern with GreenWERCS**



*Walmart uses GreenWERCS, a database of product ingredient information pictured here, to score its products for risks that ingredients could pose to the environment and public health. With this information, Walmart can identify components of concern and ask its suppliers to reformulate a product using safer alternatives, or choose to sell products with the smallest hazard profile.*

## Apple Computer, Hewlett-Packard and Seagate: Increasing Global Competitiveness with Comprehensive Action Against Toxic Flame Retardants and other Problematic Ingredients

The consumer technology industry is highly innovative, highly competitive, and requires the use of a lot of exotic – and sometimes toxic – substances. For example, many consumer devices contain toxic flame retardant chemicals (such as polybrominated diphenyl ethers). These chemicals turned out to be reminiscent of PCBs, in that they concentrate in the food chain (or bioaccumulate), have toxic effects and do not readily degrade in the environment.

In recent years, electronics companies such as Apple Computer, Hewlett Packard, and Seagate have used green chemistry principles to eliminate toxic flame retardants from their products. Moreover, by taking a comprehensive approach to the problem, these companies are increasing the odds that replacement chemicals or design approaches will actually be safer. Their actions have enabled them to respond nimbly to new regulations in markets such as Europe, which passed a new chemicals policy called REACH, and reduced the cost of

compliance – thereby improving their competitiveness.

### Apple and the “Elemental” Approach

Apple 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.

Apple’s innovation in product design extends into the realm of green chemistry. Starting in the 1990s, Apple 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.

Apple’s introduction to green chemistry came in no small part from the

**Company:** Apple and Seagate

**Locations:** Apple is headquartered in Cupertino, CA, with retail locations nationwide; Seagate is headquartered in Scotts Valley, CA.

**Innovation:** Eliminated any chemical containing the elements chlorine or bromine from its products

**Environmental Benefits:** Reduces the use of toxic flame retardants and other potentially hazardous chemicals; increases odds that substitute chemicals will be safer.

**Economic Benefits Profiled:** Enables the company to continue to access European markets covered by new chemical regulations, makes the company better able to respond nimbly to new regulations, reduces the cost of determining supplier compliance.

European Union. About a quarter of the company's business is in Europe. Thus, regulations passed in Europe have had an important influence over product design strategies. 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.<sup>102</sup>

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.<sup>103</sup>

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.<sup>104</sup>

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.<sup>105</sup> The situation was eerily reminiscent of 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.<sup>106</sup>

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

*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.*

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.<sup>107</sup> For example:

- Apple went above and beyond the European directive on hazardous chemicals, voluntarily phasing out the use of many persistent toxicants and other dangerous materials, including asbestos, cadmium, hexavalent chromium, organic tin, polychlorinated biphenyls, polychlorinated dibenzodioxins, polychlorinated naphthalene, polychlorinated terphenyls, and chlorinated paraffins.<sup>108</sup>
- 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.<sup>109</sup> Two years later, Apple transitioned to light emitting diode (LED) displays, largely eliminating mercury, another toxic metal.<sup>110</sup>
- 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.<sup>111</sup> By October 2008, Apple had succeeded in reforming its entire supply chain.<sup>112</sup>

Broadly eliminating all chlorinated and brominated compounds – what Apple calls the “elemental” approach – 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 customers from a variety of toxic chemicals all at once, and increases the odds that replacement chemicals or design approaches will actually be safer.<sup>113</sup>

Apple has continued to grow and succeed while making major green chemistry innovations in the information technology world. 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.<sup>114</sup> Its proactive stance on chemicals will help to ensure that its products meet the standards of marketplaces around the world, and prepare the company to respond rapidly to the evolving regulatory landscape.

### **Seagate Manufactures Drives without Chlorine or Bromine**

To make its products broadly compatible with Apple, Seagate – the world’s largest manufacturer of disk drives, based in Scotts Valley, California – eliminated chlorine- and bromine-based ingredients from its products.<sup>115</sup> As a result, when the European Commission enacted REACH, Seagate spent about three-eighths as much as their competitors retrofitting their hard drives to meet REACH regulations.<sup>116</sup>

In 2005, Seagate adopted an entire set of safety protocols with the goal of meeting or exceeding global requirements for the environmental safety of its products.<sup>117</sup> 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.<sup>118</sup> These restricted chemicals include any compound containing bromine or chlorine, and also antimony trioxide, lead, mercury, hexavalent chromium, and cadmium.<sup>119</sup>

Seagate’s protocol has allowed it to stay ahead of restrictions on chemicals, saving it millions of dollars as it does not have to remove chemicals piecemeal from its products and hastily develop toxic-free alternatives in response to chemical regulations.



*Seagate restricted the use of more than 200 problematic chemicals conventionally used in disk drives.*

**Company:** Hewlett-Packard

**Locations:** Headquarters in Palo Alto, CA

**Innovation:** Maintains a list of restricted chemicals, updated annually. Requires suppliers to comply, and submit information about an additional 240 chemicals of concern.

**Environmental Benefits:** Reduces exposure to toxic flame retardants and other hazards.

**Economic Benefits Profiled:** Ensuring access to markets in Europe and preparing the company to respond to any future concerns about hazardous chemicals in advance of many of its competitors.

## Hewlett-Packard – Staying on Top of Chemicals of Concern

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.<sup>120</sup>

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.<sup>121</sup> 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.<sup>122</sup> For example, HP is restricting three additional types of phthalates by 2012.<sup>123</sup>

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.<sup>124</sup> 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.

HP has continued to grow and succeed while addressing chemicals of concern. HP is the largest company of its kind, earning almost \$120 billion in revenue in 2008.<sup>125</sup> Its example shows that a thoughtful approach to product design – including green chemistry principles – can be a strong component of business success and deliver customer satisfaction.

*Photo: Hewlett-Packard*



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

**Company:** Johns Manville

**Locations:** Headquartered in Denver, CO. Factories in TX, CA, MT, KS, IN, OH, VA, NJ, and GA

**Innovation:** First company to develop and market formaldehyde-free insulation.

**Environmental Benefits:** Protects homeowners from exposure to a substance that causes asthma and cancer.

**Economic Benefits Profiled:** Creating a new market and capturing market share, reducing exposure to liability, and improving business reputation.

## Johns Manville: Learning from Asbestos Liability

In 2002, Johns Manville became the first company in the United States to develop and market insulation that does not contain the toxic chemical formaldehyde.<sup>126</sup>

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.<sup>127</sup> The company switched to an alternative acrylic compound in place of formaldehyde – protecting its workers and the public from harm. The company broke ahead of its competition, developed a new market and a new revenue stream, and prepared the company to respond nimbly to new indoor air quality regulations under development in California at the time.

Importantly, this innovation also reduced Johns Manville's exposure to potential legal liability and damage to its reputation that could have resulted from continuing to use formaldehyde in its products.

As Johns Manville knows, a positive public image is intangible – but extremely

valuable – to the continued success of a company. It learned this lesson the hard way, through its experience with asbestos.

In the 1880s, Johns Manville 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.<sup>128</sup>

The only problem was that inhalation of even tiny amounts of asbestos can cause lung disease and cancer, leading to disability and death.<sup>129</sup> On the order of 10,000 Americans now die every year due to asbestos-related illness.<sup>130</sup>

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.<sup>131</sup> 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.<sup>132</sup>

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 of dollars in compensation to injured workers, but also shielded the company from future asbestos claims.<sup>133</sup>

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.”<sup>134</sup> In other words, good business strategy involves anticipating and planning to avoid problems from the start.

Green chemistry is an important tool that businesses such as Johns Manville can use to maintain their good reputations and reduce their exposure to possible liability for environmental problems.

*Photo: Greenguard.org*



*Johns Manville manufactures insulation using an acrylic binder instead of formaldehyde, a chemical linked to allergies, asthma and cancer.*



## Headwaters Technology Innovation Group: Making an Alternative to Chlorine Economical

**Company:** Headwaters Technology Innovation Group

**Locations:** Headquartered in New Jersey

**Innovation:** Invented a new way to manufacture hydrogen peroxide, an important chemical used in many green chemistry processes

**Environmental Benefits:** Reduced energy use and waste in manufacturing hydrogen peroxide

**Economic Benefits Profiled:** Reduced the cost of manufacturing hydrogen peroxide, helping to make it more feasible for other companies to use it in developing their own green chemistry innovations.

Green chemistry provides good opportunities for start-up companies to take good ideas and turn them into successful businesses. Headwaters Technology Innovation Group, a chemical company based in New Jersey, provides a good example. The company develops new inventions, identifies those most likely to be successful, and then spins them off to form new companies.

One of the company's innovations promises not only to make an industrial process cleaner through the principles of green chemistry – it also promises to make a raw ingredient useful in many other types of green chemistry processes more accessible and affordable.

Headwaters Technology's innovation offers a possible substitute for chlorine in industrial processes. The use of chlorine results in many different types of waste products. For example, the pulp and paper industry has used chlorine-based bleach to whiten its fibers – a process which generates toxic byproducts, such as furans and dioxins, that contaminate our water and food.<sup>135</sup>

Chlorine and chlorine-compounds are often dangerous themselves. For example, as of 2007, more than 70 pulp and paper mills stored almost 4 million

pounds of chlorine or chlorine dioxide, putting nearly 6 million people at risk of acute injury or death in the event of an accidental release.<sup>136</sup>

In place of chlorine, many industrial processes can use hydrogen peroxide. However, industry has not fully captured the potential of hydrogen peroxide to make chemical processes safer – primarily because hydrogen peroxide has been more expensive than chlorine.

Headwaters Technology took a closer look at the conventional process for manufacturing hydrogen peroxide. They found that the process used undesirable organic solvents, consumed a large amount of energy, and produced toxic byproducts that required special disposal. Moreover, it was these very attributes that made hydrogen peroxide expensive to produce.<sup>137</sup>

In what Headwaters president Bing Zhou has called a “one stone, two bird process,” Headwaters Technology invented a new metal catalyst that enabled the synthesis of hydrogen peroxide without any of the undesirable reaction conditions or toxic byproducts associated with conventional manufacturing methods.<sup>138</sup> The catalyst enables the manufacture of hydrogen peroxide directly from hydro-

*Photo: Headwaters Technology Innovation Group*



*The team at Headwaters Technology Innovation Group, pictured here, invented a new way to manufacture hydrogen peroxide, a safer alternative to chlorine in many industrial processes.*

gen gas at low concentrations in air to eliminate the hazard of flammability. As a result, it promises to produce hydrogen peroxide at costs that should make it much more widely used to replace hazardous chlorine in industrial processes.<sup>139</sup>

The company, in partnership with major hydrogen peroxide manufacturer Degussa AG, opened a demonstration plant in 2006.<sup>140</sup> In 2008, the company purchased a hydrogen peroxide plant in

Korea and doubled its production capacity using the new technology.<sup>141</sup>

This application of green chemistry principles not only makes the process of manufacturing hydrogen peroxide cleaner – it opens the door to an economic way for many types of companies to apply green chemistry in their own industrial processes, from bleaching paper to manufacturing a wide variety of chemical ingredients.

# Policy Recommendations

**D**espite all the “out-of-the-box” thinking that is happening around green chemistry in America today, state and federal chemical regulatory policies are not doing enough to promote widespread adoption of safer chemicals and manufacturing processes. Our laws are based on outdated thinking that fails to focus our attention on making products better and safer by design.

In order to make the green chemistry approach more widespread, federal and state leaders should take advantage of existing authority while working toward comprehensive reform of chemical regulatory policy. The right policies can make it much easier for companies to invest in developing safer approaches and then use them to make America cleaner, healthier and more prosperous in the years to come.

## Chemical Policy Reform Can Accelerate the Development and Deployment of Green Chemistry Solutions

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. This represents a missed opportunity to advance green chemistry practices throughout the economy.

Policy reform should focus on three key goals: increasing access to information, requiring safer alternatives and ensuring that polluters pay for the costs imposed by undesirable business activities.

## Increase Access to Information on Toxic Chemicals

Lack of public information about chemical use and toxicity is a major obstacle to the expansion of green chemistry practices. Consumers only begin searching for safer alternatives once they become aware that a particular substance poses a health threat. As in the case of Walmart described in this report, companies can only demand safer alternatives from suppliers when they have accurate information about toxic chemicals used and their environmental impacts.

Unfortunately, existing policies keep the public in the dark when it comes to chemicals' toxicity. When Congress passed the Toxic Substances Control Act in response to the PCB crisis 35 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, it and did not require toxicity testing for health effects.

As a result, 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.<sup>143</sup> Manufacturers can sell a chemical or product without studying or sharing information about its potential health or environmental hazards. And consumers and businesses have difficulty knowing what ingredients are in a product, whether those ingredients are safe, or even whether an alternative to a hazardous chemical is actually better.

By requiring manufacturers to study and share information about the potential health or environmental hazards of chemical ingredients and products, green chemistry entrepreneurs can anticipate consumer demand for thousands of safer alternatives and begin bringing those alternatives to market.

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“[S]ometimes green products need a little kick from a regulation to overcome the barrier to change.”<sup>142</sup>

– Colin Gouveia, marketing director at building products company Rohm and Haas, in the *Los Angeles Times*, September 14, 2008.

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## Require the Use of Safer Alternatives

Developing safer chemicals and their applications in manufacturing can be a costly endeavor, and so potential investors in green chemistry need to know that there is a high likelihood of market demand for their products. Strong regulatory authority to phase out the worst toxic chemicals can overcome this barrier – as in the case of BASF and the California Air Resources Board's tough restrictions on VOCs in paint reviewed in this report. If entrepreneurs know that toxic chemicals will be phased out in favor of safer alternatives, they will move much more broadly to develop those alternatives and have much greater success in bringing them to market.

Unfortunately, the current chemical policy regime makes it exceedingly onerous for the EPA to phase out even the worst toxic chemicals. For starters, current policy places the burden of proving that a chemical is unsafe on the EPA and the scientific community. And the burden of proof is impossibly high. Approximately 1,400 chemicals with known or probable links to cancer, birth defects, reproductive impacts and other health problems are still in use

today.<sup>144</sup> Even in the case of asbestos, the EPA was unable to successfully ban its use despite decades of evidence that inhalation of asbestos causes cancer.<sup>145</sup>

Reform requiring the phase-out of toxic chemicals as viable safer alternatives are established for particular uses would give entrepreneurs and investors the right market assurances to invest in developing new approaches, spurring a major leap in the development of such alternatives. Some states are already taking this approach, at least on a case-by-case basis. For example, state legislatures have passed bans of certain toxic flame retardant chemicals in California, Hawaii, Illinois, Maine, Maryland, Michigan, Minnesota, New York, Oregon, Rhode Island, and Washington.<sup>146</sup> Additionally, several states and cities have taken action against the developmental toxicant bisphenol-A in children's formula containers, sippy cups or other food containers, including Connecticut, Minnesota, Washington, Wisconsin and the city of Chicago.<sup>147</sup>

However, to create comprehensive change on the national level, Congress should update the Toxic Substances Control Act (TSCA) to require companies to prove that their chemicals are safe and to give EPA broad authority to phase out toxic chemicals, especially where safer alternatives have been established. In the meantime, EPA should use the limited authority it has under TSCA to create "action plans" that restrict the use of the most dangerous toxic chemicals in commerce today.

### **Ensure that Polluters Pay**

One of the reasons that toxic chemicals are still widely viewed as "economical" is that manufacturers are never required to bear the full health and environmental costs that toxic chemicals impose. Policies that internalize at least some of these costs – like restoring the polluter pay fee to Superfund – help restore balance to the playing field and allow non-toxic alternatives to compete on equal footing.

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