Advancing Green Chemistry in Oregon

Recommendations from the
Oregon Green Chemistry Advisory Group
July 2010

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Elizabeth Whalen, Portland State Univ.

“The results of the Oregon Green Chemistry Advisory Group provide a sound blueprint for the work the state of Oregon and Oregon businesses and universities can undertake to solidify our leadership in an arena that will benefit the health of our economy and our citizens for decades to come.”

Executive Summary

Green chemistry can help Oregon businesses create and produce cleaner, safer products and is integral to our pursuit of a more sustainable economy. Green chemistry innovation is helping a variety of Oregon businesses dramatically improve their environmental performance and overcome some of their most significant sustainability-related challenges. It is increasing their profitability, reducing costs and liability, and catalyzing new fields of entrepreneurial activity in the state. Supporting green chemistry research, development and education capacity will cement Oregon's reputation as a national leader in sustainable business and green innovation.

Green chemistry reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemicals and chemical products.[1] Green chemistry is used to create products and processes that are safer for workers, the public, and the environment. The principles of green chemistry help chemists and engineers consider the toxicity, energy efficiency, water usage, and source materials throughout the life cycle of chemicals, products and processes—and can help prevent pollution by creating substances that are benign by design.

Oregon has several strategic advantages that can help the state successfully advance the use of green chemistry: Nationally recognized academic expertise in green chemistry; a business environment geared toward sustainability; and a consumer base interested in purchasing "green" products.

In recognition of these advantages, the Oregon Environmental Council (OEC) convened the Oregon Green Chemistry Advisory Group (OGCAG), which is comprised of leaders from industry, academia, public agencies, and non-governmental organizations (NGOs) (see Appendix B). For six months, members of the group analyzed findings from case studies of how green chemistry has been successfully used by Oregon companies, evaluated strategic efforts undertaken by other states and organizations to develop this field, and immersed itself in dialogue to develop recommendations to strengthen green chemistry in Oregon.

The OGCAG arrived at four key recommendations that focus on supporting the development, manufacturer, and use of safer chemicals, materials and products through an integrated, multi-sector approach. The recommendations aim to further establish a nexus of people, ideas, tools, and practices that will spur innovation to develop and produce safer chemicals and materials.

Jason Smith, Blount Inc.

"Our new process is not only better for our employees and the environment, but the cost savings Blount has realized is better for our bottom-line as well."

Recommendations

1 Increase understanding and awareness of the benefits of using green chemistry among key decision makers.

Green chemistry makes products and processes inherently more sustainable. Oregon should facilitate a focused, multi-sector dialogue that will identify how we can use green chemistry to meet business needs and take advantage of opportunities to grow our economy and protect Oregon's citizens and the environment.

2 Enhance Oregon's existing and future workforce through education and training that supports the use of green chemistry.

Academia, government and NGOs should bridge knowledge gaps among employees and management to help organizations use green chemistry to foster innovation by making informed decisions about the types of chemicals, materials, products, and processes used throughout the lifecycles of their goods and services.

3 Expand Oregon's public and private green chemistry research and development capacity.

Many of the tools needed to apply green chemistry—including reactions, solvents and reagents—do not exist. They need to be invented and developed through a combination of public and private research. Increasing the availability of green chemistry tools will enable chemists, engineers, and other professionals to successfully incorporate green chemistry into a wider range of products and processes.

4 Commit state and local resources to support green chemistry innovation.

The state of Oregon should foster collaboration and build capacity for green chemistry. This would include adopting policies that support the use of green chemistry through an executive order, legislation and/or modification of administrative rules.

Implementing these recommendations will require the input of a wide array of organizations and expertise. The best way to coordinate, manage and leverage investment in these efforts is to create an integrated organization dedicated to the advancement of green chemistry. We advocate for the formation of a statewide green chemistry resource "Hub". The Hub will build on the existing work and partnerships in the state to help ensure Oregon's leadership in this emerging field.

BACKGROUND

Chemicals are present in almost every consumer, commercial and industrial item used. They are integral to our economy and their wise use creates significant benefits for our society. However, over the course of their life cycle, many chemicals have been shown to harm our health and impact the environment. Efforts to mitigate the dangers of hazardous chemicals and to reduce their risk have come at great public and private expense—with mixed success.

Meeting the chemical and material needs of our economy in ways that are safer, more efficient, and based on sustainable raw materials requires new tools and techniques. Consumers, workers, governments and businesses are increasingly aware of potential impacts that can result from the use and generation of hazardous substances. Green chemistry can be used to prevent pollution at the source, and will dramatically reduce unintended health impacts to people and the environment, while simultaneously limiting the associated social and financial costs of toxic chemicals.

Innovation will continue to be important in maintaining competitiveness in a global economy. Green chemistry provides the means to create and produce the next generation of greener materials and products. Supporting green chemistry innovation can benefit businesses in every sector of our economy and communities across Oregon. Pioneering companies are demonstrating that this is not only possible, but also profitable. Leading organizations and governments are taking action to build their green chemistry capacity through policies and strategic investment.

The Oregon Green Chemistry Advisory Group (OGCAG) studied this issue using case studies of successful Oregon early-adopter businesses and evaluations of green chemistry efforts in Oregon and other leading states. The group found that the public and private benefits of green chemistry are significant and include increased profitability, reduced costs and liability, and safer workplaces and products, among others.

Oregon has a window of opportunity to lead in this field. We can be the source of innovative solutions to some of our sustainability-related challenges, but there are barriers and needs that must be addressed. This report includes four straightforward, practical recommendations that can meet these needs and ensure successful, widespread use of

A recent Presidential Green Chemistry Challenge Award winner converts abundant plant sugars from non-food and home grown sources into gasoline, jet fuel, and diesel hydrocarbon molecules previously refined only from petroleum. They can be replacements for, or used at high blends with, petroleum fuels in today's petroleum infrastructure. According to the company, the exothermic process is energy efficient, carbon neutral, water positive, and has low life cycle emissions. It runs under moderate conditions and requires no external energy inputs. It yields 30 percent more net energy than corn ethanol processes.

green chemistry in Oregon. By doing so, we can support a stronger, more diverse economy in the state and protect human health and the environment. A growing group of stakeholders is ready to make this vision a reality across the state.

The OGCAG was convened by Oregon Environmental Council (OEC) in 2009 to develop integrative recommendations to advance green chemistry in Oregon. The group, whose members include representatives from Oregon Department of Environmental Quality (ODEQ), Business Oregon (Oregon Business Development Department), Oregon Manufacturing Extension Partnership (OMEP), University of Oregon, Portland State University, and business leaders from Nike, Inc., Blount International, Inc., and Coastwide Laboratories, worked collaboratively for six months to develop consensus recommendations on how to advance green chemistry in Oregon (see Appendix B). By promoting the design and redesign of chemicals, materials, products, and processes, Oregon can stimulate innovation, reduce overall costs, and increase our competitiveness in the global market.

PROCESS

The OGCAG used a collaborative stakeholder process to create consensus-based, priority recommendations for advancing green chemistry in Oregon. OEC initiated the process with a review of green chemistry efforts underway in other states and conducted interviews with a diverse group of stakeholders. Based on this information, a group of experts representing businesses in key Oregon industries, universities, public agencies, and NGOs was selected to serve on the OGCAG. The composition of the group was designed to provide an optimal blend of perspectives and experience related to green chemistry in Oregon.

The group then worked to establish a common body of knowledge of the benefits and challenges associated with the use of green chemistry. This involved analyzing case studies, reviewing green chemistry initiatives and policies throughout the United States, and examining barriers to implementing green chemistry programs. A facilitated dialogue among members allowed the group to develop a dynamic approach to information exchange. With a comprehensive understanding of the topic the group then developed and prioritized a set of recommendations.

An integral part of the group's strategy to facilitate learning and information sharing was a series of questions:

Who are the key decision-makers who can help realize the OGCAG's vision of Oregon as a leader in green chemistry innovation? This allowed the group to identify Oregonians who can take concrete actions to advance green chemistry.

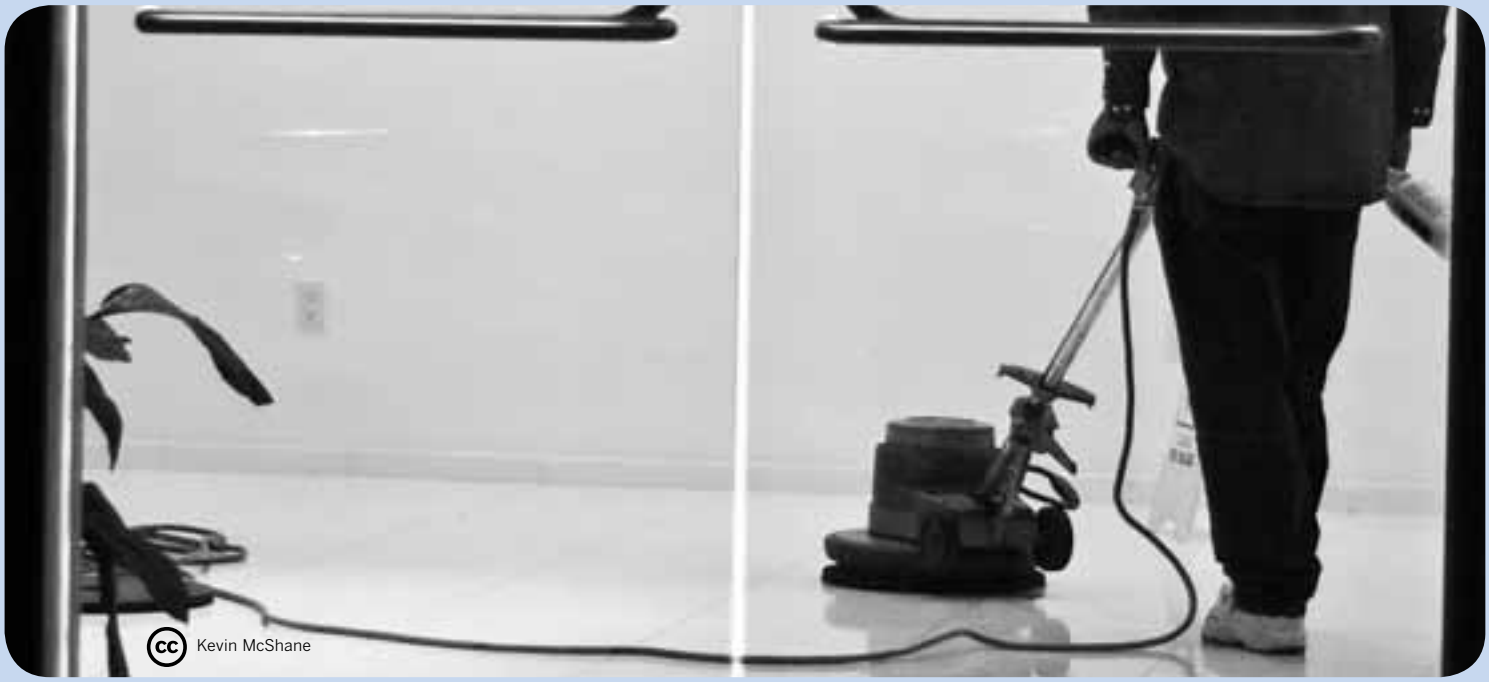
How can these decision-makers help advance green chemistry in Oregon? This question involved considering in broad terms the roles individuals and organizations can play in advancing green chemistry.

Why aren't these decision-makers already taking these types of actions? This led to an exploration of the numerous, interdependent barriers that prevent decision-makers from taking actions that advance green chemistry.

What is needed to enable these decision-makers to take actions that advance green chemistry? This exploration of needs generated a wide range of potential actions that could be taken to advance green chemistry.

CASE STUDIES

Coastwide Laboratories Builds a New, Highly Profitable Cleaning Product Line



How green chemistry was used:

Coastwide Laboratories' green chemistry efforts began in 1988—and the company was able to successfully develop greener ingredients to replace "bad actors" in their cleaning product formulations. Coastwide soon recognized that there was an emerging market for greener chemicals and began researching green chemistry options for cleaning products. The company found a number of product design models on which it could base its research efforts, but most didn't adequately integrate human health and safety criteria. To fill this gap, Coastwide partnered with a university to create a new product design model. The resulting model is called the Sustainable Earth Green Chemistry Standard. The Sustainable Earth line of commercial and industrial cleaning products is based on the standard.

Benefits of using green chemistry:

- Sales of the 15 Sustainable Earth products comprise more than 70% of total proprietary sales for the company and continue to grow at double-digit rates
- Coastwide's chemical profit margins have improved significantly with the growth of Sustainable Earth product sales
- Customers have reported cost savings of over 50% using SE products based upon improved product performance
- Higher product concentrations for SE chemicals allows Coastwide to eliminate tons of packaging annually, resulting in significant cost savings

Blount, Inc. Develops a Safer Manufacturing Process that Increases Production Capacity and Reduces Costs

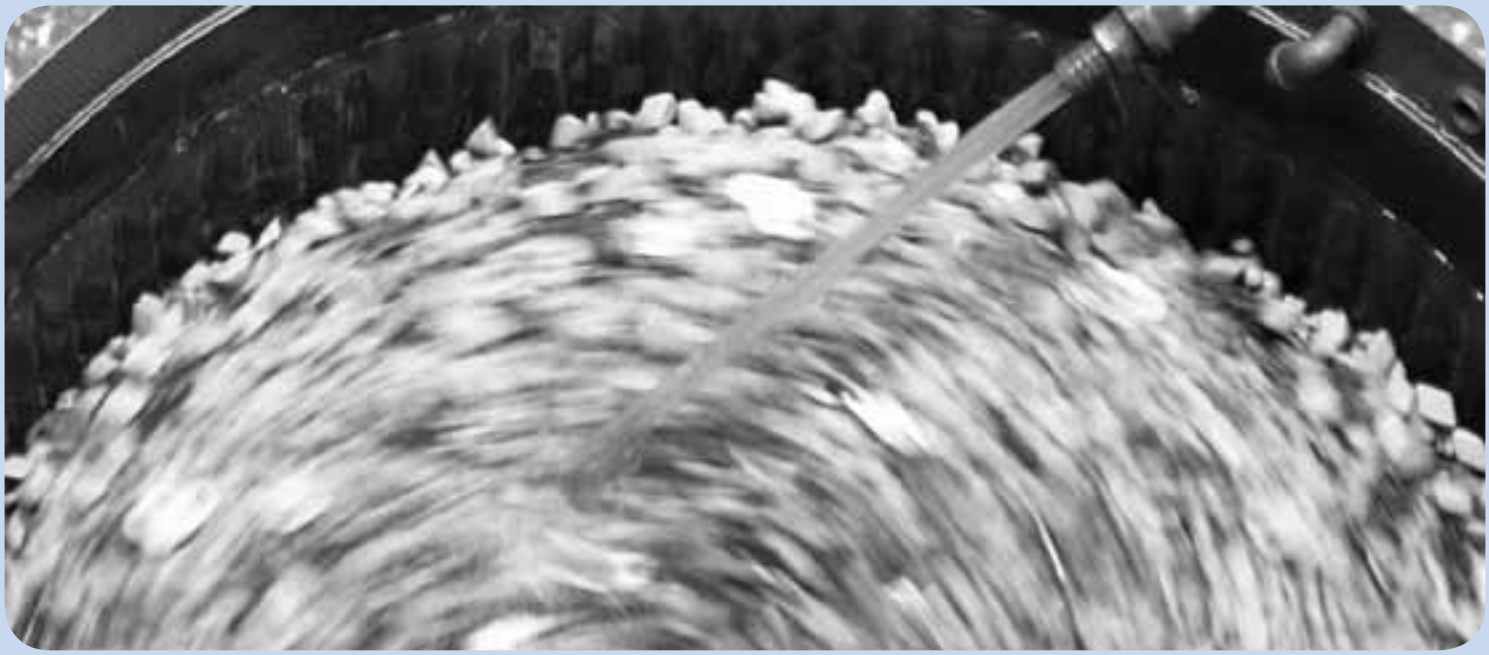
How green chemistry was used:

Blount continually seeks to reduce its use of toxics, hazardous materials, and waste as part of its journey to sustainability. This led to a partnership with the Environmental Protection Agency to reduce the use of lead, a toxic metal. To meet its target, Blount seized an opportunity to replace an electrolytic cleaning process that used acids, caustics, rinse water, and lead anodes to prepare parts for chrome plating. The process generated acid-, caustic-, and lead-contaminated waste, wastewater, and process emissions.

Green chemistry enabled Blount to utilize a new technology that substitutes lead and the other hazardous chemicals for non-toxic and nonhazardous alternatives. But there were barriers: the initial cost of new equipment was high; performance tests of the new process required significant amounts of time and money; and there were space constraints in the existing facility. Blount was able to overcome these challenges because of strong support from both staff and management to invest in the technology and comprehensive accounting that showed a total cost savings would be generated from the switch.

Benefits of using green chemistry:

- Elimination of 1,400 pounds of lead, 63,000 pounds per year of related waste, and 800,000 gallons per year of hazardous waste water
- Hundreds of thousands of dollars of annual savings in labor and raw material costs
- Increased production capacity within the existing facility footprint as a result of improved process efficiency
- Ability to provide a cleaner, healthier work environment for employees



Columbia Forest Products Gains a Competitive Advantage

How green chemistry was used:

The use of urea formaldehyde-based adhesives has been the standard practice in manufacturing decorative hardwood plywood for decades. Columbia Forest Products had been searching for alternative adhesives for many years since formaldehyde is a toxic chemical—but they needed one that didn't add any costs to the operation. Through a partnership with Dr. Kaichang Li at Oregon State University and another business, the company was able to develop a stronger adhesive that is, unlike its predecessor, moisture resistant and environmentally benign, even going so far as to be compostable.

Benefits of using green chemistry:

- Reduced mill emissions by as much as 95%, creating a healthier workplace for employee-owners and the surrounding community
- Avoided $2.5 million in equipment upgrade costs
- Helped maintain the company's market share during an economic downturn that impacted the forest and wood products industry
- Created new business opportunities and customer relationships
- Kept product lines cost-competitive and compliant by implementing the most stringent environmental standards

Nike, Inc. Overcomes Sustainability Challenges by Creating Greener High-Performance Materials

How green chemistry was used:

A vast array of materials go into Nike products. In the mid-nineties Nike began integrating sustainability goals into the design and manufacturing of its products, with a particular focus on the toxicity of the materials the company used in products and processes.

Through an evolutionary process, Nike has been able to find better ways to evaluate materials and make products that are safer for consumers and the environment over time. However, access to complete and reliable data from suppliers has often been a challenge. Developing partnerships with suppliers has helped address this challenge. The partnerships have also allowed Nike to clearly communicate its goals and reach its desired outcomes in pursuit of more sustainable materials and products. Using green chemistry, Nike was able to produce a more environmentally friendly rubber for its footwear that was created with benign accelerators, vegetable oils, and modified processing chemicals and methods. The environmentally friendly rubber performs as well as the one it replaced.

Benefits of using green chemistry:

- Allows Nike to create materials and products that are in compliance with the strictest global chemical legislation, avoiding potential regulatory issues in different countries or regions
- Reduces waste associated with their global supply chain, resulting in cost savings

FINDINGS

These case studies illustrate numerous important points about the benefits and challenges associated with the use of green chemistry. With these as the backdrop for dialogue and information exchange, members arrived at a variety of findings during the OGCAG process. These findings fall into three categories including benefits, opportunities, and barriers and needs.

BENEFITS

The use of green chemistry generates public and private economic, environmental, and social benefits.

Case studies from businesses and research institutions in Oregon, the United States, and around the world create a convincing body of evidence of these benefits. Economic benefits include competitive advantages, access to new markets, cost savings, and reduced risks to shareholder value and direct liability. Environmental benefits include improved water and energy efficiency, and the reduction or elimination of toxic substances. Social benefits include improved safety of products used in the home and workplace.

OPPORTUNITIES

Oregon has the opportunity to further support a high quality of life for citizens by fostering innovation through the use of green chemistry.

The pursuit of new and innovative approaches to sustainability through green chemistry helps to protect the quality of Oregon's environment by providing voluntary solutions that complement regulatory approaches to toxics use reduction. It can also improve the safety of our homes and workplaces through the use of safer, less-toxic chemicals, materials, products and processes. Finally, it can create, attract and retain businesses with living-wage jobs for Oregonians.

Building on Oregon's existing resources in ways that advance green chemistry is an opportunity to support sustainable businesses.

Oregon is uniquely positioned to implement green chemistry to promote innovation, economic growth and sustainable practices because of our state's deep technical expertise, compelling successes, resource and energy base, collaborative environment, and public/consumer support for sustainability. The state's economic future requires diversity and innovation, including a manufacturing sector that is cleaner and more sustainable.

Stakeholders across Oregon have the opportunity to take actions that will advance green chemistry.

Key decision-makers in **industry** can design products and develop supply chains that reduce the use and generation of hazardous substances. They can also support research, development, and commercialization of clean technologies and collaborate with stakeholders across sectors. In **academia**, educators can set the stage to solve environmental problems with green chemistry by preparing and inspiring scientific leaders, the emerging and existing workforce, and students. Researchers can support new and existing chemical enterprise leaders and discover and design greener chemicals and materials. Administrators can provide support for green chemistry research and education with seed and matching funds and provide needed visibility to green chemistry efforts in their institutions.

Decision-makers at various levels in state and local **government** can provide leadership in transitioning to a clean economy by taking actions to prioritize green chemistry within key departments and programs in the state. Public agencies can use resources and adopt policies that support green chemistry through collaborative partnerships by investing in research and development that leads to innovation and diffusion. Household **consumers** can support greener products and markets by purchasing and using them. They can act as champions for green products among peers, at stores, and in their workplaces. They can encourage the design of safer products and processes through financial investments and support policy reform to help create a modern, comprehensive chemical regulatory system.

Retailers can help create demand for green products and act as stewards of public and environmental health. They can advocate for full disclosure of product toxicity and hazard to make informed purchasing decisions and carry products that are safer for consumers and the environment. Advocates with **NGOs** can increase awareness about how green chemistry can be used and the associated benefits among key decision-makers and the public. They can support the public-policy process and advocate for chemicals policy reform, help provide technical assistance for businesses, and facilitate cross-sector partnerships and collaboration.

BARRIERS AND NEEDS

Multiple barriers prevent individuals and organizations from fully capitalizing on the benefits of green chemistry.

The most significant barrier to the widespread use of green chemistry is a lack of understanding about how it can be used and the benefits it creates. A dearth of resources to support the continued development of green chemistry in Oregon is also a significant barrier. The misperception that green products and processes are not cost-effective or have a lower level of performance can deter investment in green chemistry solutions.

Stakeholders do not yet realize the full scope of opportunities there are to use green chemistry–or the value it would create for businesses, academia, government, and residents in Oregon. Insufficient public and private investment in building intellectual capital and research & development capacity also acts as a barrier. Inadequate incentives and/or significant disincentives to warrant investment in green chemistry solutions are also barriers, as are technical challenges associated with designing and producing greener products and processes.

To ensure the widespread use of green chemistry throughout the state, Oregon needs to further encourage collaboration.

The fact that a cross-sector, collaborative group of professionals donated significant time and effort over six months illustrates a fundamental point about Oregon's collaborative spirit and the value of an integrated approach. Collaboration helps identify synergies, coordinate efforts, build resources and expertise, bridge gaps, identify needs and opportunities, and facilitate implementation.

Oregon needs a balanced policy approach to support the use of green chemistry.

A wise combination of policies that support innovation, foster new ventures, create new jobs, and spur entrepreneurial activity in the field of green chemistry, coupled with traditional regulatory approaches for protecting public health and the environment will optimize our success. We need both "push" and "pull" policies that stimulate supply and demand for greener products and processes in Oregon. Such policies should occur at the state and local levels.

RECOMMENDATIONS

How the recommendations were developed

A diverse set of draft recommendations were developed based on the OGCAG's findings. The draft recommendations were compared with options generated by green chemistry efforts in other states and by different organizations.[2] This analysis helped the group evaluate gaps in the recommendations and understand other approaches. Those recommendations were subsequently refined to achieve consensus on a set of four priority recommendations that embody the most important and effective next-step actions that Oregon can take to advance green chemistry.

The OGCAG encourages interested individuals and organizations to join us in making the following vision a reality: Oregon is a national leader in the development and implementation of green chemistry to design products and processes that protect the public and our environment from hazardous materials while promoting innovation and a vital economy. To help make this vision a reality, the OGCAG has come to consensus on the priority recommendations beginning on page 17.

1 Increase understanding and awareness of the benefits of using green chemistry among key decision-makers.

Green chemistry provides innovative solutions to sustainability challenges related to the safety, efficiency, and source of products and processes used by organizations throughout our economy. Oregon should facilitate a focused, multi-sector dialogue that will identify how green chemistry will be used to meet needs and take advantage of opportunities to grow our economy and protect people and the environment.

Building understanding among key stakeholders about the benefits of green chemistry and motivating them to act by addressing factors that influence their decision-making is the first step. It will require a more robust dialogue across sectors in the state and should involve the following outreach efforts:

- **Academia:** Build understanding and awareness with administrators and educators to encourage them to embed green chemistry into academic programs. Develop materials and programs that train and enable educators to effectively teach green chemistry. This could include the development of curricular materials for chemistry and multidisciplinary programs, teacher and continuing education programs, and teacher mentoring, among others.

- **Industry:** Develop and disseminate information to build the business case for the use of green chemistry in industry. Develop and implement education and outreach programs that increase green chemistry awareness among key decision-making groups, particularly in industry, through case studies and other information that helps drive change.

- **Consumers:** Educate and motivate consumers to make informed decisions about products through simple messaging about green chemistry and safer products. Social marketing strategies designed to enable consumers to make informed decisions about products could include topics related to performance, price, health, safety and environmental issues, product marketing, and chemical policy reform. Overall, these strategies will help stimulate demand and result in the increased use of green chemistry by industry.

Next Step

Stakeholders from the private, public and non-profit sectors should support work that increases our understanding of where there are strategic needs and opportunities to use green chemistry in the state. To accomplish this, we need to evaluate where green chemistry can be used to generate the best economic, environmental, and social return on investment. Initially this evaluation could take place through a series of events designed to foster relationships and information exchange between decision-makers. In the long-term, the role of facilitating this dialogue should be institutionalized.

2 Enhance Oregon's existing and future workforce through education and training that supports the use of green chemistry.

Academia, government, and NGOs should bridge knowledge gaps among employees and management to help make informed decisions about the types of chemicals, materials, products, and processes companies use in their goods and services.

An understanding of how green chemistry is used isn't the only knowledge gap that prevents businesses from innovating in ways that create safer products and processes. Other knowledge gaps that need to be addressed include lifecycle thinking and analysis; true cost and sustainability accounting; the integration of safer alternatives and green chemistry into existing lean/high performance manufacturing; and building values-based relationships with suppliers. Creating an integrated approach to designing green products will require a variety of disciplines.

Next Step

Bridge these gaps by conducting or facilitating training and providing resources and tools that will result in the increased ability to make production decisions that are economically and environmentally sound. Information and training that addresses these gaps will help organizations "travel a path" to greener products and processes through green chemistry. Expanding the availability of this type of information and training through university coursework and internships, continuing education credits, and other opportunities to learn and apply these skills through new or existing programs is necessary.

Julie Haack, Univ. of Oregon

"Education is critical for building the kinds of knowledge and understanding that empowers decision makers to use green chemistry as a tool for innovation."

3 Expand Oregon's public and private green chemistry research & development capacity.

Many of the needed tools to apply green chemistry—including reactions, solvents, reagents, and assessment tools—do not exist. They can be created through a combination of public and private research & development. Increasing the availability of green chemistry tools will help professionals make informed decisions and allow green chemistry to be applied in a wider range of products and processes more effectively. Resources available to help researchers develop the green chemistry toolbox are needed. Providing these resources should be a shared investment between academic institutions, government and industry.

Next Step

A strategic approach for identifying opportunities to meet the greener materials and processes needs of companies is to create an inventory of existing green chemistry techniques and tools. Based on this inventory, an evaluation of existing fields of expertise among researchers at Oregon universities can be used to identify potential synergies. In cases where there is strong potential for meeting research and development needs, the state can provide seed funding or other financial assistance. This funding could come from a source like the Oregon Innovation Council or other statewide economic development initiative.

Building Oregon's green chemistry capacity through a strategic statewide initiative would give key industries, like clean technology and renewable energy, additional access to expertise that can ensure the chemicals, materials, and processes used to make these products are as green as possible, without compromising quality or profitability. It would also help ensure that Oregon businesses are globally competitive with products that exhibit the highest level of environmental performance throughout their lifecycle.

4 Commit state and local resources to support green chemistry innovation.

Leaders in both state and local government have important roles to play in advancing green chemistry in Oregon. Strategic resources and integrated policies that support the use of green chemistry will help ensure that sustainability continues to thrive in the state. Decision-makers in public agencies and legislative bodies have the opportunity to strengthen our economy while protecting people and our environment. Supporting green chemistry means investing in innovative solutions that benefit all Oregonians.

Oregon needs a variety of "push" and "pull" policies that stimulate supply and demand for greener products and processes. A wise combination of policies that support innovation, nurture new ventures, create new jobs, and spur entrepreneurial activity in the field of green chemistry, coupled with traditional regulatory approaches for protecting public health and the environment will optimize our success.

Therefore, the State of Oregon should take actions to foster collaboration and build our capacity to innovate through green chemistry. This would include adopting policies that support the use of green chemistry through an executive order, legislation and/or modification of administrative rules. The following actions are recommended:

- **Integrate green chemistry into existing state and local programs and agencies.** This could include incorporating green chemistry into initiatives funded by the Oregon Innovation Council and Business Oregon, making green chemistry activities eligible for state economic development funds. Incorporating green chemistry into agency sustainability plans and Oregon Department of Environmental Quality's Toxics Reduction Strategy will provide support to existing firms and eventually act as an incentive for new firms to locate in Oregon.

- **Develop a diverse set of tools and resources that support the use of green chemistry by Oregon companies.** These could include incentives to help mitigate some of the financial risk for businesses and recognize those that are green chemistry leaders. In addition, Oregon should improve the nature and diversity of technical assistance available to businesses, public agencies, and NGOs through new and/or existing programs and organizations. The Energy Trust is a model that could be applied to green chemistry. The state could also create a green chemistry awards program.

In 2009 Michigan passed three bills that update state economic development programs to make enterprises engaged in the development of green chemistry eligible for grants, tax credits, and other benefits.

This year, Connecticut passed legislation that attempts to put the state at the forefront of green chemistry and clean technology development by creating an institute at the University of Connective to help in-state businesses.

The California Green Chemistry Initiative was launched in 2007 to engage the public in developing policy goals and recommendations for implementing a comprehensive green chemistry policy framework in the state.

- **Develop a purchasing policy that prioritizes products that utilize green chemistry.** Require state contracts use green or greener products that exist and are competitive in terms of price and performance. The development of clear metrics and criteria for determining what is classified as green chemistry or greener products is necessary to ensure the effectiveness of a purchasing policy being used to create demand.

Next Step

Successful implementation of these recommendations will require collaboration between stakeholders from academia, industry, government and NGOs. To ensure an integrated approach that maximizes the value of investment in green chemistry, we advocate for the formation of a statewide green chemistry resource "Hub". The Hub will build on the existing work and partnerships in the state to help ensure Oregon's leadership in this emerging field.

The Hub will lead and facilitate the application of green chemistry in existing industries while supporting new ventures and entrepreneurial activity. It will help catalyze and strengthen cross-sector collaboration between academic and industry much in the way Oregon's other innovation initiatives do. As these initiatives demonstrate, partnerships between these sectors help harness the creativity, inventiveness, and research and development skills at Oregon's universities. The open exchange of information between researchers and manufacturers will result in valuable learning, increased awareness and new, stronger relationships. This will, in turn, aid the development of partnerships that result in the strategic application of green chemistry.

An informal network should be established during the summer of 2010 with the intent of formalizing the resource Hub by the end of the year. As a way to help the Hub succeed over time, it needs a home. A program, department or institute at an Oregon university could house it. Ideally, the Hub will be fully resourced and functioning by mid-2013.

CONCLUSION

Green chemistry is a tool that has the potential to improve almost every single product and process in our material economy. Currently, many green products involve unintended trade-offs in their environmental footprints. Reducing the net environmental footprint requires a holistic lifecycle approach. This involves addressing challenges related to what our products are made out of, how they are manufactured, and what happens to them when their useful life is over. Through green chemistry, we have the means to address some of these challenges with solutions that result in safer products that are better for people, the planet, and profitability.

The recommendations included in this document are considered priorities by the OGCAG. They reflect a synthesis of efforts currently being undertaken by other states and incorporate the unique resources and advantages that exist in Oregon. When implemented, they will put Oregon in a leadership position among states in the U.S., but we have a limited window of opportunity to capitalize on it. Oregon is already recognized as a leader in clean technology and green building and Oregonians enjoy a wonderful legacy of caring for the natural and built environment. Green chemistry can support these kinds of industries and help them create a more holistic approach to improving their environmental performance and overall sustainability.

The OGCAG is already making progress to implement these recommendations—but we need your help. Collaboration is a cornerstone to our success. We need diverse expertise and additional resources to strengthen our growing partnerships. Join us in supporting a healthy, profitable future for all Oregonians.

APPENDIX A

Green chemistry is defined as the "...utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products".[3] It's an approach to pollution prevention that creates substances that are inherently safer for people and the environment. The twelve principles of green chemistry were defined by Paul Anastas and John Warner in *Green Chemistry: Theory and Practice* (1998). In summary, these principles include:

1. Prevent waste rather than treating it or cleaning it up
2. Incorporate all materials used in the manufacturing process in the final product
3. Use synthetic methods that generate substances with little or no toxicity to people or the environment
4. Design chemical products to be effective, but reduce toxicity
5. Phase out solvents and auxiliary substances when possible
6. Use energy efficient processes, at ambient temperature and pressure, to reduce costs and environmental impacts
7. Use renewable raw materials for feedstocks
8. Reuse chemical intermediaries and blocking agents to reduce or eliminate waste
9. Select catalysts that carry out a single reaction many times instead of less efficient reagents
10. Use chemicals that readily break down into innocuous substances in the environment
11. Develop better analytical techniques for real-time monitoring to reduce hazardous substances
12. Use chemicals with low risk for accidents, explosions and fires[4]

APPENDIX B

Oregon Green Chemistry Advisory Group Members

- Mark Brady, **Business Oregon**
- Jim Evans, **Coastwide Laboratories, a Division of Staples**
- John Frazier, **Nike, Inc.**
- Julie Haack, **University of Oregon**
- Jim Hutchison, **University of Oregon**
- David Livengood, **Oregon Department of Environmental Quality**
- Charlie Martin, **Oregon Manufacturing Extension Partnership**
- Colin Price, **Oregon Environmental Council**
- Jason Smith, **Blount International, Inc.**
- Grant Watkinson, **formerly with Coastwide Laboratories, a Division of Staples**
- Elizabeth Whalen, **Portland State University, formerly with Columbia Forest Products**

ENDNOTES

1. Anastas, P. T. & Warner, J. C. (1998). Green Chemistry: Theory and Practice. Oxford Science Publications. For a list of the 12 principles, please see Appendix A.

2. This included publications on state efforts in California, Michigan and Maine, and publications by the Harvard-Yale-American Chemical Society Green Chemistry Institute's Green Chemistry Project, the Green Chemistry and Commerce Council, the Lowell Center for Sustainable Production at the University of Massachusetts Lowell and the National Pollution Prevention Roundtable, among others.

3. Anastas, P. T. & Warner, J. C. (1998). Green Chemistry: Theory and Practice. Oxford Science Publications.

4. Green Chemistry Science Advisory Panel. (2008). Green Chemistry Options for the State of California. Department of Toxic Substances Control, California EPA.

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