Green Chemistry: A More Sustainable Approach to Medicine Development

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Credit: Getty Images

In 1962, Rachel Carson galvanized public interest in the environmental effects of chemicals. Her book "Silent Spring" detailed how common pesticides were killing not only insects, but also birds, larger animals, and even humans.[1]

Chemicals are essential to so many products people rely on in their daily lives, from phones and cars to medications. But these items can be produced in ways that have fewer negative effects on the environment, human health, and society. Since the 1960s, and Carson's seminal work, chemists across industries have worked to refine chemical production, eventually coalescing in a practice called green chemistry.[1,2]

What Is Green Chemistry?

As defined by the United States Environmental Protection Agency (EPA), green chemistry is “the design of chemical products and processes that reduce or eliminate the generation of hazardous substances.”[2]

For the pharmaceutical industry, scientific innovation begins in the lab, where chemistry is foundational to designing and delivering medicines and vaccines to prevent and treat disease. During drug development, as part of Pfizer’s focus on green chemistry, the utmost care is taken to try and select materials that have less environmental impact, reduce the use of resources, minimize waste, and run safe processes.[2]

While patients may only see the end results of drug development, pharmaceutical companies and medical device companies have been increasing their focus on reducing environmental impact. A transition toward a sustainable future will require the use of greener technologies that change the way we manage the entire chemical lifecycles, from chemical supply chains and chemical manufacturing to use and end-life of final products.[3]

For example, reducing the use of nonrenewable raw materials, solvents, and other reagents with safer, environmentally preferable alternatives have been an important part of Pfizer’s green chemistry strategy. Another has been investing in technology that has allowed Pfizer to introduce and leverage continuous processes as part of its manufacturing operations.[4]

Adopting more mature analytical procedures that lead to reductions in material use is yet another. In one example, efforts in green chemistry were linked to 19% reduction in waste and 56% improved productivity compared with past drug production standards.[5]

As the U.S. evaluates the toxicity of existing chemicals[6] and the U.S. and other nations enact climate change legislation7, chemists adopt green chemistry at all stages of drug development.[8] Pfizer started using green chemistry principles in drug development more than two decades ago as part of a commitment to reduce its environmental footprint and use science to drive societal benefit.[9]

In 1998, the American Chemical Society outlined 12 principles of green chemistry to guide such efforts. The first of the 12 principles, Prevention, states, "It is better to prevent waste than to treat or clean up waste after it has been created." Some of the goals of these principles include reducing waste, using sustainable ingredients, and developing energy-efficient manufacturing processes.[8]

"All people deserve to live healthy lives," says Barry Dillon, Director of Product Stewardship at Pfizer. "This is what motivates our scientists at Pfizer to develop innovative medicines through more sustainable and environmentally responsible processes. Application of green chemistry has been key to continuous improvement."

Examples of Green Chemistry

Green chemistry provides a framework to evaluate, innovate and identify more effective practices. For example, precious metals such as palladium, platinum, and iridium are rare and expensive, but have been used to aid in the formation of chemical bonds during pharmaceutical manufacturing. And as the science evolves, Pfizer is at the forefront of adopting these advances. Scientists at Pfizer have identified alternatives that produce less waste and are more readily available and cheaper, such as nickel.[10]

Drug developers employ a range of actions to reduce resource use. This includes substitution of solvents, reagents that are less hazardous and environmentally preferable; optimization of process conditions to maximize yield and reduce waste, and use of renewable energy sources.[5]

"Our scientists are committed to applying the best scientific practices and innovations in order to reduce the environmental impact of our medicines," says Dillon. "And it's not just for regulatory reasons or finance reasons. We genuinely want to see the minimum number of resources used."

Companies are also working to implement manufacturing processes to minimize waste and energy consumption. Pfizer is committed to being net zero by 2040. As part of the ambitious goal, Pfizer is on a path to a 95% reduction in company greenhouse gas emissions and a 90% reduction in value chain emissions from 2019's numbers, which includes getting 100% of purchased electricity from renewable resources.[11]

Why Green Chemistry Matters to Patients

"As scientists, we care about delivering life-saving drugs that improve the lives of patients, and we care about doing it in a responsible way," says Juan Colberg, Senior Director Chemical Technology and Small Molecules Green Chemistry Leader at Pfizer. "As we take care of our customers and patients, we also seek to take care of communities, employees, and society, in general, in the way we manufacture and get drugs from discovery into the hands of our patients."

In addition to the environment and human health, the development of more sustainable pharmaceutical practices can also help promote societal equity. As Colberg points out, many precious metals have been mined in countries that use exploitative labor practices, and climate change disproportionately affects people whose incomes are below the federal poverty threshold.

The Future of Green Chemistry

Colberg says the time between drug discovery and the manufacturing of new drugs has decreased, particularly when the Food and Drug Administration (FDA) provides accelerated reviews. Even during shorter timelines, environmental regulations could change what materials are acceptable and Dillon notes that substances that are acceptable for use today could be forbidden within a few years.

That’s why early and aggressive application of green chemistry principles throughout the development process—balanced with maintaining quality and safety standards—is so important. Achieving this requires a forward-thinking approach to environmental responsibility not only in the lab, but throughout the organization.

"The advent of corporate goals, climate change awareness, sustainability awareness, and the broader agenda has meant that the lab scientists can better communicate their improvements and findings," says Dillon. "We have an active audience and a receptive audience and that leads to an acknowledgment of their efforts and an understanding of why it's important."

Colberg anticipates Pfizer and other pharmaceutical companies will use more computer-based selection tools, innovative manufacturing technology as one way to increase yield and efficiency and to have the flexibility to make decisions faster.

More than 20 years ago, this was just a grassroots effort by a few Pfizer colleagues who were passionate about minimizing the impact on the environment by using less harmful chemicals, eliminating waste, and conserving energy in our chemical processes. Now it’s a much broader company initiative. It’s this passion, together with Pfizer’s commitment

to help address climate change and environmental inequality, that inspires us to aim to be NetZero by 2040.[11]

Article References

1. Carson R. Silent Spring. Houghton Mifflin. 1962.
2. Green Chemistry. U.S. Environmental Protection Agency. https://www.epa.gov/greenchemistry. Updated November 2, 2022. Accessed November 22, 2022.
3. Desai, M., Njoku, A., and Nimo-Sefah, L. Comparing Environmental Policies to Reduce Pharmaceutical Pollution and Address Disparities. *International Journal of Environmental Research and Public Health*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9325029/. Published July 7, 2022. Accessed November 22, 2022.
4. Greener Processes. Pfizer. https://www.pfizer.com/about/responsibility/green-journey/greener-processes. Accessed November 22, 2022.
5. Mishra, M., Sharma, M., Dubey, R., et al. Green synthesis interventions of pharmaceutical industries for sustainable development. Current Research in Green and Sustainable Chemistry. https://www.sciencedirect.com/science/article/pii/S2666086521001211. Published September 20, 2021. Accessed November 7, 2022.
6. Prioritizing Existing Chemicals for Risk Evaluation. U.S. Environmental Protection Agency. https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/prioritizing-existing-chemicals-risk-evaluation. Updated April 2, 2021. Accessed October 26, 2021.
7. Climate Change Laws of the World. Grantham Research Institute on Climate Change and the Environment. https://climate-laws.org/. Accessed October 26, 2021.
8. 12 Principles of Green Chemistry. American Chemical Society. https://www.acs.org/content/acs/en/greenchemistry/principles/12-principles-of-green-chemistry.html. Accessed October 26, 2021.
9. Presidential Green Chemistry Challenge: 2002 Greener Synthetic Pathways Award. https://www.epa.gov/greenchemistry/presidential-green-chemistry-challenge-2002-greener-synthetic-pathways-award. Updated January 10, 2022. Accessed November 22, 2022.
10. In Drug Creation, Less Precious, More Green. Pfizer. https://www.pfizer.com/news/articles/drug-creation-less-precious-more-green. Accessed November 22, 2022.
11. Net Zero by 2040: How Pfizer is Fighting Climate Change with Ambitious Science Based Goals.

https://www.pfizer.com/news/articles/net_zero_by_2040_how_pfizer_is_fighting_climate_cha
. Published May 29, 2022. Accessed November 22, 2022.

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