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CHEMICAL INNOVATION

Technologies for Making Products and Processes More Sustainable

GAO Highlights

Highlights of GAO-19-660T, a testimony before the Subcommittee on Research and Technology, Committee on Science, Space, and Technology, House of Representatives

Why GAO Did This Study

Chemistry contributes to virtually every aspect of modern life, and the chemical industry supports nearly 26 percent of the gross domestic product of the United States. While these are positive contributions, chemical processes and production can have negative health and environmental consequences. Mitigating these potential consequences requires thoughtful design and evaluation of the life cycle effects of chemical processes and products.

This testimony—based on a 2018 technology assessment, GAO-18-307—discusses (1) how stakeholders define and assess the sustainability of chemical processes and products, (2) available or developing technologies to make chemical processes and products more sustainable, (3) the roles of the federal government and others in supporting the development and use of more sustainable chemical processes and products, and (4) opportunities and challenges in the field of sustainable chemistry.

For the 2018 report, GAO selected for assessment three technology categories—catalysts, solvents, and continuous processing; interviewed stakeholders from various fields, such as government, industry, and academia; convened a meeting of experts on sustainable chemistry technologies and approaches; and surveyed a non-generalizable sample of chemical companies.

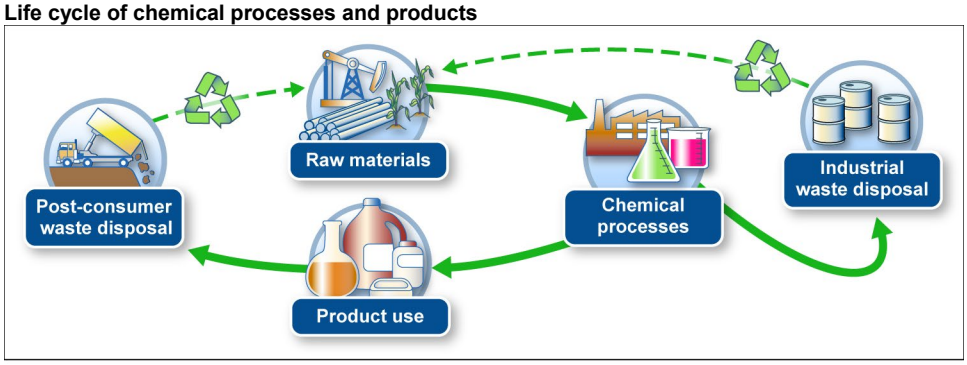
View GAO-19-660T. For more information, contact Timothy M. Persons at (202) 512-6412 or personst@gao.gov.

What GAO Found

Stakeholders vary in how they define and assess the sustainability of chemical processes and products; these differences hinder the development and adoption of more sustainable chemistry technologies. However, based on a review of the literature and stakeholder interviews, GAO identified several common themes underlying what sustainable chemistry strives to achieve, including:

- improve the efficiency with which natural resources are used to meet human needs for chemical products while avoiding environmental harm;
- reduce or eliminate the use or generation of hazardous substances,
- protect and benefit the economy, people and the environment using innovative chemical transformations;
- minimize the use of non-renewable resources; and
- consider all life cycle stages when evaluating a product (see figure).

Life cycle of chemical processes and products



Source: GAO. | GAO-19-660T

There are many technologies available and in development that can improve chemical sustainability at each stage of the chemical life cycle. GAO identified three categories of more sustainable chemistry technologies—catalysts, solvents, and continuous processing.

- Catalysts are used to make chemical processes run faster or use less material. Without catalysts, many everyday items such as medicines, fibers, fuels, and paints could not be produced in sufficient quantities to meet demand. However, the most common catalysts—including those used in automobile catalytic converters—are rare, nonrenewable metals such as platinum and palladium. Researchers are working to replace such metals with alternatives, including abundant metals (e.g., iron and nickel) where possible.
- Solvents are used to dissolve other substances so reactions can occur, to separate and purify chemicals, and to clean the equipment used in chemical processes, among other uses. Solvents constitute a large portion of the total volume of chemicals used in industrial chemical processes. However, many conventional solvents are considered hazardous. There are a variety of alternatives that can be used in some situations, including biobased solvents.

- An alternative to traditional batch processing is continuous processing, which allows chemical reactions to occur as the reaction mixture is pumped through a series of pipes or tubes where reactions take place continuously. Compared to batch processing, this approach can improve product yield, product quality, and process safety while reducing waste and costs.

The federal government and other stakeholders play several roles, sometimes in collaboration, to advance the development and use of more sustainable chemistry technologies. The federal government supports research, provides technical assistance, and offers certification programs, while other stakeholders conduct research, develop industry-specific standards, support workforce development development, and address chemicals of concern in consumer products, among other roles.

Strategic Implications

While using more sustainable options entails challenges--including technological, business, and industry-wide and sector-specific challenges, the field of sustainable chemistry has the potential to inspire new products and processes, create jobs, and enhance benefits to human health and the environment. Stakeholders identified strategic implications of sustainable chemistry and offered a range of potential options and realize the full potential of these technologies, including the following:

- Breakthrough technologies in sustainable chemistry and a new conceptual framework could transform how the industry thinks about performance, function, and synthesis.
- An industry consortium, working in partnership with a key supporter at the federal level, could help make sustainable chemistry a priority and lead to an effective national initiative or strategy.
- Integrating sustainable chemistry principles into educational programs could bolster a new generation of chemists, encourage innovation, and advance achievement in the field.
- A national initiative that considers sustainable chemistry in a systematic manner could encourage collaborations among industry, academia and the government, similar to the National Nanotechnology Initiative.
- There are opportunities for the federal government to address industry-wide challenges such as developing standard tools for assessment and a robust definition of sustainable chemistry. Federal agencies can also play a role in demonstrating, piloting, and de-risking some technology development efforts.

According to stakeholders, transitioning toward the use of more sustainable chemistry technologies will require national leadership and industry, government, and other stakeholders to work together.