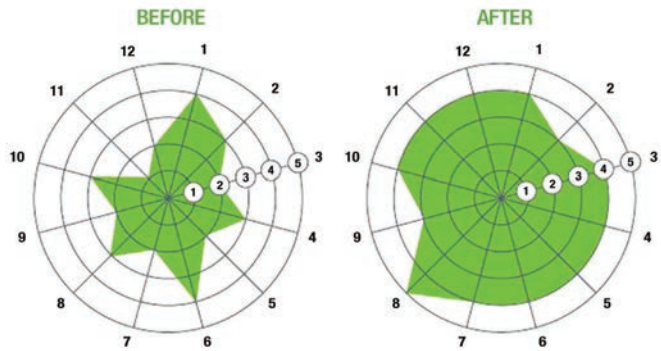
Q&A: Going Green with Chemistry

How to implement and measure the impacts of green chemistry in F&F.

The U.S. Environmental Protection Agency (EPA) defines green chemistry as "the design of chemical products and processes that reduce or eliminate the generation of hazardous substances." Coined in 1998, the term green chemistry comprises 12 principles (see sidebar).[1]

Today, the contributions of green chemistry to the sustainability and innovation of the flavor and fragrance industry are being realized. According to a Navigant Research report (www.navigantresearch.com)*, green chemistry will save industries $65.5 billion by 2020. In addition, the green chemistry market is forecast to grow to $98.5 billion during the same time period.*

Recently, Ahmet Baydar, senior vice president, research and development, and Michael Popplewell, vice president, corporate research and development (both of International Flavors & Fragrances, Inc.) sat down to discuss green chemistry's impact on the flavor and fragrance industry. What follows is a Q&A based on their conversation.



IFF's green chemistry product evaluation tool scores products against the Anastas and Warner principles on a spider graph.

P&F: Can you provide a simple explanation of what green chemistry is?

Baydar: Green chemistry is the design of ingredients and processes that reduce or eliminate solvents, chemical reagents and energy. There are a set of principles adopted by the American Chemical Society. In simple terms, these principles govern chemistry with the environment, human health and renewability in mind.

Popplewell: It is the foundation of creating sustainable products. For example, in the development and manufacture of ingredients, it drives a detailed review with regard to key environmental and renewability factors.

P&F: Why does the industry care about green chemistry?

Popplewell: As an industry, we care about the health of people and the environment, so the way we make ingredients and products in general has to reflect that concern as well.

Baydar: We care because it is all about producing ingredients in an environmentally sustainable way.

P&F: What are the benefits to customers and consumers?

Popplewell: People care about what they eat and use on a day-to-day basis, and want to know where things come from. So, for consumers it boils down to them having more confidence that the products they purchase align with their values—for example knowing they have been made in an environmentally friendly manner. The consumer then drives our customers' need to have a more sustainable supply chain. Green chemistry helps the industry be responsive to that need.

P&F: Why has it become so important now?

Baydar: Consumers, the general public and industries are becoming more aware and demanding than ever before. Understanding what they use, consume and where it comes from has become very important to them. This awareness will drive the F&F industry as our customers strive to satisfy the changing demands. We touch people's lives every day with the flavor and fragrance ingredients we produce. Therefore, as an industry, we have a responsibility as a critical part of the supply chain to be responsive to the consumer's needs.

P&F: Is green chemistry commonly used in the F&F industry?

Baydar: Over the last several years, green chemistry has become a stronger focus of our industry. As the consumer asks for more, the industry is responding. At IFF, a major global supplier of flavor and fragrance ingredients, we are constantly changing the way we create products with achieving excellence in sustainability—starting in the lab and going through the process all the way to manufacturing.

P&F: Can you give an example of the use and benefits of green chemistry?

Baydar: One simple use of green chemistry was our introduction of catalysis to our manufacturing operations, reducing and in some cases totally eliminating the use of solvents and chemical reagents.

12 Principles of Green Chemistry[1]

1. Prevention
It is better to prevent waste than to treat or clean up waste after it has been created.

2. Atom Economy
Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product. Waste few or no atoms.

3. Less Hazardous Chemical Syntheses
Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.

4. Designing Safer Chemicals
Chemical products should be designed to affect their desired function while minimizing their toxicity.

5. Safer Solvents and Auxiliaries
The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used. If you must use chemicals, use safer ones.

6. Design for Energy Efficiency
Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.

7. Use of Renewable Feedstocks
A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable. The source of renewable feedstock is often agricultural products or the wastes of other processes; the source of depletable feedstock is often fossil fuels (petroleum, natural gas, or coal) or mining operations

8. Reduce Derivatives
Unnecessary derivatization (use of blocking groups, protection/deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

9. Catalysis
Catalytic reagents (as selective as possible) are superior to stoichiometric reagents. Catalysts are effective in small amounts and can carry out a single reaction many times. They are preferable to stoichiometric reagents, which are used in excess and carry out a reaction only once.

10. Design for Degradation
Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

11. Real-time analysis for Pollution Prevention
Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of byproducts or hazardous substances.

12. Inherently Safer Chemistry for Accident Prevention
Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including explosions, fire and releases to the environment.

Popplewell: It also reduces energy use and carbon, and ultimately can help control costs.

P&F: How can a company get chemists trained and up to speed?

Popplewell: It is critical that all chemists in R&D and key manufacturing facilities are trained in the green chemistry principles. At IFF, we partnered with experts in green chemistry to build a proprietary training module that we started in one location and then rolled out to other regions. It includes a focus on the fundamental principles, plus extensive case studies utilizing our proprietary assessment tool. The tool is especially helpful in the case of new molecules, which are invented and optimized in a laboratory, and then transferred to a manufacturing facility for scale-up and production. Improvements can be made at each stage to ensure optimal green chemistry performance.

Baydar: To avoid a learning gap, we have an onboarding program to train new scientists in green chemistry as they join IFF. The training is continuous, with annual refreshers. At IFF, we look at green chemistry training like safety training.

P&F: Are your chemists embracing it?

Baydar: Our scientists all love the training we give in green chemistry. Everyone understands green chemistry is about being more environmentally prudent. The most exciting part is every time they are designing the synthesis of a new ingredient, the way they think in making them follows the principles of green chemistry.

P&F: How can you measure whether it is effective or not?

Popplewell: Commercialization is the best indicator. We now have commercial ingredients that integrate green chemistry advances. Additionally, all the new R&D ingredients and technologies are assessed via our green chemistry tool. This will drive an increase in industrial green chemistry over time.

P&F: Is there a tie-in to lifecycle assessment (LCA)?

Popplewell: There are many commonalities between LCA and green chemistry such as energy, carbon and waste. Green chemistry gives us a good window into LCA and allows us to assess possible improvements.

P&F: Are there best practices that can be shared?

Popplewell: At IFF, we have a proprietary evaluation tool that helps us rate a chemical process with regard to green chemistry principles using specific criteria.[a] We have published this information in our sustainability report and would welcome sharing our approach with the F&F industry.

P&F: In closing, what is the one thing you want to say about the role of green chemistry in the future of the F&F industry?

Baydar: Green chemistry will continue to grow in importance and demand. It is the only way to go. Successful companies will need to adopt the practices. At IFF, we are fortunate that we started this early and have embedded green chemistry into our processes.

[a]The company's green chemistry product evaluation tool scores products against the Anastas and Warner principles on a spider graph (pictured).

References

1. PT Anastas and JC Warner, Green Chemistry: Theory and Practice. Oxford University Press, New York, p 30 (1998)