Perspective

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# Describing Chemical Processes that is Kind to the Environment: Green Chemistry Metrics

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## Description

Green chemistry metrics that make it possible to quantitatively compare industrial processes and, more or less, direct the development of brand-new ones. The work includes solvent-based, mass-based, energy-based, greenhouse gas emission-based and mass-based metrics that offer distinct perspectives on chemical process analysis. In contrast to environmental chemistry, which focuses on the effects of polluting chemicals on nature, green chemistry focuses on the environmental impact of chemistry, including lowering consumption of nonrenewable resources and technological approaches for preventing pollution. One of the most widely used metrics for measuring the "greenness" of a process or synthesis is the idea of making Atom Economy (AE) a primary criterion for chemistry improvement, which is part of the green chemistry movement. A process known as "good atom economy" ensures that the majority of the reactant atoms end up in the products that are desired while only a small number of unfavourable byproducts are produced, thereby lessening the financial and environmental impact of disposing of waste.

## Energy Consumption

Due to the close connection between energy consumption and the use of natural resources, the energy industry has a significant impact on the environment. Energy consumption, transportation, and production all have an impact on the environment. Humans have used energy for millennia. Fire has been used for light, heat, cooking, and safety since at least 1.9 million years ago. Recently, there has been a trend toward the increased commercialization of renewable energy sources. There is scientific agreement that increasing concentrations of greenhouse gases, which have a warming effect, global changes to the land surface, such as deforestation, have a cooling effect, and increasing concentrations of aerosols, primarily, have a cooling effect. Due to the fact that they are affected by human activities in a variety of nations, many of the earth's resources are particularly vulnerable. As a consequence of this, numerous attempts are made by nations to create agreements that are ratified by multiple governments to mitigate the effects of human activity on natural resources or prevent damage. Agreements that have an effect on climate, oceans, rivers, and air pollution are examples of this. These international environmental agreements can be legally enforceable with legal repercussions if they are not adhered to, or they can be more of an agreement in principle or codes of conduct. Metrics for green chemistry explain how the principles of green chemistry apply to a chemical process. The metrics enable performance changes to be measured and serve to quantify chemical processes' efficiency or environmental performance. The expectation that quantifying technological and environmental advancements can make the benefits of new technologies more tangible, perceptible, or understandable is the motivation for using metrics. This, in turn, is likely to facilitate the spread of green chemistry technologies throughout industry and improve research communication. Metrics' primary function is to facilitate comparisons. Which of several economically viable methods for producing a product is the least harmful to the environment there are two categories of metrics that have been developed to accomplish that goal: Impact-based and mass-based metrics.

## Pharmaceutical Sector

The mass of the materials, not their impact, serves as the foundation for the simplest metrics. They do not distinguish between waste that is more harmful and waste that is less harmful. According to mass-based metrics, a process that produces less waste may appear to be greener than other options, but it may actually be less green if the waste produced is particularly harmful to the environment. Mass-based metrics cannot be used to determine which synthetic method is greener because of this serious limitation. On the other hand, mass-based metrics have the significant advantage of being extremely straightforward: They can be calculated with few assumptions using readily available data. Mass-based metrics may be the only option for monitoring company-wide reductions in environmental harm for businesses that produce thousands of products. Impact-based metrics, on the other hand, such as those used in life-cycle assessment, evaluate environmental impact in addition to mass. As a result, they are much better suited for choosing the greenest option or synthetic pathway. It emphasizes the waste produced during the process rather than the reaction, assisting those attempting to adhere to one of the twelve green chemistry principles. E-factors can be combined to evaluate multi-step reactions in one calculation or step by step. E-factors don't take into account recyclables like recycled solvents and repurposed catalysts, which obviously improve accuracy but don't take into account the energy needed to recover (these are often theoretically included by assuming 90% solvent recovery). The need to define system boundaries, such as which stages of the production or product life-cycle should be taken into consideration before calculations can be made, is the primary issue with E-factors. Industrially, this metric is simple to use because a production facility can directly calculate an accurate global E-factor for the site by measuring how much material enters the site and how much leaves as waste or product. According to Sheldon's analyses, pharmaceutical companies generate more waste per unit of processed material than oil companies. This reflects the fact that the oil industry's profit margins require them to reduce waste to a minimum and find uses for products that would otherwise be discarded. In contrast, the pharmaceutical industry places a greater emphasis on the production and quality of molecules. It is important to note that, despite the high percentage of waste and E-factor, the pharmaceutical sector produces much less waste than any other sector. This is due to the sector's high profit margins, which means that there is less concern about the relatively large amounts of waste that are produced (especially in light of the volumes used). A number of large pharmaceutical companies were encouraged to start "green" chemistry programs. Green solvents, on the other hand, are more sustainable and generally less harmful to health and the environment. When selecting a solvent for a product or process, the environmental impact of solvent manufacturing must be taken into consideration. Additionally, the solvent's fate after use must be taken into consideration. In an ideal world, solvents would be derived from renewable resources and biodegrade to harmless, frequently a naturally occurring product. The environmental harm and energy costs of recycling should be taken into account if the solvent is being used in a closed environment where solvent recycling is possible; water, which requires a lot of energy to purify, might not be the best option for the environment in such a scenario.