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## Green chemistry design, innovation, solutions and a cohesive system

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## EDITORIAL COMMENT

### Green chemistry design, innovation, solutions and a cohesive system

Paul Anastas

*Chair of the Editorial Board, Yale University*

The highest quality scientific discovery and innovation is the heart and soul of green chemistry. In the absence of scientific excellence, the noble goals of advancing sustainability become hollow words. However, in the presence of the best we have to offer in science and technology, from conceptualization to implementation, the great challenges we face in achieving sustainability become possible. Therefore, when we speak of sustainability, we certainly align with the definition put forward over twenty years ago by the Brundlandt Commission of meeting the needs of the current generation while preserving the ability of future generations to meet their needs, and that sustainability has the three elements of environment, economy and society. Therefore, when green chemistry is described as “the chemistry of sustainability,” it is referring to the demonstrated ability of green chemistry to meet economic and environmental goals simultaneously for societal benefit.

As we reflect on the years since the early 1990s, when green chemistry emerged as a cohesive research field, it has undergone periods when due to the excitement concerning a particular emerging area at any one time, people would frequently associate that one area as being synonymous with the field. In other words, during different times it may be said that “green chemistry is all about...”:

- supercritical fluids
- organic synthesis
- biodegradable polymers
- ionic liquids
- nanotechnology
- catalyst design
- renewable feedstocks
- biosynthesis
- and on and on.

The truth of course lies in this breadth and diversity. Green chemistry crosses the traditional sub-disciplines and allows fundamental research to take place in a cross-disciplinary and integrated approach. So, as this new journal engages in seeking to advance

green chemistry research through partnership with all the active members of the field, it is useful to review the essential elements of green chemistry research.

1. *Green chemistry is about design.* Design is the conscious statement of human intention. While it may be possible to make products and processes less hazardous or more efficient as a by-product of research endeavors, green chemistry is a framework for the design of these products and processes such that the goals are themselves essential performance criteria.

2. *Green chemistry is about innovation.* Too often in the past, any new technology that has benefited human health and the environment has focused on what one is not allowed to do or what one must do less. The historical approaches were to eliminate, minimize, lessen, reduce, etc. In green chemistry, the strategy is to see what can be created and invented. New materials, transformations, methodologies, solvents, molecules, analyses and tools are the hallmark of green chemistry, and the research portfolio of the field reflects this orientation.

3. *Green chemistry is about solutions.* As we look at advancing sustainability, there has been a tremendous effort in measuring, monitoring, reviewing, assessing, and characterizing problems – problems in energy, climate, water availability, food production, health and medicine, and pollution. While it is important to understand the nature of the problems we face in order to effectively address them, green chemistry focuses on the solutions to these problems. What are the new alternatives, the next generation of substances that will ensure that the energy and material basis of our society and economy is more sustainable? As important as fully understanding a problem is, a diagnosis is only good if it assists in creating a cure.

4. *Green chemistry is a cohesive system.* Many of the advances in green chemistry technologies have been important incremental advances that have illustrated the ability to achieve various goals. Research has focused on particular principles within the Twelve Principles of Green Chemistry, such as solvent replacement or atom economy. As green chemistry evolves,

there is a recognition that the most transformative breakthroughs will occur when the Twelve Principles are viewed as an integrated system. This system will be used to design synergies and minimize trade-offs between the Principles. In order to truly address many of the sustainability challenges we face, the leap-frog innovations that will result from using the systems approach will be necessary.

In all, there is reason for excitement that the nascent research field of green chemistry has only begun to demonstrate its power and potential to use fundamental sciences for the benefit of man,

the environment, and the economy. Now that the concepts have been dramatically demonstrated over the course of recent years, we are entering the phase of exploring the breadth, range and scope of the possible achievements in green chemistry. This new journal seeks to do this in collaboration with the research community and in partnership with complementary journals in the field. By facilitating energetic dialogue between the creative researchers in the field, and ensuring the widest range of productive collaborations, the expansion and success of the research field of green chemistry is assured.