Green Chemistry: Current Status and Future Challenges

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In its essence, green chemistry is a science-based, non-regulatory and economically driven approach to achieving the goals of environmental protection and sustainable development. The approach has been utilized in a number of industrialized and developing nations. The results in these countries have been that of extremely positive results in terms of both protection of human health and the environment as well as significant economic benefit to the industrial interests involved.

While very broadly applicable, Green chemistry has a very specific and well-defined scope. Green chemistry is chemistry for pollution prevention which strives to reduce or eliminate the use and generation of hazardous substances. This scope explicitly does not include approaches such as waste treatment, waste control or re-mediation even though these elements are recognized as important, but separate, elements of an environmental protection programs. While many countries have those elements capable of reacting to environmental problems once they are formed, there is a need for the introduction and focus on initiatives that design products and processes such that these environmental problems never occur. This is the focus of green chemistry.

The range of green chemistry includes products and processes. This means that not only the structures of a final product can be designed to be non-hazardous but also each of the transformations along the way to manufacture of a product are designed so that they don't use or generate hazardous substances. There is an implicit consideration life cycle impacts with the scope of sustainable chemistry. Although traditionally pollution prevention was thought to focus on waste reduction and waste minimization sustainable chemistry includes and expands this focus to all stages of the life cycle. The importance of this expansion is seen through commonly reported achievements from industry where the greatest economic benefit as well as the greatest environmental benefits are being realized as much in the early stages of the process or product life cycle as they are in the latter stages.

The green chemistry programs implemented by government industry and academia on a voluntary basis have achieved success in reducing risk through the reduction of intrinsic hazard at the molecular level. The types of hazards that can and are being addressed by scientific and industrial concerns include physical hazards, toxicological hazards (both human & ecotox, and global hazards), all of which are effected by proper and innovative molecular design.

As we review the success of green chemistry thus far, it is as important to keep an eye on the challenges of the future and identify the scientific challenges confronting green chemistry. Questions such as:

- What is the molecular basis of hazard – toxicological, physical and global?
- Can we use weak forces as a design tool in imparting performance as we have done with covalent forces?
- What is the pathway toward designing catalysts from first theoretical principles?
- Can we use energy in the place of matter to effectively carry out transformations catalytically on a commercial scale?
- Are the reaction types and feedstocks we use currently in chemical manufacturing the one's we should be using in the next ten, twenty years?

If we are to meet the challenges of sustainability, it will require that we address the problem at the molecular level as one part of the solution.