From: ACS GCI Formulator's Roundtable

Date: January 29, 2010

Subject: Memorandum of understanding of the 12 Principles of Green Chemistry

The ACS Green Chemistry Institute® Formulator's Roundtable (Roundtable) is a partnership between the ACS Green Chemistry Institute® (ACS GCI) and the formulated products industry designed to be the driving force to use green chemistry in creating innovative products that are environmentally sustainable throughout the entire product life cycle and safer to make and use. The Roundtable fully embraces the 12 Principles of Green Chemistry as developed by Paul T. Anastas and John C. Warner. Many of the 12 Principles of Green Chemistry may be applied directly when formulating and others can be used when selecting ingredients for a formulation. We encourage formulators to work with suppliers to use the 12 Principles of Green Chemistry in developing greener chemicals and the Principles of Green Engineering when developing processes for their chemicals. We also recognize that Green Chemistry is a continuous endeavor to design products and processes to minimize the use and/or generation of hazardous chemicals. When developing a product, formulators consider a holistic approach to assure a more sustainable product. It is understood that scientific limitations may hinder the ability to meet all 12 Principles at a given time, and recognize that one of the objectives of the Roundtable to identify those challenges and to work to find resolution.

The Twelve Principles of Green Chemistry*

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.

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 effect 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.

6. **Design for Energy Efficiency**
   Energy requirements of chemical processes should be recognized for their environmental and

American Chemical Society Green Chemistry Institute®
1155 Sixteenth Street, N.W. Washington, D.C. 20036 **T** [202] 872 6102 **F** [202] 776 8009
www.acs.org/greenchemistry

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.

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.

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 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 releases, explosions, and fires.

*Anastas, P. T.; Warner, J. C. Green Chemistry: Theory and Practice, Oxford University Press: New York, 1998, p.30. By permission of Oxford University Press.

Members of the ACS GCI Formulator's Roundtable (as of Dec 2009)