

Green Chemical Management

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ES&H Programs and CSLM

- Most ES&H programs are concerned with Hazardous Materials issues
 - **Strongly linked program examples**
 - Waste Management (traditional EMS/Green program)
 - Pollution Prevention/Reapplication/Reclamation (traditional EMS/Green program)
 - Air Quality/NESHAPS (traditional EMS/Green program)
 - Environmental Monitoring (traditional EMS/Green program)
 - Environmental Remediation/Tanks (traditional EMS/Green program)
 - Industrial Hygiene/Occupational Medicine
 - Fire Protection
 - Emergency Management
 - Risk Management
 - Pressure Safety
 - **Weakly linked program examples**
 - NEPA (traditional EMS/Green program)
 - Ecology (traditional EMS/Green program)
 - Explosives Safety



CSLM Drivers - Recently Updated Green DOE Requirements

- Significant Federal/DOE Requirements
 - EO 13423 Strengthening Federal Environmental, Energy, and Transportation Management (1/2007)
 - DOE O 450.1A, *Environmental Protection Program* (6/2008)
 - DOE O 430.2B *Departmental Energy, Renewable Energy and Transportation Management* (2/2008)
 - DOE requirement on the Management of Unneeded Materials and Chemicals (UMC) (12/2005)
 - DOE O 151.1C Emergency Management - Hazards Survey focus on NFPA Health 3 & 4 Materials (11/2005)
- Environmental Risk Management Focus Examples
 - EPCRA 313 (Toxic Release Inventory)
 - High VOC Substances (Adhesives/Solvents)
 - Ozone Depleting Substances
 - EPCRA 302 Extremely Hazardous Substances List



Green Chemistry - Introduction

- What is Green Chemistry? (EPA)

http://www.epa.gov/gcc/pubs/basic_info.html

- Green chemistry consists of environmentally friendly, sustainable chemicals and processes whose use results in reduced waste, safer outputs, and reduced or eliminated pollution and environmental damage. Green chemistry encourages innovation and promotes the creation of products that are both environmentally and economically sustainable.



Sustainable Chemistry Hierarchy

(http://www.epa.gov/gcc/pubs/about_gc.html)

Chemical products and processes should be designed to the highest level of this hierarchy and be cost-competitive in the market.

1. Green Chemistry: Source Reduction/Prevention of Chemical Hazards

- Design chemical products to be less hazardous to human health and the environment*
- Use feedstocks and reagents that are less hazardous to human health and the environment*
- Design syntheses and other processes to be less energy and materials intensive (high atom economy, low E-factor)
- Use feedstocks derived from annually renewable resources or from abundant waste
- Design chemical products for increased, more facile reuse or recycling



Sustainable Chemistry Hierarchy

2. Reuse or Recycle Chemicals

3. Treat Chemicals to Render Them Less Hazardous

4. Dispose of Chemicals Properly

*chemicals that are less hazardous to human health and the environment are:

- Less toxic to organisms and ecosystems
- Not persistent or bioaccumulative in organisms or the environment
- Inherently safer with respect to handling and use



Green Chemical Management - Introduction

- What is Green Chemical Management? (CSLM)
 - Green Chemical Management consists of an innovative and efficient chemical management system that encourages the use of the twelve EPA Green Chemistry Principles to promote environmentally friendly and economically sustainable business processes that results in reduced waste, safer outputs, and reduced or eliminated pollution and environmental damage.



Green Chemical Management and the Twelve Principles of Green Chemistry

<http://www.epa.gov/gcc/pubs/principles.html>

1. Prevent waste: Design chemical syntheses to prevent waste, leaving no waste to treat or clean up.

- Experimental design resources (MSDS library)
- MSDS review for low hazard/"Green" chemicals
- Experimental/process design review
- Procurement controls
- Use smaller quantities
- Use existing resources (e.g. Chemical Inventory System, Chemical Exchange)
- Use refillable containers
- Storage location limit on hazardous materials
- Manufacturer "take-back" exchanges
- Pharmacy storage and dispensing processes
- Contract management

2. Design safer chemicals and products: Design chemical products to be fully effective, yet have little or no toxicity.

- High performance, sustainable buildings
- Provide a "safer chemicals" facility consulting and education service
- Experimental design resources (MSDS library) and review
- MIT Green Chemical Alternatives Purchasing Wizard

3. Design less hazardous chemical syntheses: Design syntheses to use and generate substances with little or no toxicity to humans and the environment.

- Experimental design resources (MSDS library) and review

4. Use renewable feedstocks: Use raw materials and feedstocks that are renewable rather than depleting. Renewable feedstocks are often made from agricultural products or are the wastes of other processes; depleting feedstocks are made from fossil fuels (petroleum, natural gas, or coal) or are mined.

- Experimental design resources (MSDS library) and review
- Procurement controls
- Bio-based products



Green Chemical Management and the Twelve Principles of Green Chemistry

5. Use catalysts, not stoichiometric reagents (chemical reaction leveraging): Minimize waste by using catalytic reactions. Catalysts are used in small amounts and can carry out a single reaction many times. They are preferable to stoichiometric reagents, which are used in excess and work only once.

- Experimental design resources (MSDS library) and program review

6. Avoid chemical derivatives: Avoid using blocking or protecting groups or any temporary modifications if possible. Derivatives use additional reagents and generate waste.

- Experimental design resources (MSDS library) and program review

7. Maximize atom economy: Design syntheses so that the final product contains the maximum proportion of the starting materials. There should be few, if any, wasted atoms.

- Experimental design resources (MSDS library) and program review

8. Use safer solvents and reaction conditions: Avoid using solvents, separation agents, or other auxiliary chemicals. If these chemicals are necessary, use innocuous chemicals.

- Experimental design resources (MSDS library) and program review
- Procurement Controls
- Green or bio-based organic-based oils and solvents (low peroxide forming or low VOC solvents)
- Water-based solvents



Green Chemical Management and the Twelve Principles of Green Chemistry

9. Increase energy efficiency: Run chemical reactions at ambient temperature and pressure whenever possible.

- Experimental design resources (MSDS library) and program review
- Energy Management Plan
- Conservation of water

10. Design chemicals and products to degrade after use: Design chemical products to break down to innocuous substances after use so that they do not accumulate in the environment.

- Experimental design resources (MSDS library) and program review

11. Analyze in real time to prevent pollution: Include in-process real-time monitoring and control during syntheses to minimize or eliminate the formation of byproducts.

- Inventory accuracy requirements & expectations
- Recycle, Reduce, & Reuse
- Air monitoring

12. Minimize the potential for accidents: Design chemicals and their forms (solid, liquid, or gas) to minimize the potential for chemical accidents including explosions, fires, and releases to the environment.

- Experimental design resources (MSDS library) and program review
- Housekeeping
- Monitor age of chemicals (peroxide forming chemicals, expiration dates)

Originally published by Paul Anastas and John Warner in Green Chemistry: Theory and Practice (Oxford University Press: New York, 1998).



Green Chemical Management Challenges

- Line Issues
 - Education & Training
 - Procurement guidelines & controls
 - Location based material permit limits
 - Excess material redeployment - Chemical Exchange
 - Housekeeping
- Management System Issues
 - Education & Training
 - Graded risk-based approach
 - Application specification changes
 - Chargeback on new chemical procurement
 - Chargeback for waste disposal
 - Inventory ownership & orphaned inventory
 - Inventory shelf life guidelines
 - Inventory age profile metrics
 - Inventory accuracy requirements & expectations
 - Inventory reduction frequency
 - Material Safety Data Complete Set
 - Position paper on Chemical Management