

Innovation for Green Chemistry: Policy Options and Challenges

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Definitions

- Green chemistry, also known as sustainable chemistry, refers to environmentally friendly chemicals and processes that result in: reduced waste, eliminating costly end-of-the-pipe treatments; safer products; and reduced use of energy and resources—all improving the competitiveness of chemical manufacturers and their customers. (EPA Website, 2008)
- Green chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances (Anastas et al. 2000)
- Surprising uniformity—but what does this mean?

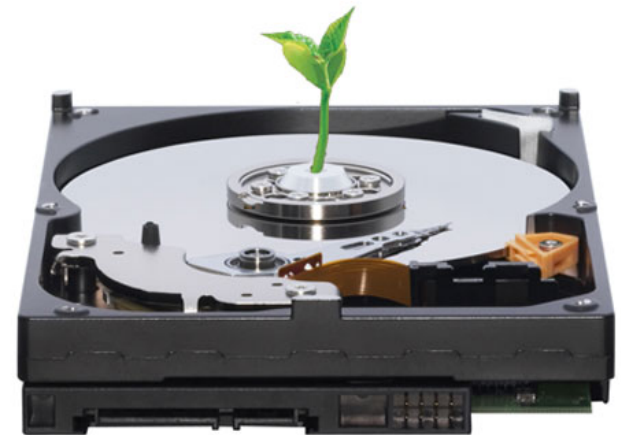
Twelve Principles of Green Chemistry

- Prevent waste
 - Design safer chemicals and products
 - Design less hazardous chemical syntheses
 - Use renewable feedstocks
 - Use catalysts, not stoichiometric reagents
 - Avoid chemical derivatives (increase waste)
 - Maximize the atom economy
 - Use safer solvents
 - Increase energy efficiency
 - Design chemicals and products to degrade after use
 - Analyze in real-time to prevent pollution
 - Minimize the potential for accidents
- (EPA 2006, based on Anastas and Warner 1998)



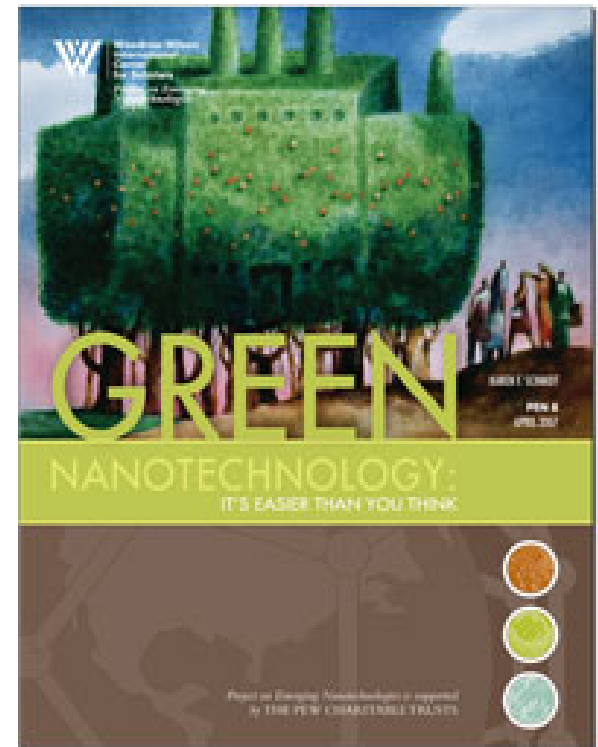
9 Principles of Green Engineering

- Engineer processes and products holistically, use systems analysis and integrate environmental impact assessment tools
- Conserve and improve natural ecosystems while protecting human health and well-being
- Use life cycle thinking in all engineering activities
- Ensure that all material and energy inputs and outputs are as inherently safe and benign as possible
- Minimize depletion of natural resources
- Strive to prevent waste
- Develop and apply engineering solutions, **while being cognizant of local geography, aspirations and cultures**
- Create engineering solutions beyond current of dominant technologies; improve, innovate and invent technologies to achieve sustainability
- **Actively engage communities and stakeholders in development of engineering solutions.**
- (EPA 2006)



Green nanotechnology

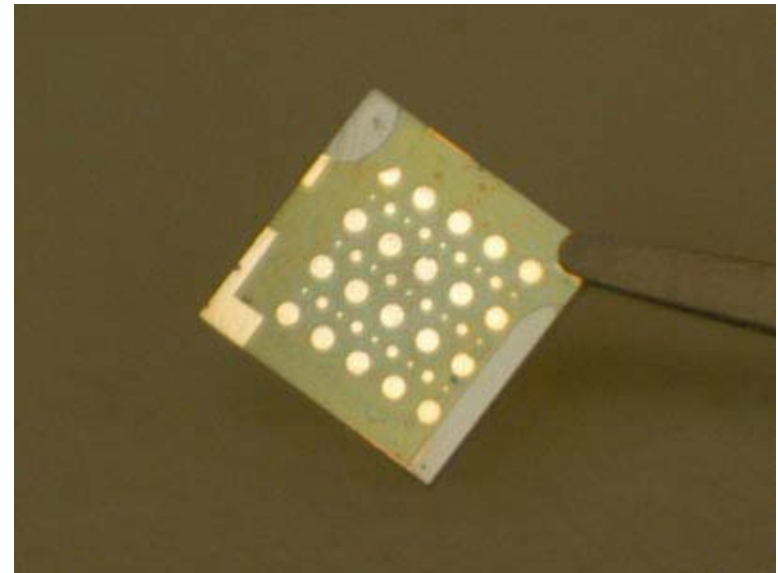
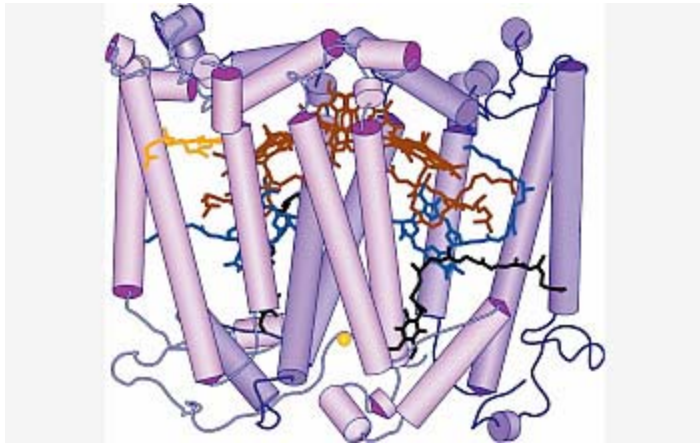
- Nanotechnology—manipulation of matter at the nanometer scale (1-100 nm) that takes on novel properties.
- A class of novel properties includes the ability of smaller amounts of material to accomplish same objective
 - (more surface area to mass ratio, higher reactivity)
- Designing nanoproducts for the environment and with the environment in mind.



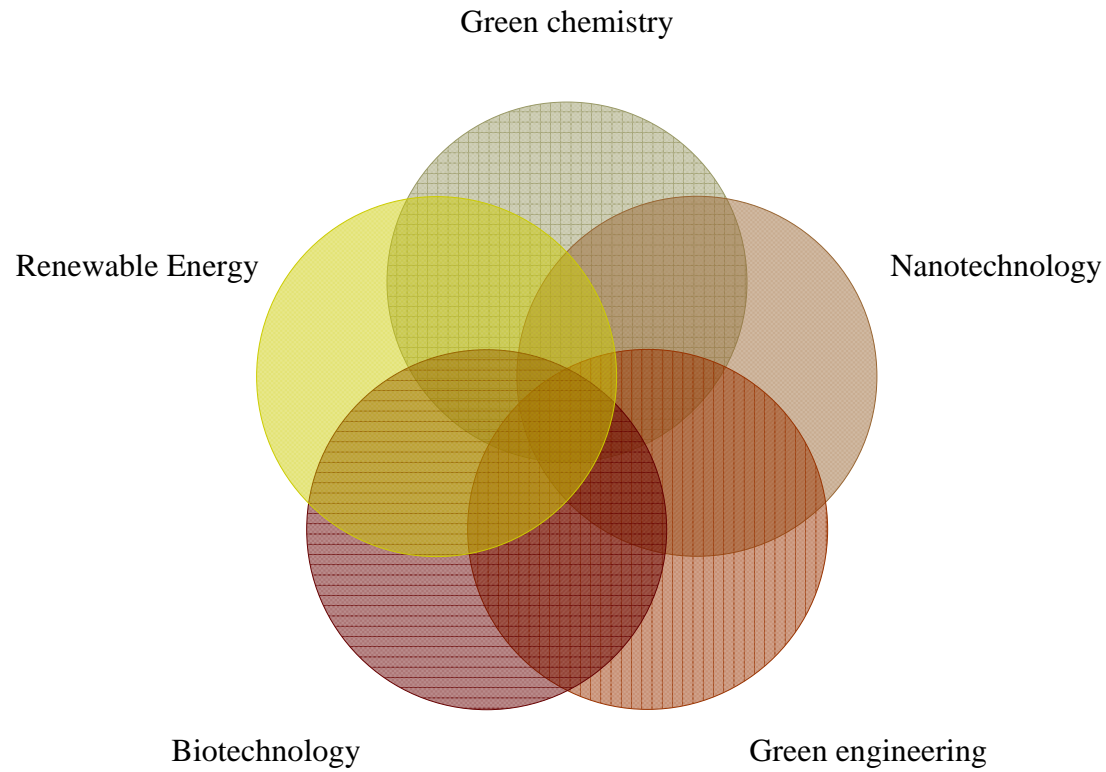
(Project on Emerging Nanotechnologies, 2007)

Example: Organic NanoSolar Cells

- Photosynthesis “machinery” from biological systems
- Nanoscale science and engineering to build solar cells with nanoscale components
- (Woodbury et al. ASU) (Zhang et al, MIT, 2004)



Convergence



Policy Issues

- “Certify”
 - Identify what is and what is not “green” (e.g. safe AND sustainable)
 - Ensure products made using green methods (e.g. organic solar cell)
 - Rigorous and standardized life cycle analysis methods (boundary issues--what to include?)

- “Boost”
 - Green awards (like EPA’s)
 - Funding analysis and gaps
 - Federal procurement of green products
 - Incentives for industry-university collaborations
 - Legislation (e.g. in reauthorization of 21st Century Nano R&D Act)



Speakers

- Mark Richtie, MN Secretary of State
- David Foster, National Director of the Blue-Green Alliance
- Garth Hickle, MN Pollution Control Agency
- Jim Boerboom, MN Dept. of Agriculture