Chemical Policy Reform and Green Chemistry

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Problems with Current Chemicals Policies

1. Lack of information on chemicals in commerce
2. Unequal treatment of new/existing chemicals
3. Slow, inefficient chemical by chemical risk assessment/management processes
4. Increasing public concern about chemicals
5. Lack of public confidence in government and industry
6. Lack of incentives to stimulate development of safer substitutes
7. Lack of integrated, modernized, and forward-looking approach to chemicals management.

New Market Drivers

- Increasing public interest in chemicals in products (food, cosmetics, electronics, etc.)
- Large retailers/manufacturers placing demands on suppliers
  - Manufacturers such as H&M, Nike, Interface, Herman Miller
  - Retailers and service providers such as WalMart, Kaiser Permanente

- Government and institutional purchasing growing more environmentally conscious.

Policy History on Chemicals

- Stage 1 Disposal and Dilution
- Stage 2 Waste Treatment and Pollution Control
- Stage 3 Toxics Policy
  - chemical by chemical regulation (US TSCA, EU Dangerous Chemicals)
- Stage 4 Chemicals Policy
  - chemical systems

U.S. State Policies on Chemicals

Toxics Policies

1986	California "Proposition 65"
1990-94	State Pollution Prevention Laws
1998-2004	Mercury in Products Laws (10 states)
2002	Washington's "PBT Elimination Strategy"
2003-2007	Brominated Flame Retardant (PDBE) Laws (California, Maine, Hawaii, Michigan)

Chemicals Policies

2007 ->	State Chemicals Policies (Massachusetts, California?)

New International Chemicals Policies

- Denmark: Danish Chemicals Policy
- Sweden: A Sustainable Chemicals Policy
- Netherlands: Strategy on the Management of Substances
- Germany: Product Chain Chemicals Policy
- European Union: REACH
- International:
  - Stockholm Convention (POPs)
  - Rotterdam Convention (PIC)
  - Strategic Approach to International Chemicals Management (SAICM)

Six Core Elements of Chemicals Policy

1. Comprehensive: covers all chemicals
2. Tiered: Classifies chemicals into categories for specialized treatment
3. Hazard - rather than exposure - based
4. Transparent and information generating
5. Promoting the substitution of higher hazard chemicals with safer alternatives
6. Innovation driving: promoting green chemistry and safer technologies

Green Chemistry Initiatives

- **U.S. and U.K. Green Chemistry Awards**
- **ACS Green Chemistry Institute/U.K. Green Chemistry Network/Japanese Chemical Innovation Institute**
- **U.S. State Green Chemistry Programs**
  - Michigan, California, Maine
- **University Green Chemistry Curricula**
  - 16 U.S. colleges offer green chemistry classes
  - U. of Massachusetts Green Chemistry Ph.D.
- **Two Green Chemistry Journals**
- **Green Chemistry Programs in 23 Countries**

What is Green Chemistry?

Alternative Visions

- Chemistry---Benign synthesis and processing
  - a sub-field or meta-discipline
  - an interdisciplinary perspective
- Environmental---Processing without toxic (hazardous) chemicals
  - “green” or “greener” chemistry

History of Green Chemistry

1990	Council for Chemical Research— begins ”environmentally-benign chemical synthesis and processing program”
1992	U.S. NSF Environmentally Benign Chemistry Program
1996	ACS Green Chemistry and Engineering Conference
	Green Chemistry Institute established
	First Gordon Conference on Green Chemistry
	IUPAC-- Int. Conference on Green Chemistry-Venice
	U.S. Green Chemistry Presidential Awards established
1998	*Green Chemistry: Theory and Practice* published
1999	RSC begins publishing journal, *Green Chemistry*

Green Chemistry Definition

"Green chemistry is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products."

-Anastas and Warner, *Green Chemistry: Theory and Practice*, 1998

Twelve Principles of Green Chemistry

- Prevent waste (unconverted feedstock, spent reaction fluids)
- Maximize the incorporation of all process materials into the finished product
- Use and generate substances that possess little or no toxicity
- Preserve efficacy of function, while reducing toxicity
- Minimize auxiliary substances (e.g. solvents, separating agents)
- Minimize energy inputs (process at ambient temperatures and pressures)
- Prefer renewable materials over non-renewable materials
- Avoid unnecessary derivations (e.g. blocking groups, protection/de-protection steps)
- Prefer catalytic reagents over stoichiometric reagents
- Design products for natural, post-use decomposition
- Use in-process monitoring and control to prevent formation of hazardous substances
- Select substances and processes so as to minimize the potential for accidents

-- Paul Anastas and John Warner, 1998

What is Not Green Chemistry?

- Conventional environmental chemistry
- Green chemical products without green chemical production
- Process chemical substitutions if the chemical product is not green

New Synthetic Pathway in Manufacturing Sertraline

- Sertraline--active ingredient in Zoloft
- Pfizer's conventional 3 step process reduced to a single step
- Imine formation of monomethylamine with tetralone reduced with mendelic acid
- Increased purity and yield and cut monomethylamine by 60% and tetralone by 45%

Alternative Solvents in Manufacture of PLA

- Cargill makes Nature Works with poly lactic acid
- New process generates lactic acid, lactide and PLA
- Water is used in fermentation while molten lactide is used as the reaction media in the monomer and polymer production
- Reduces energy and increases yield
- PLA product is readily hydrolyzed into lactic acid for recycling

Policies Initiatives for Green Chemistry

- **European Platform for Sustainable Chemistry (SusChem)—***Vision for 2025 and Beyond*
- **UK Chemistry Leadership Council—***Vision for Sustainable Production and Use of chemicals*
- **Crystal Faraday—***Green Chemical Technology, 2004 Roadmap*
- **State of Michigan**--*Green Chemistry Executive Directive*
- **California Policy Research Center—***Green Chemistry in California*

Chemical Policy as a Driver for Green Chemistry

- Green chemistry is an “approach” or a “perspective” on chemistry
- Green chemistry can be taught and practiced
- Green chemistry can not be legislated or mandated

- However, state government policy can promote green chemistry in many ways

Executive Administrative Programs

- **Establish administrative coordination and promotion initiative**
  - High level agency, industry, public interest council
  - Create state strategy "Roadmap"
- **Environmentally-preferred purchasing**
  - Promote procurement of green chemistry derived products
- **Labeling and product declaration**
  - Establish product labels for green chemistry and agriculture derived products

Research and Development Support

- **Government Funding Programs**
  - Seed funding for green chemistry research
  - Industry partnership research initiatives
- **Cooperative State Research Programs**
  - Cooperative agricultural research programs, biobased materials research
- **University-based Center Support**
  - ex.: Un of Mass Lowell, Carnegie-Mellon, Un of Oregon

Technical Assistance

- **Sector-specific green chemistry workshops and symposia**
  - Pharmacuetical green chemistry conference, green chemistry and pollution prevention workshops, etc.
- **On-site industrial technical services**
  - Integrate green chemistry research into state pollution prevention assistance services
- **Awards and demonstration programs**
  - Competitive programs for public recognition
- **Guidance documents and brochures**

Education and Training

- Promote college courses in green chemistry
  - Support curriculum development
  - Encourage toxicology and environmental courses in mainstream chemistry programs
- Provide scholarships and graduate student support
  - Offer competitive student financial aide
- Encourage K-12 programs
  - Provide guest projects and student awards
  - Summer teacher training programs

Regulation on Hazardous Chemicals

- **Phase outs of targeted hazardous chemicals**

  PBTs, POPs, carcinogens

  ex.: EU RoHS Directive in Electronics

- **Increased regulatory restrictions on hazardous processes**

  Dioxin restrictions in effluents, perfluorinated compound and brominated flame retardant restrictions

- **Safer substitution plan requirements**

  Toxics Use Reduction plan requirements,

  ex.: Massachusetts Safer Alternatives Bill

State Chemical Policy Reform can Promote Green Chemistry

- States must take the lead in promoting new comprehensive chemicals policies that encourage the substitution of hazardous chemicals and the development of sustainable businesses.

- These new policies should be strategically linked to research and education programs that develop and promote sustainable materials and green chemistries.

Thank You

For more information:

http://turi.org
http://sustainableproduction.org
http://chemicalspolicy.org