Being Green – Teaching Green – Doing Green

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IGSS'09 The Institute for Green and Sustainable Science

MARIAN UNIVERSITY Indianapolis A Catholic and Franciscan University

What is Green Chemistry?

Green chemistry is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances.

Green chemistry applies across the life cycle, including the design, manufacture, and use of a chemical product.

The 12 Principles of Green Chemistry

1. **Prevent, rather than treat waste**
2. **Maximize use of materials (atom economy)**
3. **Less Hazardous Chemical Synthesis**
4. **Design Safer Chemicals**
5. **Safer Solvents**
6. **Energy Efficiency**
7. **Renewable Feedstocks**
8. **Reduce Derivatives (less steps)**
9. **Catalysis**
10. **Design for Degradation**
11. **Real-Time Analysis for Pollution Prevention**
12. **Accident Prevention**

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

Why Green?

Finite natural resources

Limited space for trash

Polluting our air, water and ground

Safety in the home and workplace

For our future!

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Green What?

Green Energy
- Solar
- Wind
- Geothermal
- Hydroelectric
- Renewable fuels
  - from algae
  - from solid waste
  - from non-food crops

Green Farming
- Better pesticides / herbicides
  - do not leach
  - do not bioaccumulate
  - do not persist in the environment
  - demonstrate selective toxicity

Green Solvents
- Safer solvents
- Reduced solvent use

Green Cleaning Products

Green Life Cycle Analysis

Green Buildings

Careers in Green Chemistry

Renewable Energy	Genetics
Planning & Land Use	Geology
Agriculture	Health and medicine
Biomedical	Life science
Biotechnology	Mathematics
Brain and behavior	Pharmaceuticals
Cell and molecular biology	Physics
Chemistry	Plant science
Developmental biology	Policy
Ecology and evolution	Space and astronomy
Environmental science	Technology

In the Classroom

The first step is to educate the children by making them aware of the scope of green chemistry and its applications in and out of the classroom.

Next is to get to the hands-on lab work that they can relate to and see the relevance of green chemistry,

Who is Going Green

DUPONT

PRATT & WHITNEY DEPENDABLE ENGINES

ALCOA

ExxonMobil

GE

Dow AgroSciences

HERITAGE

Frito Lay

coskata

Stellarwind Bio Energy algaeoil

green Chemistry

Lilly

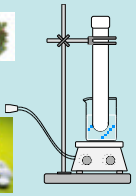
New Labs Developed

The dose makes the poison: Measuring ecotoxicity using a lettuce seed assay
Introduces the student to ecotoxicity of different alternative starting materials commonly used for the preparation of biodiesel.

New Labs to add to Tipton High School curriculum

Natural Synthesis of Aspirin, Part I: Synthesis of Salicylic Acid from Wintergreen Oil
Winter green oil replaces benzene as the feedstock in this reaction and represents a renewable source for salicylic acid.

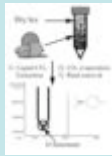
Natural Synthesis of Aspirin, Part II: Acylation of Salicylic Acid
Continuing in our synthesis of salicylic acid, our objective here is to optimize the acylation and evaluate the procedure for greenness.



A Solventless Atom Efficient Reaction: The Crossed-Aldol Condensation
The reason this reaction is solvent free is because melting point depression occurs when the 2 solids are mixed resulting in the reaction occurring in the liquid phase.

The Effect of pH on Sodium Benzoate
Done as an inquiry based lab, using whatever tools and equipment one has available, the student determines whether a chemical reaction occurs, the identity of the new compound, and if it is safe for human consumption.

Introduction to Liquid CO_2
By increasing the pressure on a quantity of dry ice, the student liquefies it and utilizes it as a green alternative solvent.



Liquid CO_2 Extraction of Limonene from Orange Rind
Using the same process from the intro lab on CO_2, the students extracts the oil from the orange rind using liquid CO_2. This lab illustrates the usefulness of this bench top extraction while highlighting the green lessons of solvent waste and safer solvents.

Synthesis of Creatine
A simple procedure representing the greenest route to creatine.

Biodiesel Synthesis
The biodiesel fuel produced in this lab from vegetable oil is biodegradable and non-toxic. The glycerol byproduct can be used as an additive to make glycerin soap.

Future Labs

Greening the Oxidation of Borneol to Camphor
To use an alternate reaction that utilizes a safer oxidant, requires minimal solvent and requires a minimal energy use, producing less waste than a standard oxidation procedure.