



The EPA Green Chemistry Program



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US EPA

Cal-EPA Green Chemistry Symposium
October 24, 2007





Research



Education



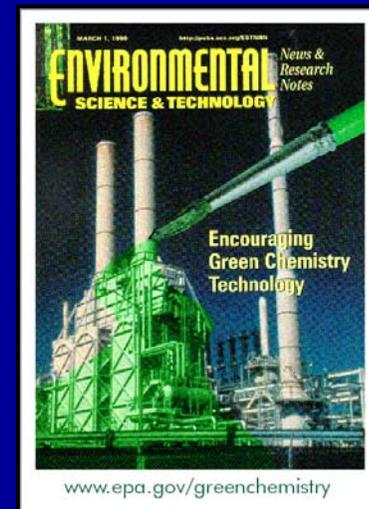
Awards



**International
Collaboration**

Green Chemistry Mission:

“To promote the design of innovative chemical technologies that reduce or eliminate the use or generation of hazardous substances from the manufacture and use of chemical products.”



Outreach



Pollution Prevention Act: Risk Management Hierarchy

**Green
Chemistry**



Source
Reduction

Recycling

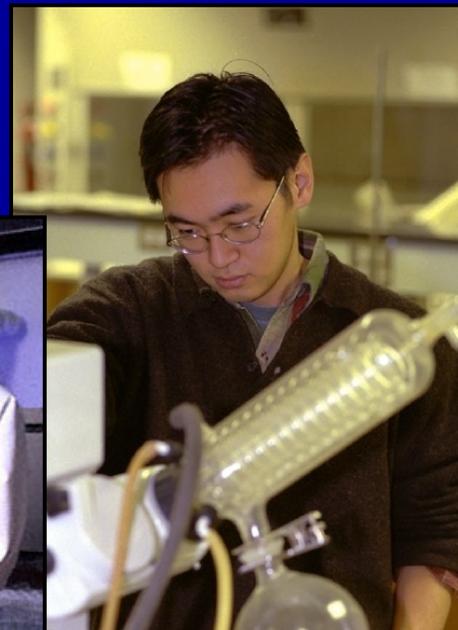
Treatment

Disposal





EPA's Green Chemistry Program Facilitates Change



Green chemistry R&D provides industry with scientifically sound and cost-effective alternatives.



EPA's Green Chemistry Program Demonstrates Benefits



Presidential Green Chemistry Challenge Awards demonstrate scientific, economic, environmental benefits of green chemistry technologies.





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

Maximize atom economy

Use safer solvents and reaction conditions

Increase energy efficiency

Design chemicals and products to degrade after use

Analyze in real time to prevent pollution

Minimize the potential for accidents





Principle 2

Design Safer Chemicals and Products

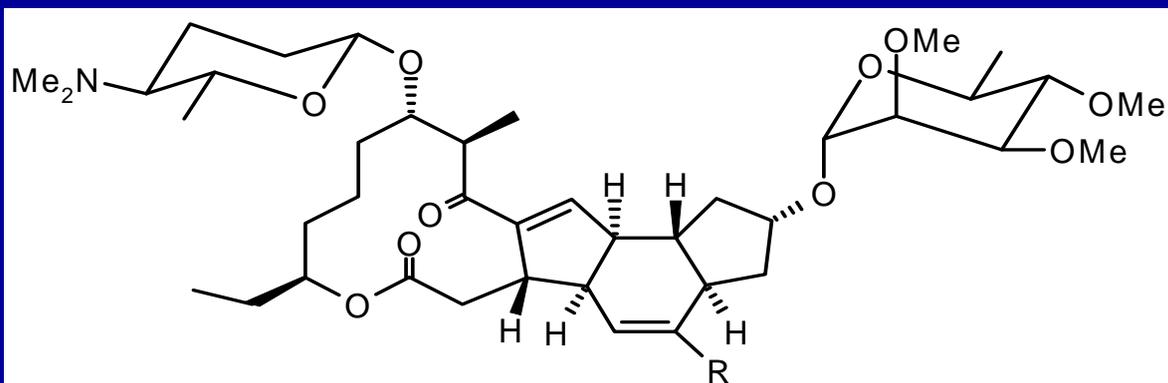




Principle 2: Design safer chemicals and products

◆ Spinosad: a natural product for insect control

- produced by *Saccharopolyspora spinosa*
- organophosphate replacement
- demonstrates high selectivity, low toxicity



Spinosyn A: R = H
Spinosyn D: R = CH₃

Dow AgroSciences





Principle 2: Design safer chemicals and products

- ◆ Agraquest - California small business (partners w/UC Davis) developed Serenade® Biofungicide used (among other things) as an antifungal on grapes.
- ◆ Serenade® represents the first non-toxic broad spectrum microbial fungicide compatible with both organic and conventional farming.





Principles 5 and 7

**Use catalysts,
not stoichiometric reagents
and Maximize atom economy**

$$\% \text{ Atom Economy} = \frac{\text{FW atoms utilized}}{\text{FW reactants used in reaction}} \times 100$$

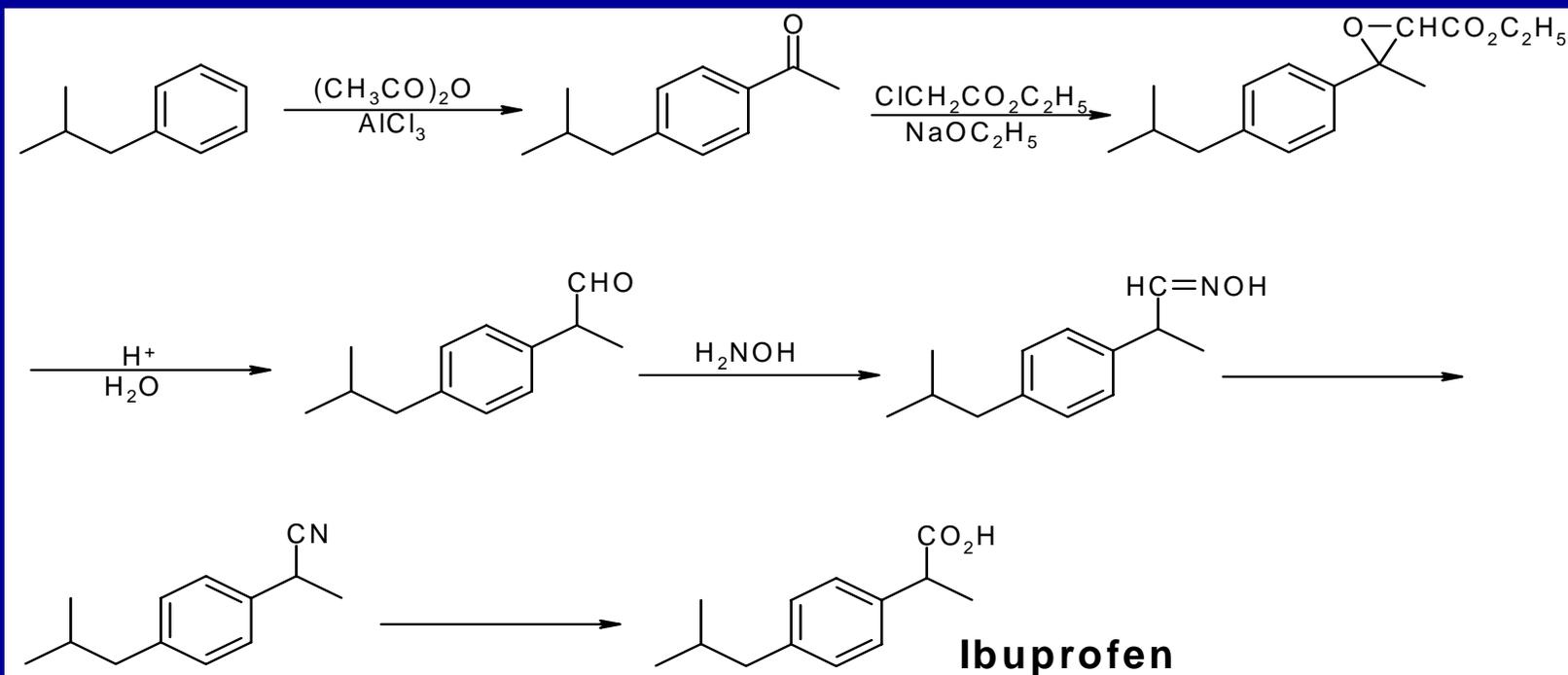




Principles 5 and 7: Use catalysts, not stoichiometric reagents; Maximize atom economy



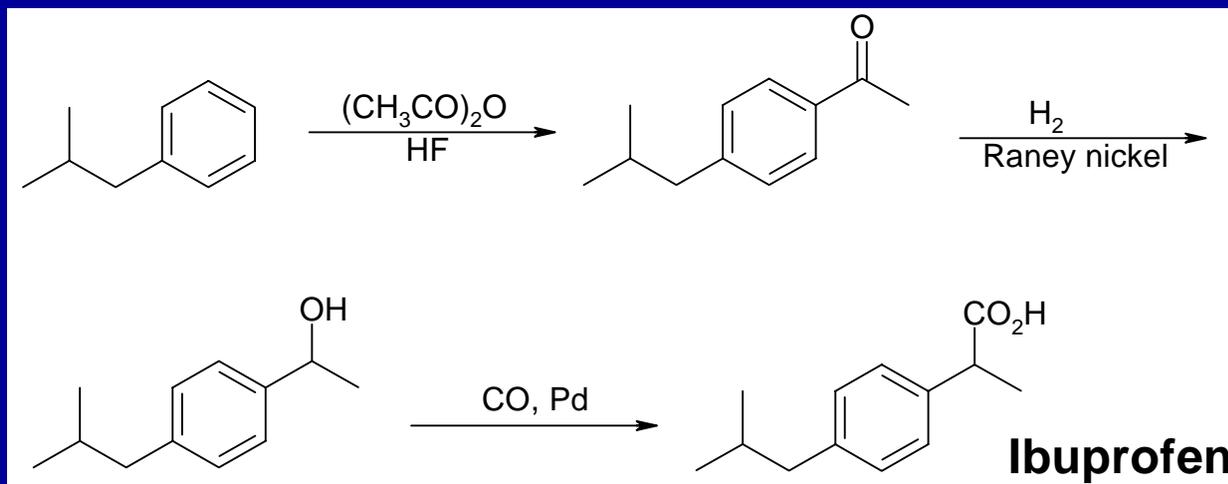
- ◆ Traditional synthesis of ibuprofen
 - 6 stoichiometric steps
 - <40% atom utilization





Principles 5 and 7: Use Catalysts, not stoichiometric reagents and Maximize atom economy

- ◆ Catalytic synthesis of ibuprofen
 - 3 catalytic steps
 - 77% atom utilization (99% with recovered acetic acid)

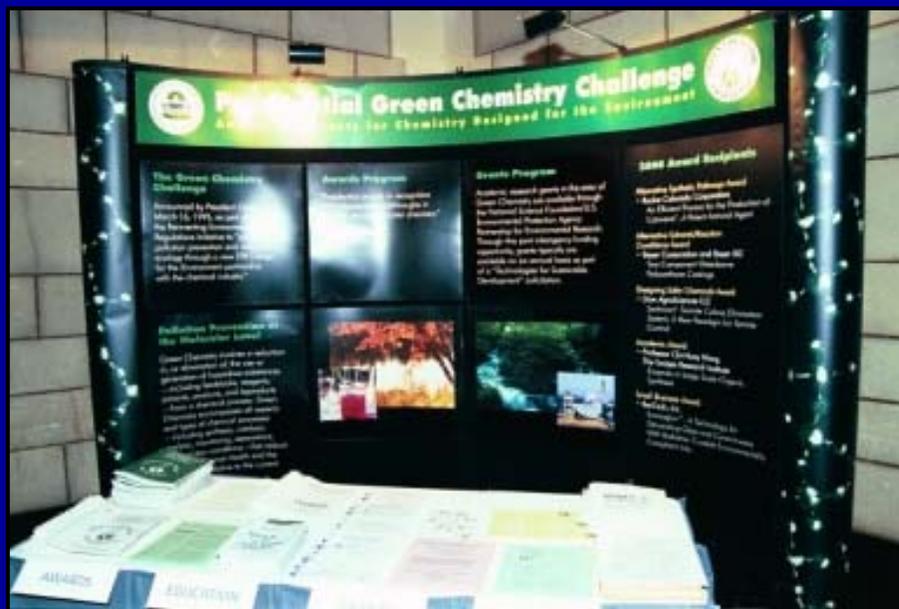


BHC





EPA's Green Chemistry Program Communicates Benefits



Green chemistry outreach activities communicate benefits to all sectors of industry, at all levels of education, and to the scientific community in general.





EPA's Green Chemistry Program Educates

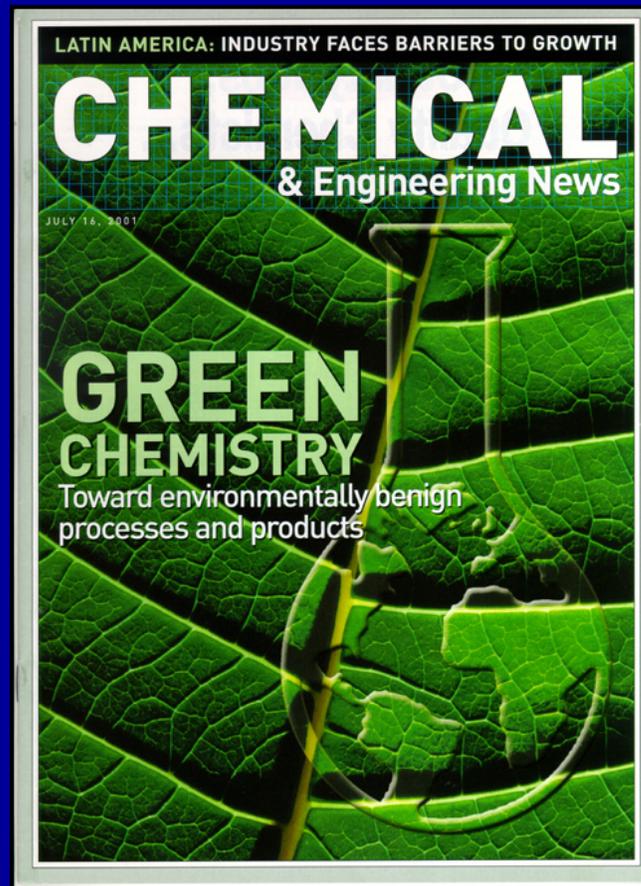


Green chemistry education efforts prepare students and professionals for today's responsibilities and tomorrow's challenges.



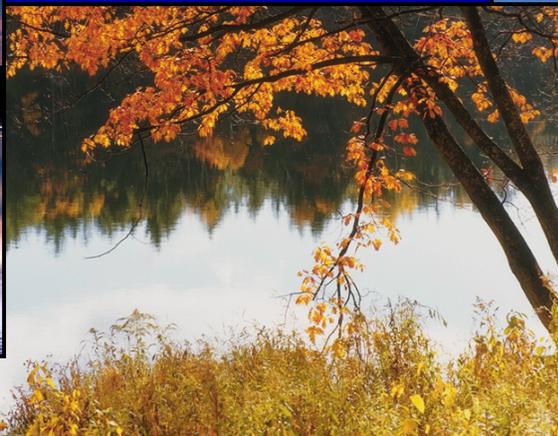
EPA's Green Chemistry Program Leads

Green chemistry international collaborations lead the way to global sustainability.





EPA's Green Chemistry Program Produces Measurable Results



Award winning technologies have eliminated the use and generation of 38 million pounds and 2.6 million gallons of hazardous chemicals and saved 275 million gallons of water.



<http://www.epa.gov/greenchemistry>



Green
Chemistry

*Click on any
of the test
tubes to learn
more about
EPA's Green
Chemistry
Program*

Contact Info



Office of Pollution
Prevention and Toxics

EPA's Green Chemistry Program

Green Chemistry Mission

"To promote innovative chemical technologies that reduce or eliminate the use or generation of hazardous substances in the design, manufacture, and use of chemical products."

*What is Green
Chemistry?*

*International
Activities*

*EPA Projects
& Programs*

*Tools &
Literature*

*Research
Grants*

*Calendar &
Conferences*



Other Green Chemistry References

- ◆ **EPA's Green Chemistry R&D :**
<http://www.epa.gov/ORD/NRMRL/std/research.htm>
- ◆ **Link to ACS education:**
<http://www.chemistry.org/education/greenchem>
- ◆ **Environmental Chemistry textbook Baird and Cann** <http://www.amazon.com/Environmental-Chemistry-Colin-Baird/dp/0716748770>
- ◆ **Green Engineering Textbook Allan and Shonnard** http://www.amazon.com/Green-Engineering-Environmentally-Conscious-Processes/dp/0130619086/sr=1-1/qid=1161287062/ref=sr_1_1/104-2116596-3293540?ie=UTF8&s=books

