

Green Chemistry (Chemistry 393-0), Spring 2003

Literature Summaries

Literature Assignment #1:

Begins March 31, 2003

What are the general areas of investigation in green chemistry?

- 1.1. "Chapter 1: Frontiers in Green Chemistry," Green Chemistry, Frontiers in Benign Chemical Synthesis and Process," Anastas, P.T.; Williamson, T.C. Editors, Oxford University Press, New York, 1998.

What is green chemistry?

- 1.2a. Breslow, R.; "The Greening of Chemistry," *Chem. Eng. News*, **1996**, 72 (August 26), 72.
 1.2b. Morrissey, S., "Green Chemistry, ACS institute aims to get the word out about alternative environmentally safe processes," *Chem. Eng. News*, **2002**, (February 25), 46.
 1.2c. Wilkinson, S.L. "'Green' is Practical, Even Profitable. No Longer a Luxury, Green Chemistry Becomes a Central Strategy for Sustainable Firms," *Chem. Eng. News*, **1997**, 75 (Aug 4), 35 – 43.

What is green chemistry?

- 1.3a. Lancaster, M. "Green Chemistry," *Education in Chemistry*, **2000**, 40 – 43.
 1.3b. Clark, J. H. "Green Chemistry: Challenges and Opportunities," *Green Chemistry*, **1999**, 1, 1 – 8.

What is atom economy?

- 1.4 Cann, M.C.; Connelly, M.E. "Chapter 1: The Concept of Atom Economy," *Real World Cases in Green Chemistry*, American Chemical Society: Washington DC. 2000.
 1.4a. Trost, B.M.; "The Atom Economy - A Search for Synthetic Efficiency," *Science*, **1991**, 254, 1471 – 1477. (Supplemental reading only)
 1.4b Trost, B.M.; "On Inventing Reactions for Atom Economy," *Acc. Chem. Res.* **2002**, 35, 695 – 705. (Supplemental reading only)

How can atom efficiency be applied?

- 1.5 Cann, M.C.; Connelly, M.E. "Chapter 3: BHC Company Synthesis of Ibuprofen," *Real World Cases in Green Chemistry*, American Chemical Society: Washington DC. 2000. What is click chemistry?

Literature Assignment #2:

Begins April 7, 2003

In what way(s) is click chemistry related to green chemistry?

- 2.1a Borman, S.; "In-Situ Click Chemistry," *Chemical & Engineering News*, February 11, 2002, 29 – 34.
 2.1b Kolb, H.C.; Finn, M.G.; Sharpless, K.B. "Click Chemistry: Diverse Chemical Function from a Few Good Reactions," *Angew. Chem. Int. Ed.*, **2001**, 40, 2004 – 2021.

Explain sustainable development and the triple bottom line.

- 2.2 <http://www.sustainability.com/philosophy/triple-bottom/tbl-intro.asp>
<http://www.sustainability.com/philosophy/what-is-sustainable-development.asp>

How does polymer regeneration differ from standard recycling methods?

- 2.3 Cann, M.C.; Connelly, M.E. "Chapter 4: DuPont Petretec Polyester Regeneration Technology," *Real World Cases in Green Chemistry*, American Chemical Society: Washington DC. 2000.

Are the properties of recycled plastics as good as the properties of virgin plastics?

- 2.4 Hooper, R.; Potter, A.K.N.; Singh, M.M. "Diversion from landfill: mechanical recycling of plastics from materials recovery facilities and from shredder residue" *Green Chemistry*, **2001**, 3, 57 – 60.

Discuss the life cycle of plastics and why reducing is better than recycling and reusing.

- 2.5 http://www.plasticsresource.com/disposal/life_cycle_feature/index.html

Literature Assignment #3:**Begins April 14, 2003**Why is Life Cycle Assessment important?3.1a Allen, B., "MTBE-friend or foe?" *Green Chemistry*, **1999**, *1*, G142 – G143.3.1b Lam, K.K.; Ottewill, G.; Plunkett, B.; Walsh, F. "Lead at the Roadside," *Green Chemistry*, **1999**, *1*, G105 – G109.

3.1c U.C Report: MTBE Fact Sheet, November 12, 1998.

What is green analytical chemistry entail? How can analytical techniques be used to follow the course of a reaction? Why was IR the best method to study this reaction?3.2 Rocha, F. R. P.; Nóbrega, J.A.; Filho, O. F. "Flow Analysis Strategies to Greener Analytical Chemistry. An Overview" *Green Chemistry*, **2001**, *3*, 216 – 200.3.2 Cshony, S.; Mehdi, H.; Horváth, I.T. "In situ Infrared Spectroscopic Studies of the Friedel–Crafts Acetylation of Benzene in Ionic Liquids Using AlCl₃ and FeCl₃," *Green Chemistry*, **2001**, *3*, 307 – 309.What is the Toxics Release Inventory?3.3 <http://www.epa.gov/tri/>What are green metrics? Are mass and energy good enough indicators of environmental impact?3.4 Curzons, A.D.; Constable, D. J. C.; Mortimer, D. N. Cunningham V. L.; "So you think your process is green, how do you know? - Using principles of sustainability to determine what is green - a corporate perspective," *Green Chemistry*, **2001**, *3*, 1 – 6.What are green metrics? What are the advantages/drawbacks of their template tool?3.5 Constable, D. J. C.; Curzons, A.D.; Freitas dos Santos, L.M.; Geen, G.R.; Hannah, R.E.; Hayler, J.D.; Kitteringham, J.; McGuire, M.A.; Richardson, J.E.; Smith, P.; Webb, R.L.; Yu, M. Green Chemistry Measures for Process Research and Development," *Green Chemistry*, **2001**, *3*, 7 – 9.**Literature Assignment #4:****Begins April 21, 2003**Why are solid, largely unmodified alumina, silicas, and zeolites able to be used as catalysts?4.1a van Vliet, M.C.A.; Mandelli, D.; Arends, I.W.C.E.; Schuchardt, U.; Sheldon, R.A. "Alumina: A Cheap, Active, and Selective Catalyst for Epoxidations with Aqueous Hydrogen Peroxide," *Green Chemistry*, **2001**, *3*, 243 – 246.4.1b Smith, K.; He, P.; Taylor, A. "Selective *para*-Bromination of Phenyl Acetate," *Green Chemistry*, **1999**, *1*, 35 – 38.4.1c Clark, J.H.; Macquarrie, D.J. "Catalysis of Liquid Phase Organic Reactions Using Chemically Modified Mesoporous Inorganic Solids," *Chem. Commun.*, **1998**, 853 – 860.Are lanthanide catalysts really environmentally friendly?4.2 Braddock, C.; "Novel Recyclable Catalysts for Atom Economic Aromatic Nitration," *Green Chemistry*, **2001**, *3*, G26 – G32.What are solid acids and solid bases and how can they be used for catalysis?4.3a Choudary, B.M.; Kantam, M.L.; Neeraja, V.; Rao, K.K.; Figueras, F.; Delmotte, L. "Layered Double Hydroxide Fluoride: A Novel Solid Base Catalyst for C-C Bond Formation," *Green Chemistry*, **2001**, *3*, 257 – 260.4.3b Brown, A.S.C.; Hargreaves, J.S.J. "Sulfated Metal Oxide Catalysts," *Green Chemistry*, **1999**, *1*, 17 – 20.4.3c Yadav, G.D.; Pujari, A.A. "Friedel-Crafts Acylation Using Sulfated Zirconia as a Catalyst," *Green Chemistry*, **1999**, *1*, 69 – 74.Why is catalysis a foundational pillar of green chemistry?4.4 Anastas, P.T.; Kirchoff, M.M.; Williamson, T.C. "Catalysis as a Foundational Pillar of Green Chemistry," *Applied Catalysis A: General*, **2001**, *221*, 3 – 13.What are the advantages of using a totally chlorine free bleaching process? If hydrogen peroxide bleaching has been known for years why did the TAML process warrant an award?

4.5 Cann, M.C.; Connelly, M.E. "Chapter 9: TAML Oxidant Activators: General Activation of Hydrogen Peroxide for Green Oxidation Processes," *Real World Cases in Green Chemistry*, American Chemical Society: Washington DC. 2000.

Literature Assignment #5:

Begins April 28, 2003

What solvents are green? What needs to be considered before a solvent can be classified as green?

5.1 Nelson, W.M. "Chapter 24: Choosing Solvents that Promote Green Chemistry," **2000**, American Chemical Society.

What are fluoruous solvents? Why are fluoruous solvents green? What research is still needed? What are the advantages and drawbacks of using fluoruous solvents?

5.2 Curran, D.; Lee, Z. "Fluorous Techniques for the Synthesis and Separation of Organic Molecules," *Green Chemistry*, **2001**, 3, G3 – G7.

What are ionic liquids? Why are ionic liquids green? What research is still needed? What are the advantages and drawbacks of using ionic liquids?

5.3 Holbrey, J.D.; Seddon, K.R. "Ionic Liquids," *Clean Products and Processes*, **1999**, 1, 223 – 236.

Explain the difference between the current ionic liquids that have been developed. How can each be used?

5.4 Earle, M.J.; Seddon, K.R. "Ionic Liquids: Green Solvents for the Future," *Pure Appl. Chem.* **2000**, 72(7), 1391 – 1398.

Why is supercritical carbon dioxide a green solvent? What practical considerations does one need to consider if super critical carbon dioxide is used? What is the cost involved?

5.5a Cann, M.C.; Connelly, M.E. "Chapter 2: Design and Applications of Surfactants for Carbon Dioxide," *Real World Cases in Green Chemistry*, American Chemical Society: Washington DC. 2000.

5.5b Kirchoff, M. "A Supercritical Clean Machine," *Chem. Matters*, **2000**, 14 – 15.

Literature Assignment #6:

Begins May 5, 2003

What is biocatalytic synthesis? How are biocatalytic syntheses developed if a new target molecule is desired?

6.1 Frost, J.W.; Lievense, J. "Prospects for Biocatalytic Synthesis of Aromatics in the 21st Century," *New J. Chemistry*, **1994**, 18, 341 – 348.

What are fuel cells? How do they work?

6.2a Jones, D. "Hydrogen Fuel Cells for Future Cars," *Chem. Matters*, **December 2000**, 4 – 6.

6.2b <http://auto.howstuffworks.com/fuel-cell.html>

How can chemicals be produced from renewable resources?

6.3a Bozell, J.J.; Hobers, J.O.; Claffey, D.; Hames, B.R.; Dimmel, D.R. "New Methodology for the Production of Chemicals from Renewable Feedstocks," *Frontiers In Green Chemistry*, Chapter 2, 27 – 43.

6.3b Bartle, I.; Oliver, N. "A 'Growth' Industry: Renewable Raw Materials," *Green Chemistry*, **1999**, 1, G6 – G9.

What is the biofine process? Why is the inexpensive production of levulinic acid important commercially?

6.4a <http://www.earthscope.org/t3/acs01/acs01aa.html>

6.4b Forest Products: Project Fact Sheet : <http://www.oit.doe.gov/forest/factsheets/biofine.pdf>

6.4c Conversion of Biomass Wastes to Levulinic Acid: <http://www.pnl.gov/biobased/docs/mthf.pdf>

6.4d USEPA 1999 Small Business Award: <http://www.epa.gov/greenchemistry/sba99.html>

What is biodiesel?

6.5a Fukuda, H.; Kondo, A.; Noda, H. "Biodiesel Fuel Production by Transesterification of Oils," *Journal of Bioscience and Bioengineering*, **2001**, 92, 405 – 416.

6.5b Haas, M.J.; Scott, K.M.; Alleman, T.L.; McCormick, R.L. "Engine Performance of Biodiesel Fuel Prepared From Soybean Soapstock: A High Quality Renewable Fuel Produced from a Waste Feedstock," *Energy & Fuels*, **2001**, *15*, 1207 – 1212.

Literature Assignment #7:

Begins May 12, 2003

What is microwave-assisted synthesis? What are the advantages over traditional reaction methods?

7.1a Horeis, G.; Pichler, S.; Stadler, A.; Gössler, Kappe, C.O. "Microwave-Assisted Organic Synthesis – Back to the Roots," *Fifth International Electronic Conference on Synthetic Organic Chemistry, September 2001*. <http://www.mdpi.net/ecsoc-5/e0000/e0000.html>

Additional references:

<http://www-ang.kfunigraz.ac.at/~kappeco/microlibrary.htm>

http://www-ang.kfunigraz.ac.at/~kappeco/microlibrary_feature.htm

Varma, R.S. "Solvent-Free Organic Synthesis," *Green Chemistry*, **1999**, *1*, 43 – 55.

How can electrochemical methods be applied to synthesis?

7.2 Hudlicky, T.; Frey, D.A.; Koroniak, L.; Claeboe, C.D.; Brammer, Jr.; L.E. "Toward a 'Reagent-Free' Synthesis," *Green Chemistry*, **1999**, *1*, 57 – 59.

Additional references:

<http://www.buscom.com/chem/C175.html>

What is sonochemistry? How can sonochemistry be applied to synthesis?

7.3 <http://www.scs.uiuc.edu/suslick/britannica.html> and links therein.

Additional references:

<http://www.und.ac.za/und/prg/sonochem/ultragen.html>

http://www.fb-chemie.uni-rostock.de/ess/sonochem_intro.htm and links therein.

How can reactions incorporate photochemical methods as an alternative energy source?

7.4 Schiel, C.; Oelgemöller, M.; Ortner, J.; Mattay, J. "Green Photochemistry: the Soloar-chemical 'Photo-Friedel-Crafts Acylation' of Quinones," *Green Chemistry*, **2001**, *3*, 224 – 228.

What is process intensification?

7.5 http://europa.eu.int/comm/energy_transport/atlas/htmlu/intensification.html

Literature Assignment #8:

Begins May 19, 2003

Industrial Case Study #1

Bashkin, J.; Rains, R.; Stern, M. "Taking Green Chemistry From Laboratory to Chemical Plant," *Green Chemistry*, **1999**, *1*, G41 – G43.

Industrial Case Study #2

Cann, M.C.; Connelly, M.E. "Chapter 6: Designing an Environmentally Safe Marine Antifoulant," *Real World Cases in Green Chemistry*, American Chemical Society: Washington DC. 2000.

Industrial Case Study #3

Cann, M.C.; Connelly, M.E. "Chapter 7: The Invention and Commercialization of a New Chemical Family of Insecticides Exemplified by CONFIRM Selective Caterpillar Control Agent and the Related Selective Insect Control Agents MCH 2 and INTREPID," *Real World Cases in Green Chemistry*, American Chemical Society: Washington DC. 2000.

Industrial Case Study #4

Cann, M.C.; Connelly, M.E. "Chapter 8; The Development and Commercial Implementation of 100% Carbon Dioxide as an Environmentally Friendly Blowing Agent for the Polystyrene Foam Sheet Packaging Market," *Real World Cases in Green Chemistry*, American Chemical Society: Washington DC. 2000.

Industrial Case Study #5

Cann, M.C.; Connelly, M.E. "Chapter 10: Production and Use of Thermal Polyaspartate Polymers," *Real World Cases in Green Chemistry*, American Chemical Society: Washington DC. 2000.