Green general organic and biological (GOB) chemistry
An opportunity for reform

Carol Higginbotham

Department of Science, Central Oregon Community College, Bend OR

Introduction

Green Chemistry is being incorporated into the chemistry course serving pre-nursing, pre-health career and liberal arts students at a community college in Bend, Oregon.

Inclusion of Green Chemistry has principally affected the laboratory portion of the course. Green activities have replaced traditional activities without converting or adding to course outcomes. However the change to greener activities has opened up an opportunity to reconsider some outcomes towards a beneficial reform of the course.

Specific changes include adaptation of Green Chemistry activities already in existence but directed to different audiences, such as those available on the GEMS database and intended for second year Organic students (GEMS, 2008). Packaged Green Chemistry curriculum materials for GOB students are not currently available.

Many of the benefits realized by adopting Green Chemistry for science majors can be expected to extend to this new audience.

Three laboratory activities used at COCC to green our GOB curriculum are described here.

Why green chemistry in GOB?

The GOB course at COCC is populated by students pursuing careers in nursing, dental hygiene, radiation technology, and other health careers, as well as liberal arts students. Most of these jobs require less than a bachelor degree and employ students educated at Community Colleges. Students studying for these degrees often get their only exposure to chemistry in the GOB course. The work environment for those practicing these professions includes extensive exposure to sophisticated technologies, pharmaceutical agents, and materials.

These health care workers are part of the largest and fastest-growing industries in the nation, employing more than 16 million in 2006. Nursing and Dental Hygiene are expected to see employment growth of greater than 25% during the term 2006-2016 (source: US Bureau of Labor and Statistics, 2008). An awareness of green chemistry among this population has the potential to have great impact.

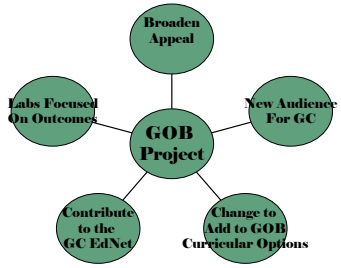
Health Care Without Harm is an international coalition of 473 partners in 50 countries working to reduce harm to people and the environment from health care delivery. The goals of this organization overlap with those of the Green Chemistry community.

Including Green Chemistry in GOB results in a number of benefits to the institution. Student risk and hazardous waste production are both reduced. Perhaps more important, Green Chemistry asks students to consider the health and environmental impacts of their work. Students are asked to think critically about the things they do in the laboratory and wrestle with open-ended questions about what it means to be green.

Development

During the academic year 2007/2008, GOB was altered to incorporate Green Chemistry in the laboratory portion of the course. Specifically, several outdated and hazardous labs were targeted and changed. A number of external pressures created an incentive to change. The college has been increasingly interested in aligning course activities to outcomes at the course, program, and institutional level. Course demographics have changed as a result of reduced chemistry requirements for admission to many nursing programs in Oregon. Green chemistry and sustainability have been the subject of increasing attention by the press. Course reform was overdue. The project also was supported by Green Chemistry educators who recognized the value of bringing Green Chemistry to the GOB audience.

Viewed another way, these pressures provided a chance to focus the laboratory course on outcomes, broaden appeal of the course to a more diverse audience, raise awareness of Green Chemistry, add to the suite of curricular options for GOB, and contribute to the development of the Green Chemistry Education community.



Activity 1: The hydrocarbons

In the traditional activity used to give an introduction to organic chemistry and experience with the hydrocarbons, there was far too much detail to manage. Students were asked in a single lab period to become familiar with alkanes, alkenes, alkynes and aromatic compounds by studying their densities, solubilities and a variety of chemical reactivities. This lab was replaced with an investigative procedure focused on solubilities, which used straight-chain alcohols and alkanes (Creegan, 2003).

The new procedure is more appropriately **focused on course outcomes**. In this instance the student experience did not include direct instruction in Green Chemistry principles. However the new lab is greener from the institutional perspective, since it reduced exposure to hazardous chemicals (including bromine) and generates far less waste.

This addresses the **Green Chemistry principles:**

#1 Prevention
#12 Inherently safer chemistry for accident prevention

Activity 2: Biodiesel

An activity on alcohols presented another excessively detailed procedure, but was mostly problematic because it included hazardous solvents and oxidizers. This lab was replaced with a transesterification reaction to form biodiesel from vegetable Oil (Thompson, 2006).

While synthesizing biodiesel, students learn about alcohols and esters, functional group transformations, and basic ways to monitor reaction progress. This activity **has broad appeal** in part because of recent interest in alternative energy sources.

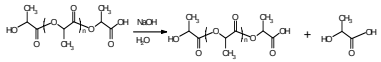
Meanwhile they are also encountering **Green Chemistry Principles:**

#7 Use renewable feedstocks
#10 Design for degradation

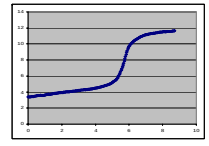
Biodiesel synthesis is included as a new procedure because it is current and appeals to a broad audience.

Activity 3: Polylactic acid depolymerization with lactic acid titration

In this activity students depolymerize lactic acid in base. The activity was introduced to **add a new option to the GOB curriculum** and to get students to think about materials development (Boice, 2007).



The titration of the resulting lactic acid introduces students to solutions, pH, acid/base chemistry, the concept of weak acids and buffers.



Titration of lactic acid solution produced from depolymerization

In the process students are learning more **Green Chemistry:**

#4 Design safer chemicals
#7 Use renewable feedstocks
#10 Design for degradation

Conclusions

Incorporating Green Chemistry activities into the GOB course at COCC has already provided substantial benefits. Students benefit from exposure to Green Chemistry Principles and the institution benefits from reduced risk to students and the environment. The change does not require a wholesale restructuring of the course.

Anecdotal evidence indicates increased interest in chemistry among the GOB students. Students ask more questions both in and outside of the laboratory setting, often indicating they are linking their experiences in the laboratory to other aspects of their lives. As a result of these changes they may enter the workforce more aware of the potential impacts of the chemicals they will handle, and with a heightened appreciation for the work that goes into designing and bringing to market chemicals and processes that are more green.

In the coming academic year Green Chemistry will be discussed more frequently in the classroom portion of the course. Discussions will include green chemistry in pharmaceutical manufacture and toxicology, in addition to the issues raised in the lab activities described here.

The changes that are reported and proposed are well aligned with current concerns on the campuses of many colleges similar to COCC. Providing GOB students with a curriculum that is current, that fits the goals of the academic programs served by GOB, and that connects chemistry to the lives of all of these students is our goal.

Literature cited

Boice, J.N., King, C.A., Higginbotham, C., and Gurney, R.W., *Journal of Materials Education* (invited article), submitted December 2007.

Bureau of Labor Statistics, U.S. Department of Labor, *Career Guide to Industries, 2008-09 Edition*, Health Care <http://www.bls.gov/oco/cg/cgs035.htm> accessed July 07, 2008.

Creegan, F., Visitors and Governors of Washington College, 2003. *How and why do substances dissolve?* <http://creegan.washcoll.edu/gilabs/solubility%20folder/solubility_vpl.html.> accessed July 7, 2008. The procedure has been modified for the GOB audience at COCC.

Department of Chemistry, University of Oregon and CET Interactive Media, GEMS Database, 2004 http://www.greenchem.uoregon.edu/gems/html accessed July 8, 2008.

Thompson, J.E., Science Division, LCC, 2006. *Biodiesel Synthesis*, GEMS database <http://greenchem.uoregon.edu/Pages/Overview.php?CategoryIDString=&FullTextSearchKeywords=biodiesel&CategoriesToSearch=&NumberOfMainCategories=7&AnyAll=Any&ID=87> accessed July 7, 2008.

Acknowledgments

Thank you to Julie Haack and the Green Chemistry Education Network (GC EdNet) both on the national and regional level (PacNW GC EdNet) for their support.

Thank you to Rich Gurney for his assistance in the PLA activity development.

COCC has provided generous support for professional development, making this presentation possible.

For further information

Please contact *chigginbotham@cocc.edu*. This poster is available as a .pdf by linking from the PRESENTATIONS section at:
http://web.cocc.edu/chigginbotham/e-vita.htm