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Issues in Science and Technology Librarianship

Winter 2012

DOI:10.5062/F4F18WNS



Science and Technology Resources on the Internet

Green Chemistry Web Resources

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Introduction

The "Green Chemistry" initiative has gained momentum since first emerging in the early 1990s ([American Chemical Society n.d.](#)). In the landmark book *Green Chemistry: Theory and Practice* (1998), Anastas and Warner divide the goals of green chemistry into 12 principles which emphasize the fundamental position that it is easier to prevent the creation of hazardous material than it is to treat it. According to them, "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" (p.11). These principles serve as guidelines for chemists seeking to create more earth-friendly chemicals to fulfill the world's medical, agricultural, and manufacturing needs.

The green movement has been part of the cultural landscape since Rachel Carson's eye-opening book, *Silent Spring*, which motivated people to examine the negative impact of humans on the natural environment. The publication of *Silent Spring* helped to create political discussions on environmental concerns which ultimately led to the establishment of the United States Environmental Protection Agency (EPA) and laws such as the Clean Air Act, the Toxic Substances Control Act of 1976, and the Pollution Prevention Act of 1990 ([EPA 1992](#)). Anastas and Warner reignited the campaign against toxic chemicals by embracing the "greening" of chemical processes in order to make the practice of chemistry more eco-friendly.

Recently, Anastas stated, "We'll know that green chemistry is successful when the term 'green chemistry' disappears because it's simply the way we do chemistry" ([Jacobs 2011](#)).

As the green chemistry movement progresses, it is important that current research and information be readily available to students, chemists, researchers, and the general public. While there have been multiple bibliographies on chemistry, resources with information about green chemistry have not been adequately addressed. The purpose of this guide is to identify some of the most informative green chemistry web sites in addition to highlighting free educational resources.

Scope

The intent of this guide is to provide a green chemistry resource list which can be used by students, librarians, and/or professionals who are interested in the topic. This directory is not an exhaustive list, but it includes current authoritative resources on the web. Additionally, the key text that defines the green chemistry movement is included.

Methods

In order to compile the Green Chemistry Resource Guide, online and print resources were evaluated based on their relevance, content quality, ease of use, authority, and currency. While numerous resources on green chemistry exist, there is an overabundance of outdated web sites that are no longer maintained. This guide attempts to provide only the most up-to-date information on this exciting new field of study.

Green Chemistry Resources

Key Text

Green Chemistry: Theory and Practice

New York, NY: Oxford University Press, 2000, ISBN 0198506988

Written by Paul Anastas and John Warner, this book is the fundamental text on green chemistry. It provides an excellent introduction to the topic as well as examples of green chemicals and chemical reactions. This book is accessible to both chemists and interested nonprofessionals.

Major Web Sites

American Chemical Society (ACS) Green Chemistry Institute

<http://portal.acs.org/portal/PublicWebSite/greenchemistry/index.htm>

The ACS Green Chemistry Institute provides an overview of green chemistry. Along with information about green chemistry, the institute

includes green engineering and a list of principles related to both disciplines. This portal provides information about news, awards, conferences, and events. This is an excellent place to look for green chemistry academic programs as well as continuing education.

Green Chemistry, United States Environmental Protection Agency (EPA)

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

The EPA is one of the major online information sources on green chemistry. The EPA site discusses basic concepts, programs, and projects related to green chemistry. Additionally, links are provided to grant and educational opportunities available to researchers and students. The EPA site has an excellent introduction to the topic of green chemistry. The site also includes links to the Presidential Green Chemistry Challenge Awards.

Education and Research

Berkeley Center for Green Chemistry, University of California, Berkeley

<http://bcgc.berkeley.edu/>

The Berkeley Center for Green Chemistry features information on educational activities at the center. In order to make green chemistry more accessible in chemistry education, the center includes free examples of green chemistry courses. The courses can be located by selecting *Example Resources* under the *Green Chemistry Laboratory* section found beneath the *Education and Outreach* tab. In an effort to keep their site current, the center offers to forward curriculum revisions and share teaching experiences with interested parties.

Beyond Benign, Green Chemistry Education

<http://www.beyondbenign.org/>

Beyond Benign is an educational non-profit organization that provides materials for teachers in K-12 and higher education. Additionally, the organization features professional development opportunities for teachers to incorporate green science into their curriculums. The site includes news and informational videos related to green chemistry. The mission of Beyond Benign is to promote sustainable science including green chemistry, green math & engineering, and biotechnology.

Green Chemistry Assistant, St. Olaf College

<http://fusion.stolaf.edu/gca/>

This web application, designed by St. Olaf College in conjunction with the EPA, provides assistance with green chemistry applications for all levels of chemistry students. Some of the interesting features of this web application are the ability to aid in the performance of chemistry calculations, the inclusion of chemical safety information, and the ability to create green process analysis reports.

Green Chemistry, University of Oregon

<http://greenchem.uoregon.edu/>

Sponsored by the University of Oregon, this site provides links to information about the school's undergraduate curriculum and research programs. One of the most important resources on the site is the Greener Education Materials (GEMs) for Chemists database. Developed by the University of Oregon, the database hosts a variety of green chemistry education materials. The GEMs database allows users to search by chemistry concepts, laboratory techniques, and green chemistry principles. Additionally, the database includes both published and unpublished materials which can be used to teach students ranging from elementary school to university level. This is an excellent resource for instructors interested in incorporating green chemistry into their chemistry courses. Another interesting feature of the site is the inclusion of an up-to-date Google map which provides names and locales of green chemistry educators and researchers from all over the world.

Green Chemistry Education Network (GCEdNet), University of Oregon

<http://emetim.ning.com/>

The Green Chemistry Education Network is a social network that endeavors to provide resources and opportunities for the incorporation of green chemistry into standard chemistry curriculums. This site is produced by the University of Oregon and links to the GEMs database. Additionally, users can find worldwide green chemistry events and news.

Green Chemistry Network

<http://www.greenchemistrynetwork.org>

Originally funded by the Royal Society of Chemistry and established at the Green Chemistry Centre at the University of York, England, the Green Chemistry Network promotes education and awareness of green chemistry. The site is funded on a project-by-project basis which makes it difficult to keep all areas of the site up-to-date. This site is most useful to general consumers as it provides basic explanations of green chemistry.

Green Chemistry Research Exchange (GreenChemEx)

<http://www.greenchemex.org/gccx/>

The Green Chemistry Research Exchange (GreenChemEx) program is a database of green chemistry resources that are available to a variety of users including scientists, students, and the general public. The database was developed by the ACS Green Chemistry Institute in partnership with the Design for the Environment program at the EPA. Users can submit materials to GreenChemEx, which contains articles and videos. The database provides key subject areas, such as greener reagents, which users can browse. Additionally, users can use keywords to search for more in-depth information on their area of interest.

Interuniversity National Consortium "Chemistry for the Environment" (INCA)

<http://www.incaweb.org/>

Interuniversity National Consortium "Chemistry for the Environment," or INCA, was started by five Italian universities in 1993. INCA is a consortium of universities who use green or sustainable chemistry research for environmental protection. Although the site is in Italian, INCA provides English translation for most pages.

The Institute for Green Science, Carnegie Mellon University (CMU)

<http://www.chem.cmu.edu/groups/collins>

The Institute for Green Science at Carnegie Mellon University (CMU) is run by Terry Collins, the Teresa Heinz Professor of Green Chemistry. The site centers on CMU's research in green science featuring patents and other publications relating to green chemistry. In addition to research information, the institute provides a free beta version of their online course entitled, *An Introduction to Green Chemistry* which can be found under the *Education and Ethics* tab.

iSUSTAIN Green Chemistry Index v2.0

<https://www.isustain.com/>

iSUSTAIN is a web application that allows users to create reports on the sustainability of chemical products. The product was developed by Cytect Industries Inc., Sopheon, and Beyond Benign. Users can utilize a basic version of iSUSTAIN for free and purchase a membership for advanced features. Using a set form for data entry, the user creates a scenario based on the chemical process of a product. The data is then measured and scored against the twelve principles of Green Chemistry developed by Paul Anastas and John Warner.

Greening Across the Chemistry Curriculum, University of Scranton

<http://academic.scranton.edu/faculty/cannm1/dreyfusmodules.html>

The University of Scranton site features Greening Across the Chemistry Curriculum which includes modules for green chemistry. Each module includes an activity, information for the instructors, and a PowerPoint presentation. There are also a variety of green chemistry modules ranging from organic chemistry to industrial chemistry.

Consumer Information

Green Chemistry, California Department of Toxic Substances Control

<http://www.dtsc.ca.gov/pollutionprevention/greenchemistryinitiative/index.cfm>

While some states have examined green chemistry proposals, California is

one of the first states to pioneer a green chemical initiative. This site provides excellent information and media on green chemistry. Although the site is geared towards Californians, there is a wealth of information that would be useful to a person who is not fluent in chemistry.

Green Chemistry, Michigan Department of Environmental Quality

http://www.michigan.gov/deq/0,1607,7-135-3585_49005---,00.html

Michigan has started statewide green chemistry initiatives to provide research support, education, and current information on chemical processes and its impact on the environment. Michigan has also established a Michigan Green Chemistry Governor's Award Program and supports a green chemistry conference called, GreenUP. The conference proceedings are available through this site.

Inventory Update Reporting and Chemical Data Reporting, United States Environmental Protection Agency (EPA)

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

The EPA's Chemical Data Reporting, previously called Inventory Update Reporting, provides an overview of information on new and existing chemicals. Although some of the information is blocked due to confidentiality, consumers can obtain basic health risk assessment and safety information of new and currently used chemicals in products.

Chemical Regulations

Laws and Executive Orders, United States Environmental Protection Agency (EPA)

<http://www.epa.gov/lawsregs/laws/>

This site lists all the laws and executive orders which the EPA is responsible for enforcing. It provides quick links to major laws such as the Clean Air Act and the Pollution Prevention Act, as well as many others. The user can obtain regulatory information by topic or by industry sector.

Toxic Release Inventory, United States Environmental Protection Agency (EPA)

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

The EPA's Toxic Release Inventory is a database that provides information to the general public about the disposal of toxic chemicals. The site allows users to search by zip codes to find toxic chemical releases in their area. Additionally, users can also view reports about their state from 1987 until 2009. Typically, these reports have an approximate two year lag period.

Summary of the Toxic Substances Control Act of 1976, Laws and Regulations, United States Environmental Protection Agency (EPA)

<http://www.epa.gov/regulations/laws/tsca.html>

The Toxic Substances Control Act of 1976 is the law that allows the EPA to control or regulate chemicals in the United States. Since new chemicals must adhere to the standards put forth in this legislation, corporations must review the details of the law prior to processing or distributing new chemicals.

Regulation, Evaluation, Authorization, and Restriction of Chemical Substances (REACH), European Commission

http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm

Regulation, Evaluation, Authorization, and Restriction of Chemical Substances, or REACH, is the European Commission's regulation of chemicals throughout the European Union. The Toxic Substances Control Act of 1976 and REACH contain differing criteria for chemical construction which may result in chemicals being designed in multiple ways. Both REACH and the Toxic Substances Control Act are the largest components in regulating chemicals in the United States and Europe. This site provides the names of participating countries as well as information on current regulations. Additionally, the site provides news and updates on current research and events.

Awards

Green Chemistry Awards, American Chemical Society (ACS) Green Chemistry Institute

<http://portal.acs.org/portal/PublicWebSite/funding/awards/gci/index.htm>

The ACS Green Chemistry Institute has a number of green chemistry awards recognizing contributions to green chemistry techniques and technology. The links to the different awards provide information on submitting applications as well as information on previous winners.

Presidential Green Chemistry Challenge, United States Environmental Protection Agency (EPA)

<http://www.epa.gov/gcc/pubs/pgcc/presgcc.html>

The Presidential Green Chemistry Awards, developed by the EPA and ACS Green Chemistry Institute, gives an award to a research group who is developing and/or implementing new green chemistry practices. The web site provides a list of previous winners along with a summary and podcast of their award. Those individuals interested in new technologies can review the list of winners and their contributions to the green chemistry movement.

Blogs

ICIS Green Chemicals Blog

<http://www.icis.com/blogs/green-chemicals/>

Doris de Guzman is the Senior Editor at ICIS Chemical Business, a

magazine covering the global chemical trade. She blogs about green initiatives in the chemical industry and their feasibility as long-term solutions.

Green Chemistry Blog, RSC Publishing

<http://blogs.rsc.org/gc/>

RSC Publishing's Green Chemistry Blog features new research and news related to green chemistry. The blog presents articles from *Green Chemistry*, the RSC's publication. Additionally, the blog only allows its users to access articles for a short period of time.

Conclusion

Rachel Ehrenberg (2011) of *Science News* states, "Currently more than 30 million metric tons of chemicals are produced in or imported to the United States each day, a quantity that would fill a line of tanker trucks 10,000 miles long" (p.26). Green Chemistry is an initiative that will ideally continue to expand in order to reduce the environmental impact of the increasing number of chemicals released into the environment. As green chemistry research and techniques become more widely available through digital resources, it will be easier for educators and chemists to stay up-to-date in this exciting field of study.

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