

# Challenges

Interview with Dr. Jennifer L. Young,  
ACS Green Chemistry Institute<sup>®</sup>, American Chemical Society

**Green Chemistry is one of the leading topics in the market today – sustainability gains more and more in importance for the strategic development of companies. The term „Green Chemistry“ was coined in 1991 and aims for the protection of human health and the environment. Twelve principles of Green Chemistry have been formulated to assist chemists and the chemical industry to develop new chemical products and processes or reengineer existing ones to reduce or eliminate industrial pollution. The American Chemical Society Green Chemistry Institute (ACS GCI) was founded in 1997 as a non-profit organisation dedicated to the advancement of green chemistry. In 2001 the institute, which has chapters in more than 24 countries, joined ACS in an effort to further advance its global mission.**

**„q&more“ asked Dr. Jennifer L. Young, renowned expert and Manager at ACS GCI, about current questions and challenges in the field of Green Chemistry.**

## **Dr. Young, could you give us an overview of the aims and activities of the ACS GCI?**

The mission of ACS GCI is to enable and catalyse the implementation of green chemistry and engineering principles throughout the global chemical enterprise. We accomplish this mission by focusing on education, industry, advocacy, and certification. We also host the annual Green Chemistry & Engineering Conference, the premier event which brings together industry, academia, government, and non-profit organisations from around the world to discuss the latest advances in green chemistry, green engineering, and business applications.

Additionally, the ACS GCI engages with the community through a variety of communication vehicles such as educational materials and industrially-relevant business case studies. The number of subscribers to our online newsletter, the Nexus, is growing rapidly and currently it is distributed to over 7,000 individuals worldwide.

## **What are the main areas in the field of Green Chemistry?**

Green chemistry touches on all chemistry disciplines and sectors. It is not a discrete sub-discipline, but rather a systems approach that pervades all of chemistry. The 12 Principles of Green Chemistry, as you mentioned, really illustrate this broad scope of green chemistry. Green chemistry considers where the chemicals come from, how they are made, how they are used, where they will end up, and aims to prevent any negative impact they will have on human health and the environment.

## **How could the industry profit in realising environmental goals?**

Green chemistry is good for business. In industry its financial impact is most often seen in context of a Life Cycle Assessment or Life Cycle Inventory (LCA/LCI). The new business gains can be attributed to green chemistry



**Prof. Paul Anastas** during his Keynote Address at this year's 15th Annual Green Chemistry & Engineering Conference and 5th International Conference on Green and Sustainable Chemistry in Washington, DC. Paul Anastas of Yale University is regarded one of the "fathers" of the original 12 principles of Green Chemistry and Green Engineering.



**Dr. Jennifer L. Young** is Manager at ACS GCI. Her work has focused on building green chemistry information databases, managing awards and grants programs, promoting through communication and outreach, and producing educational materials. Prior to joining ACS GCI in 2004, she held an industrial polymer research position at DuPont in the Ink Jet business. Her research involved synthesising and studying new water-borne polymeric dispersant and binder technologies for inkjet inks. Jennifer earned a Ph.D. in polymer/organic chemistry in 2000 from the University of North Carolina at Chapel Hill by investigating polymerisations in supercritical carbon dioxide under the direction of Joseph DeSimone.

when you add up the cost savings of preventing waste and pollution, reducing the inherent hazard of their chemicals and processes, and increasing safety. Green chemistry has also proved to reduce energy consumption (and attendant greenhouse gases), improve process efficiency, and in some case eliminate the use of materials and solvents. To succeed in the market-place, the green product must perform at least as well as, if not better than, the other products that it is competing against, and have acceptable economics. Consumers are also willing to make a trade off and many companies will find they can charge a premium for their green products. The recently released Pike Research report estimates the global green chemical industry will hit \$100 billion by 2020. The forecast growth is exponential and it is all driven by the economic benefits.

**Could you give us some examples for a successful industrial implementation? Are there milestones in the history of Green Chemistry?**

Since 1996, 82 Presidential Green Chemistry Challenge Awards (PGCCA) have been awarded to companies, small businesses, and professors who have demonstrated innovative chemical technologies that prevent pollution and have broad applicability in industry. These are excellent examples of successful industrial implementation. For every award given there are typically 20 applications per category and this award has been duplicated in a number of other countries. The 2011 PGCCA winners included:

- Greener Synthetic Pathways Award: Genomatica for "Production of Basic Chemicals from Renewable Feedstocks at Lower Cost".
- Greener Reaction Conditions Award: Kraton Performance Polymers, Inc. for "NEXAR™ Polymer Membrane Technology".
- Designing Greener Chemicals Award: The Sherwin-Williams Company for "Water-based Acrylic Alkyd Technology".

- Small Business Award: BioAmber, Inc. for “Integrated Production and Downstream Applications of Bio-based Succinic Acid”.
- Academic Award: Professor Bruce H. Lipshutz, University of California, Santa Barbara for “Towards Ending Our Dependence on Organic Solvents”.

And I think interest from industry in green chemistry has exponentially grown in the past few years. For example, ACS GCI started the Pharmaceutical Roundtable in 2005 with 3 member companies. Today, this roundtable has 17 member companies, and additionally ACS GCI has a Formulator’s Roundtable and Chemical Manufacturer’s Roundtable that combined engage another 21 member companies.

The world faces many challenges in the 21st century. At ACS GCI we believe green chemistry is the key to meeting those challenges while creating a sustainable future.

### Green chemistry is a fundamental science-based approach. What is the role of research and development?

Green chemistry is best incorporated at the earliest stages of research, and fundamental research is certainly important, such as discovering new types of chemical reactions that are atom economical and non-hazardous.

But green chemistry is also important at all stages of research and development, and through to commercialisation. To give an example, consider the pharmaceutical industry. It would be ideal if green chemistry is incorporated in the medicinal chemistry stage, where the initial routes to the target drug molecules are discovered. But in reality, a lot of the green chemistry progress is made in the research and development stages, and particularly in the process scale-up stages before reaching commercialisation.

### The application of Green Chemistry to analysis has been gaining attention in the last few years within academic research and industrial applications. What are the main subjects of Green Analytical Chemistry?

Looking at the 12 Principles of Green Chemistry, several are particularly relevant to analytical chemistry. In general terms, green analytical chemistry means preventing waste, using chemicals and solvents that are less hazardous or that are even recoverable, and conserving energy. Many aspects of an analytical method affect the “greenness” of a method, including sample preparation, any reagents or solvents used to prepare the sample for analysis (such as for derivatisation, digestion, preservation, extraction, mobile phase, etc.), the measurement/detection, and the amount and hazard of the waste that is generated. Green chemistry can be applied to each of



**The recipients of the Kenneth G. Hancock Memorial Student Award.** (Left to right): Nancy Jackson (President, ACS), Swapnil Jadhav (Hancock Award recipient, The City College of New York), Huan Cong (Hancock Award recipient, Boston University), and Madeleine Jacobs (Executive Director, ACS).



these aspects to reduce the environmental footprint of the method. It is amazing when you look at the integrated footprint of analytical methods over the course of a year and see just how big it can be.

**The ACS GCI established a project to identify and apply Green Chemistry to approximately 850 analytical methods in the National Environmental Methods Index (NEMI; [www.nemi.gov](http://www.nemi.gov)). How does it work and how can the information in the NEMI database be used to develop greener methods? What impact accords to the sample preparation?**

The greenness of the analytical methods in NEMI was assessed by considering four criteria. A method is considered less green if: 1) a chemical used in the method is listed as persistent, bioaccumulative, and toxic (PBT), as defined by the EPA's Toxic Release Inventory (TRI); 2) a chemical used in the method is listed as hazardous in the TRI or on one of the RCRA's D, F, P or U hazardous waste lists; 3) pH during the analysis is less than 2 or greater than 12 (corrosive); or 4) the amount of waste generated is greater than 50 g.

As a result, when a search is conducted in the NEMI database, the greenness of the method is included with the other characteristics of the method (such as detection level, precision, instrumentation, etc.), so comparisons can be made between methods.

For the types of environmental testing methods that are contained within NEMI, such as water quality testing methods, sample preparation often includes large sample sizes, preservation, and liquid-liquid extractions, all which can lead to the method being „less green“ according to the 4 criteria outlined above. Some of the greenest methods against those 4 criteria often involve small sample sizes, without any addition of chemicals or solvents, and which are directly injected into the instrument for the analysis.

**Let's get back to the activities of your institute – what is your actual grant programme and who can apply for the sponsorship?**

We are currently accepting pre-proposals until September 14, 2011 for the 2012 ACS GCI Pharmaceutical Roundtable Research Grant on green engineering research areas. Proposals will be accepted from public and private institutions of higher education worldwide, in the areas

of Continuous Processes; Bio-Processes; Separation and Reaction Technologies; Solvent Selection, Reactions and Optimisation; and Process Intensification. One grant is planned to be awarded for up to \$150,000 for a grant period of 12 to 24 months. The detailed Request for Proposals can be downloaded from [www.acs.org/gcipharmaroundtable](http://www.acs.org/gcipharmaroundtable).

We also annually offer several awards for students, which support travel to conferences or acknowledge outstanding research. More information about each of these Green Chemistry Awards is available through our website, [www.acs.org/greenchemistry](http://www.acs.org/greenchemistry).

**The ACS GCI awards several prizes, for example the worldwide established Presidential Green Chemistry Challenge Award, which has just been made for the 16th year. For what is this commendation awarded? What is its special significance in this year?**

ACS GCI convenes the independent judging panel for the prestigious Presidential Green Chemistry Challenge Awards, which are administered by the U.S. Environmental Protection Agency ([www.epa.gov/greenchemistry](http://www.epa.gov/greenchemistry)).

In celebration of the International Year of Chemistry, this year's award ceremony was held on June 20 in conjunction with the 15th Annual Green Chemistry & Engineering Conference and 5th International Conference on Green and Sustainable Chemistry in Washington, DC. The conference drew a record number of over 660 participants, including 23% internationally from 30 different countries. Participants from industry, academia, and government had the opportunity to hear from many of the leading experts in green chemistry from around the world. We hope you and your readers can join us at the conference next year, June 18–20, 2012!

**Dr. Young, we thank you for this discussion.**

(Interview by Claudia Schiller)