

2014 Year in Review

ACS GCI Industrial Roundtables

Pharmaceutical • Formulators • Chemical Manufacturer's • Hydraulic Fracturing

Introduction

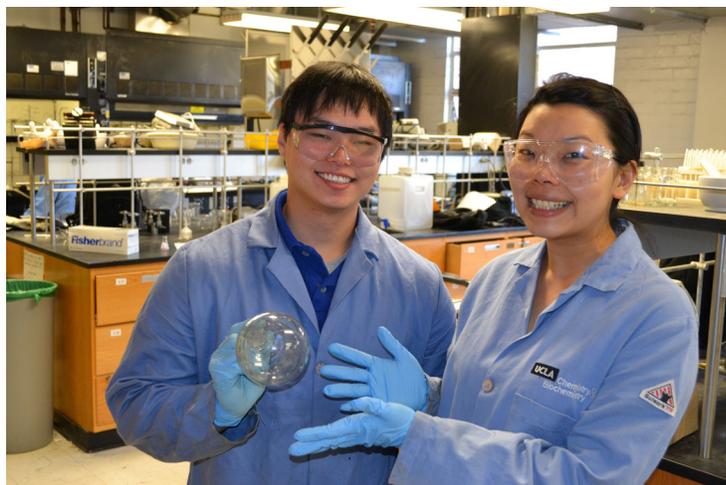
Beginning in 2005 with just three companies on one Roundtable, there are now four Roundtables serving 43 members. The ACS GCI Industrial Roundtables are a proven concept, demonstrating that collaboration among peer companies can effectively provide value directly to the company, as well as to the collective industry, in designing more sustainable processes and products, a pursuit that is imperative for a sustainable business and environment.

The ACS Green Chemistry Institute® would like to thank the 43 corporations that worked collaboratively and non-competitively throughout 2014 to catalyze the integration of sustainable and green chemistry and engineering in the global chemical enterprise.

Pharmaceutical Roundtable

In its 9th year, the ACS GCI Pharmaceutical Roundtable continued to deliver on their four strategic priorities (inform and influence the research agenda, tools for innovation, education resource, and global collaboration) and welcomed a new member, Cubist Pharmaceuticals. David Leahy of Bristol-Myers Squibb completed his two-year tenure as a co-chair, and the group voted in John Tucker of Amgen as his successor.

The Roundtable also continued development on several of their established tools that can assist chemists, engineers, academics, students, and other professionals to incorporate greener chemistry into their research. The Biopharma team initiated a Process Mass Intensity benchmarking activity and collected best engineering practices. There were initial efforts to expand the solvent selection guide and fill data gaps in the existing guide. Furthermore, the reagent selection guide was enhanced, including the development of original reagent guides and the expansion of guides donated by member companies. These guides provide background on important transformations in the pharmaceutical industry, and evaluate potential reagents based on greenness, wide utility, and scalability.



Students in Neil Garg's UCLA Lab work on Pharmaceutical Roundtable funded research.

2014 ACS GCI Roundtable Members

Ajinomoto North America, Inc.
Amgen
Amway
Apache Corporation
Arizona Chemical Company LLC
AstraZeneca
BASF
Boehringer Ingelheim Pharmaceuticals, Inc.
Bristol-Myers Squibb
Codexis
Cubist Pharmaceuticals
Dixie Chemical Company, Inc.
The Dow Chemical Company
Dr. Reddy's Laboratories Ltd.
DSM Pharmaceutical Products
E.I. du Pont de Nemours and Company
Eli Lilly and Company
F. Hoffmann-La Roche Ltd.
Florida Chemical Company, Inc.
GlaxoSmithKline
Johnson & Johnson
Johnson & Johnson Consumer Products
The Lubrizol Corporation
Marathon Oil Company
Merck & Co., Inc.
Nalco Champion, An Ecolab Company
Novartis
Novozymes North America Inc.
Penn A Kem LLC
Pfizer Inc.
Rochester Midland Corporation
Rockwater Energy Solutions
Rug Doctor LLC
Sanofi
S. C. Johnson & Son
Seventh Generation, Inc.
Sigma-Aldrich
Solvay USA Inc.
State Industrial Products
Trican Well Service
Virox Technologies Inc.
Zep Inc.

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Industrial Roundtables

This year several grants were awarded by the Pharmaceutical Roundtable to inform and influence the research agenda:



\$100,000 to **Professor Paul Chirik** of Princeton University for base metal-catalyzed cross-coupling in the pharmaceutical industry



\$100,000 to **Professor Neal Mankad** of University of Illinois at Chicago for a bimetallic approach to iron-catalyzed coupling reactions



\$50,000 to **Professor Daniel Weix** of University of Rochester for the synthesis of alkylated arenes and heteroarenes from the cross-coupling of heteroaromatic halides in non-amide solvents



\$50,000 to **Professors Matthias Beller** and **Elisabetta Alberico** of the Leibniz-Institut für Katalyse for ligand-metal cooperative catalysis for the mild and selective synthesis of amines

Finally, in efforts to build and contribute to education resource, as well as collaborate globally, the Roundtable continued collaborations with the IQ Working Group to create training sessions in green chemistry for industrial chemists. The group also explored collaboration opportunities with IMI CHEM21 on an education and training work plan for students, industrial scientists and engineers, and other stakeholders. Another highlight was continuing a collaboration with a previous grant winner. Professor Neil Garg, as part of an extension of his 2012 Roundtable grant, published a manuscript on greener methodologies

for Suzuki couplings in ACS Catalysis and an article highlighting the related undergraduate lab experiment in J. Chem. Ed.

The Roundtable organized and chaired six sessions at the 18th Green Chemistry & Engineering Conference. The in-person meetings were held in Paris, France (hosted by Sanofi), Bethesda, MD (hosted by ACS GCI), and Rahway, NJ (hosted by Merck & Co., Inc.). All meetings were also web-based to assure global participation.

Formulators' Roundtable

In order to identify key needs for formulated consumer products industry, this year the Formulators' Roundtable collaborated closely on a manuscript with Dr. Philip Jessop (Professor of Chemistry at Queen's University and ACS GCI Board Member), defining opportunities for greener alternatives. The group identified 10 classes of components (such as chelants and sequestering agents, corrosion inhibitors, fragrance raw materials, and more) that are in need of replacement, as well as the characteristics that ideal replacements should possess. The manuscript has been submitted for publication.

Continuing discussions from 2013, the Roundtable acted as an industry voice, engaging with fragrance suppliers and developers, third-party reviewers, and the U.S. EPA to enable informed discussions on the interim fragrance criteria and the design of more sustainable alternatives. The Roundtable facilitated regular conversations with the U.S. EPA to be updated about the current status of the this Design for the Environment Program, to learn about a hazard-based calculator being developed to assist fragrance houses, and to stay abreast of the

fragrance compliance deadline, and several other topics. Furthermore, the Roundtable engaged with guest speakers at their bi-monthly meetings, including:

- Suzanne Hartigan (Director, Science Policy and Regulatory Affairs) and Megan Ekstrom (Manager, Government Affairs) of International Fragrance Association-North America to explore opportunities to collaborate in the development of greener products
- Clive Davies, Joyce Parker, and Aly Lorenz of the U.S. EPA's Design for the Environment Program Branch, provided an overview of their new criteria and calculator for fragrances

At the GC&E conference in June, the Roundtable organized two sessions on defining greener and more sustainable consumer products. Chaired by Phil Sliva of Amway, the presentations featured industry professionals discussing topics ranging from hazard data transparency to life cycle assessment for greener products.

Chemical Manufacturer's Roundtable

Last year the Chemical Manufacturer's Roundtable conducted a scouting survey to better understand the current implementation of green chemistry in the chemical manufacturing sector. In 2014, they published (in ACS Sustainable Chemistry & Engineering) the findings of a survey on the current implementation of green chemistry in the chemical manufacturing sector and identified actionable projects.

Moving forward, the Roundtable seeks to evaluate how members can better highlight the process metrics they use, track green chemistry implementation across the industry, and define research, development, and demonstration needs for industrial application of green chemistry.

A major focus area for the Roundtable is reducing the energy required

to manufacture products. Building on the work to define opportunities for alternative separation technologies, the ACS GCI Roundtables (led by the Chemical Manufacturers), submitted a proposal for consideration for the NIST Advanced Manufacturing Technology Planning Grant.

The Roundtable also organized sessions at ACS GCI's 18th Annual Green Chemistry and Engineering Conference in Bethesda, MD. "Greening the Supply Chain Using Biobased Chemicals" was organized by Paul Williams (Arizona Chemical) and Bogdan Comanita (Market Chemica on behalf of Penn A Kem). Alan Phillips (Arizona Chemical) chaired the session on-site. A tools and metrics related session was organized and chaired by Robert Giraud of DuPont.

Throughout the year the Roundtable also hosted several distinguished guest speakers at their bimonthly meetings, including Ron Buckhalt (U.S. Department of Agriculture), Blandine Trouille (U.S. Department of Commerce), Nancy Jackson (U.S. Department of State), Rich Engler (U.S. EPA), and I.S. Jawahir (Institute for Sustainable Manufacturing at University of Kentucky).

In May, a transition in Roundtable leadership occurred when Paul Williams' (Arizona Chemical) term as co-chair came to a close, and Amit Sehgal of Solvay USA Inc. was voted in as the new co-chair.

Hydraulic Fracturing Roundtable

Building on efforts initiated in 2013 to create a Roundtable to improve the sustainability profile of hydraulic fracturing through green chemistry, in June 2014 the ACS GCI Hydraulic Fracturing Roundtable opened for membership. The group welcomed nine founding members: Apache Corporation, BASF, The Dow Chemical Co., The Lubrizol Corporation, Marathon Oil Company, Nalco Champion (An Ecolab Company), Rockwater Energy Solutions, Solvay USA Inc., and Trican Well Service. The appointed co-chairs are Danny Durham from Apache Corporation and Dave Long of the ACS GCI Board.

In partnership with Clean Production Action, members are provided 40 GreenScreen assessments of widely used fracturing chemicals (an \$8,700 value). These assessments are able to be used internally by member companies to better determine the sustainability profile of their fracturing chemicals and identify where replacements might be needed.

The newly formed Roundtable also organized a session at the 18th Annual Green Chemistry and Engineering Conference titled "Exploring Greener Approaches to Hydraulic Fracturing." The session was chaired and organized by Danny Durham of Apache Corporation, and featured academic and industrial presentations on progress and improvements to fracturing chemicals. Moving forward in 2015, the Roundtable will establish annual goals supporting the strategic priorities including an analysis of chemical data from hydraulic fracturing well reports.

Roundtables at GC&E

Once again, in addition to hosting their in-person meetings and organizing technical sessions, all four roundtables sponsored and organized a poster reception in conjunction with the Annual Green Chemistry and Engineering Conference. In its fourth year, the ACS GCI Roundtable Poster Reception was a highly focused networking event with posters featuring a wide range of industrially relevant green chemistry work presented by industry professionals, professors, and students. Attendees consistently praise the reception as being "an excellent venue for interacting with individuals from all phases of the chemical supply chain" and to meet other professionals doing similar work. In each of the past four years the event has been held, over 72% of attendees have indicated they learned about a greener technology of potential relevance to their organization. Sponsors for the event were Florida Chemical Company, Inc. of Flotek, ILSI Health and Environmental Sciences Institute (HESI), and Launch.

2014 Roundtable Publications

Green Chemistry Articles of Interest to the Pharmaceutical Industry, Rakeshwar Bandichhor, Apurba Bhattacharya, Louis Diorazio, Peter Dunn, Kenneth Fraunhofer, Fabrice Gallou, John Hayler, Matthew Hickey, Bill Hinkley, David Hughes, Luke Humphreys, Bernard Kaptein, Suju Mathew, Lynnette Oh, Paul Richardson, Timothy White, Stijn Wuyts, *Org. Process Res. Dev.*, **2014**, 18 (7), pp 863-874. DOI: 10.1021/op500167y

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Implementing Green Chemistry in Chemical Manufacturing: A Survey Report, Robert J. Giraud, Paul A. Williams, Amit Sehgal, Ettigounder Ponnusamy, Alan K. Phillips, and Julie B. Manley, *ACS Sustainable Chem. Eng.*, **2014** 2 (10), pp 2237-2242. DOI: 10.1021/sc500427d

Sustainable Chromatography (an oxymoron?), Emily A. Peterson, Barry Dillon, Izzat T. Raheem, Paul Richardson, Daniel Richter, Rachel Schmidt, and Helen F. Sneddon, *Green Chem.*, **2014**, 16, pp 4060-4075. DOI: 10.1039/C4GC00615A



ACS GCI Roundtable co-chairs with Director David Constable, from left to right: Amit Sehgal (Solvay), Danny Durham (Apache), Phil Silva (Amway), Dave Long (ACS GCI Governing Board), John Tucker (Amgen), Juan Colberg (Pfizer), David Constable (ACS GCI), Ettigounder 'Samy' Ponnusamy (Sigma-Aldrich).