

DAVID CONSTABLE

## “Green chemistry & engineering is a way of thinking & requires a collection of diverse skills to excel”

Dr. David J C Constable, a leading authority on sustainability management was recently in India to participate in IGCW 2013. He was the founder and principal of Sustainability Foresights, LLC, prior to which he worked with Lockheed Martin as the Corporate Vice President of Energy, Environment, Safety & Health (ESH) and as Director of Operational Sustainability in the Corporate Environment, Health and Safety Department at GlaxoSmith-Kline.

Dr. Constable is currently the Director of American Chemical Society's Green Chemistry Institute (ACS GCI), where he is catalysing and enabling the implementation of green chemistry & engineering in the global chemical enterprise.

He spoke to *Chemical Weekly* on a range of issues concerning sustainability management in the chemical industry, progress of green chemistry (GC) in India and diverse options before the industry & researchers to further sustainability processes in the chemical industry.

### How would you sum up your experience of GC in India and IGCW 2013?

I had an interesting and invigorating time in Delhi and Mumbai meeting academics, students and people working in industry. I enjoyed hearing about the many different initiatives in industry as represented by companies like Dr. Reddy's. I was excited and inspired by the enthusiasm and interest in green chemistry shown by faculty and students. If my experiences at both conferences are an indication of the interest and commitment in



India to Green Chemistry, then there is cause for great optimism. I think, however, that the reality is different and the barriers to green chemistry are formidable. As long as the Indian chemical industry remains as a collection of small to medium sized companies, it will take much longer to make great progress collectively. That's why there is a need to train more chemistry and chemical engineering students in green chemistry and engineering as the normal way of performing their work.

### Could you elaborate on the present and future green chemistry initiatives at ACS GCI?

The ACS GCI's mission is to catalyse and enable green chemistry and engineering in the global chemical enterprise. We approach this by focusing on three strategic areas: 1) Advancing scientific research and innovation for sustainability; 2) Advocating progress in education and communicating the science of green chemistry; and 3) Ac-

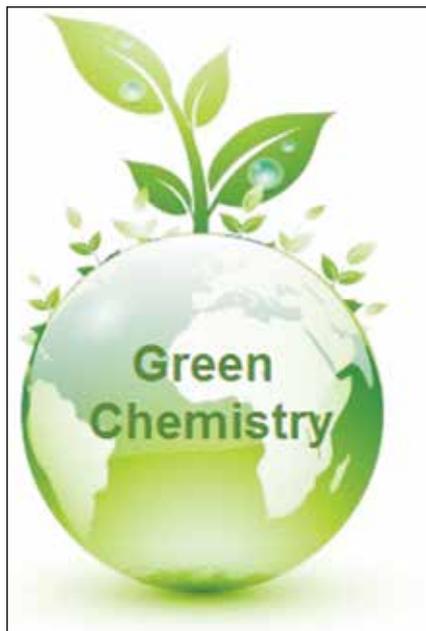
celerating the industrial adoption of green chemistry and engineering.

As a small Institute within the American Chemical Society, we strive to identify the leverage points that offer the greatest opportunities to make the largest differences in key areas. Our leadership role is best described as an impartial convener to promote the best possible science. We bring together groups to provide development opportunities, catalyze discussions, and develop greater collaboration in an increasingly diverse community.

Since 1997, ACS GCI has been organizing an annual Green Chemistry and Engineering Conference ([www.gcande.org](http://www.gcande.org)) to provide a venue for technical programming and business-to-business interaction. We also host business roundtables for pharmaceuticals, chemical manufacturing and formulators, with a new roundtable planned in 2014 for those oil and gas companies involved in hydraulic fracturing. Finally, we are working to put together a workshop this year on green chemistry and engineering education that will lay the foundation for an educational "road map," i.e., what are the things educators need to do to ensure the best educational outcomes for green chemistry and engineering students. In each of these, there are a host of initiatives and opportunities that we are pursuing.

### How do you perceive stakeholder collaborations between ACS/EPS/ Industry/Universities /Civil Societies to realize the goals of green chemistry?

Over the past several decades, the ability of any one company,



government, organization or university to unilaterally take on an initiative like green chemistry and engineering has steadily decreased. There simply are not enough people in any one organization to achieve a critical mass and the problems are greater than any one group can solve. Consequently, partnerships and collaborations are the only way in which one can reasonably move things forward. However, partnering and collaborating is not something that comes naturally to most people, and is frequently almost impossible between competitors or between regulators and those being regulated.

Sustainability and green chemistry and engineering are two areas, however, where many can find common ground. Yes, there is often an initial hurdle where potential partners and collaborators need to make sure they have a common understanding of definitions and areas of mutual interest, but usually it is possible to work on a large number

of common problems that don't impact any one company's ability to compete. The best example of this may be found with our Pharmaceutical Roundtable where member companies have collaborated over the past nine years to create tools for solvent selection, bi-annually benchmark process mass intensity, are developing reagent guides, and sponsor academic research to spur green chemistry and engineering innovations in key areas of interest.

**What do you think are the major gains accrued from the practice of green chemistry since last two decades?**

The largest gain, in my opinion, is that people are routinely talking about green chemistry and engineering. There has been a rapid increase in the number of conferences and symposia dedicated to green chemistry and engineering and there are now multiple academic, business and non-profit centers for green chemistry and engineering. A significant number of companies are also talking about it and communicating their accomplishments. There are now three or more journals devoted exclusively

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to sustainable and green chemistry and engineering and the number of submissions to these journals has increased exponentially. And, these submissions are submitted from institutions throughout the world.

There has also been an increase in the quantity and quality of tools and methodologies available to perform hazard and risk assessments; process

and product assessments; and sustainability assessments. Life cycle assessments, the associated data to perform a credible assessment, and the number of people trained in performing a LCI/A has also dramatically increased.

The U.S. Presidential Green Chemistry Awards have also been a wonderful platform for companies to be recognized for innovations in green chemistry. These awards have shown that it is possible for large corporations and small businesses to bring green chemistry innovations to market and in the process dramatically reduce the generation of toxic compounds and waste.

**How do you perceive global progress in GC and what will be the key challenge in promoting it in developing economies?**

As I have stated in a few of the other questions, I think that there has been significant progress in green chemistry as more people are aware of it and there are many things being done to reduce the environmental impact of chemicals production and use. There are certainly more institutions teaching green chemistry and engineering and there are more centers devoted to advancing solutions and innovation.

I think Europe has done the most to implement green chemistry in business. I think this is a reflection of the nature of the chemical industry in Europe, i.e., largely batch chemical operations and higher value added products. I also think the implementation of the REACH regulations is leading some companies to move basic chemical manufacturing off-shore while others are promoting the shift to chemical feedstocks that are less toxic and more

sustainably produced. Challenges in promoting green chemistry in the developing economies are the same as those in the developed world wherever there is an existing, profitable way of making chemicals. Much has been written about the challenges facing green chemistry, so I will not repeat that but there are a few more things I would like to say.

The greater use of hydraulic fracturing in the oil and gas industry, especially in the U.S., is paving the way for continued use of petroleum and natural gas as the primary source of chemical building blocks. While there is great opportunity to implement green chemistry approaches and solutions in the petrochemical complex, there is little appetite for it. Moreover, the average petrochemical complex is operating at high levels of efficiency given the amount of process optimization that has been done over the past 50 years. Most will continue to produce the same molecules for as long as they are able to do so.

The nature of the Indian chemical industry, as I mentioned in the first question, continues to be a challenge. I would also say that when chemical manufacturing plants are being built in the devel-

oping economies using current technologies, you are creating a challenge that has existed in the developed economies and that is the barrier of in-ground capital. It is very difficult to build new plants unless there is an overwhelming economic incentive to do so. Moreover, unproven technologies at large scale look like risky” investments to lenders, so it is difficult



to raise capital to build manufacturing plants with newer technologies.

**To what extent do you think IP will limit the flow of GC knowledge from west to east?**

I don't think that IP is a limiting factor in green chemistry and engineering. Green chemistry and engineering is a way of thinking about chemistry and

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engineering and requires a collection of diverse skills to excel at it. I think not having enough people trained to do green chemistry and engineering is a bigger barrier than IP.

**How would you sum up the sustainability progress and gaps within the industry?**

Sustainability in most companies

is restricted to environmental concerns and is generally focused on water, energy and waste (hazardous and non-hazardous). Few see sustainability as an opportunity to address global challenges through different ways of doing what we have always done in chemistry. Few even understand the pivotal role chemistry plays in all areas of life. Large gaps remain in our use of water, energy (mostly transportation, but also space heating/cooling) and food. There are also enormous sustainability challenges in supplying key elements critical to how society functions. These include elements used for electronics, energy production, catalysis, and food production.

**How do you view green chemistry research heading in future? Where would you advise research dollars to be spent?**

My immediate response is that we need to have money for green chemistry research; there is in fact very little spent or devoted to it by governments or private sources. If research money becomes available, it should be spent to

change the practice of chemistry; the way it is practiced today, chemistry is inherently mass and energy inefficient and inherently unsustainable. The many ways in which we react chemicals, make bonds, the framework molecules we use, etc. needs to change. This does not mean that we are changing fundamental principles of bond formation or reactivity, rather it is in the selection of the framework or scaffold molecules we use, the reaction conditions, the use of more biochemical mechanisms, cascade reactions, etc. It also means we need to invest more in our understanding of structure-activity

relationships and modes of action so we are able to design molecules that are safer to humans and the environment. We also need to do better at separations and reuse and recovery of key elements. There is no end to a list of critical research needs.

**What is the present status of design and development of sustainability tools and metrics? Do you expect sustainability exchanges to bring about more informed investment decisions?**

I think that there are a variety of metrics that can be used to assess the sustainability profile of products, processes and companies. I am not sure, however, that most senior business leaders understand these or routinely use them. There is also a considerable amount of filtering that goes on

to put those metrics that are collected and reported in the most positive light. Investors also vary in the attention they give to sustainability metrics. It would be wrong to generalize too much, but I think it's fair to say that the investor community is mostly known for its ability to either make large returns on investment over a short period of time or for its ability to make predictable

returns over time. *In the world of sustainability, the time horizons are generally longer than investor attention, and in most cases, there are not such large short-term sustainability risks that would outweigh other more traditional business risks of greater concern to the investor community*

**What are your views on human resources availability to meet sustainability goals in the industry?**

If you take my assertion that industry is mainly reporting environmental sustainability through its performance in reducing energy use, water use and the discharge of hazardous and non-

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hazardous waste, then I would say that industry is well-equipped to meet these needs. If you are more interested in integrating triple bottom line sustainability as a business goal equivalent to increasing sales, market share, or price-to-earnings ratio (or whatever financial measure you choose) then industry is ill-equipped. Business leaders, investors, and those who lead

sustainability efforts, in my opinion, generally lack the scientific and engineering expertise to understand what it would take for a business to become more sustainable. For those that may have the expertise, they generally lack the passion and will to make sustainability a reality.

**How do you view chemistry and chemical engineering education and related knowledge domains moving ahead to address the sustainability challenges?**

I think that many in the educational community are becoming more alive to the challenges of sustainability and

are seeking to develop courses and curricula that help students better understand sustainability. Unfortunately, most graduate

level research and the incentives that are associated with obtaining a Ph.D. and funding are overwhelmingly stacked against sustainable and green chemistry and engineering. Those in the scientific review process for academic research grants are resolutely stuck in the past and generally reject perfectly good scientific inquiry that does not fit their idea of good scientific investigation.