

# REPORT 5<sup>th</sup> IGCW 2017

## Convention & Ecosystem





# 5<sup>th</sup> IGCW-2017 Convention & Ecosystem Outcome Report

## Table of Contents

Executive Summary .....	1
Overall Participation .....	2
Partners and Supporters .....	2
IGCW-2017 Convention Structure & Events .....	3
Inauguration .....	4
1. IGCW 2017 Symposium .....	5
2. SERB-IGCW 2017 Awards .....	7
3. IGCW 2017 EXPO .....	9
4. IGCW-PCB Conference for State Pollution Control Boards .....	11
5. FCS Workshop on Flow Chemistry .....	12
6. 180° Seminars .....	14
Green Processes, Green Catalysts, Green Solvents & Green Engineering .....	14
7. IGCW- ACS GCIPR Workshop on Solvent & Reagent Selection Tools .....	15
8. IGCW Workshop on Emerging Tools & Technologies .....	16
9. IGCW-CSIR Industry Interactions.....	17
10. IGCW Workshop for Students .....	22
11. IGCW Workshop for Teachers .....	24
Feedback & Testimonials .....	24
Overall Outcome .....	26
Conclusion .....	28
Annexures - Photo Report, List of Attendees, Media Articles.....	

## Executive Summary

The 5<sup>th</sup> Industrial Green Chemistry World – Convention and Ecosystem (IGCW-2017) was successfully held from 5<sup>th</sup> to 8<sup>th</sup> October 2017, in Mumbai. The key objective of facilitating the 5<sup>th</sup> IGCW-2017 was to expand the technical know-how on implementing green chemistry and green engineering (GC&E) through industrial case-studies, tangible tools, expert interactions,

focused networking; and thereby to accelerate the real-time implementation of GC&E practices by the participating companies.

This report aims to provide a glimpse into the various features of 5<sup>th</sup> IGCW-2017, overall participation and their key take-aways, share indicators of industry's growing response to GC&E practices and the overall outcome of the Convention.

## Overall Participation

The IGCW-2017 Convention was attended by over 400 chemical industry representatives from about 100 chemical companies locally and internationally.

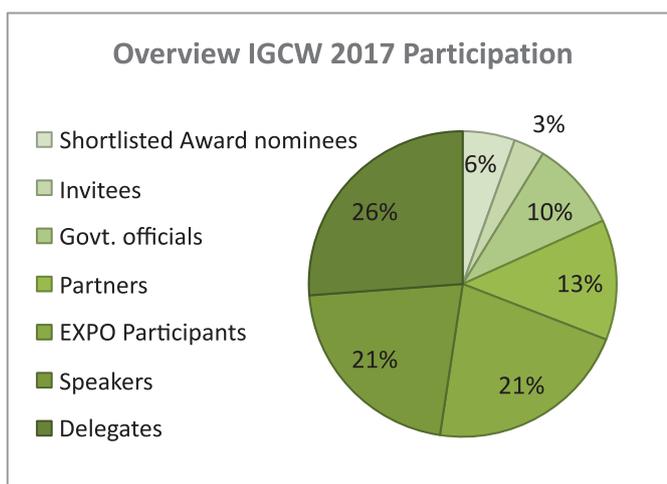


40% of the total attendees were senior management representatives of the participating companies attending the Day I of the Convention in various capacities either as delegates, Partners OR Speakers. About 50% of attendees comprised senior Technical representatives from R&D and Production attending both the days of the Industrial event.

10% representatives were from various Govt. bodies and Research Institutes, including senior representatives from State Pollution Control Boards.

The graph here is to give an at-a-glance summary of the participants' profile and distribution. Overall the IGCW-2017 attendees fairly well represented the local and international Chemical community.

The total number of attendees witnessed an all-time increase of 30% in participation. This indeed indicates the rising fervor of GC&E practices amongst diverse stakeholders of Indian Chemical Industry.



## Partners and Supporters

The 5<sup>th</sup> IGCW 2017 was supported by the Department of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilisers, Govt. of India; the Department of Science & Technology and Science & Engineering Research Board (SERB), Ministry of Science & Technology, Govt. of India; the Ministry of Environment and Forests, Govt. of India; the Maharashtra Pollution Control Board (MPCB); and the Maharashtra Industrial Development Corporation (MIDC), State Govt. of Maharashtra.



The 5<sup>th</sup> IGCW 2017 was organised in partnership with Excel Industries Ltd. as the CSR Partner; PI Industries Ltd., as the SERB-IGCW 2017 Awards' Partners; ACS-Green Chemistry Institute's Pharmaceutical Roundtable (GCIPR) as the Solvent Selection Workshop Partner. Solvay Global partnered with the IGCW 2017 under the title of Green Chemistry Partner. Cipla Ltd., Dr. Reddy's Laboratories, L'Oreal Research & Innovation Centre, and Godrej Industries Ltd. contributed in the capacity of Cause Partners; while Clariant Chemicals India Ltd., Laurus Labs, Pfizer India and Viswaat Chemicals supported the event in the capacity of Donor Partners. Advanced Enzyme Technologies and Geocycle India contributed as Session Partners and thus supported respectively the subject-specific sessions viz.: Green Catalysts Seminar; and the workshop on Emerging Tools & Technologies.

Together for Sustainability (TFS), and the Ecological and Toxicological Association of Dyes and Organic Pigments Manufacturers (ETAD) came on board in the Capacity of Associate partners, while Chemical Weekly, Chemical Watch and Green Chemistry Journal served as Media Partners

## IGCW-2017 Convention Structure & Events

The 5<sup>th</sup> IGCW-2017 was designed by incorporating the participants' feedback and suggestions from the previous four IGCW Conventions held biennially in Mumbai since 2009.

While concluding the 4<sup>th</sup> IGCW Convention in December 2015, it was declared as the "Completion of GC&E awareness phase in India" and the beginning of the "Implementation phase".

With this context and spirit was designed the structure of the 5<sup>th</sup> IGCW-2017 Convention. The four-day Convention integrated eleven events delivering subject-specific interactions and presentations.

Following were the various features / events held during the 5<sup>th</sup> IGCW-2017 Convention:

1. IGCW 2017 Symposium, 5<sup>th</sup> & 6<sup>th</sup> Oct. 2017
2. SERB-IGCW 2017 Awards Evening, 5<sup>th</sup> Oct. 2017
3. IGCW 2017 EXPO, 5<sup>th</sup> & 6<sup>th</sup> Oct. 2017
4. IGCW-MPCB Conference on “Pollution Prevention at Source – Green Chemistry & Engineering Approach” for State Pollution Control Boards, 5<sup>th</sup> Oct. 2017
5. IGCW-FSC Workshop on Flow Chemistry, 5<sup>th</sup> Oct. 2017
6. IGCW Workshop on Emerging Tools & Technologies, 5<sup>th</sup> Oct. 2017
7. IGCW 2017 180° Seminars, 6<sup>th</sup> Oct. 2017
8. IGCW-ACS GCIPR Workshop on Solvent & Reagent Selection Tools, 6<sup>th</sup> Oct. 2017
9. IGCW-CSIR Industry Interactions, 6<sup>th</sup> Oct. 2017
10. IGCW Workshop for Teachers on “Advancing Green Chemistry Education in India”, 7<sup>th</sup> Oct. 2017
11. IGCW Workshop for Students on “Global Trends & Opportunities in Green Chemistry”, 8<sup>th</sup> Oct. 2017

## Convention and Ecosystem

2 days | 6 dimensions | 40+ global experts  
Over 300 chemical community stakeholder's participation



Below given is the brief account of the above events held during IGCW 2017 Convention & Ecosystem.

### Inauguration



The IGCW-2017 Convention was inaugurated by distinguished leaders and senior representatives from various Govt. bodies. Their presence and address to the audience indicated their endorsement of GC&E practices and emphasised the role of each stakeholder towards accelerating GC&E implementation in India.

The Inaugural Guests included:

- Shri. Subhash R. Desai, Hon'ble Minister for Industries & Mining, Maharashtra State. The Hon'ble Minister graced the occasion as the Special Guest at the launch of SERB-IGCW Awards.
- Shri Rajeev Kapoor, IAS, Secretary, Dept. of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilisers, Govt. of India.
- Shri. (Dr.) Rajiv Sharma, Secretary, Science & Engineering Research Board (SERB), Dept of Science & Technology, Govt. of India.
- Shri. Sanjay Sethi, IAS, CEO, Maharashtra Industrial Development Corporation (MIDC), Govt. of Maharashtra, India.
- Shri. R. Gopalkrishnan, Former Director, TATA Sons, Author & Corporate Advisor, India.
- Dr. David Constable, Science Director, American Chemical Society – Green Chemistry Institute, USA.

## 1. IGCW 2017 Symposium

The IGCW Symposium retained its structure based on the *9-i Theme Approach* whereby the speakers oriented their presentations and case-studies corresponding to the session themes.

Day	Themes	Target Audience
Day I, 5 <sup>th</sup> Oct.	Ignition Inspiration Initiation	Senior Management, Chairpersons, Managing Directors, Founders, Presidents, CXOs & decision makers.
Day II, 6 <sup>th</sup> Oct., Pre-lunch	Identification Invention Innovation	R&D and Technology Leaders, CTOs, CSOs, R&D Managers, Inventors, Innovators, Consultants, Technocrats, etc.
Day II, 6 <sup>th</sup> Oct., Post-lunch	Implementation Industrialization Impact	Plant and Operations' Managers, Technical Directors, VPs, Plants Managers, EHS Managers, etc.

Refer as enclosed the Convention Catalogue to view the overall flow of the Symposium (pg. 16 & 17) followed by the profiles and brief abstracts of respective speaker presentations (pg.18 to 38). The IGCW 2017 Symposium, like the earlier editions, brought together an eminent panel of speakers from Industry and Academia. Each session was chaired either by an Industry leader



OR Co-speakers.



The opening talks by Dr. David Constable, Science Director, ACS-Green Chemistry Institute; Mr. R. Gopalkrishnan, Former Director, Tata Sons; and Mr.

Rafael Cayuela, Chief Economist, Dow Chemicals; provided disrupting insights and thought processes on the urgency and opportunities of implementing GC&E practices and thereby impacting the triple bottom-line of People, Profits and Planet.



One of the most noticeable progress in the content of the IGCW Symposium presentations was the shift of focus from “problem-specific case-studies” to the sharing of “integrated models and approaches” to GC&E implementation as adopted by few leader companies. This was evident in the presentations shared by senior representatives of L’Oreal France, Merck KGaA, Johnson Matthey plc,

MSD, USA; as well as by few Indian companies such as Jubilant Life Sciences Ltd.; Cipla Ltd.; and by few MNCs in India such as Clariant Chemicals India Ltd., SABIC India Pvt. Ltd., to name few.

The Keynote Talk on Day II of IGCW Symposium was given by Prof. Ashwini Kumar Nangia, Director of National Chemical Laboratories. Prof. A. K. Nangia emphasised few of the pressing innovation and implementation gaps in the areas of energy management, process intensification and continuous chemicals processes, catalysis for high turnover and milder conditions, biomass feedstocks for value-added chemicals and fuels, raw materials sourcing and by-products valorisation.

Prof. Nangia shared industrial case-studies on successful collaborations between CSIR Labs and the chemical Industry on some of the above mentioned areas and urged the Industry to work in collaboration for resolving the process-related environmental challenges of chemical sector.



Presentations by Speakers such as Prof. Chao-Jun Li from McGill University, Mark Dorfman from Biomimicry 3.8; and Prof. Oliver Kappe of University of Graz, Austria; brought to the audience new insights and case-studies of their path-breaking and pioneering work in the field of Green Chemistry & Green Engineering.

The IGCW 2017 Symposium was well received by the participants for its outstanding content of presentations and the opportunity of cross-leadership networking and interactions. Overall, the content of IGCW 2017 presentations fulfilled the intention of the 9-i Theme Approach.

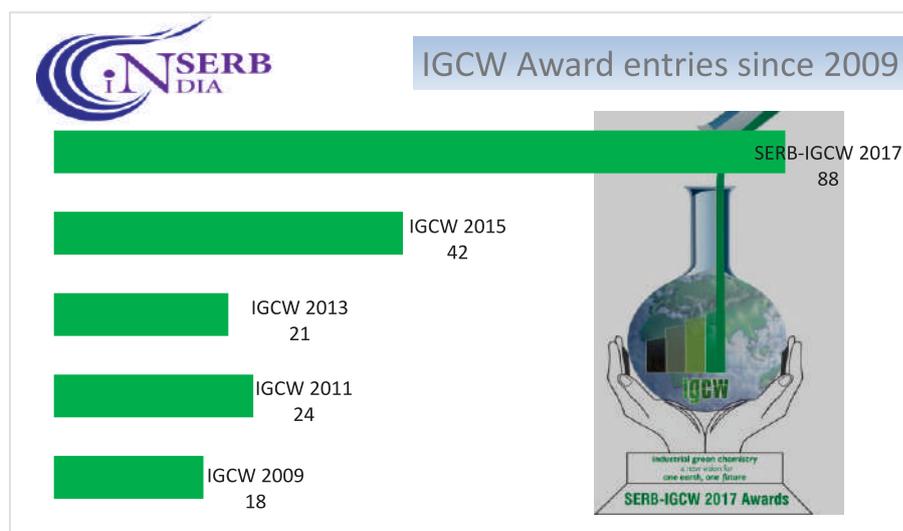
For summary of each presentations discussed during the IGCW Symposium, please refer enclosed article as appeared in the Chemical Weekly issue of 14<sup>th</sup> November 2017.

Visit link as suggested below to download copy of presentations (those consented by Speakers):  
[http://www.industrialgreenchem.com/presentation\\_form.html](http://www.industrialgreenchem.com/presentation_form.html)

## 2. SERB-IGCW 2017 Awards

The IGCW Awards from this year onwards have been endorsed by the Science & Engineering Research Board (SERB), a statutory body formed by the Dept. of Science & Technology, Govt. of India to support and advance basic research in emerging areas of Science & Engineering.

With SERB's partnership, the IGCW Awards from 2017 onwards have been co-felicitated under the prestigious title of SERB-IGCW Awards. Apart from providing financial aid to encourage wider award applications from Industry, Academia and Research Institutes; the SERB also provided monetary recognition to the award winners from Academia and Students' categories.



Over 80 submissions were received for the SERB-IGCW 2017 Awards, out of which 55 nominees met the shortlisting criteria, followed to which the short-listed nominations were sent to the external jury comprising local and international experts' panel.

According to the jury, the submissions have shown an increase both in terms of number and the quality of the case-studies. Overall the nominations reflected industry's understanding of GC&E practices for "prevention at source" and their subsequent initiatives in that direction.

The SERB-IGCW Awards were launched on the evening of 5<sup>th</sup> Oct. 2017 at Ramada Powai - Hotel & Convention Centre, Mumbai; by the Hon'ble Minister for Industries & Mining, Maharashtra State - Shri Subhash R. Desai; and Dr. Rajiv Sharma, Secretary, Science & Engineering Research Board (SERB).



The SERB-IGCW Awards were presented to the winners by the special guests invited for the Awards' evening - Dr. Bettina Rechenberg, Head of Division "Sustainable Production 7 Products, Waste Management", German Environment Agency; Dr. Ajay Deshpande, Former Expert Member, National Green Tribunal; Member of Compliance Panel of Asian Development Bank, India; Mr. Srinivasa, Managing Director, Pfizer Global Supply and

R&D; Mr. Ravi Kapoor, Managing Director, Heubach Colour Pvt. Ltd.; Dr. Harish Swarnkar, Sr. Team Leader, PI Industries India Ltd.

The IGCW Awards evening over the years has been consistently supported by PI Industries Ltd.; and with their continued support the SERB-IGCW Awards evening, followed by networking dinner was attended by over 300 industry and academia colleagues.

An overview of the selection process and criteria was presented to the audience by Dr. David Constable, Science Director, ACS-Green Chemistry Institute.



The winners of SERB-IGCW 2017 Awards are listed in table below.

Category	Winner	Topic
MNC, large and medium scale	Aarti Industries Ltd., Jhagadia, Gujarat.	Manufacturing Route Change in hydrogenation
Small-scale Industries	STEP Pvt Ltd., Mumbai.	Novel Gas-Liquid reactor, Downflow Gas Contactor (DGC) for efficient & effective, effluent treatment.
Green Start-ups	Growtech Innovations India Pvt Ltd., IIT-M, Chennai.	Application of tropical thermoelectric technology to replace CO2 and R134a Refrigerant Compressor based Commercial Refrigerator.
Technology Developers	Geist Research Pvt Ltd., Goa.	Recovery of anhydrous sodium sulphate from brine solution – caustic chlorine industry.
Students	Ms. Nalinee Suryawanshi, CSIR-National Chemical Laboratories (CSIR-NCL), Pune.	Green Approach to Deep Desulfurization using Hydrodynamic Cavitation.
Researchers	Dr. S Venkata Mohan, Indian Institute of Chemical Technology (CSIR –IICT), Hyderabad.	Sustainable Biohydrogen Production from waste: Pilot scale Demonstration

For a detailed report on the SERB-IGCW Awards Evening please refer enclosed article as appeared in the Dyechem Bulletin of 5<sup>th</sup> November 2017.

### 3. IGCW 2017 EXPO

The IGCW EXPO is one of the key features of the IGCW Ecosystem, and over the years a growing number of solution provider companies, both locally and internationally, are actively participating to showcase their GC&E relevant technologies, solutions and competencies. This IGCW, close to 40 solution providers including Academia & Research Institutes participated in the EXPO, of which 18% were international exhibitors indicating India's growing potential for Green Chemistry and Engineering solutions.



The approach adopted by Green ChemisTree Foundation for reaching out to solution providers globally is by identifying immediate to long-term solution providers and thereby inviting them to the IGCW ecosystem for exploring the emerging GC&E market in India. Refer graphic below.

The IGCW EXPO offers opportunity to the exhibiting companies to engage in focussed networking and business interactions with the senior decision makers and their technical teams participating in the various features of IGCW Convention.



Around 50% of the participating companies at the IGCW –EXPO have been regular exhibitors at earlier IGCW events indicating the business value and opportunity obtained from IGCW.

IGCW 2017 presented for the first time, an exclusive platform for start-up companies incubated at institutions like IIT-B, IIT-M, NCL Venture Centre and Riidl at Somaiya Vidyavihar.

25% of the exhibitors were start-up exhibitors who showcased their technology solutions and innovations thus expanding the awareness among solution seeking organisations and furthering business opportunities through new partnerships.

The 5<sup>th</sup> IGCW provided a conducive platform and environment for the launch of Green Polar Aprotic solvent from Circa Sustainable Chemicals Ltd, UK, Green Catalysts from Reaxa Chemistry Solutions., and EnginZyme, Sweden.

Another first for IGCW was the Flow Chemistry Pavilion for Flow Chemistry technologies and solutions. Three CSIR institutes viz: Indian Institute of Chemical Technology (IICT), National Environmental Engineering Research Institute (NEERI) and National Chemical Laboratories (NCL) were represented in the CSIR Pavilion. Noteworthy among exhibitors was India's foremost Innovation facilitator, Science and Engineering Research Board (SERB), which was also the sponsor of the IGCW 2017 Awards.



A survey was conducted to understand the exhibitor's experience with the purpose of enhancing future

exhibitor events. A questionnaire was administered with an option to keep the responses anonymous. The feedback received was encouraging.

- 74% of exhibitors of the IGCW –EXPO surveyed mentioned that the overall experience was good with 78% saying that footfalls and exhibition space was good.
- 79% felt that the visitors to their booth were the right level of decision makers/influencers from solution seeking organisations while 74% felt that the IGCW ecosystem provided ample opportunity to meet business potentials.
- 48% of respondents were first time exhibitors. 75% felt that the 5th IGCW was better than previous IGCW events. When asked to compare IGCW with other Green Chemistry trade shows, 53% thought IGCW fared better than most. 52% of the respondents responded that they would be most likely exhibitors at future IGCW events.



#### 4. IGCW-PCB Conference for State Pollution Control Boards

One of the features introduced to the IGCW Ecosystem in 2013 was the exclusive conference for State Pollution Control Boards. This event has been receiving encouraging response from the senior officials of State PCBs. The 5<sup>th</sup> IGCW-2017 hosted the 3<sup>rd</sup> PCB Conference on “Pollution Prevention at Source – Green Chemistry & Engineering approach”, on 5<sup>th</sup> Oct. 2017. The said



Conference was supported and sponsored by Maharashtra State Pollution Control Board (MPCB).

The IGCW-PCB Conference was attended by around 36 senior officers from five State PCBs including Andhra Pradesh, Gujarat, Maharashtra, Tamil

Nadu, and West Bengal State PCBs. The Conference was also attended by senior representatives from the Environment Division of Maharashtra Industrial Development Corporation (MIDC).

The Conference was inaugurated by Dr. P. Anbalagan, IAS, Member Secretary, Maharashtra Pollution Control Board, who graced the occasion as the Chief Guest for the event.

The panel of Speakers for the PCB Conference included distinguished leaders and subject-experts from relevant Government bodies, Research Institutes and Industry. The topics discussed during the Conference aptly addressed the concerns and challenges of State PCBs in driving regulations while ensuring sustenance and growth of the chemical manufacturing sector.

The two inaugural speaker provided global perspectives on the subject. Dr. Bettina Rechenberg, Head of Division “Sustainable Production and Products Waste Management,” German Environment Agency, shared commercial relevance of the German chemical sector vis-à-vis its size and structure in Germany. Dr. Rechenberg further introduced with examples and case-studies the concept of Best Available Techniques (BAT) and its economic aspects. BAT is a dynamic concept based on promoting continuous improvements in environmental performance.



Whereas, Dr. David Constable, Science Director, ACS-GCI, shared global case-studies and key insights on the “Role of Environment Regulatory bodies in driving Green Chemistry Implementation”.

Followed to which, Mr. Bimal Goculdas, Chairman –Sustainability Committee of ICC, shared industrial perspectives on “Pollution Control and Prevention”. Mr. Goculdas also in his talk introduced the concept of “Responsible Care V/S Sustainability”; and presented the Ten guiding Principles and Six Codes of the Responsible Care initiative. The Six codes are Process Safety, Occupational Health and Employee Safety, Pollution Prevention, Emergency response and Communication with Community, Distribution Code and Product Stewardship. Mr. Goculdas concluded his talk by sharing few tangible benefits and success stories of implementing the “Responsible Care” certification programme.

Dr. Rakesh Kumar, Director CSIR-NEERI, with his core-competency and years of experience in environmental compliances, shared about various sustainable technologies for better compliance and governance, which the State PCBs could promote amongst the chemical manufacturing companies in their respective zones.

Dr. Rajesh Singh, Managing Director, ThinkStep Sustainability Solution Pvt. Ltd. introduced various “Life Cycle Assessment” tools, its impacts and benefits to the chemical companies in meeting their regulatory norms.

One of the key take-backs of the PCB Conference is sharing and exchange of best practices implemented by the participating States. This session included presentation sharing by:

- Mr. Subrato Ghosh, Chief Engineer - West Bengal Pollution Control Board;
- Dr. Madhusudhan Rao, JOEE - Andhra Pradesh Pollution Control Board;
- Mr. Y. A. Tai, Sr. EE - Gujarat Pollution Control Board; and
- Mr. P. K. Mirashe, Asst. Secretary- Maharashtra State Pollution Control Board.

The concluding remarks and acknowledgment was given by Dr. Amar Supate, Principal Scientific Officer, MPCB; and Mr. Nitesh Mehta, Convener 5<sup>th</sup> IGCW-2017 Convention.

## 5. FCS Workshop on Flow Chemistry

The IGCW 2017 Convention for the first time integrated the topic of “Continuous Flow Chemistry” as a potential solution to accelerate the implementation and impact of Green Chemistry & Engineering based practices. For this purpose, IGCW partnered with the Flow Chemistry Society- India Chapter as a Knowledge Partner to design and co-organise the said Workshop on Flow Chemistry.

The topics undertaken in the course of the Workshop included both basic introduction and overview, as well as sharing of industrial case-studies and exchange of implementation experiences by peer companies.

Mr. Vijay Kirpalani, President, Flow Chemistry Society-India Chapter, provided a comprehensive overview and introduced the basic concepts of continuous process chemistry and flow reactors. Whereas, Mr. Kumar Oza, CSO, PI-LLP, introduced to the audience various choices of microreactors vis-à-vis its unique functionalities and benefits.



Prof. C Oliver Kappe, Dept. of Chemistry, University of Graz, Austria, presented an overview on the wide range of hazardous chemistries which can be carried out in microreactors. The examples

of in situ generators of hazardous intermediates like ozone, CF<sub>3</sub>, BrCN, and Br<sub>2</sub> were exemplary. Prof. Kappe's lab has also achieved the success in the development of multistep synthesis using micro-reactors.

Prof Anil Kumar, Department of Chemistry, Indian Institute of Technology Bombay (IIT-B), presented in detail the requirements for the study of flow chemistry principles in the laboratory. Prof. Kumar also shared about the demonstration facilities that are made available at the Dept. of Chemistry, IIT-B; and invited interested companies to explore various flow chemistry equipment. The companies can also establish proof-of-concept with respect to their own synthesis projects that can be carried out at the IIT-B laboratory, under the supervision of Prof. Anil Kumar and his team.

Mr. Manjinder Singh Phull, Unit-Head, API-R&D, Cipla Ltd., and the Chairman, Flow Chemistry Society- India Chp., gave an outline of the differences in principles of operations between batch processes and continuous flow chemistry. Mr. Vijay Kirpalani, took the delegates through several examples of projects involving flow chemistry principles and outcome of results from concept stage to commercial manufacturing.

Dr. Karim Engelmark Cassimjee, Co-founder & CEO, EnginZyme AB, gave an interesting talk on the use of enzymes for catalytic processes. The easy operation principles of enzyme based chemistries can be exploited by the industry, particularly in the area of Chiral compound synthesis.

Mr. Sandip Darji, Deputy GM, Global Process & Technology – API, Sun Pharmaceutical India Ltd, shared two industrial success-stories of process development and optimization of new drugs using flow chemistry.

The program was concluded by Mr. Surendra Bhatia, Director, Sapec Agro, summarizing the details and lively discussions with the participants and key take-away as follows:



- i. Proof of concept using flow chemistry can be explored in-house through the services of expert.
- ii. In Situ generators as explained by Prof. Kappe can be studied by the individual companies to substitute the current practices of handling hazardous chemicals and chemistries by use of flow chemistry techniques
- iii. HAZOP studies techniques be developed and studied for scale up studies of various chemistries developed using flow reactors.
- iv. A road map of developing a module from concept to commercial manufacturing will help in faster realization of successes of flow chemistry projects.

## 6. 180° Seminars

### Green Processes, Green Catalysts, Green Solvents & Green Engineering

The 180° seminar series held on the 6<sup>th</sup> Oct. 2017, comprised the four selected areas which are Green Processes, Green Solvents, Green Catalysts and Green Engineering. These have been identified as the maximum-impact areas in the implementation of industrial green chemistry and engineering practices.

The invited speakers presented case studies offering solutions, technologies or products that offer immediate, short, medium term solutions to the industry's challenges in each of the four selected areas.

The session opened with presentations on Green Processes where Prof. Dr. Sunil Bhagwat of ICT explained process intensification for sustainable industrial activities and Mr. Hemant Joglekar of Ion Exchange (I) Ltd presented its technology to purify and recycle/reuse process streams. Ms. Ashwini Gunnal Kothe and Ms. Megha Shanbhag discussed Newreka Green Synth's Recycle at source solutions for green processes.



The session on Green Catalysts followed with Dr. Michael Puls of Evoxx Technologies GmbH, Germany elucidating on enzyme technology for chemical processes followed by Biocatalysis developments in Pregabalin and Sitagliptin by Mr. Saravanan Jothi of Iosynth Labs.

Mr. Tanmay Godiawala of Reaxa Ltd discussed on Encapsulated metal catalysts to achieve faster and cleaner hydrogenation and coupling reaction processes with Dr. B Bhanage closing before lunch with sustainable catalysts for fixation of carbon dioxide and carbon monoxide as C-1 sources to synthesize value added chemicals.



The post lunch session was on the area of Green Solvents with Dr. Jeff Eaves of Circa Sustainable Chemicals Ltd, UK presenting on developing value added products from waste cellulose with the case of Cyrene. Mr. G Ramprasad of S Amit Speciality Chemicals Pvt Ltd discussed on behalf of Zeon Corporation, Japan its new Ether process solvent, Cyclopentyl methyl ether (CPME) for Green process innovation. Opportunities for

bio-based green solvents was presented by Dr. Sangeeta Srivastava of Godavari Biorefineries Ltd and Dr. C Nandi of NOCIL made a case of how water can be used as a solvent for chemical transformations.

The Green Engineering area was ably addressed by Dr. .M.G. (Deepak) Palekar of STEP Pvt. Ltd with the topic Process Intensification with Downflow Gas Contactor Reactor and Mr. Sandip Bose of Sun Pharmaceutical Industries Ltd highlighting green engineering in Pharma industry.

All the four sessions were well attended by Managers and senior representatives from R&D and Production and interesting interactions were facilitated between participants and technology solution providers.

## 7. IGCW- ACS GCIPR Workshop on Solvent & Reagent Selection Tools

The hands-on workshop on “Solvent & Reagent Selection & Reagent Selection Tools & Techniques” to drive green & sustainable chemistry, was conducted by:

- Dr. David Constable, Science Director, ACS-Green Chemistry Institute, USA
- Dr. Ingrid Mergelsberg, Director, Process Chemistry, MSD, USA
- Dr. Rajappa Vaidyanathan, Group Director, Chemical, Synthetic & Analytical Development, Bristol-Myers Squibb (I) Pvt. Ltd., India

The speakers provided an in-depth understanding to the audience on various tools and techniques which are available for designing greener route, select the most appropriate reagents and solvents to minimise waste and maximise safety, choose right sustainability metrics that can enable smooth monitoring of greener manufacturing and introduced various other technologies for streamlining synthetic approaches.



This apart, the workshop also gave a brief overview about the history of Green and Sustainable Chemistry, an introduction to the different metrics to enable the monitoring of success toward Green Chemistry, introduced the concept to making smarter decisions on solvents and reagents by applying selection guides, discussed flow chemistry as a potential greener option for certain reactions and also discussed various examples of successful greener process developments within the ACS GCI PR member companies which illustrated the importance of key elements to drive and develop greener and more sustainable processes.



The key outcomes of the GCIPR Workshop were:

- better understanding on how to minimize (hazardous) materials
- streamlining construction of complex molecules in a more sustainable and greener way.



The workshop also facilitated extensive interactive exercises that familiarized the participants with the concepts of Green and Sustainable Chemistry, while demonstrating benefits when applied in practice.

## 8. IGCW Workshop on Emerging Tools & Technologies

IGCW 2017 included for the first time a Workshop on IGCW Emerging Tools, Technologies and Solutions. The workshop was designed in two parts:

The first part was on Emerging Tools & Technologies using the Green chemistry and Engineering approach aimed at bringing forth synergies between physical /chemical technologies with digital IOT technologies deliberating on how such integration is likely to shape the practice of GCE and enable sustainable chemical manufacturing.



Dr. R. Rajagopal, CEO of Knowgenix chaired the session and also spoke on how digital technologies are key to shaping future sustainability pathways. Dr. Kamlesh Padiya, Associate Director of Lupin Ltd presented a 'Greenformatics' tool for enabling green amplification. Mr. K K Bhagchandani, Sr. Director of ACD Labs explained its software technology for dealing with Organic Impurities for Effective Life Cycle Management of chemical Products.

Multi Batch Distillation System (MBDS) which is a new approach to batch distillation design and simulation was jointly presented by Dr. Sanjiv Bachal of Equinox Software and Services India

Pvt. Ltd in person and by Dr. Urmila Diwekar of Vishwamitra Research Institute, USA over Skype – web meeting.

The second part of the workshop was on the Emerging Tools & Technologies using the Zero Discharge Approach. This part aimed at synergizing technologies in Zero Solid, Liquid and Gaseous Discharge systems with digital tools and other innovative technologies to shape the practice of greening current discharge systems and technologies for sustainable chemical manufacturing.

Ms. Sharmishtha Nandi, Head, Business Development, Geocycle India presented on Co-processing technology as the preferred option of for greening the nation's backyard. Six case studies were presented by Mr. Nitin Umbralkar, Assoc VP & Western Ops Head of Ion Exchange to showcase their success stories on alternate sources of water. Dr. Avinash Kadam, MD of Sugam Paryavaran Vikalp Pvt. Ltd highlighted the Constructed Geological Filter System as one of the green ways for Zero Liquid Discharge. Mr. Srinivas PAES, Chief Manager, Tech and Project Management, Sud-Chemie India Pvt. Ltd presented on catalysts for Industrial Exhaust Gas Treatment addressing gaseous waste.

Dr. Chandrashekhar, CEO of Vision EarthCare discussed the heuristics of process design for Industrial wastewater recycling while Mr. Rahul Chhabra, CEO of Transchem Agritech presented the Trans Bio-Filter as a green, efficient and cost effective waste treatment technology.



The session addressed technologies to reduce Solid Waste, Liquid waste and gaseous waste.

With the participation of chief representatives from R&D, R&T, production, operations, the workshop on Emerging Tools, Technologies and Solutions facilitated an exchange of learning between solutions available and opportunities for organisations to

incorporate such solutions for greening their manufacturing operations for sustainability.

## 9. IGCW-CSIR Industry Interactions

The CSIR - Industry Interactions, were integrated for the first time in the IGCW Ecosystem, with the objective to facilitate active interactions between the Research Institutes and the participating companies for exploring collaborative projects on GC&E related areas. The session was designed exclusively for CSIR Labs with the objective to provide a focussed platform to the CSIR Research Scientists for presenting their successful case-studies and collaborative models.



To that effect, the event was divided into two sessions. The pre-lunch session, Chaired by Prof. Ashwini Kumar Nangia, Director CSIR – NCL, consisted of presentations by eminent global speakers to discuss the collaborative models within their research institutes as well as a panel discussion to discuss and elaborate on the problems and solutions within the CSIR – Industry collaboration within India.

The post-lunch session, chaired by Dr. Jigisha K. Parikh, Scientist G, Science and Engineering Research Board, Govt. of India; was designed to demonstrate successful case studies implemented at the CSIR Labs. There were 5 presentations from 4 CSIR labs in India, demonstrating the various GC&E technologies and solutions as developed and available with CSIR Labs for Industrialisation.

Followed to the inaugural address by Prof. A. K. Nangia, Director, CSIR-NCL, the opening presentations was given by Dr. Avtar Singh Matharu, Sr. Lecturer & Deputy Director, Green Chemistry Centre for Excellence (GCCE), University of York, UK. Dr. Matharu's presentation highlighted the general problems that arise when research is moved from bench to scale (industry). Dr. Matharu further discussed various ways in which the GCCE has enabled transition of research from bench to scale as well as how the industry has enabled the same. In the same vein, Prof C. J. Li, Canada Research Chair in Green / Organic Chemistry, Dept. of Chemistry, University of McGill, Canada; demonstrated various ways that the University of McGill has overcome similar issues, citing a collaborative project with L'Oreal as one of the most successful examples of bench to scale transition.



The presentations were followed by a panel discussion, on “Identifying gaps between Research Institutes and Industry collaboration & How to overcome them?”



The panel discussion was moderated by Dr. Avtar Singh Matharu. The Panellists included Prof. A. K. Nangia, Director, CSIR-NCL; Dr. Rakesh Kumar, Director, CSIR –NEERI, Prof CJ Li, Professor, (E.B Eddy Chair, Canada Research chair(tier I) in Green / Organic Chemistry, McGill, Canada; and Mr. R. N. Mohanty, President-Technology, Pidilite Industries Ltd.

The discussion mainly covered the problems with IPR that inhibit the movement of research from the labs towards industries. The Indian approach towards IPR was discussed, as well as the approach method adopted by McGill and GCCE were discussed, as potential means to circumvent the issue. The representatives from various CSIR labs shared examples of where the IPR issues were overcome while integrating diverse research projects into industries.



The post-lunch session was chaired by Dr. Jigisha K. Parekh, Scientist G, Science & Engineering Research Board. Dr. S S Tambe and Dr. CV Rode, from CSIR – NCL, presented an overview of NCL’s ready-to-scale technologies on water treatment, continuous flow chemistry processes and catalytic valorization of biomass derived from platform molecules.

Dr. Amit Bansiwala, from CSIR – NEERI, presented the various nature-inspired ready to deploy technologies for environmental remediation. Dr. B China Raju of CSIR IICT elaborated upon CSIR – IICTs contributions towards the technology development. Dr. S. Swarnalatha, from CLRI presented on CLRIs wastewater treatment technologies for industries to meet Environmental Standards.

**Refer link below to download copy of presentations (as consented by speakers):**

[http://www.industrialgreenchem.com/presentation\\_form.html](http://www.industrialgreenchem.com/presentation_form.html)

## 10. IGCW Workshop for Teachers

The IGCW Teachers Workshop on ‘Advancing Green Chemistry Education in India’ was organized by the Green ChemisTree Foundation, in association with the R.D. & S.H. National College. It was held on the 7<sup>th</sup> October, 2017 at the National College Auditorium. The workshop was attended by 83 chemistry teachers from various colleges across the state, as well as a few doctoral candidates.



The student participants largely consisted of those pursuing masters in chemistry OR chemical engineering; however, there were also few from bio-technology and other allied streams.



The session began the Inaugural address by Dr. David Constable, Science Director, ACS – Green Chemistry Institute. He spoke on ‘How changing chemistry education is the Foundation for a more sustainable world’ and implored the teachers present to make use of the existing green chemistry tools and integrate those within the existing syllabus to create green chemistry awareness among students. This was followed by a brisk Q&A session with the audience.

The second session was conducted by Prof. Chao Jun Li, of the Dept. of Chemistry, McGill University, Canada. Prof. Li shared about the ‘Green chemistry research and education at McGill University’. He highlighted the ways in which McGill promotes Green chemistry research amongst its students; and also discussed the university’s plans in completely eliminating the use of hazardous solvents and using alternative ‘greener’ reagents from the laboratory stage of research.



The third session was helmed by Dr. Ingrid Mergelsberg, Director – Process Chemistry, MSD, USA.



Dr. Mergelsberg, with years of industrial experience, shared with the students, global industry perspective on the importance of green chemistry and sustainable science education to drive innovation and a sustainable future. In her session, she discussed how MSD (Merck USA) planned to discontinue the use of toxic/hazardous chemicals. And thus integrating green chemistry education into the syllabus would be beneficial to students, as larger companies such as Merck are actively moving away from hazardous chemistries and pursuing greener branches of chemistry will become lucrative in the near future.

The fourth session was carried out by Mr. Mark Dorfman, Biomimicry Chemist from Biomimicry 3.8. Mr. Dorfman in his talk introduced the participants to the field of biomimicry and discussed how most of the answers to our problems lie within nature itself, and we should look to nature's inherently green chemistry to find said answers. He kept his audience inspiringly engaged with the biomimicry



The next session was carried out by Dr. Anil Karnik, a professor of Organic chemistry, formerly the head of the University's Dept. of Chemistry; and currently also the Chairperson, Board of Studies, University of Mumbai. He discussed the state of green chemistry curriculum of India, highlighting the successes and shortcoming of the current system, and implored the teachers to integrate green chemistry into their everyday teaching methods.

Following the tea break, there was a short session by Ms. Mona Malik, country manager and society services, ACS India, who explained the various membership plans of ACS and their corresponding benefits.



The final session of the day was once again carried out by Dr. David Constable. The interactive session in teaching green chemistry tools such as PMI metrics, Solvent & Reagent selection guide was designed to run the participants through the various ready to use green chemistry tools available on the internet. He provided a step by step play, demonstrating how to use every single tool.

This was followed by a valedictory note by Dr. Kiron Jathar, Vice principal, R.D and S.H National College, who also served as the convenor of the Workshop.



## 11. IGCW Workshop for Students

An exclusive workshop for Chemistry & Chemical Engineering Students was organised on “Global Trends and Opportunities in Green Chemistry”. The Workshop was organised in collaboration with Department of Chemistry, K. J. Somaiya College of Science and Commerce on 8<sup>th</sup> October, 2017, held at the Smt. S. K. Somaiya Sabhagruha, Mumbai.



The workshop was attended by 240 inter-college students and few faculty members. The Welcome address was given by Shri. Samir Somaiya, CMD, Godavari Biorefineries Ltd.

The sessions were started with the talk on ‘Opportunity to create future in “GC & E” as a fulfilling & forwarding experience for all’ by Mr. Nitesh Mehta, Co-founder & Director, Newreka Green Synth Technologies Pvt.Ltd., Green ChemisTree Foundation. He explained the opportunities and challenges in Green Chemistry and elaborated the scope of Green Chemistry in Pharmaceuticals, Dyes, Agro based industry etc. He inspired the students to follow their passion and interests and asked them to invest the time in building the knowledge, skill and career competency in their chosen field. He hymned ‘No better time to be born as a chemist/chemical engineer’. The students were happy with the guidance given to them by the speaker.

The second session was on ‘Hope for A Sustainable Future- Students can Change the World’ by Dr. David Constable, Science Director, ACS –Green Chemistry Institute, USA. Population growth is imposing an increasing burden on the earth’s limited and continually degrading natural resources. So, he explained the need of development of new and sustainable processes, which is highly desirable to combat further environmental deterioration. According to him Green Chemistry is one such tool that deals with pollution prevention by designing safe reaction pathways with less hazardous alternatives.



The Q & A session of Speakers before lunch break was taken up by Shri. Samir Somaiya, Mr. Nitesh Mehta and Dr. David Constable, the speakers of the morning session. Excellent explanations and suggestions were given by the speakers to the yearning questions from the audience.

The first session after the lunch break was on ‘Opportunities for Chemists and Chemical Engineers’ by Dr. Ingrid Mergelsberg, Director, Process Chemistry, MSD, USA. She explained the mission of MSD is to discover, develop and provide meaningful, innovative products that save and improve lives. According to her, good science is the key to Green Chemistry and low-cost synthesis. If we focus on developing the best chemistry, then, almost always, this leads to the lowest cost and greenest process.



The second session in the afternoon session was on ‘Nature is Alive with Green Chemistry’ by Mr. Mark Dorfman, Biomimicry Chemist, Biomimicry 3.8, USA. In his lecture, Mark introduced the participants to the novel concept of ‘Biomimicry’. He told the participants about the research work carried out at Biomimicry 3.8 and how they use the practice of biomimicry to help innovators to find inspired design solutions. He spoke about the mission and purpose of engaging the practice of biomimicry to create conditions conducive to thriving. Mr. Dorfman enlightened the participants by discussing the ever-evolving nature since its inception to present and how they are using the nature’s wisdom to solve the needs of the humans around the world. He provided information about the application of Biomimicry to innovate by providing examples and furthered the idea of this novel concept to help solve complex issues.



Dr. Mark Dorfman’s session was followed by the talk on ‘Emerging Ecosystem for “Enviropreneurs” in India’ by Dr. Chandrashekar, Director, Vision Earth Care (VEC), India. He discussed about the human activities against environment from ancient time to present time. Dr. Chandrashekar talked about the future water purification technology. He looks forward to greater interaction between the residential communities and

Engineering fraternity in order to develop ecofriendly approaches.

In the brief lecture by Mrs. Krishna Padia on ‘Emerging Opportunity for Chemists and Chemical Engineering in the Social Sector’, the participants were introduced to the objectives and works of ‘Green ChemisTree Foundation’. Mrs. Krishna Padia also discussed on how Green ChemisTree Foundation has emerged as a focused platform to engage the Industry and Non-Industry groups in exploring the world of Green Chemistry and Engineering practices, as a possible way of doing chemistry and impacting the collective 'green' consciousness across the value chain of the Chemical Industry. The speaker, in her lecture also spoke about the career opportunities for Chemistry graduates and postgraduates in the field of social sector.

In the Special address by Ms. Mona Malik, Country manager & Society Services, ACS, India, she explained on American Chemical Society (ACS), how to get the membership of ACS and the different benefits of being the member of ACS etc.

The last session of the workshop was an Interactive session on 'Ready to use Green Chemistry Tools-PMI Metrics, Solvents/Reagent Selection Guide etc.' by Dr. David Constable, Science Director, ACS –Green Chemistry Institute, USA. This was his second session for the day. According to him minimal by-product formation, less solvent waste, catalytic, low stoichiometry, recyclable reagents and minimize usage, reduce the environmental burden. Decreasing the amount of material used to make a drug is one of the major green chemistry challenges for the pharmaceutical industry. He then explained Process Mass Intensity (PMI) Metric as the ratio of quantity of raw materials input (kg) to the quantity of bulk API out (kg).

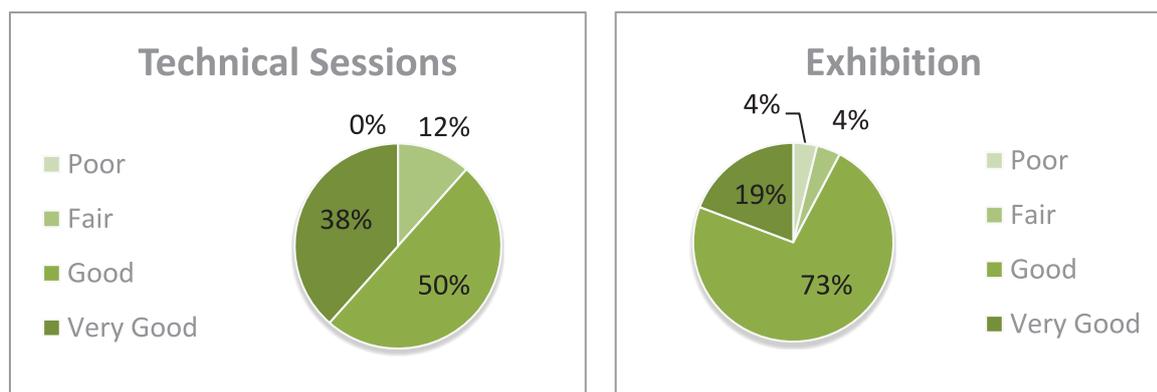


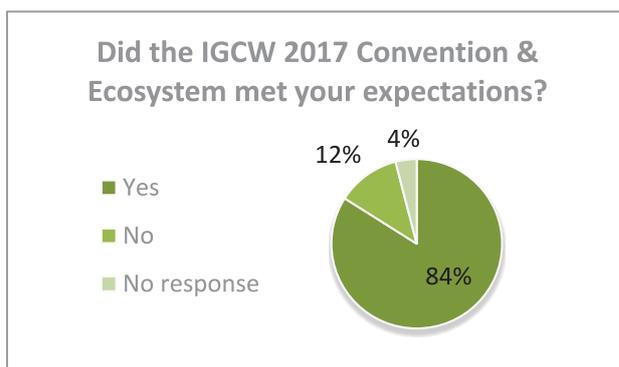
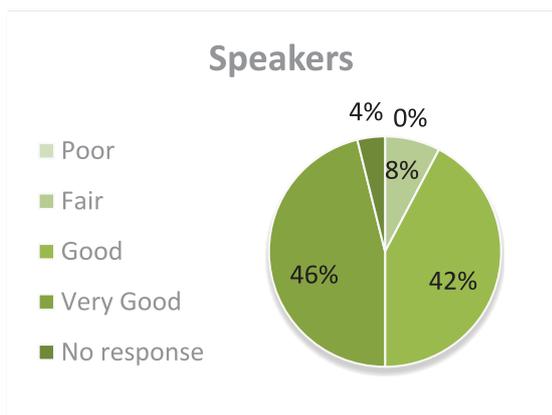
In the vote of thanks Dr. Pradnya Prabhu, Vice Principal, K. J. Somaiya College of Science and Commerce and Convener of the workshop expressed the appreciation and gratefulness to each and every one who worked for the workshop to make it a grand success, and acknowledged the workshop speakers for their time and contribution; and to the Green ChemisTree Foundation for collaborating to co-organise this workshop.

#### FEEDBACK & TESTIMONIALS

Below graphs are to share the results of the feedback survey conducted to assess participants' response to the overall content and structure of IGCW Convention.

It is observed that majority of participants (88%) of attendees found the technical sessions highly engaging as their response ranges from good (38%) to very good (50%) and about 92% attendees found the Exhibition of relevance and interest. The profile of speakers and content of the presentations received fairly balanced response, while the overall experience of the participants is evidently satisfying, with about 96% of respondents positively responding to the survey.





According to the feedback survey, majority of the respondents (84%), responded positively to the question “Did the IGCW ecosystem give you new ideas / possibilities to meet your Green Chemistry & Engineering requirements?” This evidently illustrates that the participants largely benefited from the overall structure of IGCW 2017 Convention & Ecosystem.

### Participants’ Testimonials

Below shared are few testimonials as received from the participants and exhibitors of IGCW-2017 Convention:

*“The IGCW 2017 was yet another outstanding landmark since the inception of the event in 2009. Powered by creative, diligent and committed eco-conservers the 2017 event raised the bar to a higher level of sustainability narrative and can rightfully take its position as one among the few global transformational forums. IGCW also has become an acronym for Integrated Green and Connected World”.*

Dr. R.Rajagopal, CEO, KnowGenix, India

---

*I am truly sorry I have to leave so suddenly and only after one day, but I am very proud of make part of your community and you are starting to become a tradition in my calendar! Great job!*

***Our industry is going to be exposed to massive changes and India/ Green Chemistry are going to be at the fore front!***

Rafael Cayuela, Chief Economist, The Dow Chemical Company, Switzerland.

---

*STEP winning the SERB-IGCW 2017 award was a good boost to the efforts STEP team and our partners in this technology, have taken in last 2 years to demonstrate and commercialize the novel Downflow Gas Contactor (DGC) technology for use in effluent treatment and chemical reactions.*

*We are happy that SERB and IGCW have recognized our innovative technology through this award. We are now looking forward to successfully commercialize the technology for effluent treatment.*

*We wish you & IGCW team more success in next conference in 2019, and will look forward to participate in it.*

Dr. MG Palekar, Step Solutions Pvt. Ltd., India

---

*We were overwhelmed with the hospitality offered to us by the organizers and the entire committee members of the IGCW. We also truly appreciate the efforts put by your TEAM who left no stone unturned to make it a successful event.*

Venkatesan Rajendran, Growtech Innovations India Pvt Ltd.

---

*It was great for me to see, as an Indian living abroad, how India is taking its responsibility seriously, and your great efforts to spread awareness (not all countries are doing that).*

*Even though we had some “issues”, we really enjoyed the conference. Karim got a lot of traction after his talk, and we have started discussions with many companies, interested to know more about Green Chemistry. It’s like Paul Anastas says: “Green chemistry is the best chemistry”, why shouldn’t all companies want that. Looking forward to meeting you again soon.*

Robin Chatterjee, Co-founder | Business development manager – Enginzyme. AB, Sweden.

---

*I want to express my sincere thanks to IGCW for recognizing our research labs’ work on green technology towards developing ‘biohydrogen production for waste feedstock’. The recognition conferred to this green technology will help and motivate us to take positive steps to promote and commercialize the technology with more confidence and enthusiasm. This will obviously pave way to much awaited ‘hydrogen economy’ which is needed for the sustainable future.*

*I would like to congratulate IGCW for taking up the excellent initiative to recognize the work going on in green chemistry domain from both academia and industry as well. I believe, this initiative will directly relate to the SDG goals and is crucial to promote sustainable community on the whole.*

**Dr. S Venkata Mohan, CSIR- IICT**

## Overall Outcome

The 5<sup>th</sup> IGCW 2017 Convention & Ecosystem was designed with the key agenda to progress from the “awareness phase” and accelerate the “implementation phase” of GC&E practices.

With this agenda and background, the Speakers were identified, topics were discussed and new features were integrated such that focussed interactions on subject-specific topics could be facilitated.

The regular feature of the IGCW Symposium presented about 12 case-studies by senior industry leaders, sharing their respective companies' integrated approach to drive GC&E implementation.

The other topics discussed at the Symposium also highlighted the implementation challenges and opportunities of emerging technologies and solutions such as flow chemistry processes, bio-based feedstock, biomimetic chemistries, etc.

The SERB-IGCW Awards motivated about 88 applicants from Industry, Academia and Research Institutes, of which 55 submissions met the GC&E implementation criteria and thus got shortlisted. The entire process from identifying GC&E practitioners to inviting them to apply for the SERB-IGCW Awards, and finally having received their on-line submissions has been a path-breaking journey as never in the history of Indian Chemical Industry such a single-focus attempt has been made to assess and document the trend and course of GC&E implementation in India.

The IGCW 2017 EXPO witnessed an all-time increase both quantitatively and qualitatively in its participation of solution providers. Considering the focus of the Convention on implementation the exhibitors were also broadly categorised based on their collective core-competencies vis-à-vis GC&E implementation. The categories included Green Processes & ZLD Solutions, Green Catalyst Solutions, Green Solvent Solutions and Green Informatic Tools; whereas three new clusters were integrated including the CSIR Pavilion, Flow Chemistry Pavilion and GC&E Start-ups' Pavilion.

The IGCW EXPO over the years has truly emerged as a credible platform for showcasing ready-to-implement GC&E technologies and solutions; while connecting the solution providers to the right decision makers of companies seriously engaging in the implementation of GC&E practices.

The other regular features of 180° Seminars on subject-specific topics and the exclusive PCB Conference for State PCB officers, are well received by the participants and thus continue to be important dimensions of the IGCW Ecosystem. The IGCW 2017 PCB Conference was much appreciated by the senior officer from German Environment Agency – Dr. Bettina Rechenberg, who heads the division of “Sustainable Production & Products, Waste Management”. Dr. Rechenberg's contribution as a Speaker in the PCB Conference added tremendous value to the quality of discussions and brought-home global best practices and insights to the participating State PCB Officers.

These apart, the new features as got integrated in the IGCW 2017 Ecosystem, were the practical workshop conducted by experts from ACS-Green Chemistry Institute's Pharmaceutical Roundtable (GCIPR) on topics which are most relevant and pressing for the initiation of GC&E practices- Solvent and Reagent selection tools and techniques; thus incorporating the global objective of IGCW-2017 Convention - “Accelerating GC&E Implementation”.

The other two new events viz.: CSIR Industry Interactions and the workshop on Emerging Tools & Technologies were also integrated to facilitate focussed interactions on topics pertinent for GC&E implementation. The exclusive session on CSIR-Industry interactions was found to be an essential dimension for driving successful collaborations and thereby accelerating GC&E implementation.

The exclusive workshops for Teachers (organised in collaboration with the R.D National College, Mumbai) and Students (in collaboration with Dept. of Chemistry, Somaiya College of Science & Commerce, Mumbai) received an overwhelming response from Teachers and Students across

Mumbai respectively. The speakers were particularly inspired to see the enthusiasm with which the students and teachers were engaging in interactions. Their avid interest in the subject indicates increase in awareness of GC&E amongst non-industry groups, and also indicates the rising felt-need for GC&E teaching tools and methodologies.

Overall the 5<sup>th</sup> IGCW-2017 Convention & Ecosystem met the expectations of all stakeholders, partners and participants. Most evidently it has successfully marked the beginning of the “*Green Chemistry & Engineering Implementation phase*” with companies taking keen interest in tangibly taking forward interactions with experts, solution providers; and exploring models which can enable them an integrated approach towards accelerating GC&E implementation in their respective organisations.

### Conclusion

The 5<sup>th</sup> IGCW-2017 Convention & Ecosystem was possible with support and partnership from various committed individuals and organisations who collectively share the vision of “Industrial Green Chemistry” for Indian Chemical Industry. IGCW takes this opportunity to acknowledge all its partners, speakers, sponsors for their tangible and intangible contribution; and its participants who entrusted their time and willingness to explore the promise of GC&E practices.

The 5<sup>th</sup> IGCW-2017 has been concluded with the promise to continue facilitation of GC&E interactions amongst various stakeholders. For this purpose an interactive portal in form of a digital application (IGCW App.) has been designed and launched. The objective of IGCW App. is to stay connected with experts, stay abreast on emerging technologies and solutions, exchange learnings with peer; and most importantly to sustain the momentum of GC&E implementation.



## 5th Industrial Green Chemistry World, Convention and Ecosystem, 5th and 6th October, Mumbai



Inauguration by (R to L) Dr. David Constable, Science Director, ACS-Green Chemistry Institute; Dr. Rajiv Sharma, Secretary, Science & Engg. Research Board, GOI; Shri Rajeev Kapoor, IAS, Secretary, Dept. of Chem. & PetroChem, GOI; Shri R Gopalkrishnan, Author and Corporate Advisor, Shri Sanjay Sethi, IAS, CEO, Maharashtra Industrial Development Cooperation; and Shri Nitesh Mehta, Convener IGCW 2017



Dr. David Constable, Science Director, ACS-GCI  
Keynote Address: Innovation: we won't get from here to there without it



Mr. R Gopalkrishnan, Former Director, TATA Sons  
Theme Ignition: How can smart people stop doing silly things?



Mr. Rafael Cayuela, Chief Economist, Corporate Strategy & Int. Gov. Affairs, The Dow Chemical Company  
Theme Ignition: The chemical industry under the 4th industrial revolution- Sustainable, Digital and Citizens one



Dr. Julien HITCE, L'Oreal R&I, Advanced Research, L'Oreal, France  
Theme Inspiration: Innovation from renewable resources at L'Oreal: Expanding the chemists toolbox



Mr. Srinivasaan, Managing Director,  
Pfizer Global Supply and R&D, India  
Theme Inspiration: Green For Good – Every Step Counts



Mr. Jeffrey Whitford, Head of Corporate Responsibility &  
Branding, Merck kGaA, Germany  
Theme Inspiration: Taking Green Chemistry from a  
Fad to Fixture at MERCK.



Dr. Ingrid Mergelsberg, Director-Process  
Chemistry, MSD, USA  
Theme Initiation: State-of-the-art Approaches to Sustainable  
Commercial Manufacturing Processes in the Pharmaceutical Industry



Dr. Julia Rowe, Group Sustainability Manager, Johnson  
Matthey, PLC, UK  
Theme Initiation: How our sustainability journey has been  
good for business: the first decade



Mr. Kumaresan Rajendran, South Asia Business Head,  
Clariant Chemicals India Ltd.  
Theme Initiation: Ecotain: Clariant's Approach to Sustainability



Dr. Ashutosh Agarwal, CSO, Jubilant Life Sciences Ltd.,  
Theme Initiation: Implementing Green and Sustainable  
Initiatives at Jubilant Life Sciences

## IGCW SYMPOSIUM DAY II, 6th Oct. 2017



Keynote Address By Prof. Ashwini Kumar Nangia, Director, CSIR – National Chemical Laboratories, India.  
Topic – Reducing the Carbon Footprint of Chemical Processes



Dr. Surendra Bhatia (LEFT), Sapec Agro SA – Director, Sapec Agro India &  
Mr. Nitesh Mehta (RIGHT), Co-Founder and Director, Green ChemisTree Foundation, India  
Theme: Identification: Identifying Challenging Chemistries in India



Prof. Chao-Jun Li, Canada Research Chair in  
Green/Organic Chemistry, McGill University  
Theme Identification: Exploration of New reactivities  
towards future of chemical sustainability

Mr. Mark Dorfman, Biomimicry Chemist,  
Biomimicry 3.8, USA  
Theme Invention: From Biomimetic Idea to  
Prototype: Key Factors for Success



Mr. Pascal METIVIER, Solvay Group, Senior Executive Vice President, Science and Technology Director  
Theme Innovation: Embedding Sustainability within Research and Innovation



Dr. Sandeep Mohanty, Director- Process Innovation, Dr. Reddy's Laboratories Ltd.  
Theme Innovation: Radical Approach to Simplicity in Process Design



Dr. Ashok Menon, Global Technology Leader- LCA, Corp. Sustainability. Div., SABIC India Pvt. Ltd.  
Theme Implementation: Business Value of LCA



Dr. P L Srinivas, Head, API R&D – Bangalore, Cipla India Ltd.  
Theme Implementation: Our Journey to Implementation of Green chemistry principles



Prof Oliver Kappe, Professor of Chemistry at the University of Graz, Austria  
Theme Industrialization: The use of continuous flow technology for Synthesis of Active Pharmaceutical Ingredients



Dr. Anuj Mittal, VP R&D, PI Industries Ltd., India  
Theme Industrialization: Process Control : Key to Achieve, Remove , Reduce and Recycle

## SERB – IGCW 2017 AWARDS, 5th Oct.



SERB-IGCW Winner being by Dr. Rajiv Sharma, Secretary, Science & Engg. Research Board, DST, Govt. of India  
Category: Guides and Researchers – Dr. S Venkata Mohan, CSIR-Indian Institute of Chemical Technology, Hyderabad



SERB-IGCW Winner being felicitated by Mr. Sushil Kharwal, VP-Env. & Safety, PI Industries Ltd.  
Category Students – Ms. Nalinee Suryavanshi, CSIR-National Chemical Laboratories, Pune.



SERB-IGCW Winner being felicitated by Mr. Ravi Kapoor, MD, Heubach India Ltd.,  
Category: Technology Development - GEIST Research Pvt. Ltd., Goa



SERB -IGCW Winner being felicitated by Mr. Srinivasan, MD, Pfizer Global Supply Chain and R&D, India  
Category Green Start Ups - Growtech Innovations, Chennai



SERB-IGCW being felicitated by Dr. Rajiv Sharma, Secretary, Science & Engg. Research Board, DST, Govt. of India  
Category: Small Scale Industries - Step Pvt. Ltd., Mumbai



SERB-IGCW Winner being felicitated by Dr. Bettina Rechenberg, German Environment Agency.  
Category MNC, Large & Medium Co. - Aarti Industries Ltd., Jhagadia

## IGCW-PCB CONFERENCE, 5th Oct. 2017



The MPCB Sponsored Conference on “Pollution Prevention at Source- Green Chemistry & Engineering Approach” exclusively for State Pollution Control Boards, got inaugurated by Dr. P. Anabalan, Member Secretary, Maharashtra Pollution Control Board; welcome address being given by Shri. P. K. Mirashe, Asst. Secretary, MPCB.



Dr. Bettina Rechenberg; Head of Division ‘Sustainable Production and Products, Waste Management’, German Environment Agency.  
Pollution prevention approach - models and success stories from German Environmental Agency



Dr. David Constable, Science Director, ACS-Green Chemistry Institute, USA  
Linking Enforcement with Opportunity; Driving Green Chemistry in Partnership



Dr. Sanjiv Bachal, VP- Technology, Equinox Software Services India Pvt., Ltd.  
Emerging solutions on effective solvent usage and minimization



Presentations by PCB Officers from Maharashtra, Gujarat, Telangana, West Bengal and Tamil Nadu  
Sharing of best practices on pollution prevention – collaborative approaches and initiatives

## 180° SEMINARS, 6th Oct. 2017



Prof. S S Bhagwat, Dept. of Chemical Engg., Coordinator, Centre of Excellence on Process Intensification, Institute of Chemical Technology (ICT) Process Intensification for sustainable industrial activities



Ms. Megha Shanbhag, Business Dev. Manager, Newreka Green Synth Technologies Pvt. Ltd. Recycle@SourceTM Solutions for 'green' processes



Speakers of Green Solvents Seminar: Dr. Sangeeta Srivastava, GM –Corporate R&D, Godavari Biorefineries Ltd. presented on Opportunities for Bio – Based Green Solvents; and Dr. C Nandi, Vice President, R&D at NOCIL Ltd., India Water as a solvent for chemical transformations



Dr. Jeff Eaves, General Manager, Circa Sustainable Chemicals Ltd. UK Developing Value added products from waste Cellulose



## 180° SEMINARS, 6th Oct. 2017



Dr. Bhalchandra M. Bhanage, Dept. of Chemistry,  
Institute of Chemical Technology (ICT)  
Sustainable Catalysts for the fixation of Co<sub>2</sub> & Co<sub>3</sub>  
as C-1 sources to synthesize value added chemicals



Mr. Tanmay Godiawala, GM, Reaxa Ltd., S-Amit  
Chemicals Pvt. Ltd.  
Greener Catalysts – Encapsulated metal catalysts to  
Achieve Easier, Faster & Cleaner Hydrogenation &  
Coupling Reaction Processes



Mr. Sarvanan Jothi, Associate Scientific Manager,  
IOSYNTH Labs  
Biocatalysis development in Pregabalin and Sitagliptin



Dr. Michael Puls, VP Business Development,  
evoxx Technologies, GmbH, Germany  
Enzyme Technology for Efficient Processes in Manufacturing.



Dr. M. G. Palekar, Head Strategy & Technology,  
STEP Pvt. Ltd.  
Process Intensification with Downflow Gas Contactor Reactor



Mr. Sandip Bose, Head of Operation Excellence  
at Sun API, Sun Pharmaceutical Industries Ltd.  
Green Engineering In Pharmaceutical industry.

## IGCW-FCS Flow Chemistry Workshop, 5th Oct. 2017



Mr. Kumar Oza, Pi-Process Intensification Exp. LLP  
Introduction to Flow Chemistry



Prof. C. Oliver Kappe, Professor of Chemistry,  
University of Graz  
On-Demand, On-Site Continuous Processing - The Concept of 'Chemical generators' in Modern Pharma & Fine Chemical Manufacturing



Prof. Anil Kumar, IIT – Bombay, Dept. Of Chemistry.  
Continuous flow processes, a new paradigm in organic synthesis



Mr. Manijinder Singh Phull, Unit Head, API-R&D,  
Cipla – Ltd., Intensifying Research using flow chemistry



Dr. Karim Cassimjee, Co-Founder and CEO, EnginZyme AB,  
Enzyme immobilization as an enabler for Biocatalysis in Flow



Mr. Vijay Kirplani, CEO, Pi – Process Intensification Exp. LLP,  
Tool box for Flow chemistry & Downstream Ops + Industrial Examples – Indian & Global

## IGCW Workshop on Emerging Tools and Technologies, 5th Oct. 2017



Mr. K K Bhagchandani, Sr. Dir., Asia & Pacific Business, ACD /Labs Dealing with organic impurities for Effective Life Cycle Management of chemical products



Dr. Avinash Kadam, MD, Sugam Paryavaran Vikalp Pvt. Ltd. Constructed Geological filter system : Green ways for zero liquid discharge



Dr. Chandrashekhar, CEO and Dir. Vision Earthcare Pvt. Ltd. Heuristics of ProceAss Design for Industrial Waste Water Recycling

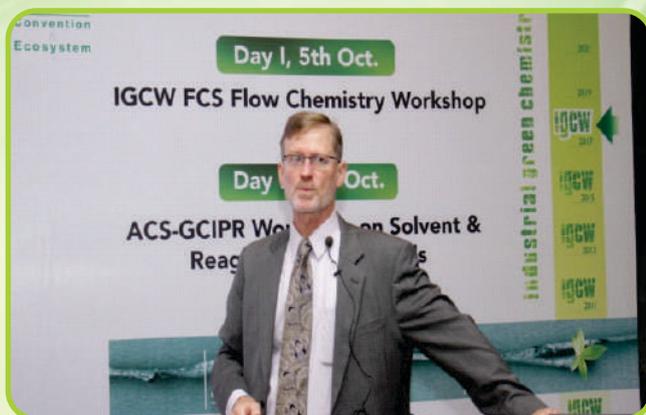


Dr. Sanjiv Bachal, VP-Technology, Equinox Software & Services MBDSTM: A new approach to batch distillation design and simulation



Industry representatives at the Workshop on Emerging Tools & Technologies

## IGCW GCIPR Workshop on Solvent and Reagent Selection Guide, 6th Oct. 2017



Dr. David Constable, Science Director, ACS -Green Chemistry Institute, Introduction / Green Chemistry Tools - Metrics



Dr. Ingrid Mergelsberg, Director Process Chemistry, MSD Green Chemistry Tools – Solvent / Reagent Selection Guides



Dr. Rajappa Vaidyanathan – Group Director, Chemical, Synthetic and Analytical Development, Bristol-Myers Squibb (I) Pvt. Ltd., Green Chemistry Case Studies based on the applications of Solvent & Reagent Selection Tools



Industry audience engaging in active interactions with the GCIPR experts

## IGCW CSIR-Industry Interactions, 6th Oct. 2017



Prof. Ashwini Kumar Nangia, Director, CSIR-NCL  
Inauguration & Welcome Address



Dr. Avtar Singh Matharu, Sr. Lecturer & Deputy Director,  
Green Chemistry Centre of Excellence, University of York  
Industry-Research Institutes collaborative models- global  
perspectives and best practices



Panel Discussion with a diverse panel of  
leaders from Industry & Research Institutes on  
Identifying gaps between Research Institutes &  
Industry collaboration & How to overcome



Dr. S S Tambe, Chair, Chemical Engg. & Process  
Devt. Div., National Chemical Laboratories  
Overview of water treatment & Continuous flow  
chemistry processes



Dr. B China Raju, Principal Scientist, CSIR – IICT  
IICT's Contribution towards the technology development



Dr. S Swarnalatha, Scientist - Environmental  
Technology, CSIR-CLRI  
CLRI's Wastewater Treatment technologies for  
industries to meet environmental standards

## IGCW TEACHERS' WOKSHOP, 7th Oct. 2017



Inauguration by dignitaries on dais and Welcome Address by Faculty



Dr. David Constable, Science Director,  
ACS-Green Chemistry Institute,  
Changing Chemistry Education is the foundation  
for a more Sustainable World



Dr. Anil Karnik, Prof. of Organic Chemistry, Former Head,  
Univ. of Mumbai- Dept. of Chemistry ;  
Chairperson, Board of Studies, University of Mumbai



Prof C. J. Li, Dept. of Chemistry, McGill University, Canada  
Green chemistry Research and education at McGill University



Dr. Ingrid Mergelsberg, Director-Process Chemistry, MSD-USA  
Industry perspective on the importance of green and sustainable  
Science education to drive innovation and a sustainable future



Mr. Mark Dorfman, Biomimicry Chemistry,  
Biomimicry 3.8 Nature is alive with green chemistry



Ms. Mona Malik, Country Manager & Society Services,  
ACS India Special address by ACS India, Chemistry for Life



Chemistry Teachers from Mumbai and Pune attended the Workshop,  
engaging in active interactions with the experts



Concluding remarks and acknowledgment by Dr Kiron Jathar, Vice-Principal,  
RD National College; and the Convener of IGCW Teachers' Workshop

## IGCW STUDENTS' WORKSHOP, 8th Oct. 2017



Inaugural Address by  
Shri Samir Somaiya, CMD, Godavari Biorefineries Ltd.



Welcome address by Dr. Vijay Doshi, Principal,  
K.J. Somaiya College of Sc. & Commerce



Dr. David Constable, Science Director,  
ACS-Green Chemistry Institute,  
Hope for a sustainable future – Students can Change the World



Mr. Nitesh Mehta, Co-founder & Director,  
Green ChemisTree Foundation  
Opportunity to create future in GC&E as a fulfilling  
and forwarding experience for all



Q&A with the Students



Dr. Ingrid Mergelsberg, Director- Process Chemistry, MSD  
Opportunities for Chemists and Chemical Engineers



Mr. Mark Dorfman, Biomimcry Chemist, Biomimicry 3.8  
Nature is Alive with Green Chemistry



Dr. Chandrashekhar, Director, Vision Earth Care Pvt. Ltd.  
Emerging Ecosystem for Enviropreneurs in India



Ms. Mona Malik Country Manager & Society Services,  
ACS - India Special address by ACS India, Chemistry for Life



Interactive Session on “Ready-to-use” Green Chemistry Tools- PMI Metrics, Solvent / Reagent Selection guide, etc.  
by Dr. David Constable, Science Director, ACS-Green Chemistry Institute, USA



## IGCW 2017 Attendees' List

Sr. No.	Company	Name	Designation	Participation Category
1	Aarti Industries Ltd.	Mr. Smit Chauhan	Manager - Process	Award Nominee
2	SOLVAY India	Dr. S. Mangaleswaran.	Research Scientist Research & Innovation.	Delegate
3	Aarvi Encon Ltd	Mr. V. D. Sanghavi	Managing Director	Delegate
4	ACD/Labs	Mr. Nancy Thomas	SM - SAARC Region	Exhibitor
5	ACD/Labs.	Mr. K. K. Bhagchandani	Sr. Director, Asia & Pacific Business	Speaker & Exhibitor
6	ACS - Green Chemistry Institute USA	Dr. David Constable	Science Director	Speaker
7	Adama India Pvt. Ltd.	Dr Bhoopal Meka		Visitor
8	Adama India Pvt. Ltd.	Dr. Bijukumar Gopinathan Pillai	R&D Head	Visitor
9	Advanced Enzyme Technologies Pvt Ltd.	Mr. Rahul Kirkinde	Business Head - API Healthcare	Delegate
10	Advanced Enzyme Technologies Pvt Ltd.	Mr. Simon Esser	Principle Scientist	Delegate
11	Advanced Enzyme Technologies Pvt Ltd.	Mr. Suresh Kumar	Project Leader - Technical	Delegate
12	American Chemical Society	Mr. Milind Wagh	Accounts executive - CAS	Exhibitor
13	American Chemical Society	Mr. Sujan Sekhar		Exhibitor
14	American Chemical Society	Ms. Mona Malik	India Program Manager	Exhibitor
15	Andhra Pradesh Pollution Control Board	Dr. B. Madhusudhan Rao	Joint Chief Envi. Engineer	PCB delegate
16	Andhra Pradesh Pollution Control Board	Shri. K. Srinivas	Sr. Envi. Scientist	PCB delegate
17	Asai Vishwa Specialty Chemicals Ltd.	Dr. Vidyadhar Jadhav		Delegate
18	Asian Paints Limited	Dr. Randhir Singh Parmar	Sr. Manager - Technology	Delegate
19	Astec Lifesciences	Mr. Valmik Dhakane	Chairman and Managing Director	Delegate
20	ATR - Asahi Process Systems (P) Ltd.	Mr. Asif T. Rangwala	Managing Director	Delegate
21	ATR - Asahi Process Systems (P) Ltd.	Mr. Girish S. Nanoti		Exhibitor
22	ATR - Asahi Process Systems (P) Ltd.	Ms. Chaitali Desai		Exhibitor
23	Atul Ltd.	Dr. Mayur Desai	Senior Manager - R&D	Visitor
24	Atul Ltd.	Shrinivas S Nituri	Senior Manager	Visitor
25	Atul Ltd.	Dr. S K Singh	Sr. Manager - Manufacturing	Visitor
26	Atul Ltd.	Nilesh Thakur	Senior Manager - Projects	Visitor
27	AVA Chemical Pvt Ltd	Mr Sankal Jivnae	Assistant Manager - Sales	Delegate
28	Azeocryst Organics Pvt Ltd	Mr. Mohit Phalak	Sr. Manager	Delegate
29	Azeocryst Organics Pvt Ltd	Mr. Nandakishor Bhirud	Manager	Delegate
30	BASF India Pvt. Ltd.	Dr. Harish Shinde	Global R & D - crop protection	Delegate
31	BASF India Pvt. Ltd.	Dr. Mushtaq Patel	Performance product discovery, RAV/OM	Delegate
32	BEW Engg Pvt. Ltd	Mr. Prakash Lade	Director	Delegate
33	Biomimicry 3.8, USA	Dr. Mark Dorfman	Biomimicry Chemist	Speaker
34	Borax Morarji Ltd.	Mr. Umesh Shetkar	Chief Executive Officer	Delegate
35	Bristol-Myers Squibb	Dr. Rajappa Vaidyanathan	Group Director-Chemical, Synthetic & Analytical Development	Speaker
36	BuchiGlas India Pvt. Ltd.	Mr. Ashwin Chawda	Managing Director	Delegate
37	BuchiGlas India Pvt. Ltd.	Mr. Raghavendra N S	Director	Delegate
38	BuchiGlas India Pvt. Ltd.	Mr. Vinamra Singh	Sales Manager	Delegate
39	Cargill	Mr. Keerthy Pethaiyan	Manager	Delegate
40	Centaur Pharmaceuticals Pvt. Ltd.	Dr. Milind Pawar	Vice President - R&D	Delegate
41	Centaur Pharmaceuticals Pvt. Ltd.	Mr. Anil Naik	Director	Delegate
42	Centaur Pharmaceuticals Pvt. Ltd.	Mr. Ashok Walunj	Works Manager	Delegate
43	Centaur Pharmaceuticals Pvt. Ltd.	Mr. Hemant Goim	Assistant Manager	Delegate
44	CETP - Badlapur	Shri. Ajay J Saboo	Director	Invitee
45	CETP - Badlapur	Shri. Dharmendra Desai	Director	Invitee
46	CETP - Badlapur	Shri. Haresh S Jasani	Director	Invitee
47	CETP - Badlapur	Shri. Khushal S Jain	Chairman	Invitee
48	CETP- Ambernath Manufacturers Association	Mr. Umesh Tayade	Chairman	Invitee
49	CETP- Thane Belapur	Shri. R. S. Diwadkar		Invitee
50	CETP- Thane Belapur	Shri. S. R. Iyer		Invitee
51	CETP, Mahad Manufacturers Association	Mr. Ashok Talathi		Invitee

52	CETP, Mahad Manufacturers Association	Mr. Govinda Borole		Invitee
53	CHEMARC Trademill Technologies Pvt. Ltd.	Punit Krishna.	Director.	Visitor
54	Chemical Regulation Advisor	Dr. Rashmi Naidu	Independent Chemical Regulations Advisor,	Invitee
55	Chemical Weekly, India	Dr. Ajit Doshi		Media
56	Chemical Weekly, India	Iyer Kiran	Head Marketing and Sales	Media
57	Chromatopak Analytical Instrumentation (I) Pvt. Ltd.	Mr. Remacio Fernandes	Director	Exhibitor
58	Chromatopak Analytical Instrumentation (I) Pvt. Ltd.	Mr. Sheldon Fernandes	DGM-Sales &Mktg	Exhibitor
59	Cipla Ltd.	Dr A Srinivasa	Senior Manager - R&D and API	Delegate
60	Cipla Ltd.	Dr. P. L. Srinivas	Head API R&D - Bangalore	Speaker
61	Cipla Ltd.	Mr. Arun Gorule		Delegate
62	Cipla Ltd.	Mr. Kapil Hire		Delegate
63	Cipla Ltd.	Mr. Manjinder Singh Phull	Unit head, API-R&D	Speaker
64	Cipla Ltd.	Mr. Nitin Thakur	R&D officer	Delegate
65	Circa Sustainable Chemicals, UK	Dr. Jeff Eaves		Exhibitor
66	Circa Sustainable Chemicals, UK	Mr. Tony Duncan	MD, Co-founder & CEO	Exhibitor
67	Clariant Chemicals India Ltd.	Mr. Adnan Ahmad	Vice-Chairman & Managing Director	Session Chair
68	Clariant Chemicals India Ltd.	Mr. Hemant Iswalkar		Delegate
69	Clariant Chemicals India Ltd.	Mr. Kumaresan Rajendran	South Asia Business Head	Speaker
70	Clariant Chemicals India Ltd.	Mr. M M Sait		Delegate
71	Clariant Chemicals India Ltd.	Mr. Mandar Lone	R&D Scientist	Delegate
72	Clariant Chemicals India Ltd.	Mr. Murali Puthige	Vice President and Regional Head - Sustainability & Regulatory Affairs	Delegate
73	Clariant Chemicals India Ltd.	Mr. Sachin Betkar		Delegate
74	Clariant Chemicals India Ltd.	Dr. Achala Danait	R&D Head	Invitee
75	Cleanchem Laboratories LLP	Mr. Nitin Bondre	Director	Exhibitor
76	Cleanchem Laboratories LLP	Dr. Babu Gawade	Director	Awards Nominee
77	Colourtex Industries Pvt Ltd.	Dr. Ashit Vashi	Manager - R&D	Delegate
78	Colourtex Industries Pvt Ltd.	Mr. Ismail Habbibullah	Head - Production	Delegate
79	Consulate General of Belgium, AWEX Mumbai	Emmanuelle Timmermans	Trade and Investment Commissioner	Invitee
80	Convener - 5th IGCW - 2017	Mr. Nitesh H Mehta	Founder Director	Organizer
81	CSIR - NCL	Ms. Nalinee Suryavanshi	Student	Awards Nominee
82	CSIR-Central Leather Research institute, India	Dr. S. Swarnalatha	Scientist-Environmental Technology	Speaker
83	CSIR-Indian Institute of Chemical Technology	Dr. S. Venkata Mohan	Researcher / Guide	Awards Nominee
84	Cygni Energy Pvt. Ltd.	Mr. Praveen B	DGM	Awards Nominee
85	Deepak Nitrile Ltd.	Mr. Praveen Desai	Chief Manager - Technical Services	Delegate
86	Deepak Nitrile Ltd.	Mr. Ravindra Ughade	SR. Manager - R&D	Delegate
87	Dept of Chemicals and Petrochemicals	Mr. Rajeev Kapoor	Secretary, Dept. of Chemicals & Petrochemicals, Govt. of India	Guest-of-honour
88	DESIGN & INNOVATION LAB.	Pradip Subramaniam.	Founder Director & CEO.	Awards Shortlisted nominee
89	Deven Supercriticals Pvt. Ltd.	Dr. Swapneshu Baser	Director	Awards Shortlisted nominee
90	Dharamsi Morarji Chemical Co. Ltd., (DMCC)	Mr. Bimal Goculdas	CEO	Speaker
91	Dombivali Better Environment System Association	Ashok Maheshwari	Chairman	Visitor
92	Dow Chemical Company, Switzerland	Mr. Rafael Cayuela	Chief Economist, Corporate Strategy & Int. Gov. Affairs	Speaker
93	Dr. Reddy's Laboratories Ltd	Dr Balasaheb More	Manager - Process Innovation	Delegate
94	Dr. Reddy's Laboratories Ltd	Dr. N. M. Sekhar	Senior Manager	Delegate
95	Dr. Reddy's Laboratories Ltd	Dr. Sandeep Mohanty	Director - Process Innovation	Speaker
96	DSM Sinochem Pharmaceuticals India Pvt Ltd	Mr. Manjit Singh		Delegate
97	Embassy of France	Mr. Kushal Sengupta	Trade Advisor- Industries & Cleantech Department	Invitee
98	Enginzyne AB	Mr. Karim Engelmark Cassimje	Co-founder & CEO	Speaker
99	Enginzyne AB	Mr. Prasad Rane	Head of Sales - India	Exhibitor
100	Enginzyne AB	Mr. Robin Chatterjee	Co - Founder & Business Development	Exhibitor
101	Equinox software & Services Pvt Ltd.	Dr. Alok Pandit	Director	Exhibitor
102	Equinox software & Services Pvt Ltd.	Dr. Sanjiv Bachal	Vice President	Exhibitor
103	Equinox software & Services Pvt Ltd.	Mr. Avinash Patil		Exhibitor

104	Equinox software & Services Pvt Ltd.	Mr. Srinivas Yerabatu		Exhibitor
105	Eternis Fine Chemicals Limited.	Dr. VedPrakash Mishra	General Manager - R&D	Delegate
106	Evonik Industries	Murali Iyer	Sr Manager - Administration	Visitor
107	evoxx technologies GmbH, Germany	Dr. Michael Puls	VP Business Development	Exhibitor
108	Excel Industries Ltd	Dr. L.S. Patil	Chief Manager – R & D	Delegate
109	Excel Industries Ltd	Dr. Ram Bankar		Delegate
110	Excel Industries Ltd	Dr. Vikas Shinde		Delegate
111	Excel Industries Ltd	Mr. A.K. Phase	Chief Manager – EHS	Delegate
112	Excel Industries Ltd	Mr. Kiran Paranjpe	Vice President - New Business Development	Delegate
113	Excel Industries Ltd	Mr. N. R. Kannan	CEO	Delegate
114	Excel Industries Ltd	Mr. Omkar Gokhale	Sr. Officer – R & D	Delegate
115	Excel Industries Ltd	Mr. Parag Karambele	Sr. Manager – Projects	Delegate
116	Excel Industries Ltd	Mr. Sachin Jadhav	Sr. Manager – R & D	Delegate
117	Excel Industries Ltd	Mr. Saurabh Shah		Exhibitor
118	G B Pant University of Agriculture and Technology	Ms.Sunita Bhandari	Phd Student	Delegate
119	Geist Research Pvt. Ltd.	Mr. Vikram Dhumal	Head - Technology	Awards Shortlisted nominee
120	Geocycle India	Mr. Ulhas Parlikar	Director	Speaker
121	Geocycle India	Mr. Varun Boralkar	RegionalSales Head - East	Delegate
122	Geocycle India	Ms. Nidhi Nair	Regional Sales Head - South Central	Delegate
123	Geocycle India	Kaushal Vyas	Asst. Manager - Business Development & Market Intelligence	Exhibitor
124	Geocycle India	Satish Salunkhe	Sales Head - South Central	Exhibitor
125	Geocycle India	Sanket Deshmukh	Business Development Manager	Exhibitor
126	Geocycle India	Sharmistha Nandi	Head - Business Development & Market Intelligence	Exhibitor
127	German Environment agency	Dr. Bettina Rechenberg	Head of division "Sustainable Production and Products, Waste Management", German Environment Agency	Delegate
128	Gharda Chemicals Ltd	Taher S Dakorwala	General Manager - Marketing	Delegate
129	Glenmark Pharmaceuticals Ltd	Dr. Anthony Melvin Crasto	Principal scientist, Process research,	Invitee
130	Global Infinite Green Power	Mr. Ravindra Adage	Founder and Director	Delegate
131	Global Infinite Green Power	Mr. Willson Chatair	Marketing Manager	Delegate
132	Godavari Biorefineries Ltd.	Ms. Alka Jayaswal		Exhibitor
133	Godavari Biorefineries Ltd.	Dr. Ganesh Kumar		Exhibitor
134	Godavari Biorefineries Ltd.	Ms. Manisha Jadhav		Exhibitor
135	Godavari Biorefineries Ltd.	Mr. S. G. Mokashi		Delegate
136	Godavari Biorefineries Ltd.	Mr. Sandeep Gupta		Exhibitor
137	Godavari Biorefineries Ltd.	Mr. Shirish Paranjpe		Exhibitor
138	Godavari Biorefineries Ltd.	Mr. Vishal Wadangale		Exhibitor
139	Godavari Biorefineries Ltd.	Ms. Shanta Pillai		Delegate
140	Godavari Biorefineries Ltd., India	Dr. Sangeeta Srivastava	Corporate R & D	Speaker
141	Godrej Agrovet Limited	Mr. Burjis Godrej	New Product Development Manager at	Delegate
142	Godrej Agrovet LTD	Dr. Jayant Umarye		Delegate
143	Godrej Agrovet LTD	Dr. Pramod Sahu		Delegate
144	Godrej Consumer Products Ltd.	Keshav Kabra.	Senior Executive - Green.	Delegate
145	Godrej Industries ltd	Mr. Vidyadhar L Takle	Assistant Manager	Delegate
146	Godrej Industries ltd	Ms. Susmita Ray	Senior Officer - Safety	Delegate
147	Green ChemisTree Foundation	Mrs. Krishna B Padia	Executive Director	Organiser
148	Green ChemisTree Foundation	Mrs. Sandra D'sa	Manager - Green Partnerships	Organiser
149	Green ChemisTree Foundation	Ms. Malka Doshi		Organiser
150	Green Chemistry Centre of Excellence, University of York, UK	Dr. Avtar Matharu	Deputy Director	Exhibitor & Speaker
151	Green Pyramid Biotech Pvt. Ltd.	Mr. Mihir Mehta	Founder	Exhibitor
152	Growtech Innovation, IITM	Mr. Pradip Subramaniam	CEO & Founder	Exhibitor
153	Growtech Innovation, IITM	Mr. Venkatesan Rajendran	Innovation Manager	Exhibitor
154	Gujarat Pollution Control Board	Shri. M. G. Barad	Dy. Envi. Engineer	PCB Conference
155	Gujarat Pollution Control Board	Shri. V. M. Prajapati	Dy. Envi. Engineer	PCB Conference
156	Gujarat Pollution Control Board	Shri. Y. A. Tai	Sr. Envi. Engineer	PCB Conference
157	GVK Biosciences Pvt Ltd.	Mr. Tapas Chakraborty	Head - Corporate EHS and Sustainability	Delegate
158	Harmony	Mrs. Vineeta Muni	Proprietor	Invitee
159	Hikal Ltd.	Mr. Narendra Dharmadhikari	AGM	Delegate
160	Hikal Ltd.	Mr. Sachin Potdar	Sr. Manager	Delegate
161	Hikal Ltd.	Mr. Shrikant Kamble	AGM	Delegate
162	Hikal Ltd.	Mr. Shrikant Padhy	Dy. Manager	Delegate
163	Hikal Ltd.	Mr. Suresh Sutar	Manager	Delegate

164	Huntsman International India Pvt Ltd	Mr. Jitesh shah	Process Development Chemist	Delegate
165	Huntsman International India Pvt Ltd	Mr. Nipun Soni	Site Head	Delegate
166	Huntsman International India Pvt Ltd	Mr. Rajendra Gohil	Process Engineering Manager	Delegate
167	Huntsman International India Pvt Ltd	Mr. Vishal Oberoy	Site Project Manager	Delegate
168	IICT-Hyderabad	Dr. B. China Raju	Principal Scientist	Exhibitor
169	IICT-Hyderabad	Dr. Haridas B Rode	Sr. Scientist	Exhibitor
170	IIT - B Monash Research Academy	Ms. Vasudha Kotia	Student	Delegate
171	IIT Bombay, Dept. of Chemistry	Prof. Anil Kumar	VP - Flow Chemistry Society-India Chapter	Speaker
172	IIT-Bombay	Prof. Sambasivarao Kotha	Researcher / Guide	Delegate
173	IIT-Kharagpur	Prof. Sirshendu De	Researcher / Guide	Awards Shortlisted nominee
174	Independent Biocatalyst Consultant	Mr. Vyasa Rajasekar	Consultant - Enzyme process	Delegate
175	Institute of Chemical Technology (ICT)	Anil Satpathy		Delegate
176	Institute of Chemical Technology	Mr. Anand Jadhav	Student	Awards Shortlisted nominee
177	Institute of Chemical Technology	Mr. Chandrakant Holkar	Student	Delegate
178	Institute of Chemical Technology	Prof. Bhalchandra M. Bhanage	Professor of Industrial and Engineering Chemistry & Dean (ICD)	Speaker
179	Institute of Chemical Technology	Prof. Dr. M. Sivram	Visiting Professor	Invitee
180	Institute of Chemical Technology	Prof. S. S. Bhagwat	Professor of Chemical Engineering	Speaker
181	Ion Exchange India Ltd.	Mr. C. K. Sandeep	Senior Vice President	Exhibitor
182	Ion Exchange India Ltd.	Mr. Hemant Joglekar	Associate VP Resin Sales	Speaker
183	Ion Exchange India Ltd.	Mr. Nitin Umbralkar	Associate VP Western Operations Head	Speaker
184	Ion Exchange India Ltd.	Sneha Ramji	Officer - Technology	Exhibitor
185	Ion Exchange India Ltd.	VishalSathe	Deputy Manager - Corporate Marketing	Exhibitor
186	Ion Exchange India Ltd.	Amit Deka	Product Manager - Specialty Applications	Exhibitor
187	Ion Exchange India Ltd.	Poulomi Banerjee	Sr. Executive - Technology	Exhibitor
188	Iosynth Labs Pvt Ltd.	Mr. Prasad Nair	Director	Exhibitor
189	Iosynth Labs Pvt. Ltd.	Mr. Saravanan Jothi	Associate Scientific Manager	Speaker
190	Jay Chemical Industries Ltd.	Mr. Amrut Dama	Senior Executive	Delegate
191	Jay Chemical Industries Ltd.	Mr. Pradeep Gandhi	Principal Scientist	Delegate
192	Jay Chemical Industries Ltd.	Mr. Rajesh Mishra	Senior Scientist	Delegate
193	Johnson Matthey	Mr. Abhik Tayal	Deputy Manager - Business Development	Delegate
194	Johnson Matthey, plc, UK	Dr. Julia Rowe	Group Sustainability Manager	Speaker
195	Jubilant Life Sciences Ltd.	Dr. Ashutosh Agarwal	CSO	Speaker
196	Kairav Chemofarbe Industries Ltd	Mr. Aditya Pattani	Director	Delegate
197	Kansai Nerolac Paints Ltd	Mr. Mahesh Darekar	Chief Manager - Technical Services	Delegate
198	Kansai Nerolac Paints Ltd	Mr. Manoj Somani	Senior Manager - QA	Delegate
199	KnowGenix, India	Dr. R. Rajagopal	CEO	Speaker
200	L'Oreal India Pvt. Ltd.	Dr. Nita Roy	Head Advanced Research	Delegate
201	L'Oreal India Pvt. Ltd.	Dr. Prashant Shankar Hegde	Principal Scientist	Delegate
202	L'Oreal India Pvt. Ltd.	Dr. Steve Thomas Pannakal	Senior Scientist	Delegate
203	L'Oreal India Pvt. Ltd.	Mr. Sanket Shetty	Senior Executive	Delegate
204	L'Oreal India Pvt. Ltd.	Mr. Siddhesh Saigaonkar	Executive	Delegate

205	L'Oreal India Pvt. Ltd.	Ms. Tejal Adulkar	Executive	Delegate
206	L'Oreal, France	Dr. Julien Hitce	Process-driven Innovation – Team leader, L'Oreal R&I - Advanced Research	Speaker
207	Lupin Ltd.	Dr. Kamlesh Padiya	Associate Director	Speaker
208	Lupin Ltd.	Mr. Amit Karche	Research Scientist	Delegate
209	Lupin Ltd.	Mr. Rajendra Pawar	SR Vice president	Delegate
210	Lupin Ltd.	Mr. Rajesh Shankar	Research Scientist	Delegate
211	Lupin Ltd.	Mr. Sachin Ingawale	Research Scientist	Delegate
212	Lupin Ltd.	Mr. Shantanu Varade	Research Associate	Delegate
213	Lupin Ltd.	Mr. Yogesh Pawar	Research Scientist	Delegate
214	Lupin Ltd.	Ms. Priyanka thakur	Quality Control	Delegate
215	M. R. Impex	Mr. Rajesh Jain		Invitee
216	Maharashtra Pollution Control Board	Dr. P. Anbalagan	Member Secretary	Guest-of-honour
217	Maharashtra Industrial Development Corporation	Shri R. V. Sonje	CE (HQ)	PCB Conference
218	Maharashtra Industrial Development Corporation	Ku. S. K. Sonule	JE (Env)	PCB Conference
219	Maharashtra Industrial Development Corporation	Mrs. P. S. Rele	DE (Env)	PCB Conference
220	Maharashtra Industrial Development Corporation	Shri K. S. Bhandekar	EE (Alibaug)	PCB Conference
221	Maharashtra Industrial Development Corporation	Shri P. P. Nandusekar	Advisor (Env)	PCB Conference
222	Maharashtra Industrial Development Corporation	Shri P. T. Karavade	EE (Env),	PCB Conference
223	Maharashtra Industrial Development Corporation	Shri R. S. Zanzad	SE (Kokan)	PCB Conference
224	Maharashtra Industrial Development Corporation	Shri S. A. Darade	SE (Pune II)	PCB Conference
225	Maharashtra Industrial Development Corporation	Shri S. B. Patil	CE (Pune)	PCB Conference
226	Maharashtra Industrial Development Corporation	Shri S. H. Kalaskar	DE (Taloja)	PCB Conference

227	Maharashtra Industrial Development Corporation	Shri. Sanjay Sethi	CEO	PCB Conference
228	Maharashtra Pollution Control Board	Dr. A. N. Harshvardhan	Regional Officer, Raigad	PCB Conference
229	Maharashtra Pollution Control Board	Dr. Amar R. Supate	Principal Scientific Officer	PCB Conference
230	Maharashtra Pollution Control Board	Dr. Y. B. Sontakke	Joint Director WPC	PCB Conference
231	Maharashtra Pollution Control Board	Mr. Amar Durgule	Sub-Regional Office Kalyan-I	PCB Conference
232	Maharashtra Pollution Control Board	Mr. Anirudha P. Varale	Field Officer, AST Section	PCB Conference
233	Maharashtra Pollution Control Board	Mr. Manchak Jadhav	Sub-Regional Office Kalyan-II	PCB Conference
234	Maharashtra Pollution Control Board	Mr. Manish Holkar	Sub-Regional Office Tarapur-I	PCB Conference
235	Maharashtra Pollution Control Board	Mr. P. K. Mirashe	Asst. Secretary (Tech.)	PCB Conference
236	Maharashtra Pollution Control Board	Mr. Pradeep Wankhede	Sub-Regional Office Navi Mumbai-II	PCB Conference
237	Maharashtra Pollution Control Board	Mr. Rajaram Injulkar	Field Officer, AST Section	PCB Conference
238	Maharashtra Pollution Control Board	Mr. Sachin Adkar	Sub-Regional Office Raigad-I	PCB Conference
239	Maharashtra Pollution Control Board	Mr. Sangram Nimbalkar	Field Officer	PCB Conference
240	Maharashtra Pollution Control Board	Mr. Shankar R. Said	Sub-Regional Office Thane-I	PCB Conference
241	Maharashtra Pollution Control Board	Mr. Shankar Waghmare	Sub-Regional Office Raigad-II	PCB Conference
242	Maharashtra Pollution Control Board	Mr. Sujit Dholam	Sub-Regional Office Kalyan-III	PCB Conference
243	Maharashtra Pollution Control Board	Mr. Yogesh Deshmukh	Field Officer, AST Section	PCB Conference
244	Maharashtra Pollution Control Board	Mr. A. D. Mohekar	Regional Officer, Navi Mumbai	PCB Conference
245	Maharashtra Pollution Control Board	Mr. D. B. Patil	Regional Officer, Kalyan	PCB Conference
246	Maharashtra Pollution Control Board	Mr. V. V. Killedar	I/c. Regional Officer, Thane	PCB Conference
247	McGill, Canada	Prof. Chao-Jun Li	Professor - Canada Research Chair in Green/Organic Chemistry	Speaker
248	Mechemo Resins Pvt Ltd.	Mr. Chaitanya Shah	Executive Director	Full Convention
249	Meghmani Pigments	Mr. Neeraj Kumar	Director	Full Convention
250	Meghmani Pigments	Mr. Satrugna Maity	Vice President	Full Convention
251	Merck KGaA, Germany	Mr. Jeffrey Whitford	Head of Corporate Responsibility & Branding	Speaker
252	Mettler Toledo India Pvt. Ltd.	Mr. Dilip Khandekar	Technological and Application Scientist	Exhibitor
253	Mettler Toledo India Pvt. Ltd.	Mr. Harshwadan Joshi	Senior Technological and Application Consultant	Exhibitor
254	Mettler Toledo India Pvt. Ltd.	Mr. Mehul Rajgor	Business Manager	Exhibitor
255	Micro Labs Ltd.	Mr. Pramod Kumar	AGM	Delegate
256	MIDC. MPCB.	P.P. Nandusekar.		PCB Conference
257	MSD, USA	Dr. Ingrid Mergelsberg	Director - Process Chemistry	Speaker
258	Navin Flourine international Ltd.	Dr. Vitthal Gund	AGM	Delegate
259	Navin Flourine international Ltd.	Mr. Sanjay Suman	Research Scientist	Delegate
260	NCL-Pune	Dr. C. V. Rode	Chief Scientist, Chemical Engineering and Process Development Division	Delegate
261	NCL-Pune	Dr. P. K. Ingle	Head, Publication and Science Communication	Delegate
262	NCL-Pune	Dr. S. S. Tambe	Chair, Chemical Engineering and Process Development Division	Delegate
263	NCL-Pune	Dr. V. M. Bhandari	Senior Principal Scientist, Chemical Engineering and Process Development Division	Delegate
264	NCL-Pune	Prof. Ashwini Kumar Nangia	Director	Speaker
265	NEERI-Nagpur	Dr. Amit Bansiwala	Principal Scientist, CSIR-NEERI.	Delegate
266	NEERI-Nagpur	Dr. Rakesh Kumar	Director	Speaker
267	NEERI-Nagpur	Dr. Shalini Tandon	Sr. Scientist, CSIR-NEERI	Exhibitor
268	NEERI-Nagpur	Dr. Yogesh Pakade	Scientist, CSIR-NEERI	Exhibitor

269	NEERI-Nagpur	Mr. Jowin Joseph	Scientist, CSIR-NEERI.	Exhibitor
270	NEERI-Nagpur	Mr. Prakash Kumbhare	Principal Scientist, CSIR-NEERI.	Exhibitor
271	NEERI-Nagpur	Ms. Shilpa Kumari	Scientist, CSIR-NEERI.	Exhibitor
272	Newreka Green Synth Technologies Pvt Ltd	Mr. Ajay Ratnaparkhi	Production Manager, Newreka Green Synth Technologies Pvt. Ltd.	Organiser
273	Newreka Green Synth Technologies Pvt Ltd	Mr. Bhadresh K Padia	Founder Director	Organiser
274	Newreka Green Synth Technologies Pvt Ltd	Mr. Gaurav Bartakke	Accounts executive	Organiser
275	Newreka Green Synth Technologies Pvt Ltd	Mr. Ishan Rawal		Organiser
276	Newreka Green Synth Technologies Pvt Ltd	Mr. Krishnakumar Shukla	Sr. R & D Chemist	Organiser
277	Newreka Green Synth Technologies Pvt Ltd	Mr. Munavvar Ali Shaikh		Organiser
278	Newreka Green Synth Technologies Pvt Ltd	Mr. Muneer Shaikh	Sr. R & D Chemist	Organiser
279	Newreka Green Synth Technologies Pvt Ltd	Mr. Nagnath Gaikwad		Organiser
280	Newreka Green Synth Technologies Pvt Ltd	Mr. Prakash Dussa	Chemical Engineer	Organiser
281	Newreka Green Synth Technologies Pvt Ltd	Mr. Rupesh		Organiser
282	Newreka Green Synth Technologies Pvt Ltd	Mr. Satish Shinde	Admin Officer	Organiser
283	Newreka Green Synth Technologies Pvt Ltd	Mr. Tushar Chaudhari	Sr. R & D Chemist	Organiser
284	Newreka Green Synth Technologies Pvt Ltd	Mrs. Ashwini Gunnal-Kothe	R&D Manager	Speaker
285	Newreka Green Synth Technologies Pvt Ltd	Mrs. Pinki Patel	R & D Incharge	Organiser
286	Newreka Green Synth Technologies Pvt Ltd	Mrs. Shruti		Organiser
287	Newreka Green Synth Technologies Pvt Ltd	Mrs. Sonam		Organiser
288	Newreka Green Synth Technologies Pvt Ltd	Ms. Alpa Gohil		Organiser
289	Newreka Green Synth Technologies Pvt Ltd	Ms. Megha Shanbhag	Business Development Manager	Speaker
290	Nocil Ltd.	Dr. C. Nandi	V.P - R&D	Speaker
291	Nocil Ltd.	Dr. Santosh Chemate		Delegate
292	Nocil Ltd.	Dr. Vikas Padalkar	Manager	Delegate
293	Novecare Technology Center	Mr. Balvant Singh	Senior Scientist - R&I	Delegate
294	Novozymes	Dr. Dinesh Nair	Sales Manager	Delegate
295	Novozymes	Mr. Michael Foldager	Director	Delegate
296	Novozymes	Austin Huang	Sales & DB Manager - Biocatalyst/Production	Delegate
297	Panel of Asian Development Bank	Dr Ajay A Deshpande	as Member of Compliance Panel of Asian Development Bank, Pune.	Guest-of-honour
298	Pfizer	Mr. Srinivivasan	Managing Director	Speaker & Invitee
299	PI Industries Ltd.	Dr. S. Srinivas Rao.	DGM - Research & Development.	Delegate
300	PI Industries Ltd.	Dr. Harish Swarnkar.	Sr. Team Leader.	Invitee
301	PI Industries Ltd.	Dr. Anuj Mittal	VP R&D	Speaker
302	Pidilite Industries Ltd.	M. Bhavana Motirale	Section Head	Delegate
303	Pidilite Industries Ltd.	Mr. Arun Waghmare	Vice president	Delegate
304	Pidilite Industries Ltd.	Mr. Arvind Mahajan	Head	Delegate
305	Pidilite Industries Ltd.	Mr. R. N. Mohanty	President - Technology	Speaker
306	Pidilite Industries Ltd.	Mr. S. K. Tewari	Manager	Delegate
307	Pidilite Industries Ltd.	Mr. Sachin Kirne	Executive	Delegate
308	Pidilite Industries Ltd.	Mr. Sharad Patel	Section Head	Delegate
309	Pi-Process Intensification Exp. LLP	Mr. Kumar Oza		Exhibitor
310	Pi-Process Intensification Exp. LLP	Mr. Madhav Sapre		Exhibitor
311	Pi-Process Intensification Exp. LLP	Mr. Vijay Kirpalani	CEO	Speaker
312	Praj Industries Ltd	Mr. Gaurav Goyal	Head Of Business Development-Critical Process Equipment	Delegate
313	Praj Industries Ltd	Mr. Mangesh Kulkarni	Principal Technologist	Delegate
314	Prasol Chemicals Ltd.	Mr. Gaurang Parikh	Managing Director	Delegate
315	Pratap Organics Pvt. Ltd.	Mr. Pratap Deshmukh	CMD	Delegate
316	Pratap Organics Pvt. Ltd.	Mr. Suneel Dike	R&D Head	Delegate
317	Process Consultancy	Dr. Kelkar	Process Consultant	Invitee
318	Progenitive Technologies	Mr. Subhash	Progenitive Technologies	Invitee

319	R. L. Chemical Industries Pvt. Ltd.	Janak Gupta.	B E (Chem.).	Delegate
320	R. R. Muni & Co.	Mr. Divyesh Muni	Partner	Invitee
321	R. R. Muni & Co.	Mr. Rajesh Muni	Partner	Invitee
322	Rallis India Ltd.	Mr. Gajanan Pokale	Senior Manager - Process	Delegate
323	Rallis India Ltd.	Mr. Kishor Patil	Manager - EHS	Delegate
324	Reliance Industries Limited	Mr. Vinayak Marathe	VP	Invitee
325	Reliance Industries Limited	Nibedita Banik	Research Scientist	Delegate
326	Reliance Industries Ltd	Dr. Asitkumar Das	Sr. Vice President	Delegate
327	Reliance Industries Ltd	Dr. Haribhau Kumbhar	Research Scientist	Delegate
328	Reliance Industries Ltd	Dr. Pravinkumar Chinthala	general manager	Delegate
329	Reliance Industries Ltd	Dr. Sanjibdas Sharma	General Manager	Delegate
330	Reliance Industries Ltd	Mr. Akhilesh Yadav	Research Scientist	Delegate
331	Reliance Industries Ltd	Mr. Balu L. Gadilohar	Research Scientist	Delegate
332	Reliance Industries Ltd	Mr. Ritesh Dhanorkar	Manager	Delegate
333	Research Center Pharmaceutical Engineering GmbH (RCPE) Austria	Prof. Oliver Kappe	Prof. of Chemistry at the University of Graz	Delegate
334	RiiDL (Indra), Somaiya Vidyavihar	Mr. Krunal Nitin Patel	Founder	Exhibitor
335	RiiDL (Jalparivartan), Somaiya Vidyavihar	Mr. Bhavik Mehta		Exhibitor
336	SABIC India Pvt. Ltd.	Dr. Ashok Menon	Global Technology Leader Life cycle Assessment, Corp. Sustainability Div.	Speaker
337	S-Amit Chemicals Pvt. Ltd.	Mr. K. V. Suriyanarayan	General Manager - Technical	Exhibitor
338	S-Amit Chemicals Pvt. Ltd.	Mr. Ram Prasad	General Manager - Technical	Exhibitor
339	S-Amit Chemicals Pvt. Ltd.	Mr. Tanmay Godiawala	General Manager - Reaxa Ltd.	Speaker & Exhibitor
340	S-Amit Chemicals Pvt. Ltd.	R K Desai	Consultant	Visitor
341	S-Amit Chemicals Pvt. Ltd.	Ashok Philse		Exhibitor
342	Sanofi	Mr. Girish Dhamat		Delegate
343	Saptec Agro India	Dr. Rashmi Sharma	Project Coordinator	Delegate
344	Saptec Agro SA	Dr. Surendra Bhatia	Director, Saptec Agro India	Speaker
345	Science & Engineering Research Board (SERB),	Dr. Jigisha K. Parikh	Scientist G	Invitee & Session Chair
346	Science & Engineering Research Board (SERB),	Dr. Monika Agarwal	Scientist - E	Exhibitor
347	Science & Engineering Research Board (SERB),	Dr. Pravakar Mohanty	Scientist - C	Exhibitor
348	Science and Engineering Research Boards	Dr. Rajiv Sharma	Secretary	Guest-of-honour
349	Sequent Scientific Limited	Dr. Anil Holkar	VP	Delegate
350	Sigma-Aldrich Chemicals Pvt Ltd	Mr. Palaniraja Subramaniam	Associate Manager Lab Operations	Delegate
351	Sigma-Aldrich Chemicals Pvt. Ltd.	Mr. Hiren Joshi		Delegate
352	Sigma-Aldrich Chemicals Pvt. Ltd.,	Mr. Debasis Chakraborty	Deputy General Manager	Delegate
353	Sigma-Aldrich Chemicals Pvt. Ltd.,	Mr. Manu Kumar		Delegate
354	SIIB	Mr. Harsha Bake	Student	Delegate
355	SIIB	Mr. Bharat Juyal	Student	Delegate
356	Solvay Group	Dr. Pascal Metivier	Senior Executive Vice President, Science & Technology Director,	Speaker
357	Solvay R&I Center	Dr. G. Padmanaban	R&I Lab Manager	Delegate
358	Solvay R&I Center	Dr. S. Mangaleswaran	Research Scientist	Delegate
359	Solvay R&I Center	Dr. Bala Thota	Research Scientist	Delegate
360	STEP Solutions Pvt. Ltd.	Dr. M. G. Palekar	Head – Strategy and Technology	Awards Shortlisted nominee
361	STEP Solutions Pvt. Ltd.	Mrs. Jyoti Palekar	Co - Founder and Managing Director	Exhibitor
362	STEP Solutions Pvt. Ltd.	Ms. Saili Indurkar		Exhibitor
363	STEP Solutions Pvt. Ltd.	Ms. Sayali Dhanawade		Exhibitor
364	Sud-Chemie India Pvt. Ltd.	Mr. Srinivas PAES	Chief Manager - Tech & Project Mgmt.	Speaker
365	Sugam Paryavaran Vikalp Pvt. Ltd.	Dr. Avinash Kadam	Managing Director	Awards Shortlisted nominee
366	Sugam Paryavaran Vikalp Pvt. Ltd.	Ankur Turakhia		Exhibitor
367	Sun Pharmaceuticals Ltd.	Dr. Laxmi Gaitonde	General manager - R&D	Delegate
368	Sun Pharmaceuticals Ltd.	Dr. Sandeep Jain	Senior General Manager	Delegate
369	Sun Pharmaceuticals Ltd.	Mr. Ramendra Rathore	Senior Research Manager	Delegate
370	Sun Pharmaceuticals Ltd.	Mr. Sandip Bose	Head Of Operation Excellence	Speaker
371	Sun Pharmaceuticals Ltd.	Mr. Sandip Darji	Dy. G.M. Global Process & Technology	Speaker
372	Syngene	Mr. Athimoolam A. Pillai	Research Scientist	Delegate
373	Syngene	Mr. Gurupadaswamy H.D.	Research Scientist	Delegate
374	Syngene	Mr. Manoj Kakwani	Sales Manager	Delegate

375	Syngene	Mr. Prabu C	Research Scientist	Delegate
376	Syngene	Mr. T. Karthikeyan	MD	Delegate
377	Syngene	Mr. U. Shri Harsha	General Manager R&D	Delegate
378	Syngene	Mr. Vasanthakumar Gedela	Research Scientist	Delegate
379	Tamil Nadu Pollution Control Board	Thiru R.Kannan	Joint Chief Environmental Engineer	PCB Conference
380	TATA Chemicals Ltd.	Mr. Rahul Nagarkar		Delegate
381	Tata Institute of Fundamental Research	Mr. Ayan Maity	Student	Delegate
382	TATA Sons	Mr. R. Gopalkrishnan	Former Director	Speaker
383	Tesla Enviro	Mr. Ashu Sahu	Executive Marketing	Exhibitor
384	Teva API India Pvt. Ltd.	Dr. Parven Kumar Luthra		Delegate
385	Teva API India Pvt. Ltd.	Mr. Anchal Tyagi		Delegate
386	Teva API India Pvt. Ltd.	Mr. Arun Thiruselvam		Delegate
387	Teva API India Pvt. Ltd.	Mr. Yogesh patil		Delegate
388	Thakkar Dye Chem Industries	Mr. Amit Thakkar	Partner	Delegate
389	Thakkar Dye Chem Industries	Mr. Milin Thakkar	Partner	Delegate
390	Thane Belapur Industries Association	Mangesh Brahme	General Manager	Invitee
391	The Dharamsi Morarji Chemical Co Ltd.0	A K Nagarch	General Manager - R&D	Delegate
392	Thinkstep Sustainability Solution Pvt. Ltd.	Dr. Rajesh Singh	Managing Director	Exhibitor
393	Thinkstep Sustainability Solution Pvt. Ltd.	Mr. Ritesh Agarwal	Principal Consultant	Exhibitor
394	Thinkstep Sustainability Solution Pvt. Ltd.	Ms. Hiranmayee Kanekar	Associate Consultant	Exhibitor
395	Transchem Agritech Pvt Ltd	Mr. Rahul Chhabra	CEO	Exhibitor
396	Transchem Agritech Pvt Ltd	Ajay Padhye		Exhibitor
397	Transchem Agritech Pvt Ltd	Bhavar Upadhyay		Exhibitor
398	Transchem Agritech Pvt Ltd	Nihar Mehta	Technical Head	Exhibitor
399	Trignosis	Dr. Milind Deshpande		Invitee
400	United Phosphorus Ltd.	Mr. Kiran Prajapati	Sr. Manager	Awards Shortlisted nominee
401	United States Pharmacopeia (USP)-India	Mr. Mohamed Takhi		Delegate
402	UPL Limited	Dr. Ajinkya Bhasme		Delegate
403	UPL Limited	Dr. Sunil Waje		Delegate
404	UPL Limited	Mr. Pritesh Desao	DGM	Delegate
405	Vedant dyes	Mr. Piyush Maheshwari		Delegate
406	Virupaksha organics	Mr. Biradar Narayan	R&D	Delegate
407	Vision Earth Care, SINE-IIT Bombay	Mr. Abhishekh Singh	Business Development Manager	Exhibitor
408	Vision Earth Care, SINE-IIT Bombay	Mr. Chandrashekhar Shankar	CEO	Exhibitor
409	Viswaat Chemicals Limited	Mr. Dattatriya Thorat	R&D	Delegate
410	Viswaat Chemicals Limited	Mr. Nitin Kayande	R&D	Delegate
411	Viswaat Chemicals Limited	Mr. Subiman Ghosh	R&D	Delegate
412	Viswaat Chemicals Limited	Mr. Vivek Shetty	Chairman and Managing Director	Delegate
413	Viswaat Chemicals Limited.	Dr. Suneel Chennamsetty, PhD.	Deputy General Manager - R & D.	Delegate
414	Vivira Process Technologies Pvt Ltd, NCL Venture Centre	Mr. Karan Chavan	Product Manager	Exhibitor
415	Wallonia.be Export Investment.	Emmanuelle Timmermans.	Trade & Investment Commissioner.	Invitee
416	West Bengal Pollution Control Board	Shri. Subrata Ghosh	Chief Engineer	PCB Conference
417	ZCL Chemicals	Dr. Hitin Hirpara	General Manager R&D	Delegate
418	Zeon Corporation	Mr. Jun Oka		Exhibitor
419	Zeswa Catalysts	Mr. Satish Lanke	Dy. Manager	Delegate
420		Jignesh Gosaliya	CA	Invitee

## Green chemistry & engineering becomes a movement.....

The Green ChemisTree Foundation, Mumbai, organized a two-day symposium and a series of seminars, workshops and industry interactions on the theme of 'Profitability from Industrial Green Chemistry and Engineering', under the banner of the 'Industrial Green Chemistry World (IGCW) – 2017 – Convention & Eco system', on October 5-6, 2017 in Mumbai.

Over 400 delegates from industry, research institutes, regulatory bodies and students, attended the event. Several departments of the government of India, chemical companies from various sectors in India and abroad, as well as the American Chemical Society-Green Chemistry Institute (ACS-GCI) supported the event.

Green Chemistry (GC) is about reducing waste, materials, hazards, risks, energy consumption and costs. It is one of the biggest cultural transformations that the chemical industry has seen and the pace of change has accelerated in recent years, including in India.

The seminars conducted in parallel

covered: Pollution Prevention at Source – Green Chemistry Approach; Flow Chemistry; Emerging Tools and Technologies; Solvent & Reagent Selection Tool Guide; and CSIR-Industry interactions.

The Green ChemisTree Foundation also announced several awards for meticulously selected 'green' processes and projects from industry and research institutes in India.

### 'Innovation – We won't get from here to there without it'

Delivering the keynote address on 'Innovation – We won't get from here to there without it,' Dr. David Constable, Science Director, ACS-GCI pointed out that the chemistry enterprise as currently operating is completely unsustainable. The sustainability risks are real and the supply of several critical elements of the Periodic Table is not sustainable. Even today, chemists use 'old' chemistries to produce various products – about 54% have been in use since World War-I and 74% come from before World War-II. Manufacturing equip-

**DR. AJIT JOSHI**

Email: drjoshi9@gmail.com

ment too has not changed much – batch reactors, distillation columns, crystallizers, etc. used today are not very different from decades ago.

"Innovation is essential for designing new ways or new chemistries to design sustainable chemical processes," Dr. Constable noted. He called for "system-level thinking," and more "use-inspired" fundamental research. "Green is not synonymous with sustainability; efficiency is necessary, but not sufficient," he added, pointing to Jevon's Paradox (which states that when technological progress increases the efficiency with which a resource is used, the rate of consumption of that resource rises because of increasing demand). Sustainability research and education, he added, are multidisciplinary and collaborative. "Collaboration has been the hallmark of green chemistry development."

Dr. Constable listed several sustainable chemistry opportunities:

- Exploiting greater chemical diversity, especially from bio-based or renewable feedstock;
- Greater understanding and uptake of synthetic biology as a synthesis tool;
- New reactions focused on biologically derived molecules;
- Low energy direct conversion of carbon dioxide (CO<sub>2</sub>) to methanol or higher carbon molecules;
- Sustainable production of hydrogen (H<sub>2</sub>); and



- Closing the materials loop, i.e., using wastes as raw materials.

He also discussed several success stories of sustainable chemistries, including manufacture of propylene oxide (PO) using hydrogen peroxide (the HPPO process), metathesis technology, and the bio-succinic acid process from Myriant.

“There is a lot going on in green and sustainable chemistry, which is much more than just hazard and pollution reduction. Innovation and early design are key necessities for sustainable green chemistry,” he concluded.

### ‘Need to minimize folly...’

Mr. Ashwin Shroff, Chairman & Managing Director, Excel Industries Ltd., highlighted some GC initiatives undertaken by his company over several years. The company has discontinued use of carbon tetrachloride, a hazardous solvent; meets 50% of its power needs from wind energy; purifies & reuses 50% of wastewater generated; composts degradable solid waste and converts the non-degradable waste to synthesis gas.

Mr. R. Gopalkrishnan, Former Director, Tata Sons, spoke on the theme of ‘How can smart people stop doing silly things?’ He opined that the checks and balances of sustainability are disturbed today and this has led to the generation of lots of waste. “There is a need to go back to chemistry to find solutions.”

Mr. Gopalkrishnan pointed to several examples from history on the folly of men: Mutiny of Indian soldiers in 1857; Partition of India in 1947; Extinction of Maori tribe on Easter Island and that of Aztec rulers in Mexico; the sinking of the *Titanic* in 1912; and the cold war incidence in the Bay of Pigs in Cuba. He reiterated the need to change

mindsets or mind-frames to minimize folly. “It is necessary to improve our common-sense by retiring into ‘ekanta’ (solitude) and to remove the fear of failure from our minds,” he noted.

### Greener, sustainable process for Letermovir

Dr. Ingrid Mergelsberg, Director, Department of Process Chemistry, MSD (USA), noted that sustainable green chemistry is all about innovation, and gave several examples from Merck’s strong legacy of innovation – including the hormone cortisone, and the anti-HIV drug indinavir sulfate (*Crixivan*).

She presented the case study of process development of Letermovir – a life-saving drug for the treatment of human cytomegalovirus (HCMV). The original process route, licensed from Aicuris, had an overall yield of just 10%; about 20% loading of palladium; needed nine different solvents; had a Process Mass Intensity (PMI) of 700; and released an estimated 1,657-kg of CO<sub>2</sub> per kg of the drug.

The innovation focused on developing a process route having ease of operation, low cost, high yields & efficiency, ease of supply of raw materials, safety, reproducibility & robustness, freedom to operate and sustainability. The goal was to develop a process with zero waste by designing for atom economy, inventing new chemical transformations, and prioritization & optimization for sustainability. Several chemical reactions such as hydrogenation, amino-carbonylation, etc. were studied in high-throughput experiments with analyses in parallel. After trying several phase transfer catalysts, which had many disadvantages, the researchers went back and identified new chemical transformations and a new, stable, re-usable catalyst was developed.

Optimization for sustainability led to the development of the currently used greener process with simple, clean, homogeneous reactions; one-pot direct isolation of product; stable and easily recycled catalyst; use of only two solvents; and 91% yield. The PMI was reduced by 75%, while raw material costs were reduced by 93%.

### Chemical industry under the 4th Industrial Revolution

While fossil fuels, computers and the Internet characterized the second and third industrial revolutions respectively, the ongoing 4th industrial revolution is about sustainability, digitalization and people.

“Today, there are multiple disruptions due to exponential innovation and convergence of technologies. These innovations also offer better operational efficiencies,” noted Mr. Rafael Cayuela, Chief Economist, The Dow Chemical Corp. (USA).

Mr. Cayuela pointed to a report published by McKinsey, a consultancy, which showed that the chemical industry’s R&D efforts between 2010 and 2015 generated 25% new chemistry and 75% incremental innovation. The main playground for the industry today is China, where the industry recorded the highest capacity growth of 14.3% CAGR between 2000 to 2014, in contrast to global capacity growth of around 4% CAGR. In absolute terms, the global chemical industry’s capacity grew from 1,179-mtpa in 2000 to 2,156-mtpa in 2014, while that in China grew from 246-mtpa to 741-mtpa.”

Dow Chemical, he added, has set seven goals to be achieved by the year 2025, of which two are related to GC, viz. delivering sustainable innovations and advancing a circular economy. He pointed to the use of high throughput

experimentation, enabling nearly two million experiments to be carried out every year, to deliver on the goals for innovation.

**‘Green for good – every step counts’**

Mr. Srinivasan, Managing Director, Pfizer Global Supply and R&D, pointed out that ‘going green’ means taking steps – big or small – in making environmentally friendly and ecologically responsible decisions. “Positivity is key – believe there is good in the world. Take ownership of the problem and focus on developing solutions. Believe that you can bring in the change. As Mahatma Gandhi said, ‘Be the change you want to see in the world,’ he noted.

In his view, ‘Green Change’ starts within the organization, with strong commitment at every level. “Green chemistry collaborations are happening at multiple forums: industry, supply chain partnerships, with industry associations, as well as in industry-government partnerships.”

Mr. Srinivasan highlighted of Pfizer’s green journey from 2001 to 2017, which resulted in significant benefits. For example, the company achieved a 98% reduction in the use of chloroform in manufacturing, besides reduction in carbon dioxide emissions, use of water & solvents, and waste generation.

**Renewable resources: Expanding the chemists’ toolbox**

Dr. Julien Hitce, Process Innovation & Development – Advanced Research, L’Oreal (France), discussed innovation based on renewable resources. In the company’s raw materials portfolio, as of 2016, 54% of ingredients were of renewable origin. “Specifically optimized transformations add value in the deve-

lopment of innovative cosmetic ingredients from biomass,” he noted.

Sugars or polysaccharides are building blocks of nature and can be used in cosmetics for multiple functions by fine-tuning their physico-chemical properties. L’Oreal has developed, for example, a renewable ingredient from carrageenan, a polysaccharide, which is marketed under the tradename *ProXylane*, as a new anti-aging active for skin care products.

Other GC developments at L’Oreal include bio-catalysed carboxylation of phenols for preparation of resveratrol and its structural variants at optimized conditions.

**GC – from a fad to a fixture**

Mr. Jeffrey Whitford, Head – Corporate Responsibility & Branding, Merck KGaA (Germany), discussed the progress of GC at Merck, where more than 40 scientists work in nine GC centres to develop green alternatives for various products and packaging. More than 35 products have been re-engineered till date to make them greener.

Merck has also developed its own greener alternatives evaluation matrix called ‘Quantitative Green Chemistry Evaluator’ (DOZN) and has evaluated several raw materials, catalysts, solvents etc. including beta-amylase, Cyrene, bio-based acetone, butanol and para-xylene, using this metric.

The company also uses customer scorecards for green products. Its Environmental Opportunity Dashboard highlights potential solvent switches and packaging improvements.

**Sustainable development – key to avoiding supply chain disruptions**

Mr. Anil Kumar Jain, CEO – API Business, Sun Pharmaceuticals,

stressed the need for sustainable development in the chemical industry, adding that in the past three years, more than 15% of problems in supply of pharmaceuticals have been largely due to production disruptions in factories in China.

Several plants there have been asked to close down due to heavy pollution. “Similar events occurred in Europe several decades ago, resulting in shifting of the chemicals industry from Europe to countries like China and India,” he noted.

**‘Sustainability journey – good for business’**

Dr. Julia Rowe, Group Sustainability Manager, Johnson Matthey (UK), discussed how the sustainability journey has been good for business.

The technologies offered by Johnson Matthey, he noted, address three big global challenges – improving air quality, efficient use & transformation of natural resources, and improving healthcare. Seven tough sustainability targets were set in 2007, including halving carbon intensity and key-resources consumed per unit of product. The challenges faced were overcome by employee engagement (training of influencers and sustainability facilitator training programmes), rewarding success (JM Global Sustainability Awards launched in 2009), sharing success stories, and sharing expertise & promoting collaborations.

The successes of the past ten years include:

- 47% reduction in waster consumption at a nickel catalyst manufacturing unit in Taloja in 2015-16;
- Reduced greenhouse gas emissions by using solar energy – a 5.2-MW

## IGCW-2017 Symposium & Workshops

solar plant in New Jersey (USA) supplies 20% of the site's electricity requirements; and

- In UK, 'zero-carbon' electricity is produced from offshore wind farms.

"The six targets set for the period were achieved to the level of 36% to 154%. During the ten years of transformation, the company improved environmental performance, made Johnson Matthey a safer place to work, many new business opportunities were identified, and bottom-line savings of £142-mn achieved," she noted.

### Thriving on a GC culture

Dr. Ashutosh Agarwal, Chief Scientific Officer, Jubilant Life Sciences Ltd., noted that the company's R&D is focused on process intensification and bio-transformations, and leverages innovation to create cost-effective technologies.

Many initiatives have been taken for recycling & reuse of solvents, reagents and by-products; targeting zero discharge; and removal, substitution or minimization of hazardous chemicals in manufacturing processes. "Go Green initiatives have been implemented in supply chain management through

reduced packing, procurement through e-commerce portal, etc." he added.

Jubilant Life Sciences has also installed a 105-KW solar power plant.

### Ecotain – Clariant's approach to sustainability

Mr. Kumaresan Rajendran, South Asia Business Head, Clariant Chemicals India Ltd., noted that sustainability, as a guiding principle, is well anchored in Clariant and integrated into brand values and company strategy. "Sustainability is a value driver for business, managing risks and capitalizing on opportunities. It generates superior financial performance," he added.

The company has developed a comprehensive Portfolio Value Program (PVP) for screening its portfolio, increasing benefits and reducing impacts. PVP screening spans 36 criteria, of which 26 are related to Planet, six to People and four are about Performance. Products that contribute to more than 80% of sales turnover have already been screened and of these, more than 75% fulfil the company's sustainability criteria and about 140 have excelled and given the 'EcoTain' label.

The *Glucotain* brand name, for ex-

ample, has been given to an innovative range of sugar-based, sulphate-free, eco-friendly surfactants for cosmetics and personal care products.

### 'Reducing the environmental footprint of chemical processes'

Prof. Ashwini Kumar Nangia, Director, CSIR-National Chemical Laboratory (CSIR-NCL), Pune, highlighted some of the technologies developed at CSIR-NCL and transferred to industry. He referred to the significant waste generation in different parts of the chemical industry, as measured by the 'E-factor' (quantum of waste generated per unit of desired product) and pointed out that pharmaceuticals, which have small production volumes, have 'E factor' anywhere between 25 and 100. "From bulk chemicals to pharmaceutical products, the quantity of waste generated per kg of useful product increases substantially," he added.

Prof. Nangia discussed the impact of technologies developed and commercialized by CSIR-NCL with a few examples. Vinati Organics Ltd., for one, has become the largest manufacturer of 2-acrylamido-2-methylpropanesulphonic acid in the world, with 40% share of the global capacity, thanks to the technology developed at the laboratory. This chemical is used in paints & coatings, water treatment, adhesives and in the manufacture of polymers for enhanced oil recovery. Furthermore, intellectual property and patents developed by CSIR-NCL has been licensed to Benefuel (USA), for the production of fatty acid methyl esters and biofuels. CSIR-NCL has also developed technologies for conversion of glycerol to value-added chemicals such as glycerol carbonate (with 18% yield), glycidol (80% yield), etc.

The laboratory has also developed several other process technologies for



the production of dimethyl carbonate, 1,2-propanediol, polymer electrolytic membrane fuel cell, as also about 15 process intensification technologies for fine and speciality chemicals. It has also done work on various molecules that can be derived from crop waste. For example, glucose obtained from cellulose can be converted to gluconic acid, sugar alcohols, levulinic acid and hydroxyl methyl furfural.

“The themes for today revolve around energy management & benign environment, process intensification and continuous chemical processes, catalysis for high turnover and milder conditions, biomass feedstocks for value-added chemicals & fuels, raw materials sourcing, and by-products valorisation,” Prof. Nangia added. “Solutions to problems do not come out of working in silos, but collaborations are necessary,” he noted.

### Chemical reactions of concern

Mr. Nitesh Mehta, Director, Green ChemisTree Foundation, and Founder-Director, Newreka Green Synth Technologies Pvt. Ltd., highlighted the re-

sults of a survey conducted to highlight chemical reactions of concern.

According to the survey, the top five chemical reactions or processes of concern are: nitration (using mixed acids), Friedel-Craft reactions (alkylation/acylation), diazotisation, cyclisation, sulphonation and chlorosulphonation. Other reactions of concern include bromination, azide reduction and imide formation. “These challenging reactions represent a huge opportunity for researchers,” Mr. Mehta observed.

### Opportunities in agrochemicals

Dr. Surendra Bhatia, Director, Sapec Agro India, pointed to the opportunities for GC in the manufacture of several large volume agrochemicals, including glyphosate (850-ktpa), mancozeb (150-ktpa), and chlorpyrifos (75-ktpa).

Glyphosate, the largest-selling pesticide, generates 5.6-kg of toxic waste per kg of the pesticide during its production. The new chemistry uses hydrogen cyanide and formalin to produce the key raw material, imino diacetonitrile.

The largest-selling contact herbicide, mancozeb, was introduced in 1950. Its production capacity in India in 2016 was more than 120-ktpa and Dr. Bhatia pointed to several opportunities for improvement – development of continuous process in place of batch process; process for dust-free formulations, etc.

Chloropyrifos, a non-systemic insecticide introduced in 1965, requires an intermediate, which was available economically from China till last year (a business of more than Rs. 100-crore), but is not available today. “Production of this intermediate is an opportunity for new process development,” he added.

Dr. Bhatia also discussed other opportunities in development of better processes for S-Metalochlor, sulfonyl urea, etc. Microencapsulation technology for agrochemical formulations is another opportunity, he pointed out.

Dr. Bhatia also highlighted the growing popularity of neem-based agrochemical formulations, and noted that with about 80-kt of neem seeds being collected every year in the country, this could be another significant business opportunity.

### New chemical reactivities for future chemical sustainability

Prof. Chao-Jun Li, Professor in Green/Organic Chemistry, McGill University (Canada), pointed out that of the resources removed from the Earth, only about 10% are retained in the final product, while 90% are wasted during manufacturing. The grand challenge of sustainability stems from the fact that more than 97% of all manufactured products involve one or more chemical processes. “A major challenge for the future is chemicals syntheses. Catalytic processes, which can convert hydro-



## SERB-IGCW Award winners

Category	Company/Institute	Applicant	Case study topic
MNC, large and medium-scale companies	Aarti Industries Ltd.	Mr. Smit Chauhan, Manager – Process	Manufacturing route change in hydrogenation
Small-scale industries	STEP Pvt. Ltd.	Dr. M.G. Palekar, Head – Strategy and Technology	Novel gas-liquid reactor, downflow gas contactor for efficient & effective, effluent treatment
Green Start-ups	Growtech Innovations India Pvt. Ltd.	Mr. Venkatesan Rajendran, Innovation Manager	Application of thermoelectric technology to replace CO <sub>2</sub> and R134a refrigerant
Technology Developers	Geist Research Pvt. Ltd.	Mr. Vikram Dhumal, Head – Technology	Recovery of anhydrous sodium sulphate from brine solution in caustic-chlorine industry
Student	CSIR-NCL	Ms. Nalineer Suryawanshi	Green approach to deep desulfurization using hydrodynamic cavitation
Researcher/Guide	CSIR -IICT	Dr. S. Venkata Mohan, Principal Scientist	Sustainable bio-hydrogen production from waste: pilot scale demonstration

carbons, carbon dioxide, carbon monoxide, hydrogen, nitrogen, biomass, and oxygen into useful chemical products using clean media, are needed today.”

Prof. Li pointed to the challenge of using biomass for chemical transformations. “Biomass materials like cellulose, lignin, etc. are over-functionalized and new fundamental tools are necessary. How one can combine two different fully functionalized compounds to form another fully functionalized compound?”

Modern organic chemical science, he added, can be broadly classified on the basis of three types of reactions: protection & de-protection of groups; halogenation & dehalogenation; and functionalization & de-functionalization. “Is it possible to eliminate these types of reactions or minimize, for example, protecting & de-protecting of groups during chemical processes, to reduce waste?” he asked.

Prof. Li also observed that most of the top 200 drugs (by global sales) have at least one aromatic ring in their structure, while more than 30% have an amine group. Lignin, which con-

stitutes about 30% of biomass, can be converted to usable aromatic compounds in large quantities, and can become the most abundant renewable aromatic feedstock. Likewise, fluorine is required in many drugs and agrochemicals and trifluoromethylated building blocks are widely used. “Simple and clean photo-induced aromatic trifluoromethylation reaction can be used to produce these building blocks,” he added.

### Mimicking nature

Mr. Mark Dorfman, Bio-mimicry Chemist, Biomimicry 3.8 (USA), discussed using nature’s designs in commercial products. According to him, it is a misconception that chemicals are man-made entities that contaminate an otherwise chemical-free natural world. “Nature is alive with chemistry,” he noted.

Mr. Dorfman discussed the methodology of bio-mimicry, which takes inspiration from the living natural world, rather than the inanimate natural world – be it structural colours in butterflies, insulation in bears, strength or hardness of oyster shells etc. The

bio-mimicry innovation process, he noted, moves through several steps: scope identification, discovery, identification of deep patterns & non-critical attributes, etc. He pointed to several key success factors for developing a working prototype of bio-mimicry: commitment & leadership by the C-suite, lead chemists and creative R&D team; fostering creativity & imagination by thinking outside the box; ability to embrace failures; and dedicated resources.

“Some large global companies like Dow have shown interest in bio-mimicry,” he added.

### Embedding sustainability within research & innovation

Dr. Pascal Metivier, Senior Executive Vice President and Science & Technology Director, Solvay (Belgium), highlighted the company’s proprietary approach to assess business sustainability risks and opportunities. The Sustainable Portfolio Management Map (SPM), plots risk levels (on Y-axis) against sustainability solutions (on X-axis), and can be applied to innovation projects.

The comparison of carbon footprint of products, he noted, is one way to evaluate them for sustainability. "Manufacturing processes are the main source of carbon footprint. Different processes have different carbon footprint values," he noted, and gave the example of polyamides wherein processes based on renewable resources lower the process carbon footprint. For example, the conventional process for Nylon 6 had a carbon footprint of 11.54, while the more sustainable process had a carbon footprint value of 10.84. Similarly, the manufacturing process for Nylon 66 having carbon footprint of 10.34 was improved to reduce it to 8.54.

### Simplicity in process design

Dr. Sandeep Mohanty, Director – Process R&D, Dr. Reddy's Laboratories Ltd., discussed several aspects of a key strategy for improving chemical processes – subtraction from over-cluttered designs. "Chemical processes need to be examined for reducing unwanted or unnecessary steps, for reduction of time cycle, etc. The process steps or unit operations should flow effortlessly from one to the other," he added.

Referring to global market for APIs, which is projected to reach \$158-bn in 2017, with year-on-year growth of 4.2%, Dr. Mohanty stated that manufacturing processes are complex due to multiple isolation processes, which use water as well as organic solvents. "There is a need of simplifying these processes with Quality By Design, involving continuous improvements and process redesign."

As an example, he referred to the manufacturing of clopidogrel bisulfate before and after improvements with QbD. The benefits gained included 10% reduction in solid waste; 55% reduction in water usage; and

67% reduction in consumption of solvents.

### Business value of life cycle assessment

Dr. Ashok Menon, Global Technology Leader, Life Cycle Assessment, Corporate Sustainability Division, SABIC India Pvt. Ltd., noted that many global companies have incorporated sustainability and life cycle assessment (LCA) in their business strategies.

LCA involves assessing global warming potential, impacts on environment, effect on fossil fuel depletion, ozone depletion, etc. It can be applied to find answers to questions such as which product is better on the basis of their carbon footprint; whether bio-based raw materials are better than fossil-fuel-based ones; or which technologies are better with respect to their environmental impact, etc. "This assessment helps in decision making and for making informed choices."

SABIC, he noted, is using LCA for making decisions related to technology development, feedstock strategy, development & marketing of sustainable products, etc. LCA also helps in taking decisions on future investments.

Dr. Menon also stressed the need to evaluate products from an LCA standpoint especially when identifying and using so-called green products. "The selected green alternatives may be giving out more carbon dioxide during its life cycle," he said. "The energy consumption of a smart phone and ICT infrastructure (for Internet) from a life cycle context is very close to annual energy consumption of a high-efficiency refrigerator!"

### Barriers to GC

Dr. P.L. Srinivas, Head – API R&D –

Bangalore, CIPLA Ltd., discussed several barriers to implementation of GC in the pharmaceuticals industry – economic, financial, regulatory, technical, organizational and cultural. Inadequate norms, enforcement by regulatory bodies, academia & industry disconnect, drug substance quality and complexity, etc. are other barriers to GC implementation, he pointed out.

Dr. Srinivas detailed how GC principles were implemented in research and innovation at CIPLA. Some steps taken included:

- Adoption of a 'top-down' approach by increasing awareness of GC in developmental teams;
- Review of existing commercial APIs with key metrics;
- Increasing accountability of individuals and teams by incorporating GC targets in their KPIs; and
- Promoting use of electronic notebooks having in-built, Internet-based 'E-factor' calculation.

He also provided a case study of an API (CS-101), the process for which had several drawbacks – use of hazardous chemicals, non-green solvents, mixed solvents for separations etc. After modifying the process using GC principles, the atom economy was improved from 85.9 to 82.3; E-factor reduced from 153 to just 53; and productivity improved from 26-tpa to 46-tpa.

In the second case study, GC principles were implemented in the four-steps manufacture of CS-102, another API, at the development stage itself. Organic solvents were replaced by water in the reaction steps; and the E-factor was improved from 240 for the innovator's process to 124 for the new CIPLA process.

# Industrial Green Chemistry World 2017 Launch of SERB - IGCW Awards

By Dr.K.S.Murthy , Pidilite Industries Ltd

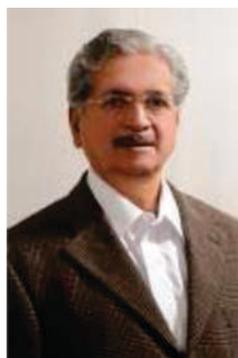
Ralph Waldo Emerson said, "Do not go where the path may lead, go instead where there is no path and leave a trail."

**Mr.Nitesh Mehta**, Co-founder & Director, Green Chemis Tree Foundation convened the IGCW, the first and largest Industrial convention with focus on expanding, implementing and commercializing green chemistry and green engineering based technologies and products in the chemical



industry. The first event was held in Powai, Mumbai, in 2009. IGCW 2017 symposium was held at Ramada Hotel & Convention Centre on 5<sup>th</sup> & 6<sup>th</sup> October 2017 with the launch of Green Chemistry and Green Engineering Awards in cooperation with Science & Engineering Research Board (SERB). Stakeholders of chemical industry like research communities, consultants, students, representatives of MPCB and MIDC were present on the occasion.

**Mr.Subhash Desai**, Minister for Industries & Mining, Maharashtra State said that institutions and sectors are turning green following green chemistry and green engineering which are the needs of the hour. He congratulated Green Chemistry Foundation for this initiative since there is a sense of self education and for bringing all the stake holders on one platform to understand the issues



and technicalities. We have enjoyed fruits of industrial development and at the same time faced adversaries through hazards of the industry and the Government faces challenges to manage such issues. During his tenure of 3 years, he came across shocking incidents like injuries to human and damage to property. Some units instead of treating effluents pass them into the streams polluting the waters and make it impossible for farmers and the

residents around to use the contaminated waters. Government officials legal rights and regulations and even members of the association are upset with actions and reactions of some of their members with consequent effect on CETP. He suggested members of the industry should regularise their activities so that the outcome would help to make our world better liveable. Further, industries should help small and medium players by providing them support and guidance to achieve our goals of improving our environment, understand responsibilities of each other and walk together while green chemistry lights up our path.



**Dr.Rajiv Sharma**, Secretary SERB-DST, Government of India congratulated the awardees and said they support the industry with expectation from them such as following group practices for any product or chemical or process that is user friendly and helps climate change.

**Dr. Ajay Deshpande**, Member, National Green Tribunal, Pune said that environmental governance in the country had seen a change during the last 5 years and many cases of violation of environmental norms and remedial actions dealt with. Environmental justice system had changed a lot due to public pressure of awareness and consciousness. Many of the industries have pre-treatment, air pollution control systems and yet the problems persist. With stringent regulations and markets becoming competitive, to get the balance of industrial sustainability warrants innovations which can emanate through green chemistry for process substitutes and technologies called just in time since environmental litigations in the criminal cases had shot up 20 times. Therefore, they must find some



way to cope in a more environmental friendly manner. Action research in the environment is carried out in academic institutions and industries should involve by handholding them for solving their problems and green chemistry would put them on a sustainable basis.



Impressed with the workshop, discussions of industry-academia and activities **Dr. Bettina Rechenberg**, Head, German Environment Agency said that production is linked to environmental load and as such the conference would deal with

issues of environmental performance of the chemical sector and how to improve the same. It is a way forward to come together to search for solutions helping the industry resulting in a clean, green India. Awards were launched to encourage activities to bring together environment and economy.

**Mr. Sushil Kharkwal**, Vice President-



Environment & Safety. PI Industries have been associated with IGCW since 2009 and congratulated Nitesh, Krishna and their team for exemplary leadership for the forum where green chemistry projects meet and work on

programs in tandem to find solutions. Established in 1947, PI Industries business has now grown on contract manufacturing where chemistry is applied for new products and to meet challenges of reducing waste, increasing yield, enhancing capacity, productivity improvement and efficiency.



**Dr. David Constable**, Science Director, ACS Green Chemistry Institute, Washington DC spoke about the rationale for this award and what they were trying to do. UN put together 17 sustainable development goals - the world to do list in terms of sustainability. From crop

protection agencies to fertilizers need chemistry and chemical engineering and their advances. Each goal

is an order and the goals are:

- Zero hunger: To meet ever increasing need for food throughout the world.
- Inclusive quality education: Require teaching green chemistry.
- Clear potable water and sanitation.
- Affordable and clean energy: Hydrogen fuel cells.
- Industry, innovation and infrastructure: Material science.
- Resilient cities and countries for sustainable industrialisation.
- Sustainable consumption and production: Function (intended use) e.g. Dyes and Pigments for colour exploit nano structures; Fashion industry.
- Climate change: Fossil fuels.
- Life below water: Sustainable use of ocean and resources.
- Innovation is essential for sustainable products and Green chemistry should spur innovation.
- Business process needs to change. Maximise resource efficiency. Eliminate and minimise hazards of pollution.
- Design system: Life cycle and sustainability perspective go hand in hand.
- EHS: Consideration for materials used, how safe are they, problems with chemistry. Innovation and Efficiency assessment.

**Award Criteria:** Chemistry or Engineering - Judging problem/challenge, connection to sustainability; addressing real world problem or challenge that is being faced. Secondly financial sustainability.

**Mr. Srinivasan**, Director, Pfizer Global Supply



Chain and R&D said that every stakeholder plays a crucial role and we need more green chemistry foundation sort of activities. He observed commitment level at the individual, industry and community since individually and

collectively we can achieve a lot to change lifestyle.

**The winners each received Cash prize of Rs. 50,000. Congratulations.**

MNCs, Large and Medium Scale Companies	Aarti Industries Limited, Jhagadia
Small-Scale industries	STEP Private Limited, Mumbai
Green Start-up Companies	Growtech Innovation India Pvt Ltd, Bangalore
Technology Developing Firms	Geist Research Private Ltd, Goa
Students	Ms.NalineeSuryawanshi, CSIR-NCL, Pune
Guides/Researchers–University and ResInst	Dr.S.Venkata Mohan, CSIR-IICT, Hyderabad

Secondly collaboration reflecting on what they are discussing about opportunities. Thirdly collection and fourthly resonance to the act of people so that future generation would follow. According to a famous TN poet, inculcate the desire to do the right thing; whatever you do, do it right like green chemistry.



**Dr. Pascal Metivier**, Solvay Group said that they set up a research centre in India 5 years ago and observed that India is progressing ahead at the same pace as the other countries and the organisers show the dynamism happening here taking the society forward.

**Mr. Ravi Kapoor**, Heubach preferred the word green thinking to green chemistry. Referring to Phthalo blue, he spoke about ammoniacal nitrogen conversion to ammonia liquor (25%) by using caustic lye and the biproduct was soda ash. In the case of Phthalocyanine green pigment, 1 ton generates 13 tons sludge at 9% solid contents (thixotropic). They neutralise mother liquor freed from copper and iron and make aluminium hydroxide pharmaceutical grade approved by FDA. This was integrated waste management. Balance out 5000 tons of blue and 3000 tons of green. Solid waste reduced by 85-90%. If you start innovating and looking at by-products everything can be recovered from the streams. Their focus is on products made in the cleanest way. Responsible care is thinking green as per the motto of their company 'Think green and think clean' and the thinking process is



more important, and the rest will follow.

**Awards selection process:** 88 nominations (researchers, students, people from sponsored industries, start-up companies and MNCs of which 5 could complete the case study/process successfully; 55 entries received in each category of 6; judges (5) for pre-screening process on a set of criteria and shortlisted 3 nominations in each category and the 18 nominations passed through second set of juries (3) who evaluated 3 finalists in each category. How much waste was reduced and improvement of efficiency; tangible difference made to quality of air, water and soil; impact of their research work and sustainability. Critical element of having green chemistry and contribution of sustainability going forward.

**ICI ACTIVITIES...**

Cont. from page 54

Mr. V. Nirmalgandhi, Sr. Manager Environment and Systems, Thirumalai Chemicals Ltd., Mr. Saravanan Kasthuri, Corporate Head EHS, Hikal Ltd., Mr. P. Manoharan, President-Safety, Sanmar Group, Mr. R. R. Gokhale, Secretary General-ICe, and Dr. V. P. Sridhar, Acutech, USA.

Overall 56 delegates registered for the programme and success rate received is 86.36%, which is significant.

The success of the programme is attributed to the ownership of the Andhra Pradesh Pollution Control Board and support of Bulk-Drug Manufacturers Association besides the composition of expert speakers from India and USA. The keen interest of chemical industry from this region towards sound management of chemicals by adopting RC programme is encouraging and ICC would be happy to extend hand-holding support to the industries which come forward for implementation.

