

# Deeper Insights on Sustainability

## Views of World Renowned Scientists and Sustainability Advocates

In the last edition (3<sup>rd</sup>) of Chemical Industry Digest Annual on Sustainability, we had views from leading chemical industry CEOs, defining the different dimensions of sustainability in the chemical industry.

This time, for this 4<sup>th</sup> edition of the Sustainability Annual, Chemical Industry Digest, quizzed leading scientists and sustainability advocates on adoption and incorporation of sustainability practices in the hydrocarbon, chemical and allied industries.

Their responses published here provide deep insights on the subject.

The gist of it is that the chemical industry has to move quickly beyond environment-friendly processes and embrace proactively and wholeheartedly the principles of sustainability and incorporate it in business and industry.

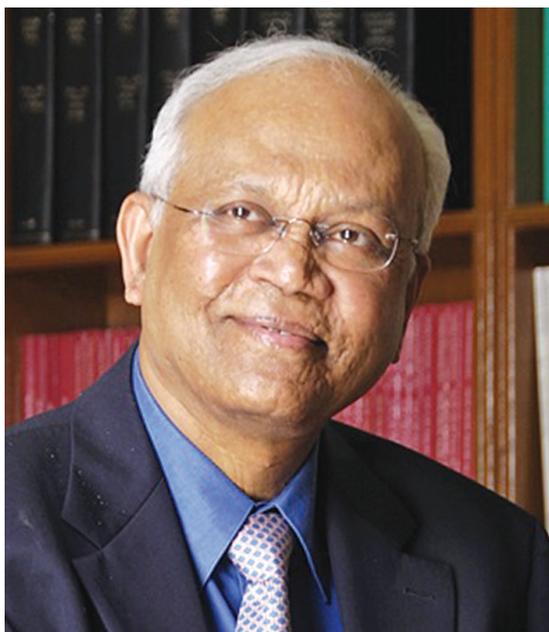
This needs huge transformational shift in mindsets and attitudes from top management to virtually all other personnel in the chemical industry. And it has to roll all along the entire manufacturing value chain from suppliers to the end users. Equally, it would need transformational changes in business and manufacturing models. If looked at positively it will drive innovation and concomitantly open up new vistas in business opportunities.

Chemical Industry Digest has been privileged to obtain views of India's leading and internationally renowned scientists, Dr R A Mashelkar and Dr S Sivaram, apart from scientist-director, Dr K M Chacko and sustainability proponents, Dr M P Sukumaran Nair and Alka Talwar.

Their views are presented here.

## Dr R A Mashelkar, FRS

National Research Professor & Former Director General of CSIR



**Chemical Industry Digest (CID):** Experts state that the survival and future of the chemical industries would depend on how quickly the industry adopts sustainability as its main principle or operating theme. To what extent is this a critical factor? Can industry adopt sustainability incrementally? Do they need to totally revamp? Would they have to change their manufacturing & business models?

**Dr R A Mashelkar (RAM):** I strongly believe the industry needs solutions that are no longer just environment friendly but fundamentally shift the paradigm and address both the ecology and the economy. The market for “green” chemistry is already expected to reach \$100 billion globally by next year. The chemical industries no longer have the luxury of adopting to sustainable goals incrementally, they have to innovate and adopt breakthrough solutions. As I have mentioned on multiple occasions, leap frogging is no longer an option, the chemical industry must pole vault. The digital revolution is another critical enabler which can provide a plethora of solutions for driving sustainability.

**Dr. R.A. Mashelkar**, National Research Professor, was the longest serving (1995-2006) Director General of Council of Scientific and Industrial Research (CSIR), also Chairman of National Innovation Foundation (2000-2018). He was the President of Indian National Science Academy (2004-2006), as also the President of Global Research Alliance (2007-2018).

42 Universities from around the world have honored him with honorary doctorates, which include Universities of London, Salford, Pretoria, Wisconsin, Swinburne, Monash and Delhi.

Dr. Mashelkar has many firsts to his credit. He was the first Indian to win the most prestigious TWAS-Lenovo Science Prize (2018), which is considered as mini – Nobel Prize for developing world scientists, first Indian from India to be elected as Fellow of US National Academy of Inventors (2017), first Asian Scientist to win the Business Week (USA) award of 'Stars of Asia' at the hands of George Bush (Sr.), the former President of USA and the first and only scientist to win the JRD Tata Corporate Leadership Award (1998) so far.

He is only the third Indian engineer to have been elected as Fellow of Royal Society since 1660, seventh Indian scientist to have been elected as Foreign Fellow of US National Academy of Science since 1863, and seventh Indian to have been elected as Foreign Associate of American Academy of Arts & Science since 1780.

In the post-liberalized India, Dr. Mashelkar has played a critical role in shaping India's science, technology & innovation policies. He was a member of the Scientific Advisory Council to the Prime Minister set up by successive governments for thirty years.

The President of India honored Dr. Mashelkar with Padmashri (1991), with Padmabhushan (2000) and with Padma Vibhushan (2014), three of the highest civilian honours.

India in particular needs to jump the development cycle – and we have done this many times in different industries. For example, we jumped the landline generation and went straight to the mobile phone era. Today, we have the same opportunity with power generation – we could transition from predominantly coal to the optimum mix of renewable energy and non-renewable energy. Also, the Indian chemical industry must strive to become world leader in setting the sustainability example - both in policy and in practice.

**CID:** An integrated approach always provides best results in any area. What should be the elements of such an integrated strategy to implement sustainability in the chemical industry?

**RAM:** In my book titled 'Leap frogging to pole vaulting: Creating the magic of a radical yet sustainable transformation', I have laid out the contours of an integrated strategy with assured success.

**ASSURED** can be a 'one word integrated strategy' for the chemical industry to implement sustainability. The industry needs to achieve an accelerated inclusive growth and the ASSURED framework would be a great tool for this. The framework can even be used for judging an institution, an enterprise irrespective of its size.

An integrated strategy to implement sustainability in the chemical industry could be based on the following elements:

“ The chemical industries no longer have the luxury of adopting to sustainable goals incrementally, they have to innovate and adopt breakthrough solutions. As I have mentioned on multiple occasions, leap frogging is no longer an option, the chemical industry must pole vault.”

**A (Affordability)** is required to create access for everyone across the economic pyramid, especially at the bottom.

**S (Scalability)** is required to make real impact by reaching out to every individual in the society, not just a privileged few.

**S (Sustainability)** is required in many contexts; environmentally sustainable, economically feasible, socially acceptable and adaptable to policy changes.

**U (Universal)** implies user-friendliness, so the innovation can be used irrespective of the skill levels of an individual.

**R (Rapid)** refers to speed. Inclusive growth cannot be achieved without the speed of our action matching the speed of our innovative thoughts!

**E (Excellence)** in technology, product quality, and service quality is required, not just for the elite few but for everyone in the society.

**D (Distinctive)** innovation is required because there is no use of creating me too' products and services.

All the above elements provide for a powerful framework to achieve the integration of environmental concerns and sustainable development, thereby promoting environmental protection, competitiveness, innovation and employment.

**CID:** Currently most of the chemical industry is in the 'take-make-dispose' mode of manufacturing. Can this shift to a cradle to cradle

(circular) manufacturing or step wise by first getting into greener processes with less environmental distress & then into circular manufacturing. Are circular processes feasible? – only in some cases or majorly?

**RAM:** The ‘take-make-dispose’ thinking clearly has its limitations. The current state of affairs of our consumption of the non-renewable resources and adding waste to our air, land, and water is just not sustainable. The chemical industry and its innovations can lead the way in this change.

However, circular manufacturing cannot be restricted to a company’s own operations. It needs to run across the value chain to embrace and provide value to customers and suppliers. This needs large amounts of renewable energy and significant investments.

I am optimistic about the change happening sooner than later, primarily driven by technology led disruptive innovation. However, we also need to realise that the change of moving to a whole new manufacturing process across the industry will not happen overnight.

We are already seeing commendable work going on across the globe. One such example that I can think of is the Waste2Chemicals initiative. This is a consortium of 8 international companies, including Enerkem, Air Liquide, and AkzoNobel, which intend to begin a joint production of bio-based methanol and ethanol from municipal waste. The technology is compatible with existing waste infrastructure and is intended to enable wastes that cannot be mechanically recycled to be converted into fuels and high-quality chemicals via synthesis gas.

**CID:** If chemical companies have to revisit their manufacturing processes to make them on sustainable lines, which areas should they start in the manufacturing cycle & how: Products (Restructuring product portfolios)? Processes (Green Chemistry)? Plant & Equipment (Improving Efficiency)? Starting Materials (Biomass/Renewables)?, Any other?

**RAM:** The chemical companies need to have a more holistic approach. Embracing sustainability gives chemical producers an opportunity to optimize their manufacturing processes, increase vertical integration of the supply chain, reduce resource consumption, and gain greater control over the entire product lifecycle, including the ability to sustainably manage the end-of-life of a product.

I believe the companies should start with one or

two initiatives and expand their capabilities and move strategically along the sustainability spectrum.

I would like to highlight example of Michelin, where I serve on their Corporate Innovation Board. In bid to strengthen their resolve for circular manufacturing, Michelin acquired U.S. specialty chemicals company Lehigh Technologies, which produces a material called micronized rubber powder (MRP) from waste tires. These powders are capable of replacing oil- and rubber-based feedstocks in a variety of applications, including the production of high-performance tires. This is a perfect example of closed-loop, zero-waste process that manufacturers need to pursue as they move towards circular manufacturing.

**CID:** Since innovation is needed across the manufacturing value chain to achieve sustainability, can the advent of Industry 4.0 technologies (IoT, Artificial Intelligence, Machine Learning, Data Analytics etc) give a fillip to accelerate innovation/sustainability.

**RAM:** The chemical industry is already entering a new phase with Chemistry4.0, in which digitalization, circular economy, and sustainability are playing keyroles. Digital technologies are already helping chemical manufacturers develop the low-carbon innovations which they need to thrive in the Circular Economy. Europe and in particular Germany is at the fore-front of applying Industry 4.0 to accelerate sustainable and inclusive innovations.

AI is being used for rethinking standardized processes as continuously adaptive and applying AI to manage processes, getting the maximum out of the data to solve previously unsolved problems and reveal hidden patterns and also in shifting toward an AI-enabled culture and reskilling employees to collaborate with machines.

Further, chemical companies can realise the full benefits of reimagined processes if with their customers, they keep on exploring the potential of intelligent virtual agents, for internal use and customer service desks. They can sweat their assets far more by creating an “intelligent plant” utilizing cognitive learning for predictive insights.

Predictive maintenance has emerged as a significant use case for Industry 4.0 technologies. The sensors collect real time bigdata, which is then analysed and specifically developed algorithms predict machine failures as well as their cause. This way production losses can be avoided through appropriate main-

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tenance measures, significantly reducing the costs and time required for maintenance.

**CID:** Do you think there is sufficient awareness on the importance of sustainability in the industry from top management to employees. Any additional steps required to increase awareness and convert awareness into action?

**RAM:** Unfortunately, it is the history of accidents, and the resultant damage to human health, flora and fauna and the environment which has created awareness on the importance of sustainability. In the last four decades, the number of manmade disasters nearly tripled, while the number of natural disasters surged sevenfold. Many regulations and awareness initiatives have sprung up as a result of these horrific accidents.

I have personally been involved in looking closely at human tragedies in India Bhopal gas tragedy, Maharashtra Gas Cracker Complex accident. As humans, we have suffered far too many such disasters and their consequences to turn a blind eye to them.

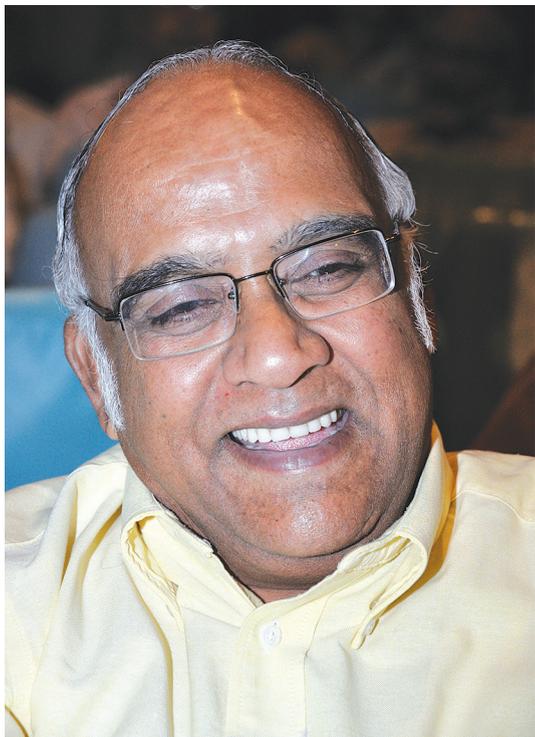
I am glad that globally, chemical companies are showcasing their sustainability intent. A quick review of the disclosures by leading chemical companies points to sustainability risks and opportunities being mainstreamed in business operations. Many of these large chemical companies are being proactive in their commitments to move to 'zero'—zero waste, zero emis-

sion or zero hazardous chemicals. The leadership of all major companies have taken initiatives to strengthen their engagement with the stakeholders (internal and external). Digital technologies and primarily social media is becoming an increasingly important tool in this aspect.

While companies do their bit, I believe awareness initiatives targeted at school and academic institutions should be undertaken, which will create huge human resource who are sensitive to sustainability and action oriented in their approach.

**CID:** While there are the Dow Jones Sustainability Index & other Indices by professional bodies like AIChe, what according to you should be the benchmarks for measuring sustainability? To what extent does obtaining a good rating facilitate a company's business?

**RAM:** I think the era of 'holding' businesses accountable or benchmarking them is far gone. Today, businesses have to be self-accountable and create cultures that deliver real improvements in health, safety and environmental performance, and have benefits to all. Take activist shareholders – they are a part of the company, and have played a big role in holding corporates accountable. Real, organic change always comes from within.



## Dr. Swaminathan Sivaram

INSA Senior Scientist and Honorary Professor, Indian Institute of Science Education and Research &  
Former Director of National Chemical Laboratory

**Chemical Industry Digest (CID):** Experts state that the survival and future of the chemical industries would depend on how quickly the industry adopts sustainability as its main principle or operating theme. To what extent is this a critical factor? Can industry adopt sustainability incrementally? Do they need to totally revamp? Would they have to change their manufacturing & business models?

**Dr Swaminathan Sivaram (SS):** Embracing sustainability is certainly critical to the future of the chemical industry. Principles of sustainability must be firmly embedded in the operational philosophy of the chemical industry, large or small. For large and listed companies, this is even more important. Often practicing principles of sustainability is considered as a cost; however, it must be really considered as insurance for future survival. Implemented with thought, it can also lead to improvement in

**Dr. Swaminathan Sivaram** is an INSA Senior Scientist and Honorary Professor at the Indian Institute of Science Education and Research, Pune, India. Prior to this he was a CSIR Bhatnagar Fellow (2010-15) and J.C. Bose National Fellow of the Department of Science and Technology (2007-15) at CSIR-NCL. He served as the eighth Director of National Chemical Laboratory from 2002-10. An alumnus of IIT-Kanpur, he received his PhD in Chemistry from Purdue University, USA. He was a Research Associate at the Institute of Polymer Science, University of Akron, USA before returning to India to pursue his professional career.

He is widely recognized for his contributions to polymer science, technology development, institution building and management of innovation in publicly funded organizations. The President of India honored Dr. Sivaram with the coveted civilian award, Padma Shri, in 2006. He was awarded the Doctor of Science (honoris causa) by Purdue University, USA in 2010 for his exceptional attainment and merit. Dr. Sivaram is a recipient of numerous professional honors and recognitions in India. He is an elected Fellow of all the learned academies of science and engineering. He is also an elected Fellow of the Academy of Sciences for the Developing World, Trieste (TWAS), Italy, a Fellow of the International Union of Pure and Applied Chemistry (IUPAC) and a Fellow of the Royal Society of Chemistry (UK). He has to his credit over 225 publications in peer reviewed scientific journals and is cited as an inventor in over 50 issued US patents and 52 Indian patents.

Dr. Sivaram is a member of the Scientific Advisory Boards of several leading companies. He is an independent director on the boards of many companies.

the bottom line of companies. In my opinion, sustainability adoption has to be incremental, with a clearly planned strategy for implementation. Well-defined annual plans with measurable targets must be laid out to make industry operations sustainable. Such incremental adoption strategy will make the process less disruptive. Depending on the business and the current levels of sustainability, companies may have to tweak their manufacturing and business models. In the end sustainability is a classic problem of the "Tragedy of the Commons", where everyone tries to maximize his/her personal gain based on perfectly good and logical reason, but collectively create damage to the eco-systems. Sustainability is also a problem related to how we handle our increasing desire for material consumption for enhancing our quality of life in a world of diminishing resources.

**CID: An integrated approach always provides best results in any area. What should be the elements of such an integrated strategy to implement sustainability in the chemical industry?**

**SS:** Elements of an integrated approach to sustainability are (a) a clear understanding of what "sustainability" means in the context of a given business (b) defining specific components of sustainability (c) understanding the current levels of each of the component and the desirable target levels to be achieved (d) mapping the sustainability journey in terms of plans, bud-

**“ Often practicing principles of sustainability is considered as a cost; however, it must be really considered as insurance for future survival. Implemented with thought, it can also lead to improvement in the bottom line of companies. In my opinion, sustainability adoption has to be incremental, with a clearly planned strategy for implementation. Well-defined annual plans with measurable targets must be laid out to make industry operations sustainable. Such incremental adoption strategy will make the process less disruptive. ”**

get, manner of implementation and defining measurable indicators of performance (e) and setting internal processes to measure the cost to benefit ratio. The battle against sustainability can be won only when a company realizes that its adoption has brought tangible benefit to the company.

**CID: Currently most of the chemical industry is in the 'take-make-dispose' mode of manufacturing. Can this shift to a cradle to cradle (circular) manufacturing or step wise by first getting into greener processes with less environmental distress & then into circular manufacturing. Are circular processes feasible? – only in some cases or majorly?**

**SS:** Circularity is a key component of sustainability. Zero-waste and zero-discharge processes can be implemented only when the concept of circularity is accepted. Like in many other activities, the journey begins once we embrace the philosophy of sustainability. The road to circularity will not be linear; it will have to go through many side alleys, with small improvements. One should not be weighed down by the thought of achieving complete "circularity". In some case even partial circularity is better than none at all.

**CID: If chemical companies have to revisit their manufacturing processes to make them on sustainable lines, which areas should they start in the manufacturing cycle & how: Products (Restructuring product portfolios)? Processes (Green Chemistry)? Plant & Equipment (Improving Efficiency)? Starting Materials (Biomass/**

**Renewables)?, Any other?**

**SS:** The manufacturing industry has to relook at all its processes. However, one is not advocating that they change it all at once. This is not practical because of sunken investments. One of the thought experiments that every industry can undertake is to ask: If we were to build a new manufacturing facility today, keeping in mind the goal of circularity and sustainability, how should we do it? How should my flow sheet ideally look like? How can I maximize output with minimum inputs of materials, energy and water? How should my wastes and byproducts be used to create additional wealth? What kind of process improvements is needed? If my final output is a product, how will I design it *a priori* to meet the needs of circularity? Such thinking will lead to solutions that can be implemented even within the constraints of existing manufacturing technologies. In addition, sustainability goals have to be extended to the entire supply chain. Manufacturers have to take responsibility for the products after their use. Labelling and information sharing with the consumers must become open and transparent.

**CID:** Since innovation is needed across the manufacturing value chain to achieve sustainability, can the advent of Industry 4.0 technologies (IoT, Artificial Intelligence, Machine Learning, Data Analytics etc) give a fillip to accelerate innovation/sustainability.

**SS:** Digital and Industry 4.0 technologies are critical to any industry of the future; however, adopting these technologies alone will not serve the cause of sustainable manufacturing. The latter will require new ways of thinking based on our understanding of chemistry and chemical engineering and devise efficient new process technologies suited specifically for the needs of the specific industry. Digital and industry 4.0 technologies are tools. Sustainability goal is a process.

Sustainability cannot be merely reduced to a problem in science and technology. Before implementing any solution deep thought and analysis is required. We still lack adequate tools and disciplined processes to define the “unintended consequences” of any new solution.

**CID:** Do you think there is sufficient awareness on the importance of sustainability in the industry from top management to employees. Any additional steps required to increase awareness and convert awareness into action?

**SS:** I tend to believe that there is sufficient awareness amongst the chemical industry leaders on the importance and relevance of sustainability and its criticality to the survival of the business. However, whether the message has trickled down to the employees is doubtful. The chemical industry is at a crossroads today and is often the whipping boy for all the ills of the society. Increasingly, the license to operate a chemical industry needs to be obtained from the citizens and the community, not the Government or regulatory bodies. Informed citizens have the power to shut down what they believe are processes with a poor record of sustainability and they have shown it so in recent times, even in India. If chemical industry has to regain its trust amongst the community, it has to behave more responsibly and communicate more effectively that they are equally, if not more, concerned about the negative impact of chemical manufacturing.

Sustainability is ultimately a new way of thinking and doing. This requires a change in mindsets and significant “social engineering”.

“Every company must devise their own internal metrics for the processes they operate. Sustainability is driven by an inner conscience which values social responsibility and places it above all other considerations. It is in effect an ethical statement.”

Embedding all dimensions of sustainability in undergraduate science and engineering education will be important to create a new generation of people who think differently. A beginning has already been made in many Universities abroad. In India too various institutions are planning to introduce structured curriculum in chemistry and chemical engineering to impart knowledge on “sustainability” thinking. There is also a need for industry personnel to be educated through short courses on this subject, so there is a common understanding on the principles of sustainability and the methods and tools available to achieve the goals.

**CID:** While there are the Dow Jones Sustainability Index & other Indices by professional bodies like AIChE, what according to you should be the benchmarks for measuring sustainability? To what extent does obtaining a good rating facilitate a company's business?

**SS:** There are a plethora of indices to measure sustainability. While they provide guidance, these indices have no absolute significance. Every company must devise their own internal metrics for the processes they operate. Sustainability is driven by an inner conscience which values social responsibility and places it above all other considerations. It is in effect an ethical statement. Therefore ratings are, in my opinion, less important.

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ISO has issued ISO 26000 as a broad guidance on social responsibility and sustainability. More than ever, both consumers and manufacturers recognize the impacts of their choices and actions. In the past, many of the costs of doing business were hidden; now ISO standards allow them to be quantified and factored in to decision-making processes. This means more responsive and responsible businesses. These ISO standards enable businesses to plan their future growth around meeting consumer expectations. They enable transparency about products and best practices for limiting

their negative impacts.

A sustainable future means balancing the needs of the environmental, social and economic systems. Every organization is increasingly expected to play a significant role in achieving this. With over 450 recommendations that directly impact the Sustainable Development Goals, ISO 26000 provides guidance on how businesses and organizations can operate in an ethical and transparent way that contributes to sustainable development.

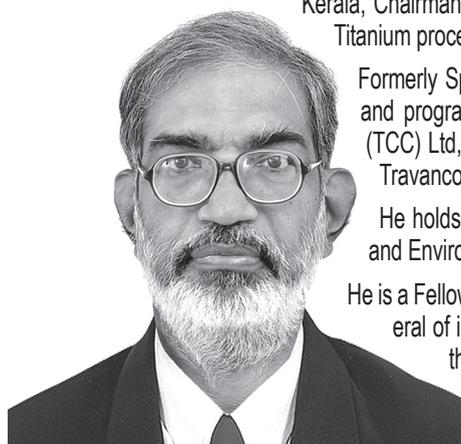
## Experts and Sustainability Proponents Provide a Variety of Interesting and Useful Information, Views and Suggestions on Sustainability

Read here!

**Chemical Industry Digest (CID) 1: Experts state that the survival and future of the chemical industries would depend on how quickly the industry adopts sustainability as its main principle or operating theme. To what extent is this a critical factor? Can industry adopt sustainability incrementally? Do they need to totally revamp? Would they have to change their manufacturing & business models?**

**Dr M P Sukumaran Nair:** With population expanding and people in the developing and underdeveloped countries aspiring to live better through economic progress, agricultural and manufacturing activities gather a renewed momentum. Both these will impose a heavy environmental burden on nature and its re-

sources which has grown beyond its inherent self-purifying limits. It is at this point that the environmental sustainability of future manufacturing operations become important. This urgency is already felt in most industrial operations using currently available technologies and having a higher resources, energy, water and waste intensity. Therefore, it has become essential for chemical industries to immediately embark on sustainability approaches for the future survival, growth and advancement of the industry. Industries can decipher its operational activities from the sustainability angle and identify the ones imposing the highest environmental burden. Later it should be retrofitted with



**Dr M P Sukumaran Nair FIE**, Chemical Engineer and Corporate Manager with extensive technical and management experience in the industry and Government for over four decades. Well-known fertilizer industry and policy analyst. Earlier Chairman, Public Sector Restructuring & Internal Audit Board (RIAB, apex body overseeing the working of public sector industries), Government of Kerala, Chairman, Kerala Minerals and Metals (KMM) Ltd and Travancore Titanium Products (TTP) Ltd both Titanium processing industries under the Govt of Kerala.

Formerly Special Secretary to Chief Minister, Government of Kerala looking after development projects and program implementation, Managing Director of Chlor-Alkali major Travancore Cochin Chemicals (TCC) Ltd, Cochin, India and Chief of Production and Corporate Planning at Fertilizers And Chemicals Travancore (FACT) and FACT Engineering & Design Organization (FEDO) Ltd.

He holds BS degree in Chemistry and AMIE Chemical Engineering, Postgraduate degree in Ecology and Environment, MBA (Marketing) and PhD in Management.

He is a Fellow of the Institution of Engineers (India), Senior Member in its National Council and headed several of its important missions, Member of the American Institute of Chemical Engineers (AIChE) and the European Federation of Chemical Engineers (EFCE), National Safety Council & All India Management Association. International speaker, contributor to major industry journals and published more than 120 technical/management papers at National/International Forums.

new methods involving technological innovation or change in operating philosophy so that the operations become increasingly sustainable. Existing industries can absorb such incremental concepts to become fully sustainable. Certainly, the manufacturing and business models have to change and the change has to come from both the internal and external environment.

A typical example of change in direction needed is in food production- one of the major activities under the CPI. A recent EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems suggest that in order to achieve sustainability in food production and feed the global community, a radical transformation of the global food system towards sustainability is needed with thrust on change in dietary habits, drastically cutting down the energy intensity of food production and avoiding large scale degradation and loss of produced food.

**Dr K M Chacko:** The wide-spectrum diversification within the chemical industry, phenomenally covering over 80,000 commercial products is playing a catalytic role towards promoting sustainable development. The chemical industry is, therefore, the backbone of industrial and agricultural development of a country through providing building blocks for several downstream industries.

The United Nations, in year 2015 launched 17 Sustainable Development Goals (SDGs) to end pov-

“ Strategies should include process optimization incorporating the best available technologies, maximizing the efficient use of all kinds of resources and creating an enabling environment for efficiency improvement through digitization and modern IT/ITES tooling. Use of renewable feedstock, advancing inherent safety concepts in every stage of production, elimination of waste on the lines of the bottomless refinery concept are all strategic tips available for the designer, operator and management in the CPI.”

- Dr MP Sukumaran Nair

erty, to protect the planet, and to ensure prosperity for all through with specific targets to be achieved by 2030. The chemical sector is uniquely placed to drive positive impact across the full spectrum of the SDG agenda. The chemical sector is indeed an innovation enabler together with solutions provider to essentially all sectors of the economy. Though SDG agenda is enthusiastic, transformative, and ubiquitous, it cannot be achieved through incremental

change alone and therefore calls upon all actors to go beyond business as usual to tackle complex societal and environmental challenges.

The SDGs are, therefore, considerably significant for the chemical sector and actions to achieve these shall clearly delineate the roadmap for simultaneously unlocking significant business opportunities through collaboration with other sectors.

**Alka Talwar:** With the visible and felt changes in the climate, it is clearly evident that sustainability is only way forward for the future of the human existence. It is important not only for the chemical industry but for all to forgo short term benefits for a long term vision with sustainability as the core of business strategy.

Many of the organisations in the chemical industry will need to take a serious look in the mirror if they are to survive and continue doing business, and radically transform to fall in line with tightening environmental norms. A sustainability initiative that is just

added on without considering the organisation's vision will not survive long enough to have any effect. Some may need a total revamp and relook at their manufacturing and business models. While the big initiatives for a large scale change may need time and investment, the industry must immediately begin with small incremental steps, en-



**Dr. K.M.Chacko** (PhD-Toxicology) is the Director of Shriram Institute for Industrial Research. Dr. Chacko has conducted and supervised several projects on the Toxicological evaluation of Agrochemicals, Drugs and Pharmaceuticals, medical devices, etc. Apart from this, he has made major contribution in evaluating the safety of many GM products like the Bt-cotton, Tomato, Potato and Mustard.

Dr. Chacko is an expert member of Food safety and Standards Authority of India. He is also a member of several National & International level professional societies/committees like, WAITRO (World Association of Industrial & Technical Organization), many BIS Committees, Society for Toxicology, CII National committee on food processing, etc.



**Alka Talwar** heads the Corporate Social Responsibility Function at Tata Chemicals. She looks after the CSR programs across the enterprise that includes projects on natural resource management, environment conservation, rural energy, sustainable livelihoods, empowerment and improving the quality of life. She has worked with Tata Chemicals in various functions over the last 27 years, which includes heading the community development functions at Mithapur Gujarat and at Babrala Uttar Pradesh. She is also Hon. Trustee & Hon. Secretary of Tata Chemicals Society for Rural Development, Okhai – Centre for Empowerment and Uday Foundation (only Hon. Trustee).

innovative products and practices to minimize detrimental impacts, protect the environment, promote social progress, and support economic growth. With this, the chemical sector can strengthen its production assets to build-up resiliency. The chemical sector industries, through symbiosis and closer synergies can promote their value chains to facilitate redressal of environmental and resource concerns, reduce raw material and waste disposal costs, earn new revenue from residues and byproducts, support circular

gaging with stakeholders and understanding the political, economic, social, technological, legal and environmental requirements that impact business. The small incremental changes towards sustainability can help organisations change the mindset and meet the larger goals sooner rather than later.

**CID 2: An integrated approach always provides best results in any area. What should be the elements of such an integrated strategy to implement sustainability in the chemical industry?**

**Dr M P Sukumaran Nair:** The top management shall adopt sustainability concepts relevant to the industry into its core activities. This is a commitment that apart from adhering to the interests of its employees, investors and other stakeholders shall comply with all social, legal, safety and environment related legislations without denting the bottom line. Strategies should include process optimization incorporating the best available technologies, maximizing the efficient use of all kinds of resources and creating an enabling environment for efficiency improvement through digitization and modern IT/ITES tooling. Use of renewable feedstock, advancing inherent safety concepts in every stage of production, elimination of waste on the lines of the bottomless refinery concept are all strategic tips available for the designer, operator and management in the CPI.

**Dr K M Chacko:** By means of Sustainable Consumption and Production, the chemical sector can support the SDGs through

business models, and develop new business opportunities. Chemical products play pivotal role in enabling and building resilient infrastructure solutions, while cooperating with other sectors. The chemical industries can further enable open-innovation together with manufacturing advancements to encourage development of integrated and end-to-end models.

**Alka Talwar:** An organisation needs to work as one coordinated entity to succeed in implementing sustainability. A long term sustainable strategy requires an integrated approach in line with the organisational objectives and vision. It needs to take into account the strategic advantages, challenges, and core competencies of the chemical industry, incorporating external inputs from stakeholders including concerns of communities who may be affected and environmental impacts. Key elements of an integrated strategy in the chemical industry will include responsible manufacturing with focus on water, energy and waste management, managing the sustainability, health, and environmental impact of the supply chain and community development. Data analytics to achieve process optimisation, supply chain innovations, and best practices in manufacturing will further the integrated implementation of sustainability practices in the chemical industry.

“ The United Nations, in year 2015 launched 17 Sustainable Development Goals (SDGs) to end poverty, to protect the planet, and to ensure prosperity for all through with specific targets to be achieved by 2030. The chemical sector is uniquely placed to drive positive impact across the full spectrum of the SDG agenda. Though SDG agenda is enthusiastic, transformative, and ubiquitous, it cannot be achieved through incremental change alone and therefore calls upon all actors to go beyond business as usual to tackle complex societal and environmental challenges. ”

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**CID 3: Currently most of the chemical industry is in the 'take-make-dispose' mode of manufacturing. Can this shift to a cradle to cradle (circular) manu-**

facturing or step wise by first getting into greener processes with less environmental distress & then into circular manufacturing. Are circular processes feasible? – only in some cases or majorly?

**Dr M P Sukumaran Nair:** It is possible and if we trace the course of development in several sectors in the CPI a steady and progressive development towards more and more greening of the industry towards sustainability is clear. The path followed in this journey is exactly what you told- gradually reduce environmental burden through process innovation, technology development, changes in operational philosophy, newer catalysts and advanced material of construction, waste reduction, recycling and reuse. The ammonia industry is the best example. Still thermodynamics impose restrictions in today's available technology and process equipment for a full-scale conversion of the raw material to the product. The present pace of R&D in the CPI encourages us to believe that sustainable and circular manufacturing is not far off in the CPI.

**Dr K M Chacko:** There is an intense need to create an enabling environment for effective implementation of Resource Efficiency and Cleaner Production (RECP), particularly in downstream segment to facilitate them to promote sustainable management of materials in all phases, thereby achieving greater transparency in environmental, health, and safety performance. Enabling circularity and maximum utility of resources in downstream sectors will increase the demand for chemical products. For example, reducing energy consumption in housing or offices would require more insulation material, but it also requires more performance-enhancing chemicals, such as air sealants and special coatings. This aggregately implies volume and value growth for virtually associated chemical segments from standard chemicals to performance and specialty chemicals.

The most promising circular-economy growth opportunities in chemical sector are emerging from the increased use of packaging that reduces food waste. Losses can be minimized with advanced packaging solutions that increases shelf life, for example, through breakage control, breathable packaging, temperature control, moisture control, oxygen control, ripening control and bacterial barriers. Sustainable packaging

“ Key elements of an integrated strategy in the chemical industry will include responsible manufacturing with focus on water, energy and waste management, managing the sustainability, health, and environmental impact of the supply chain and community development. Data analytics to achieve process optimisation, supply chain innovations, and best practices in manufacturing will further the integrated implementation of sustainability practices in the chemical industry. ”

- Alka Talwar

also drives demand for chemicals.

Hence, circular processes are feasible but to be implemented with efficient mechanism of environmental management and effective transformation to RECP.

**Alka Talwar:** With limited resources, it is time to rethink the manufacturing model from the traditional linear 'take-make-dispose' to a 'circular' approach which turns waste into a resource. This should not be seen as separate from getting into green processes but rather as the ultimate goal. This concept

of cycling materials and reusing them to reduce consumption of energy and resources will no doubt be challenging for the chemical industry, but is not impossible! An example is the 'value from waste' strategy to reduce our carbon footprint in the manufacture of bicarb by using recovered carbon dioxide from existing carbonating tower vents. The development of this process has taken significant investment. Similarly transforming to a circular manufacturing process overall will require major investments. Of course, one must understand that this change to circular manufacturing will not happen overnight, but will be a gradual process that recognizes value from waste while reducing energy consumption.

**CID 4: If chemical companies have to revisit their manufacturing processes to make them on sustainable lines, which areas should they start in the manufacturing cycle & how: Products (Restructuring product portfolios)? Processes (Green Chemistry)? Plant & Equipment (Improving Efficiency)? Starting Materials (Biomass/Renewables)?, Any other?**

**Dr M P Sukumaran Nair:** Overall optimization through digitization of the entire process and value chain, use of sensors, digital twins are all important apart from what you have indicated.

**Dr K M Chacko:** The manifold chemical sector comprising of Commodity chemicals, Diversified chemicals, Fertilizers & agricultural chemicals, Industrial gases, Specialty chemicals etc. uses a wide range of raw materials. With increasing competition worldwide, innovation remains crucial to finding new ways for the industry to satisfy its increasingly sophisticated, demanding and environmentally-conscious market. Combating climate change and transforming the energy system are core challenges on the path to a sus-

tainable future for business, society and the environment. Green Chemistry (GC) is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products. Besides, reaction efficiency, including energy efficiency, and the use of renewable resources are other motives of Green Chemistry. Putting the Green Chemistry concept in a broader market context, requires capacity building of stakeholders to maximize its benefits.

**Alka Talwar:** As moving to sustainable manufacturing processes would require substantial efforts and investments in R&D, new product design, developments in reverse logistics and much more, a practical methodology would entail focusing on two aspects to begin with. First, the raw materials by making use of renewable raw materials. An example is fossil feedstock replaced by renewable feedstock like biomass. The second would be increasing re-use or recycling of the end-products, both mechanical and chemical recycling. As mentioned earlier, small incremental steps in all areas can lead to big changes.

**CID 5:** Since innovation is needed across the manufacturing value chain to achieve sustainability, can the advent of Industry 4.0 technologies (IIoT, Artificial Intelligence, Machine Learning, Data Analytics etc) give a fillip to accelerate innovation/sustainability.

**Dr M P Sukumaran Nair:** Certainly this is what I have explained earlier as in my answer to question 4.

**Dr K M Chacko:** The main characteristic of industry 4.0 is the vertical networking of smart production structure by using cyber-physical production system to enable plants to react rapidly to changes in demand and supply and towards faults. The system not only facilitates production management but also ameliorates maintenance management. Resources and products are networked; thereby material and parts can be located anywhere at any time. All processing stages in the production can be logged with discrepancies and solutions. This enables the plants to deal more rapidly with the troubleshooting and facilitate more effective and pre-empted monitoring together with waste reductions.

Another significant aspect of industry 4.0 is horizontal integration through creation of new generation value chain networks optimized on real-time basis to enable integrated transparency to respond more rapidly to problems from inbound logistics through warehousing, production, marketing and sales to outbound

logistics and downstream services.

Hence, advent of industry 4.0 technologies will definitely give a fillip to accelerate innovation and enhance sustainability.

**Alka Talwar:** Industry 4.0 and related technologies are changing manufacturing and production processes. Achieving true sustainability with Industry 4.0 technologies will require the integration of Industry 4.0 with the sustainability goals. This would need to be on a platform that encourages eco-innovation in all areas especially to address the increasing energy demand from rising adoption of digital technologies. The technologies will enable new business models with optimisation of resource allocation and efficiency with accurate environmental management for environmentally sustainable manufacturing. Modern organisations should develop the expertise to effectively use Industry 4.0 technologies to shape the future with strategies and policies that work to achieve sustainable development.

**CID 6:** Do you think there is sufficient awareness on the importance of sustainability in the industry from top management to employees. Any additional steps required to increase awareness and convert awareness into action?

**Dr M P Sukumaran Nair:** A general awareness on the importance of sustainability is evident throughout the industry. Still concerted action to translate this understanding into the operations is a long way off. Industrial glut, investment hurdles, profitability concerns, lack of incentives to go beyond the statutory compliances etc are some of the reasons.

**Dr K M Chacko:** There is a need to assess the adequacy of prevailing awareness about the significance of sustainability across the sector based whereupon "Know-why" can be evaluated to disseminate "Know-how". The effective knowledge management creates the enabling environment together with removing barriers to understand importance of sustainability through top-down approach. This would not only enable paradigm shift in business and process modeling but also help in switching from linear economy to circular economy. There is an intensive need for conductance of capacity building programmes on continual basis in addition to the development of knowledge management tools to promote circular economy models in end-uses and downstream industries to achieve sustainability.

**Alka Talwar:** Sustainability has been a buzz word

now for over a decade. The danger to the environment from industrial pollution and other factors is common knowledge. However, in an organisation, the level of awareness and depth of knowledge regarding the importance of sustainability is different for stakeholders at different levels. The core concept of sustainability in meeting the requirements of the present without compromising the future is something that is not fully understood at all levels. While in manufacturing organisations, the focus is more on environmental protection, social development and economic development also needs to be taken into account. Organisations must also understand that environmental awareness can be a powerful tool for environmental policy making and management, and take necessary initiatives to enhance awareness levels on sustainability amongst all stakeholders. We continue to see more and more organizations taking up sustainability as a key strategic factor at the board level.

**CID 7: While there are the Dow Jones Sustainability Index & other Indices by professional bodies like AIChe, what according to you should be the benchmarks for measuring sustainability? To what extent does obtaining a good rating facilitate a company's business?**

**Dr M P Sukumaran Nair:** Both these indices are well drawn up to guide investors. The AIChe Sustainability Index reveals the company's sustainability performance with seven key metrics as perceived in the community, shareholders and customers vis a vis its peers. The Dow Jones sustainability index seeks to raise business standards and investor awareness by tracking the financial performance of leading sustainability-driven companies. Indian investments in the CPI are yet to catch up on these lines. A good rating of the above indices will certainly attract investors.

**Dr K M Chacko:** DJSI or other indices provide an in-depth assessment of industry's sustainability performance to facilitate stakeholders to monitor Key Performance Indicators (KPIs) and can serve as an essential tool to improve operations based on sustainability ranking with respect to economic, environmental and social criteria. A benchmarking scorecard covering all criteria assessed provides "Decision Support System" showing the industry's sustainability performance, both in absolute and relative terms, compared to the different DJSI indices. This would help companies to work out on strategies to reduce/ eliminate detrimental impacts and to enhance positive impacts to improve sustainability performance.

**Alka Talwar:** Most sustainability indices provide a measure of an organisation's corporate responsibility and environmental performance. However, when it comes to the chemical industry, they may not provide a complete picture due to not taking into account processes such as operations, engineering and research. The American Institute of Chemical Engineers Sustainability Index (AIChe SI) is an attempt to fill this gap as it is data-driven as against the other indices. The AIChe SI uses qualitative and quantitative metrics available in the public domain on the company and sector, integrating it into data points that provide an understanding of the success of sustainability efforts by an organisation.

Managing sustainability requires a framework that combines environmental and social performance with economic business performance. The AIChe SI allows monitoring of the complete business with reference to sustainability on the environmental, social and economic aspects.

Leadership is an important requirement of organizational change for sustainability with the top management's commitment necessary for change. It is here that embracing the IIRC framework gives organisations an opportunity to start from the top and change the mindset of the organisation in responding to Sustainable Development Goals and get board level attention and leadership commitment to act beyond certification and assimilate the goals into the organisation's business strategy to create value for all stakeholders while building a sustainable company. The Tata Group has defined a sustainability assessment framework, that comprehensively helps assess the current status and way forward on sustainability.

