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Chemistry, often called the central science, underpins the understanding of the world around us. We live in a world where our daily life is deeply influenced by contributions of chemical science. How many of us who hold a mobile phone in our hands know what a wonderful cornucopia of organic and inorganic chemicals that powers this tool, all products of the chemistry and chemical industry.

Chemistry as a scientific discipline was born just 200 years ago. The science of chemistry has made stupendous progress in the intervening period to understand matter bottoms up and to manipulate the structure and property of matter in a manner unforeseen and inconceivable to our ancestors just a century ago. Chemistry has led to a deep understanding of the molecular basis of our life, in terms of creation, transmission of traits and mechanism of diseases as well as discovery of therapeutic molecules that can cure diseases. Our ability to produce food for the growing human population, falsifying the Malthusian Prophecy, is another example of the power of chemistry. Inexpensive energy, human mobility and the revolution in computational and communication technologies could not have occurred but for revolutionary discoveries in chemical science and technology. In short, the chemical industry is believed to be the single largest contributor to human prosperity post industrial revolution. Ironic though is the fact that much of the epoch making useful discoveries in chemistry were triggered by the needs of the two world wars and not mere altruism as it made to believe in history. The challenge we face today is to direct the same chemistry to deliver solutions to some of the great problems faced by the society in an unprecedented time of peace.

The first factory to produce a chemical was established one hundred and twenty years ago. In a century since, the global chemical industry is today worth US \$ three trillion and is expected to double by 2035. The chemical industry contributes to 5 % of the world's GDP. Along the way, the epicentre of chemicals manufacturing has shifted to Asia and Middle East from Europe and America. The scene in Europe is dramatic, from a share of 33% in 2000 to 19% in 2015 and expected to be around 10 % by 2035 ! Whereas, in 2014 the chemical industry in Europe grew by 1%, the growth in Asia was 10%. By 2035, 65 % of the chemicals markets will be in Asia. Thus, the major drivers in the global chemical industry are (a) manufacturing shifting to centres of raw material availability and consumption (b) greater regulations in the developed markets; in 2015, there were 60% more regulations in Europe than in 2008 (c) the European and US Chemical industry is becoming more focussed on life sciences as a business and (d) increasing demand from customers for greater product

safety, sustainability and functionality. The chemical industry is confronted by the relentless forces of commoditization of products, shorter product life cycles, volatility in feedstock's and discerning customers. Shrinking margins, low growth rates and shifting of productions offshore has led to reduced investment in R&D by the chemical industry worldwide. Disruptive innovations appear risky in the context of short term returns. An innovation drought is staring at the global chemical industry.

Adding to the sorrow, the public perception of chemistry as a science and chemical industry is at an all time low. Chemistry and its products have become so ubiquitous that an average citizen hardly recognizes its importance. On the contrary, the ill effects of chemicals and the processes used to produce them are attracting negative attention. When a patient goes to a doctor, gets treated for a disease using drugs and gets well, he thanks the doctor, not chemistry that made the drugs possible. Amongst students, chemistry is the subject that is least attractive and even in our leading IIT's, chemical engineering is the subject of last choice amongst all engineering subjects.

Yet optimism rides high. A report published by The Royal Society of Chemistry in July 2009, titled "Chemistry for Tomorrow's World: A Road Map for Chemical Sciences" identified seven sectors where chemistry will play an ever more important role in the years ahead. These include energy, food, human health, sustainable cities and habitats, life style and recreation, raw materials and feed-stocks as well as water and air. Similar sentiments were echoed by the American Chemical Society in its report titled "The Chemistry Enterprise 2015". The report states that " the chemistry enterprise has a promising future, replete with challenges. Following the advances of the 20th century, we are poised to begin dramatic new explorations in molecular science. Breakthroughs—both intellectual and practical—will allow us to understand the chemical nature of consciousness and the molecular origins of life. We will discover new medicines and materials that improve our health and enhance our quality of life. If the enterprise rises to the challenge, our journey through the next century will be powered by safe, sustainable, and inexpensive energy. We will have improved transportation, housing, and manufactured goods that are produced in new ways, without harm to the environment. Our journey will not always be easy sailing. Chemists must work with policy-makers and the general public to chart a course that will provide a safe passage for all ".

The Indian chemical industry has grown rapidly in the past two decades; yet its growth pales in comparison to China. India's chemical industry is worth US \$ 140 billion today. The chemical industry contributes to 3 % of India's GDP and 14 % of its exports. In spite of 100 % permissible FDI, Indian chemical industry has been a laggard in attracting FDI with an annual inflow of just under Rs. 3000 crores. India has created world scale capacities in refining and primary petrochemical feedstocks. However, it still lacks a robust secondary chemical manufacturing infrastructure. For example we have very little manufacturing of feedstocks having more than three carbon atoms and less than two carbon atoms. Very little three and two carbon atom feedstocks are available for merchant sale, for others to build upon. India lacks a vigorous internal trading platform at competitive prices. Barring a few polymer manufacturing plants, most of our chemical manufacturing capacity are fragmented and sub optimal. Outside of pharmaceuticals, the industry investment in research and innovation is negligible.

The lack lustre performance of India's chemical industry is rather surprising. The economic growth of India will depend significantly on the chemical industry. Rising incomes, rapid urbanization, aspiration for improved quality of life, more educated consumers and access to communication must make India surely a major market for the chemical industry. Resources such as water, energy and air are some of India's most stressed assets. Indian chemical industry must chart its own unique agenda, of growth coupled with sustainable practices. This includes initiatives such as zero air and water discharge, atom economy, valorization of all by products, process design for inherent safety and product stewardship including taking the responsibility for the full life cycle of the product. We should not repeat the mistakes of others nor imitate the growth story of our neighbour. If the Indian chemical industry is not seen as a good and responsible neighbour by our citizens, its very existence will be threatened by the civil society.

India today faces unique challenges, that of balancing the development agenda with concerns of health, safety and environment of its people and its land. We will be under increasing pressures to contain the emission of GHG and preserve our fresh water resources. Unsustainable chemical processes will hurt our exports.

The indian chemical enterprise, by and large, is struggling to attain scale and reach. While often this is blamed on extraneous factors (infrastructure, fiscal policies, energy cost etc), the industry also needs to look within and unshackle its own internal constraints. It is interesting to draw an analogy from the automobile industry in India and ask whether it waited for the highways to be built before deciding to invest in manufacturing. When Henry Ford first put his Model T on the road, they were paved with cobble stones !

So what should the industry do ? How can we defend our home markets from the onslaught of global competition ? Here are few of my suggestions

1. Build scale, skills and reach with a set of robust sustainability metrics. Unsustainable practices may yield short term growth, but cannot ensure long term success
2. Move from selling products to offering solutions; Move from basic chemicals to formulations; create brands
3. Reverse engineering and incremental improvements are not bad words; Copying is.
4. Focus on unmet needs; create markets rather than serve existing markets. Being a pioneer is painful, but very rewarding
5. The knowledge content of India's export in chemicals is low. Define a next generation export strategy; produce chemicals and materials that serve high technology industries.
6. India will continue to suffer from domestic availability of basic chemical building blocks. Industry must build common logistics infrastructure for bulk import, storage and distribution of feedstocks. A new business model is necessary to accomplish this. We need facilities in the scale of Jurong or Rotterdam.
7. Greater focus on investment in innovation. We do not have to invent everything ourselves. Many new opportunities are available to us. There are many stressed R&D assets that are being closed down across the world. Can we acquire the know how and IP of such distressed assets? Many technologies have been developed and demonstrated in pilot scale overseas, but are languishing for want

of either capital or poor industry growth. Can we acquire them and build manufacturing capacities around them? Many research centres of the chemical industry are closing down in Europe. Can Indian industry acquire them, employ experienced professionals who are losing their jobs and build offshore R&D capabilities?

8. Lastly, the Indian chemical industry must take on the onus of communicating the benefits of chemistry to our society. Without such a proactive communication strategy, we cannot make society a partner in our growth. We have to excite young minds to take chemistry as a profession; we must create a workplace environment that is more open, less hierarchical and feudalistic and more participatory for our next generation job seekers to consider this industry a preferred place to work.

The world that we now inhabit is transforming at a rapid pace. Evolutionary biology teaches us that inability to adapt to changes leads to extinction of species. The enterprise of chemistry is no exception. More chemical companies have disappeared in the past 25 years than ever before. To survive will be challenging; to flourish will require courage and vision.

Lastly we have to create better public perception of chemistry. Chemistry's utilitarian aspect is its biggest enemy. Usefulness has become ordinary. We need to differentiate between "chemistry" and "chemicals" and communicate the centrality of this science to human civilization. We have to admit our mistakes and at the same time defend the values of chemistry. We need to engage in an informed and reasoned conversation with our fellow citizens about chemistry for the benefit of humanity.