IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.
Volume. 1 Issue. 3, PP 05-09
www.iosrjournals.org

Waste Minimization in Organic Chemical Industry with special Reference to Green Chemistry

Anupama Pradhan[1]
[1](*Department of Chemistry T.S.S. Govt.College Pathalgaon, Dist – Jashpur C.G. India)*

Abstract: *Organic chemical industry is the integral segment of chemical industry which converts raw materials into vast array of substances that are useful for our day to day life and plays a significant role in global economic and social development. The chemical industry is a major driver of economic growth and its performance is a leading indicator of economic development. Industrial production of organic chemicals comprises of various complex chemical reactions and during manufacturing process there is potential for chemicals and byproducts to enter the environment. The conventional end of pipe treatment process is unable to reduce the environmental risks effectively. Green Chemistry is a possible waste minimization tool that can be used by the chemical industry to reduce the pollution from chemical production and end use and reduction of energy used in production. Green chemistry focuses on improving the design stage of products and manufacturing process to achieve the goal of environment protection and sustainable development. Present paper analyzes the need of waste minimization in present scenario and encourages practice of green chemistry in Indian organic chemical industry so as to refine the existing technologies and also to find more environmentally benign alternatives.*

Key words: *green chemistry , organic chemical industries, sustainable development, waste minimization*

I. Introduction

The Indian chemical Industry forms the backbone of the industrial and agricultural development of India and provides building blocks for downstream industries. This sector plays a very important role in the overall development by providing vital chemicals and intermediates to other sectors of the chemical industry like pharmaceuticals; dye stuffs paints, pesticides and many others. The chemical industry is critical for the economic development of any country, providing products and enabling technical solutions in virtually all sectors of the economy. Over the last five years Indian organic chemical industry has started to evolve and its production has increased India currently account for approximately 3% of the world chemical market. Indian Chemical industry is broadly classified into bulk chemicals, specialty chemicals, petrochemicals, agrochemicals and fertilizers. Basic Organic chemical sector constitute an important part of chemical industry by producing chemicals comprising basic or commodity chemicals but most of the output from chemical companies is used by other chemical companies or industries. The demand for organic chemicals in India has increased at nearly 7.8% between 2009-13 and domestic demand of basic chemicals is expected to grow at 9% between 2014-18, mainly led by the growth in the end- user market.[1] Chemical consumption in developing countries is growing faster and could account for a third of global consumption by 2020. Five major organic chemicals produced in India are Methanol, Aniline and its derivatives Formaldehyde, acetic acid and phenol. Together they contribute to almost $2/3^{rd}$ of the Indian basic organic chemical industry. The balance $1/3^{rd}$ of the organic chemical consumption in the country is accounted by several other wide varieties of chemicals like chloro methane and ethyl acetate.

Industries associated with pharmaceuticals and fine chemicals are employing much more complex chemistry and produce relatively much more waste, which is not at all suitable for environment and nature.[2] Manufacturing of organic chemicals generates multiple effluent streams with widely differing qualities and characteristics. At present most of the organic chemical plant uses end of the pipe technology. The End of Pipe treatment of pollutant is the last stage of a process before the stream is disposed to the environment. The EOP treatment is not sufficient to remove waste and in addition to that whole process is very costly. Due to the destructive effects of industrial activities on humans' health and environmental concerns, environmental management within industrial operations are more required.[3] It is always better to reduce the waste at source and green chemistry plays an important role in minimizing waste generation, leading to safer environment. This paper highlights the need and application of green chemistry as an effective tool of waste minimization to make industrial operations inherently pollution free by making use of managerial and technical interventions.

II. Objectives

Following are the objectives of the present paper :

1. Analyzing necessity and importance of benefits of Green chemistry in Indian organic chemical industries.
2. Studying application of Green chemistry in the process of manufacturing chemicals.
3. Suggesting strategies to improve the current situation of Green energy implementation in India.

III. Need for Green chemistry

In developing countries, the thrust on economic development is often given priority to production costs than the best available technology and this results in more waste generation. During the life cycle of a chemical product, there are number of chances for it to negativity impact the environment, renewable resources and living systems. Its downstream disposal by combustion may lead to emissions of CO2, VOCs and NOX. Their processing may result in the release of hazardous pollutants into the environment. Limited Indian information is available on the volume of such chemical pollutants released to the environment, the targets of their exposure and their toxic properties. Waste minimization refers to strategies that are aiming to prevent waste at source through upstream interventions and green chemistry is a significant tool of waste minimization , which emphasize on the waste minimization by design of chemical products and processes right from initial stage. Green chemistry is the utilization of a set of principles that reduces or eliminates the use of hazardous substances in the design manufacture and applications of chemical products.[4] Green chemistry incorporates a new approach [5] to the synthesis, processing and application of chemical substances in such a manner as to reduce threats to health and the environment. This new approach is also known as 'clean chemistry', 'environmental benign chemistry', 'atom economy'and 'benign- by- design chemistry'. Green chemistry is commonly presented as a set of twelve principles, the first principle is based on the idea that prevention is better than to clean or treat wastes later and the remaining principles are focused on issues such as atom economy, safer synthetic methods, designing safer chemicals, using less toxic solvents, efficient methods to reduce energy consumption, application of raw materials from renewable sources and degradation of chemical products to simple, nontoxic substances that are environment friendly.

Chemicals are released at many steps in their life cycle, from the extraction of raw materials, through production chains, transport and consumption, to final waste disposal.

Chemical treatment technology such as hydrolysis, neutralization, oxidation reduction, precipitation is expensive and may require disposal/ treatment of residues. There is practice of end of pipe treatment conventional E-O-P treatment techniques which are not efficient in achieving goal of clean environment. Green chemistry is unlike cleaning up pollution which involves treating waste streams. This approach of green chemistry offers environmentally beneficial alternatives to more hazardous chemicals and processes, thus promotes pollution prevention. [6] In addition sustainable industrial activities generate minimum wastes and pollution to reduce the impacts on human. [7,8] It is recognized that practice of green chemistry not only leads to a cleaner and more sustainable earth, but is also economically beneficial with many positive social impacts. The practicing of Green chemistry in India is a necessity rather than an option.

IV. Applications of green chemistry in chemical process

The organic chemical sector has grown from a small-scale sector to multi-dimensional sector, which is taking on the challenges of globalization. However we are far behind other countries in implementation of green chemistry in this sector in global map. Although the scenario in India appears to be not totally dismal. Some work in the 'Green' direction, though not in a very articulated manner, has been going on in the country to improve existing processes. Some companies have now started exploring Green chemistry based routes of synthesis. In India, the focus for analytical chemistry is mainly on extraction technologies such as solid phase, ultrasound and microwave, supercritical fluid extraction, and automated soxhlet extraction. [9] Redesign of chemical processes to reduce water usage and Carbon dioxide emission is in high priority.

Solvent in particular make a large contribution to the environmental impact of chemical manufacturing and there is a growing focus on introducing greener solvents into the earliest stage of development of these processes: laboratory scale reaction and purification methods. [10] Green chemistry research in India is mainly to areas of Greener synthetic strategies, catalyst development, usage of biocatalysis, usage of non conventional technologies, and analytical techniques. Catalyst and reagent chemistry is one of the most important aspects of eco-friendly chemistry. Reagent chemists in India are working toward development of more benign and selective reagents that require ambient conditions.

Following table represents some of the important platform chemicals produced by chemical industry and possible applications of green chemistry in their manufacturing and its benefits.

NAME OF ORGANIC CHEMICAL & IT'S USE	MANUFACTURING PROCESS	APPLICATION OF GREEN CHEMISTRY	BENEFITS
Methanol Used in making formaldehyde, acetic acid, DMT,MTBE etc.	From natural gas, fuel oil and naphtha By production of syn gas at moderate pressure.	Renewable methanol from municipal waste, industrial waste and biomass.	• Reduced Green house emission. • Carbon reduction. • Decreased energy consumption. • Reduced need for fossil fuel.
Formaldehyde Used in UF resins, phenolic resins	Partial oxidation and dehydrogenation of methanol using Ag catalyst metal oxide process	Combined use of oxidation and dehydrogenation process	• Less energy consumption.
Acetic acid Used in textiles, food processing pharmaceuticals	From methanol by low pressure carbonylation with homogenous rhodium catalyst (Monsanto process)	• Use of iridium as catalyst (Cativa process) [11] • Producing acetic acid from cheese whey. [12]	• Energy saving. Faster & more effective. • reduction in water used & less emission of carbon mono oxide • Reduction in cost • Ecofreindly pathway.
Aniline Used in MDI, PU foams, rubber products, adhesive, dye, drugs.	Catalytic hydrogenation of nitrobenzene. Ammonolysis of phenol	Use of cheap, easily recyclable heterogenous catalyst nickel	High atom economy
Phenol Used in manufacture of bis phenol, resins, caprolactum	By oxidation of cumene in three steps with a potentially explosive intermediate & excess propanone production	• Zeolite catalysis • Selective oxidation of benzene with hydrogen peroxide in a biphasic system. [13]	• Reusable catalyst. • Byproduct propanone not produced. • High selectivity to phenol.

V. Challenges in implementation of green chemistry

The chemical industry has been facing challenges in implementation of green chemistry at ground level, which must be overcome in order to sustainable development laboratory to full scale production with maximum yield. Great efforts are still undertaken to design an ideal process that starts from non- polluting initial materials, leads to no secondary products and require no solvents to carry out the chemical conversion or to isolate and purify the product. However, more environmentally friendly technologies at the research stage do not guarantee that they will be implemented on an industrial scale. It is emphasized that the type and the size of the industries play a key role in determining the proper technology and methodology of waste minimization. [14,15,16] A major challenge is to integrate modern waste management as an integral aspect of material and energy flows management. Balancing economic and social benefits of chemicals with their health and environmental risks is a highly complex issue. As Chemical industries are all set up, are reluctant towards green

chemistry initiatives and not very interested to bring change in chemical process. Certain myths like about green chemistry such as it is not practical, not feasible and complex are also a hurdle.

Gap between research development and industries is a big challenge. The level of R&D investments in the Indian chemical sector is low at around 0.3% of total sales. There is lack of novel technical methods/designs and environmentally friendly substances by researchers. Noticeable barriers are encountered by the Indian research and development and academic institutions in chemical sector in commercializing their research outcomes since most of their research outcomes fall under early stage technology category with a high degree of technological/market uncertainties. Limited capabilities exist in Indian project engineering companies to develop basic design packages for complex process technologies involving catalysis, reactive separations, Biotransformation etc. Very limited availability of either government or private funding for transforming a process know how into a basic design engineering package. Lack of awareness in industry about potential Green Chemistry Solutions. To change any chemical process in chemical industries takes time and is very slow, also commercialization needs high capital cost. Due to lack of information about basic principles there is poor understanding of the distinctive advantages of green chemistry among people

VI. Recommendations to overcome barriers in green chemistry

Green chemistry involves replacement or modification of older processes by the methodologies and products that could educe or eliminate the use and generation of hazardous substances. There are certain barriers in implementation of green chemistry which must be overcome for sustainable environment. First of all at the level of research, Green chemistry and the related projects may be especially encouraged and appropriatelyfunded. Government has a major role in adopting policies that promote green chemistry innovation and implementation in the commercial sector. At the same time the chemical industry has a duty to integrate the principles of green chemistry into their manufacturing processes. Bring solution providers & industry together to enable collaboration.

The greenness of a chemical transformation can only be assessed on the context of its application and practice. [17] Most of the industrial R&D is mainly concerned with cost effectiveness rather than eco-effective methods. Therefore, a policy framework which fully credits the environmental advantages of bio-based materials needs to be established. Such a system could make carbon tax systems more effective in promoting the production of bio-based materials. Adoption of environmentally benign methods may be facilitated by higher flexibility in regulations, new programs to facilitate technology transfer among academic institutions, government and industry and tax incentives for implementing cleaner technologies. By introducing Green chemistry education at all levels, the government can build a solid foundation toward Green chemistry in India. [18,19,20] Governments have a major role in adopting policies that promote green chemistry innovation and implementation in the commercial sector. a policy framework which fully credits the environmental advantages of bio-based materials needs to be established. Such a system could make carbon tax systems more effective in promoting the production of bio-based materials At the same time the chemical industry has a duty to integrate the principles of green chemistry into their manufacturing processes while product manufacturers and retailers have a responsibility to demand chemicals from their suppliers that have been tested and shown to be inherently safe. To increase the research in this field, we need to publicize the needs, effects, and practice of Green chemistry. Green chemistry should be a part of syllabi in educational sector leading to consciousness among people of all ages.

VII. Conclusion

The above study concludes that adoption of green chemistry practices is an appropriate way to face the risks of unscientific management of chemical and process for sustainable development of chemical industries. Focus on Green Chemistry will help the companies to design new products and processes with sustainability as the core principle. Industry in India still needs to make significant improvement from the environmental point of view. Recently, researchers are identifying the barriers within the chemical industry that pre vent or slow the adoption of green chemistry industry. It is clear that the challenge for the future chemical industry is based on production of safer products and processes designed by utilizing new ideas in fundamental research which will help in designing and development of environment-friendly chemistry practices in India.

Present paper also suggests an interdisciplinary approach and healthy partnership between research institutions and industries can very effectively solve solutions to problems. The future growth of Indian chemical industry greatly depends on its ability to minimize eco footprints of its products and processes. This is now a high time to protect our environment from further damage by involving academic, industrial, and

governmental and non-governmental bodies collectively in green chemistry implementation, which will help in designing and development of environment-friendly organic chemical industries.

References

[1]. A handbook on Indian Chemical and Petrochemical sector 2014.
[2]. Sheldon, R.A. 1997. Catalysis: The Key to waste minimization., J chem. Tech Biotechnol ; 68(4): 381-388.
[3]. Srivastava, R. & Srivastava, S. 2003., How Green are Indian Firms?
[4]. Anastas, P.T. &Warner, J.C.,1998. Green Chemistry, Theory and practice, Oxford University Press, New York.
[5]. R.A.Sheldon, 2005. Green solvents for sustainable organic synthesis: State of the art. Green Chem., 7, 267
[6]. Noyori R. 2005. pursuing practical elegance in chemical synthesis. Chemical communications;14:1807-1811.
[7]. Gertsakis, J. 2008. Sustainability and the waste management hierarchy. Retrieved on January, 30.
[8]. Staniskis, J.K. & Stasiskiene, Z. 2005.Industrial waste minimization- experience from Lithuania. Waste management &research,; 23(4), 282-290.
[9]. Rani, B., Singh, U., Maheshwari, R. &Chauhan, A.K. 2011. IJSID,I(2), 115-120.
[10]. Bardley,J.C. et al, 2015. predicting Abraham model solvent coefficients, chemistry central journal 9:12.
[11]. Jones, J.H.2002, The Cativa process for the manufacture of Acetic acid, Pltinum Metals Review, 44(3): 94-105.
[12]. Nayak .J, Pal .P. 2015. A Green process for Acetic Acid production.
[13]. Molinari, R., Poerio, T.&Argurio, P. 2006, One step production of Phenol by selective oxidation of Benzene in a biphasic system. Catalysis Today Vol118(1):52-56.
[14]. Babu, B.R.,Bhanu,S.U. & Meera,K.S. 2009 Waste minimization in electroplating industries: a review. Journal of environmental science and Health Part C, 27(3), 155-17.
[15]. Begum, R.A.,Siwar, C., Pereira, J.J.& Jaafar, A.H. 2007. Implementation of waste management and minimization in the construction industry of Malaysia. Resources, Conservation And Recycling, 51(1), 190-202.
[16]. Boralkar, D.B., Mhaskar, A.K. & Dhupkar. V. 2011. A Profile on Waste Minimization and Recycling in Chemical process Indusry. presented at symposium on chemistry inn societal and environmental needs.
[17]. Glaze W.H. 2003. Sustainability engineering and green chemistry. Env Sci Technol: 34:449A.
[18]. Kidwai, M. 2007. New Trends in Green Chemistry, Anamaya Publishers, New Delhi.
[19]. Bhojak, N., Khiwani, N. and Barwar, U. 2010. "Greenchemical Biotechnology: An Innovative Concept, Theory and Practice", Advances in Applied Biotechnology and Microbiology, Chapter No.16, pp. 95-99.
[20]. Collins, T. 2001. "Towards Sustainable Chemistry", *Science*, 291, pp. 5501-5548.