

Green chemistry in India*

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Abstract: Our environment, which is endowed by nature, needs to be protected from ever-increasing chemical pollution. The challenge for the institution and industries is to come together and pursue development in the field of greener chemistry by reducing or eliminating the use and generation of hazardous substances. We have organized a national and international symposium for promoting green chemistry in India, which has provided the platform for interaction of concepts among the leading scientists. The main idea behind this to activate work toward green chemistry for which involvement of academic, industrial, and governmental and non-governmental bodies is needed collectively, which will help the designing and development of environment-friendly chemistry practices in India.

INTRODUCTION

India, second largest producer of pesticides and ranked 12th in pharmaceutical production, is fast emerging among the top 5 players in selected petrochemicals. These facts, in turn, have led to an increased stress on our delicate environmental balance, thus India needs to pursue green chemistry along with progressive chemistry more exhaustively and extensively.

Due to large-scale production of pesticides, pharmaceuticals, petrochemicals, and other consumer durables, there is a great potential for green chemistry research in India to refine the existing technologies and also to find more environmentally benign alternatives.

To increase the research in this field, we need to publicize the needs, effects, and practice of green chemistry. Currently, green chemistry research in India is confined mainly to areas of greener synthetic strategies, catalyst development, usage of biocatalysis, usage of nonconventional technologies, and analytical techniques.

GREEN STRATEGIES

In developing green synthetic strategies, Indian scientists are mainly concentrating on avoiding environmentally noncompatible reagents, solid-phase syntheses, modification of synthetic routes to decrease the number of steps and increase overall yield, usage of newer catalysts and simplification of classical procedures of reaction. However, what is required is a combined approach for a greener synthesis.

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. The elimination of hazardous solvents is one of the prime concerns among them.

Enzymes have emerged as biotechnological tools, which can offer solutions to the major problems of the chemical industry in India. Over the years, chemists in India are engaged in enhancement of an application base of enzymes to develop new alternative sweeteners such as high fructose corn

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syrup (HFCS), synthetic honey, and other food products such as polysaccharide gums, thickeners, and flavor enhancers. There is a great need to develop newer enzymes that can work at ambient conditions and to determine their optimum activity by in-depth study. An interdisciplinary approach and healthy partnership between research institutions and industry can very effectively evolve solutions to problems faced like the increase in the cost of chemical fertilizers and consequent risk of degradation of soil fertility by excessive use of chemical fertilizers, the role of biofertilizers is becoming significant. India has been using rhizobium for leguminous crops and blue-green algae for rice cultivation, but the consumption levels have been low. Keeping in view the vast Indian biodiversity, there is need to explore the same without damaging the fragile ecological balance.

In India, although there is growing awareness about the ill effects of pollution, promotion of continual introduction of environmentally friendly products and methodologies in the chemical industry needs to be furthered. Usage of nonconventional technologies is highly popular in India. First in this list is the usage of microwaves, which is also the field of my research work [1]. Further, the microwave chemists are turning their attention toward microwave-assisted dry-media reactions in order to minimize solvent usage, an added advantage to already established microwave chemistry. In addition to microwave-assisted reactions, ultrasonic and photochemical reactions are also used as nonconventional reaction technology.

Analytical chemistry has been at the center of the green chemistry movement. Advances in analytical chemistry are key to environmental protection. 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. Monitoring and analysis of heavy metals and pesticides is very important for an agro-economy-based country like India, and chief governmental institutes like the Indian Agricultural Research Institute (IARI) and the Defense Research and Development Organisation (DRDO) are working extensively in this field. Further removing of these elements from industrial and agrochemical usage is of prime importance for these institutes.

NONACADEMIC INITIATIVES

Industry in India still needs to make significant improvement from the environmental point of view. Most of the industrial R&D is mainly concerned with cost effectiveness rather than eco-effective methods. Although there has been some collaborative work between academia and industries, still there is ample opportunity for increased collaboration. There is immediate need for technology transfer from academic labs to industrial plants for meaningful application of green research. The best examples are the applications of enzymes in various industries ranging from drugs to leather. The textile industry is one of the highly revenue generating industries in India, and they are now switching over to microbial decolorization and degradation. There is an increasing need of exploring biodiversity for natural dyes and developing eco-friendly methodology for synthetic dyes. All these require more funding in the R&D of respective fields and greater interaction and coordination between industry, academia, and government.

Government can do a lot of good for the cause of green chemistry by increasing public awareness and by bringing and enforcing strict environmental legislations. One of the recent and controversial examples of government initiative is the conversion of diesel vehicles to compressed natural gas (CNG) in order to reduce pollution in the capital city Delhi. Relocation of industries into industrial areas away from residential parks is another bold step taken by the Delhi government. Further, the government is also concentrating on new projects such as fuel pellets from municipal waste, aspirated H-cylinder engines for light commercial vehicles (LCVs), meeting India 2000 emission norms, battery-powered cars for pollution-free driving, hydrogen energy and energy towers for new environment-friendly fuel, development of traditional herbal drugs as adaptogens and immunomodulators. The government should also increase funding to encourage research in green chemistry. By introducing green chemistry education at all levels, the government can build a solid foundation toward green chemistry in India.

INDIAN CHAPTER

The recently constituted Green Chemistry Chapter of India has already started working to popularize green chemistry in India. As a part of environmental movement, a National Symposium on Green Chemistry was organized by the Department of Chemistry, University of Delhi in January 1999 to bring together all who are practicing green chemistry in India for the first time. For green chemistry education, a refresher course was organized for college teachers by the Centre for Professional Development in Higher Education in University of Delhi. Inspired by the overwhelming response of participants in these events, recently an IUPAC International Symposium on Green Chemistry was organized by the Department of Chemistry, University of Delhi, which proved to be an excellent event for scientists' world over to interact on the one common platform.

The Green Chemistry Chapter of India was constituted recently to expand its domain. Some future activities under the banner of the Green Chemistry Chapter of India have been planned. Top on the priority list is to spread the awareness of green chemistry among researchers and young students by means of workshops, conferences, scholarships, and awards. Simultaneously, there is a need to encourage industries to collaborate with academia and government for effective practice of green chemistry. Another aim of the Green Chemistry Chapter of India is to encourage global partnership for effective environmental management.

CONCLUSIONS

In conclusion, the practicing of green chemistry in India is a necessity rather than an option, as this is now a high time to protect our caring environment from further damage. The future of green India is in the hands of young researchers and students, as the practice of green chemistry is a moral responsibility for them. Government agencies should enforce the laws strictly to practice green chemistry. Industries should also understand their moral responsibility toward the fragile environment.

REFERENCE

1. M. Kidwai. *Pure Appl. Chem.* **73**, 147 (2001).