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ENVIRONMENTAL AND BIOLOGICAL ASPECTS OF GREEN CHEMISTRY

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ABSTRACT

Idea of development of green chemistry in India was not too old but it's recently adopted and considered as a shift in environmental problem-solving strategies: a step towards the regulation and reduction of industrial hazardous emissions[1].This is an active prevention of pollution through the innovative design of production technologies themselves. Documentation of the concepts as green chemistry merged along with wider implementation of the term. Green chemistry emerged from a variety of existing ideas and research efforts in three decades ago, in context of increasing attention to problems of chemical pollution and resource depletion[2].

I. INTRODUCTION

Green chemistry, also called sustainable chemistry, is an area of chemistry and chemical engineering focused on the designing of products and processes that minimize the use and generation of hazardous substances.[1] Whereas environmental chemistry focuses on the effects of polluting chemicals on nature, green chemistry focuses on technological approaches to preventing pollution and reducing consumption of nonrenewable resources.[2][3][4][5][6][7]Green chemistry overlaps with all subdisciplines of chemistry but with a particular focus on chemical synthesis, process chemistry, and chemical engineering, in industrial applications. To a lesser extent, the principles of green chemistry also affect laboratory practices. The overarching goals of green chemistry—namely, more resource-efficient and inherently safer design of molecules, materials, products, and processes—can be pursued in a wide range of contexts.(which prevailed over competing terms such as "clean" and "sustainable" chemistry).[8][9]In the United States, the Environmental Protection Agency played a significant early role in fostering green chemistry through its pollution prevention programs, funding, and professional coordination. At the same time in the United Kingdom, researchers at the University of York contributed to the establishment of the Green Chemistry Network within the Royal Society of Chemistry, and the launch of the journal Green Chemistry

II. PRINCIPLES

In 1998, Paul Anastas (who then directed the Green Chemistry Program at the US EPA) and John C. Warner (then of Polaroid Corporation) published a set of principles to guide the practice of green chemistry.[10] The twelve principles address a range of ways to reduce the environmental and health impacts of chemical production, and also indicate research priorities for the development of green chemistry technologies.The principles cover such concepts as:trends-attempts are being made not only to quantify the *greenness* of a chemical process but also to factor in other variables such as chemical yield, the price of reaction components, safety in handling chemicals, hardware demands, energy profile and ease of product workup and purification. In one quantitative study,[11] the reduction of nitrobenzene to aniline receives 64 points out of 100 marking it as an acceptable synthesis overall whereas a synthesis of an amide using HMDS is only described as adequate with a combined 32 points.

Green chemistry is increasingly seen as a powerful tool that researchers must use to evaluate the environmental impact of nanotechnology.[12] As nanomaterials are developed, the environmental and human health impacts of both the products themselves and the processes to make them must be considered to ensure their long-term economic viability.ExamplesGreen solvents- Solvents are consumed in large quantities in many chemical syntheses as well as for cleaning and degreasing. Traditional solvents are often toxic or are chlorinated. Green solvents, on the other hand, are generally derived from renewable resources and biodegrade to innocuous, often naturally occurring product.[13][14]

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III. SYNTHETIC TECHNIQUES

Novel or enhanced synthetic techniques can often provide improved environmental performance or enable better adherence to the principles of green chemistry. For example, the 2005 Nobel Prize for Chemistry was awarded, to Yves Chauvin, Robert H. Grubbs and Richard R. Schrock, for the development of the metathesis method in organic synthesis, with explicit reference to its contribution to green chemistry and "smarter production."[15] A 2005 review identified three key developments in green chemistry in the field of organic synthesis: use of supercritical carbon dioxide as green solvent, aqueous hydrogen peroxide for clean oxidations and the use of hydrogen in asymmetric synthesis.[16] Some further examples of applied green chemistry are supercritical water oxidation, on water reactions, and dry media reactions

Bioengineering is also seen as a promising technique for achieving green chemistry goals. A number of important process chemicals can be synthesized in engineered organisms, such as shikimate, a Tamiflu precursor which is fermented by Roche in bacteria. The concept of 'green pharmacy' has recently been articulated based on similar principles.[17]

Carbon dioxide as blowing agent- In 1996, Dow Chemical won the 1996 Greener Reaction Conditions award for their 100% carbon dioxide blowing agent for **polystyrene** foam production. Polystyrene foam is a common material used in packing and food transportation. Seven hundred million pounds are produced each year in the United States alone. Traditionally, CFC and other **ozone**-depleting chemicals were used in the production process of the foam sheets, presenting a serious environmental hazard. Flammable, explosive, and, in some cases toxic hydrocarbons have also been used as CFC replacements, but they present their own problems. Dow Chemical discovered that supercritical carbon dioxide works equally as well as a blowing agent, without the need for hazardous substances, allowing the polystyrene to be more easily recycled. The CO_2 used in the process is reused from other industries, so the net carbon released from the process is zero.

Hydrazine- Addressing principle #2 is the Peroxide Process for producing hydrazine without cogenerating salt. Hydrazine is traditionally produced by the Olin Raschig process from sodium hypochlorite (the active ingredient in many **bleaches**) and **ammonia**. The net reaction produces one equivalent of sodium chloride for every equivalent of the targeted product hydrazine:[18]

$$NaOCl + 2\ NH_3 \rightarrow H_2N\text{-}NH_2 + NaCl + H_2O$$

In the greener Peroxide process hydrogen peroxide is employed as the oxidant, the side product being water. The net conversion follows:

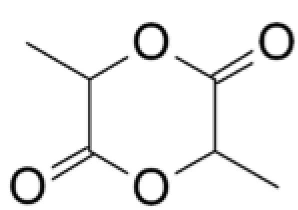
$$2\ NH_3 + H_2O_2 \rightarrow H_2N\text{-}NH_2 + 2\ H_2O$$

Addressing principle #4, this process does not require auxiliary extracting solvents. Methyl ethyl ketone is used as a carrier for the hydrazine, the intermediate ketazide phase separates from the reaction mixture, facilitating workup without the need of an extracting solvent.

1,3-Propanediol

Addressing principle #7 is a green route to 1,3-propanediol, which is traditionally generated from petrochemical precursors. It can be produced from renewable precursors via the bioseparation of 1,3-propanediol using a genetically modified strain of *E. coli*.[19] This diol is used to make new polyesters for the manufacture of carpets.

Lactide



Lactide

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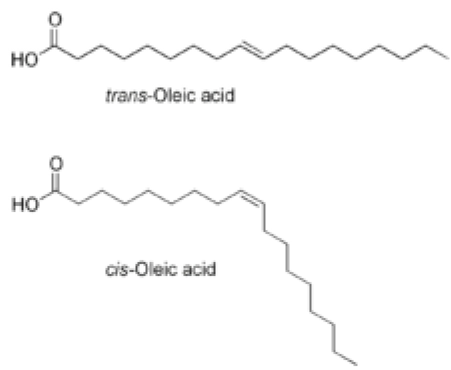
In 2002, Cargill Dow (now NatureWorks) won the Greener Reaction Conditions Award for their improved method for polymerization of polylactic acid . Unfortunately, lactide-base polymers do not perform well and the project was discontinued by Dow soon after the award. Lactic acid is produced by fermenting corn and converted to lactide, the cyclic dimer ester of lactic acid using an efficient, tin-catalyzed cyclization. The L,L-lactide enantiomer is isolated by distillation and polymerized in the melt to make a crystallizable polymer, which has some applications including textiles and apparel, cutlery, and food packaging. Wal-Mart has announced that it is using/will use PLA for its produce packaging. The NatureWorks PLA process substitutes renewable materials for petroleum feedstocks, doesn't require the use of hazardous organic solvents typical in other PLA processes, and results in a high-quality polymer that is recyclable and compostable.

IV. CARPET TILE BACKINGS

In 2003 Shaw Industries selected a combination of polyolefin resins as the base polymer of choice for EcoWorx due to the low toxicity of its feedstocks, superior adhesion properties, dimensional stability, and its ability to be recycled. The EcoWorx compound also had to be designed to be compatible with nylon carpet fiber. Although EcoWorx may be recovered from any fiber type, nylon-6 provides a significant advantage. Polyolefins are compatible with known nylon-6 depolymerization methods. PVC interferes with those processes. Nylon-6 chemistry is well-known and not addressed in first-generation production. From its inception, EcoWorx met all of the design criteria necessary to satisfy the needs of the marketplace from a performance, health, and environmental standpoint. Research indicated that separation of the fiber and backing through elutriation, grinding, and air separation proved to be the best way to recover the face and backing components, but an infrastructure for returning postconsumer EcoWorx to the elutriation process was necessary. Research also indicated that the postconsumer carpet tile had a positive economic value at the end of its useful life. EcoWorx is recognized by MBDC as a certified cradle-to-cradle design.



Trans and *cis* fatty acids

V. TRANSESTERIFICATION OF FATS

In 2005, Archer Daniels Midland (ADM) and Novozymes won the Greener Synthetic Pathways Award for their enzyme interesterification process. In response to the U.S. Food and Drug Administration (FDA) mandated labeling of *trans*-fats on nutritional information by January 1, 2006, Novozymes and ADM worked together to develop a clean, enzymatic process for the interesterification of oils and fats by interchanging saturated and unsaturated fatty acids. The result is commercially viable products without *trans*-fats. In addition to the human health benefits of eliminating *trans*-fats, the process has reduced the use of toxic chemicals and water, prevents vast amounts of byproducts, and reduces the amount of fats and oils wasted.
Bio-succinic acid

In 2011, the Outstanding Green Chemistry Accomplishments by a Small Business Award went to BioAmber Inc. for integrated production and downstream applications of bio-based succinic acid. Succinic acid is a platform chemical that is an important starting material in the formulations of everyday products. Traditionally, succinic acid is produced from petroleum-based feedstocks. BioAmber has developed process and technology that produces succinic acid from the fermentation of renewable feedstocks at a lower cost and lower energy expenditure than the petroleum equivalent while sequestering CO_2 rather than emitting it.[20]

VI. LABORATORY CHEMICALS

Several laboratory chemicals are controversial from the perspective of Green chemistry. The Massachusetts Institute of Technology has created the [2] to help identify alternatives. Ethidium bromide, xylene, mercury, and formaldehyde have been identified as "worst offenders" which have alternatives.[21] Solvents 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.[22] In the Pharmaceutical Industry, both GSK[23] and Pfizer[24] have published Solvent Selection Guides for their Drug Discovery chemists.

VII. ADVANTAGES OF GREEN CHEMISTRY

Human health

- Cleaner air: Less release of hazardous chemicals to air leading to less damage to lungs
- Cleaner water: less release of hazardous chemical wastes to water leading to cleaner drinking and recreational water
- Increased safety for workers in the chemical industry; less use of toxic materials; less personal protective equipment required; less potential for accidents (e.g., fires or explosions)
- Safer consumer products of all types: new, safer products will become available for purchase; some products (e.g., drugs) will be made with less waste; some products (i.e., pesticides, cleaning products) will be replacements for less safe products
- Safer food: elimination of persistent toxic chemicals that can enter the food chain; safer pesticides that are toxic only to specific pests and degrade rapidly after use
- Less exposure to such toxic chemicals as endocrine disruptors

Environment

- Many chemicals end up in the environment by intentional release during use (e.g., pesticides), by unintended releases (including emissions during manufacturing), or by disposal. Green chemicals either degrade to innocuous products or are recovered for further use
- Plants and animals suffer less harm from toxic chemicals in the environment
- Lower potential for global warming, ozone depletion, and smog formation
- Less chemical disruption of ecosystems
- Less use of landfills, especially hazardous waste landfills

Economy and business

- Higher yields for chemical reactions, consuming smaller amounts of feedstock to obtain the same amount of product
- Fewer synthetic steps, often allowing faster manufacturing of products, increasing plant capacity, and saving energy and water
- Reduced waste, eliminating costly remediation, hazardous waste disposal, and end-of-the-pipe treatments
- Allow replacement of a purchased feedstock by a waste product
- Better performance so that less product is needed to achieve the same function
- Reduced use of petroleum products, slowing their depletion and avoiding their hazards and price fluctuations
- Reduced manufacturing plant size or footprint through increased throughput
- Increased consumer sales by earning and displaying a safer-product label (e.g., Safer Choice labeling)
- Improved competitiveness of chemical manufacturers and their customers

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REFERENCES

[1] **Green Chem.**, 2016, Advance Article **DOI:** 10.1039/C6GC01113F, Paper **First published online :** 13 May 2016

[2] "Green Chemistry". United States Environmental Protection Agency. 2006-06-28. Retrieved 2011-03-23.

[3] Sheldon, R. A.; Arends, I. W. C. E.; Hanefeld, U. (2007). "Green Chemistry and Catalysis".doi:10.1002/9783527611003. ISBN 9783527611003.

[4] Clark, J. H.; Luque, R.; Matharu, A. S. (2012). "Green Chemistry, Biofuels, and Biorefinery". Annual Review of Chemical and Biomolecular Engineering ***3****: 183–207. doi:10.1146/annurev-chembioeng-062011-081014.PMID 22468603.*

[5] Cernansky, R. (2015). "Chemistry: Green refill". Nature ***519*** *(7543): 379. doi:10.1038/nj7543-379a.*

[6] Sanderson, K. (2011). "Chemistry: It's not easy being green". Nature ***469*** *(7328): 18. doi:10.1038/469018a.*

[7] Poliakoff, M.; Licence, P. (2007). "Sustainable technology: Green chemistry". Nature ***450*** *(7171): 810–812.doi:10.1038/450810a. PMID 18064000.*

[8] Clark, J. H. (1999). "Green chemistry: Challenges and opportunities". Green Chemistry ***1****: 1.doi:10.1039/A807961G.*

[9] Woodhouse, E. J.; Breyman, S. (2005). "Green chemistry as social movement?". Science, Technology, & Human Values ***30*** *(2): 199–222. doi:10.1177/0162243904271726.*

*[10] Linthorst, J. A. (2009). "An overview: Origins and development of green chemistry". Foundations of Chemistry****12****: 55. doi:10.1007/s10698-009-9079-4.*

[11] Anastas, Paul T.; Warner, John C. (1998). Green chemistry: theory and practice. Oxford [England]; New York: Oxford University Press. ISBN 9780198502340.

[12] Van Aken, K.; Strekowski, L.; Patiny, L. (2006). "EcoScale, a semi-quantitative tool to select an organic preparation based on economical and ecological parameters". Beilstein Journal of Organic Chemistry ***2*** *(1): 3. doi:10.1186/1860-5397-2-3. PMC 1409775. PMID 16542013.*

[13] Green nanotechnology

[14] Prat, D.; Pardigon, O.; Flemming, H.-W.; Letestu, S.; Ducandas, V.; Isnard, P.; Guntrum, E.; Senac, T.; Ruisseau, S.; Cruciani, P.; Hosek, P., "Sanofi's Solvent Selection Guide: A Step Toward More Sustainable Processes", Org. Proc. Res. Devel. 2013, 17, 1517-1525. doi:10.1021/op4002565

[15] Sherman, J.; Chin, B.; Huibers, P. D. T.; Garcia-Valls, R.; Hatton, T. A., "Solvent Replacement for Green Processing", Environ. Health Persp. 1998, 106, 253-271. doi:10.2307/3433925

[16] "The Nobel Prize in Chemistry 2005". The Nobel Foundation. Retrieved 2006-08-04.

[17] Noyori, R. (2005). "Pursuing practical elegance in chemical synthesis". Chemical Communications (14): 1807.doi:10.1039/B502713F.

[18] Baron, M. (2012). "Towards a Greener Pharmacy by More Eco Design". Waste and Biomass Valorization ***3*** *(4): 395.doi:10.1007/s12649-012-9146-2.*

[19] Jean-Pierre Schirmann, Paul Bourdauducq "Hydrazine" in Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH, Weinheim, 2002. doi:10.1002/14356007.a13_177.

[20] Kurian, Joseph V. "A New Polymer Platform for the Future – Sorona from Corn Derived 1,3-Propanediol" Journal of Polymers and the Environment, Vol. 13, No. 2 (April 2005).

[21] "2011 Small Business Award". United States Environmental Protection Agency.

[22] Coombs A. (2009). Green at the Bench. *The Scientist.*

[23] J-C Bradley *et al.*, "Predicting Abraham model solvent coefficients", *Chemistry Central Journal* 9:12 (2015)

[24]Henderson, R. K.; Jiménez-González, C. N.; Constable, D. J. C.; Alston, S. R.; Inglis, G. G. A.; Fisher, G.; Sherwood, J.; Binks, S. P.; Curzons, A. D. (2011). "Expanding GSK's solvent selection guide – embedding sustainability into solvent selection starting at medicinal chemistry". Green Chemistry ***13*** *(4): 854. doi:10.1039/c0gc00918k.*

[25] Alfonsi, K.; Colberg, J.; Dunn, P. J.; Fevig, T.; Jennings, S.; Johnson, T. A.; Kleine, H. P.; Knight, C.; Nagy, M. A.; Perry, D. A.; Stefaniak, M. (2008). "Green chemistry tools to influence a medicinal chemistry and research chemistry based organisation". Green Chem ***10****: 31. doi:10.1039/B711717E.*

[26] Wilson, M. P.; Chia, D. A.; Ehlers, B. C. (2006). "Green chemistry in California: a framework for leadership in chemicals policy and innovation" (PDF). New Solutions ***16*** *(4): 365–372. doi:10.2190/9584-1330-1647-136p.PMID 17317635.*

[27] Wilson, M. P.; Schwarzman, M. R. (2009). "Toward a new U.S. Chemicals policy: Rebuilding the foundation to advance new science, green chemistry, and environmental health". Environmental Health Perspectives ***117*** *(8): 1202–9. doi:10.1289/ehp.0800404. PMC 2721862. PMID 19672398.*

[28] California Department of Toxic Substances Control. "What is the Safer Consumer Products (SCP) Program?". Retrieved 5 September 2015.

[29] Anastas, P.T., Levy, I.J., Parent, K.E., eds. (2009). Green Chemistry Education: Changing the Course of Chemistry. ACS Symposium Series ***1011****. Washington, DC: American Chemical Society. doi:10.1021/bk-2009-1011. ISBN 978-0-8412-7447-1.*

[30] http://www.kurser.dtu.dk/26960.aspx?menulanguage=da

[31] http://www.umb.edu/academics/csm/chemistry/grad/phd_in_chemistry/cgc_phd

[32] Ecology Center Annual Report (2011). [1].

[33] Greener Education Materials, a database of green chemistry topics. EurekAlert. (2009). Thinking of turning your chemistry green? Consult GEMs. AAAS.

[34] MSc in Green Chemistry & Sustainable Industrial Technology at the Green Chemistry Centre of Excellence based at the University of York

*[35]*MásterUniversitarioenQuímica Sostenible. UniversitatJaume I

[36] MásterUniversitarioenQuímica Sostenible. Universidad Pública de Navarra (UPNA).

[37] http://www.gruene-chemie.ch/en/

[38] Matus, K. J. M.; Clark, W. C.; Anastas, P. T.; Zimmerman, J. B. (2012). "Barriers to the Implementation of Green Chemistry in the United States". Environmental Science & Technology ***46*** *(20): 10892–10899.doi:10.1021/es3021777.*

[39] "Announcing the 2005 Canadian Green Chemistry Medal". RSC Publishing. Retrieved 2006-08-04.

[40] "Chemistry for the Environment". Interuniversity Consortium. Retrieved 2007-02-15.

[41] "Green & Sustainable Chemistry Network, Japan". Green & Sustainable Chemistry Network. Retrieved 2006-08-04.

[42] "2005 Crystal Faraday Green Chemical Technology Awards". Green Chemistry Network. Retrieved 2006-08-04.

[43] "The Presidential Green Chemistry Awards". United States Environmental Protection Agency. Retrieved2006-07-31.

[44]"Information about the Presidential Green Chemistry Challenge". Retrieved 2014-08-10