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Innovation in Green Chemistry

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Abstract: Green chemistry represents the pillars that hold up our sustainable future. It is imperative to teach the value of green chemistry to tomorrow's chemists. It is clear that many industries and research of many academics recognize the significance of green chemistry. In the practice of green chemistry a set of principles that reduces or eliminates the use of hazardous substance in the design, manufacture and applications of chemical products are utilized. This article presents selected examples of the innovations of green chemistry principles in industry.
Keywords: Green chemistry, sustainable development, Innovations

Introduction

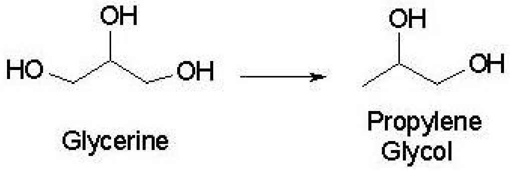
Green chemistry is not a new branch of science. It is a new philosophical approach towards meeting the sustainability. The hazards of the matter we confront are based on the physical/ chemical properties of the molecules we analyze. Through the design of matter at the molecular level, and the type of reaction and reaction conditions we choose, we can deal with fundamental problems such as toxicity, renewability and global impact. For these reasons, Green Chemistry is considered as a new chemical philosophy which encourages the design of processes and products that reduce or eliminate the use and generation of hazardous substances. Green chemistry is commonly presented as a set of twelve principles[1-3] proposed by Anastas and Warner. Green chemistry incorporates a new approach to the synthesis, processing and application of chemical substances in such a manner as to reduce threats to health and the environment. Over the course of the past decade Green chemistry has demonstrated how fundamental scientific methodologies can protect human health and the environment in an economically beneficial manner. Significant progress is being made in several key areas, such as catalysis, the design of safer chemicals and environmentally benign solvents and the development of renewable feedstocks[4-7]. It has come to recognized in recent years, that Green chemistry is central to addressing the problems facing the environment.

Innovation in Green Chemistry

Chemists from all over the world are using their creative and innovative skills to develop new processes, synthetic methods, reaction conditions, catalysts etc., under the new Green chemistry concepts. Some of these are:

- 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. Traditionally, CFC and other ozone-depleting chemicals were used in the production process of the foam sheets, presenting a serious environmental hazard. 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.
- In 2006, Professor Galen J. Suppes, from the University of Missouri in Columbia, Missouri, was awarded the Academic Award for his system of converting waste glycerin from biodiesel production to propylene glycol with the use of a copper-chromite catalyst. Propylene glycol

produced in this way will be cheap enough to replace the more toxic ethylene glycol that is the primary ingredient in automobile antifreeze.



- Propylene oxide (**PO**) is a chemical building block for a variety of products including detergents, polyurethanes, food additives. Traditional PO production uses chlorohydrin which leads to coproducts such as t-butyl alcohol, styrene monomer, or cumene. Its manufacture creates by-products, including a significant amount of waste. Dow and BASF have jointly developed a new route to make propylene oxide with hydrogen peroxide and propylene that eliminates most of waste. Dow and BASF have jointly developed a new route to make propylene oxide with hydrogen peroxide and propylene that eliminates most of waste.

- Historically, chlorofluorocarbons (**CFCs**) have been used as refrigerants in air conditioners and refrigerators. CFCs have the advantages of safe incombustibility, high stability, and low toxicity, but unfortunately they destroy the ozone layer. In the past decade, various hydrochlorofluorocarbons (**HCFCs**) and hydrofluorocarbons (**HFCs**) have replaced CFCs. HCFCs and HFCs are, indeed, safer for the ozone layer, but they have been shown to be strong greenhouse gases. A. S. Trust & Holdings has developed HCR-188C, a substitute hydrocarbon formulation that has been independently evaluated to have zero ozone-depletion potential. Its cooling efficiency exceeds that of CFC R-12. In 2008, EPA's Significant New Alternatives Program approved HCR-188C for sale in the United States as a replacement for CFC-12 coolant fluid in household refrigeration and air conditioning units.

- Chelates are complex that interact with metal ions, often increasing the solubility of the metal ion. They are used in many types of cleaners and industrial processes. Conventional chelates are based on aminocarboxylic acids (e.g., ethylenediaminetetraacetic acid, EDTA) and phosphates (e.g., sodium tripolyphosphate). Unfortunately, because EDTA is not readily biodegradable and because phosphates can cause pollution via eutrophication, these conventional materials are often viewed as environmentally unfriendly. Akzo Nobel has developed a readily biodegradable chelating agent that is manufactured principally from a renewable feedstock. This new chelate, called tetrasodium L-glutamic acid, *N,N*-diacetic acid (**GLDA**), will replace phosphates in automatic dishwashing detergents. GLDA is manufactured from the flavor enhancer monosodium glutamate (**MSG**) in an essentially waste-free synthesis. MSG is made by fermenting readily available corn sugars and is considered a renewable material. The synthesis of GLDA includes classic cyanomethylation of the primary amino nitrogen on the MSG followed by in situ alkaline saponification. In contrast with EDTA whose carbon is fossil-based, but in GLDA is biobased. Because GLDA is highly soluble, it will be offered at a significantly higher concentration (approximately 30 percent higher molar aqueous concentration) than EDTA, reducing transport and packaging costs as well as packaging waste. Most significantly, GLDA is readily biodegradable and will reduce pollution by replacing phosphates in dishwashing detergents.

- Spinosad, a product of Dow Agro Sciences and a 1999 winner of the Presidential Green Chemistry award. Spinosad, is a low-risk pesticide in widespread use on crops. Spinosad adsorbs strongly to soils and organic matter, degrades photochemically at the site of application, and is inherently unstable in water. These characteristics make it excellent for use on land, but had prevented its use in aqueous environments. Spinosad is an environmentally safe pesticide but is not stable in water and so therefore cannot be used to control mosquito larvae. Clarke launched Natular in the U.S. market in December 2008. Natular, a spinosad based mosquito larvicide that provides excellent control in aquatic environments. It is 15 times less toxic than the organophosphate alternative, does not persist in the environment, is not toxic to wildlife, and eliminates the use of hazardous materials.

Conclusions

Presently it is easy to find in the literature many interesting examples of the use of green chemistry rules. Great efforts are still undertaken to design an ideal process that starts from non-polluting materials. 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. Furthermore, the success of green chemistry depends on the training and education of a new generation of chemists. Student at all levels have to be introduced to the practice of green chemistry.

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