GREEN CHEMISTRY PROCESS FOR REDUCING WASTE AND HAZARDOUS MATERIALS IN ENIVIRONMENT

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Abstract
Green chemistry makes use of procedures that lessen waste and dangerous substances. Green is a preventative strategy that is mostly used to lessen pollution. Contrary to how pollution is cleaned up, which entails handling waste streams or cleaning up environmental spills and other discharges? Separating potentially dangerous compounds from other substances, cleaning them to make them less dangerous, or concentrating them for safe disposal are all examples of remediation. As environmental pollution from businesses and research facilities rises day by day, it is crucial to create new technologies to lessen this kind of pollution. Green chemistry is often not used in remediation processes. Remediation eliminates harmful contaminants from the environment; green chemistry, on the other hand, prevents the release of hazardous compounds into the environment in the first place.
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Introduction
Pollution is the process of making the environment unusable or unsafe by making the air, water, or other elements of the environment unclean. More than 200 million people are impacted by toxic pollution globally, claims pure earth, a nonprofit environmental group. In order to increase the environmental protection and the economics of chemical manufacture, novel chemistry is now absolutely necessary. Researchers and industrialists have produced a lot of vest items in recent decades as well, therefore in order to solve this issue; we must make our synthetic processes better. Green chemistry is a recently developed idea that is appealing to chemists, academics, and industrialists for cutting-edge chemical research and applications. The important work of green chemistry is characterized as reduction of the environmental damage accompanied by the production of materials and respective minimization and proper disposal of wastes generated during different chemical processes[1-9].
Green chemistry is a new technique devoted to the synthesis, processing, and application of chemical materials in such manner as to reduce hazards to human life and the environment[10].
Numerous new terms have been introduced associated with the concept of green chemistry, such as sustainable chemistry, eco-efficiency, product life cycle analysis, renewable energy sources, atom efficiency or atom economy, process intensification and integration, inherent safety, ionic liquids, and alternate feed stocks. Hence, there is an essentialneed to improve the synthetic chemistry either by environmental friendly starting materials or designing novel synthesis routes that reduce the use and generation of toxic substances by using modern energy sources. The term “sustainable” has been used very freely for a wide range of issues, which have had very little or nothing to do with sustainability[11-12]. It is proposed that this could be corrected by systematically applying two independent definitions:
Green chemistry is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture, and applications of chemical products.
Sustainable chemistry is the use of resources, including energy, at a rate at which they can be

replaced naturally, and the generation of waste, which cannot be faster than the rate of their remediation[13].

Principles of Green Chemistry

Twelve principles of green chemistry have been developed by Paul Anastas and John Warner of EPA[14], and in their Green Chemistry Theory and Practice book, 1998, they explained their meaning in practice.The all principals of green chemistry tells about reactants and products i.e. when we start the reaction number of products and by-product are generated, in which most of the products and by-product are toxic and affect to human health. Paul Anastas and John Warner of EPA proposed twelve principal which is helpful for all researcher to helpful for improve inhibit toxic material generated from their work.

1. Prevention

It is better to prevent waste than to treat or clean up waste after it has been created. This statement is one of the important statement for optimization the reactions.The design and synthesis reaction,which is more favourable for human health as well as environment, to generation of lower amount of hazardous waste to prevent the pollution.Rapid increase in urbanisation and per capita income in India has significantly led to an increase in municipal solid waste generation in the country.Urban Indian generates 62 million tonnes of waste (MSW) annually, said a 2014 Planning Commission report. It also predicted that the volume will increase to 165 million tonnes by 2030.India's solid waste collection efficiency, however, is around 70 per cent at present, while it is almost 100 per cent in many developed countries.Moreover, 43 million tonnes of municipal solid waste was collected annually, out of which 31 million was dumped at the landfill sites and 11.9 million was treated, the environment ministry said in 2016.India, at present, generates the most waste globally, and that's expected to increase substantially by 2050 unless urgent measures are not taken. Presently in India, about 960 million tonnes of solid waste is being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. In industry produce number of waste chemicals may include organic compounds (such as solvents), metals, nutrients or radioactive material. If the wastewater is discharged without treatment, groundwater and surface water bodieslakes, streams, rivers and coastal waters can become polluted, with serious impacts on human health and the environment.

For example, Merck and Codexis developed a second-generation green synthesis of sitagliptin, the active ingredient in Januvia™, a treatment for type 2diabetes (Fig. 1). This collaboration lead to an enzymatic process that reduces waste, improves yield and safety, and eliminates the need for a metal catalyst. Early research suggests that the new biocatalysts will be useful in manufacturing other drugs as well.

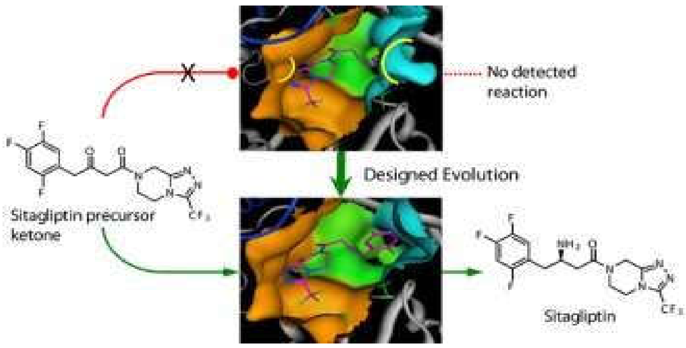

Figure 1: Synthesis of sitagliptin (Fig. adopted from google)

According to these ideas, we need to fundamentally reconsider our understanding of waste as hazardous material that needs to be disposed by enhancing the status of waste to a valued resource, which can act as starting material for generation of new products.

2. Atom Economy

The atom economy of a reaction is a measure of the amount of starting materials that end up as useful products. It is important for sustainable development and for economic reasons to use reactions with high atom economy.One example for atom economy is here that, two ideas are proposed, preparation of HCl gas which, dissolved in water produces hydrochloric acid. HCl can be prepared from various synthetic methods. One common example is the reaction of concentrated sulphuric acid (H_2SO_4), with common table salt (NaCl) accompanied by heating to drive off the volatile HCl vapour

$$2NaCl(s)+H_2SO_4(l)\rightarrow 2HCl(g)+Na_2SO_4(s)$$

This reaction can be performed so that all of the NaCl and H_2SO_4 react, which gives a 100% yield. This reaction produces Na_2SO_4 as by-product, so the atom economy is less than 100%. The percent atom economy is calculated very simply by the relationship

$$\text{Percent atom economy}=\frac{\text{Mass of desired product}}{\text{Total mass of product}}\times 100$$

We could just as well divide by the total mass of reactants since in a chemical reaction it is equal to the total mass of products. In this case, the mass of the desired product is that of 2 HCl and the total mass of product is that of 2HCl + Na_2SO_4. Given the atomic masses H (1.0), Cl (35.5), Na (23.0), and O (16.0)

$$\text{Mass of desired product}=2\times(1.0+35.5)=73.0$$

$$\text{Total mass product}=2\times(1.0+35.5)+(2\times23.0+32.0+4\times16.0)=215$$

$$\text{Percent atom economy}=73.0215\times100=34.0\%$$

This result shows that even with 100% yield, the reaction is only 34.0% atom economical and prepared HCl in large quantities of Na_2SO_4 a material with only limited value, would be produced. In contrast, the direct reaction of hydrogen gas with chlorine gas to give HCl gas,

$$H_2(g)+Cl_2(g)\rightarrow 2HCl(g)$$

here 100% atom economy if all of the H_2 reacts with Cl_2. There is no waste byproduct.

3. Less Hazardous Chemical Syntheses

In researcher and industries generate toxic products thus,synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment. In organic chemistry synthesis most of the reactions are multistep and some of reactants are toxic but these toxic reactants are contaminated to products.We should design and synthesis molecule in such a way that, product should be no or little toxic to human health and the environment.In organic chemistry Retrosynthes method is prominent or good

example to follow Less Hazardous Chemical Syntheses principal. In this method less toxic starting material can be used in synthesis and a safer route can be designed so that toxic by-products are not produced. We can also reduce the number of steps in synthesis will also ensure less by-product formation.
For example, in Chloro-alkali reaction is chlorine gas is produced.In this reaction three processes currently implemented for this reaction are mercury cell which produces mercurous toxic waste, diaphragm cell which uses asbestos, and membrane cell which uses cellulose-based membrane which is least hazardous of all three methods.

4. Designing Safer Chemicals

In this principal, again we should fallow the Reterosynthesis principal,we design synthetic reactionin such a way that all chemicals are efficient at their given purpose, andreduce their toxicity. In recent year, toxicity is big problem and its challenging task for all fields that to generate or produce less toxic molecule. It's our responsibility to checkor either predict or test formolecule's toxicity.To cheek molecule's toxicity we should collaboration with field of toxicologists. Many green chemistry educators are also pushing towards including a working knowledge of basic toxicology into undergraduate chemistry degrees, to train all future chemists to consider toxicity from the very beginnings of molecular design.

5. Safer Solvents and Auxiliaries

The use of auxiliary substances i.e. solvents, separation agents, etc. should be made unnecessary wherever possible and innocuous when used.In practical lab of organic chemistry large quantities of solvents are used and wasted and these solvents are very harmful for human health as well as environmental pollution. Most of the organic solvents are toxic, flammable and corrosive.Safer Solvents and Auxiliaries recommends that the
process of synthesis be maximally reduced and, whenever possible, avoid the use of auxiliary chemical substances (egsolvents, separating agents, etc.) When used they should be harmless. According to the principles of green chemistry, thechoice of suitable substitutions for organic solvents is based on: worker safety, process safety, environmental safety and sustainability of the process. The solvent should bechemically and physically stable, low volatility, easy to use.
Solvents are the most common example of auxiliary substances. Usually, solvents themselves do not react with the reagents but are still necessary in reactions in order to dissolve reagents, mix all reaction components, and control the temperature of the reaction. After the reaction, more solvents are then often used to separate and purify the product from other reaction components and any side-products.Use of safer solvents and auxiliaries is a principle of green chemistry it states that safer solvent like water, supercritical CO_2 should be used in place of volatile halogenated organic solvents, like CH_2CI_2, $CHCI_3$, CCI_4 for chemical synthesis and other purposes. Solvents dissolve solutes and form solutions, they facilitate many reactions. Water is a safer benign solvent while solvents like dichloromethane (CH_2CI_2), chloroform ($CHCI_3$) etc. are hazardous. Use of toxic solvents affect millions of workers every year and have implications for consumers and the environment. A large amount of waste is created by their use and they also have huge environmental and health impacts. Finding safer solvents or designing processes which are solvent free is the best way to improve the process and the product.

6. Design for Energy Efficiency

In chemistry (and in life) energy is essential thus we need energy to do work. In practical lab, without energy work is not precededfor example we're using a Bunsen burner or weighing out a reagent or dissolving our favourite compound, in all cases we're using energy in some form. In the practical lab, we need to change the pressure and temperature of experiments, and this uses a large amount of energy (water bath, Oil bath). When reactions are perform at ambient conditions, room temperature and atmospheric pressure in order to minimize energy usage.In any chemical synthesis the requirement of energy should be kept to a lower. The reaction in which the reaction mixture has to be heated to reflux for completing the reaction, the time required for completion of reaction should be minimum, so that less amount of energy is required. Even the use of a catalyst lowers the requirement of energy of a reaction.

7. Use of Renewable Feedstocks

A raw material or feedstock should be renewable rather than depleting whenever technically and economically possible.In most of the industries common feedstocks are depleting, such as petroleum and natural gas. The petrochemical industry uses petroleum and natural gas as feedstocks to make intermediates, which are later converted to final products. These final products peoples are used in daily life such as plastics, paints, pharmaceuticals, and many others.One of the good examples of a renewable feedstock is biomass, which refers to any material derived from living organisms, usually plants. After the depleting feedstocks like petroleum, new plants can easily grow once we use them up, and maintain a continuous supply. If we can use bio-based chemicals to do the same tasks that we currently accomplish using petrochemicals, we move closer to the goal of having a steady, reliable supply of resources for the future.

8. Reduce Derivatives

Unnecessary derivatization (e.g. installation/removal of use protecting groups) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.

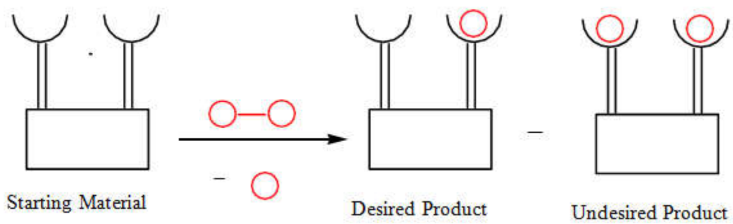

Figure 2 An unselective reaction without protection.

In Figure 2, the starting material contains two reactive sites, represented by U-shaped slots. In this figure it clearly indicates two reactive sites but we want to slot on the right to react with the reagent, shown as red circles. The starting material is reacted with the reagent in order to make the desired product, buthere reactant react both side and undesired product forms, because both U-shaped slots react with the red circle. In other words, Figure 2 shows an unselective reaction because a mixture of products (both react) is made.By using protection group formation of the undesired product can be avoided before using the red reagent, and then carrying out a finally deprotection we can get desired product. This reactions is shown in Figure 3.

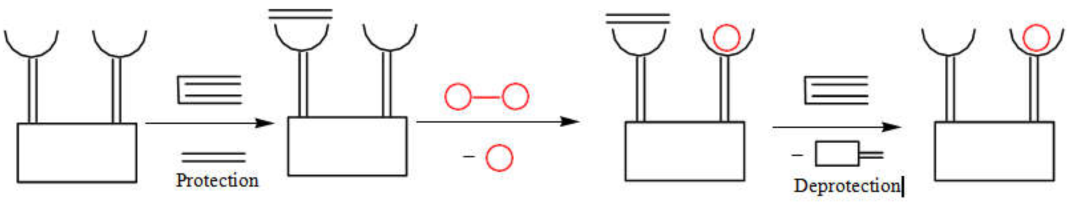

Figure 3 A selective reactions through the use of a protecting and deprotection group.

Figure 3 shows how a selective reaction is traditionally done through the use of a temporary block,this group is known as a protecting group. In figure 3 it clearly indicates that, starting material can be protected by blocking one of the reactive sites, represented by the blue rectangle covering the U-shaped slot on the left. After the blocking one reactive site, intermediate only has one reactive site left, and thenred reagent can only react at the empty U-shaped slot on the right. To get the same desired product as in Figure 2, the third and final deprotection step is carried out, which removes the protecting group.

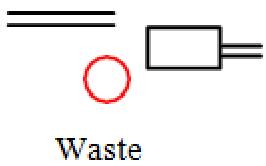

Figure 4. The waste created by all three reactions.

In Figure 2 it clearly seen to generate desired product, here to formation of product we are fallow three steps and only make one change, which is inefficient. Also, each step generates waste products which are depicted in Figure 4.Protecting groups are a useful tool that chemists use to make the molecules, because we often need to carry out selective reactions on a molecule that has multiple of the same reactive sites.

9. Catalysis

A catalyst is a reagent which plays prominent role in the reaction. In reaction catalyst participates in a chemical reaction, yet remains unchanged after the reaction is complete. Catalyst work is by lowering the energy barrier of a given reaction by interacting with reactants and product, as seen in Figure 5 below. The reactants are represented by the red and blue objects and the catalyst by the green one. In organic reaction, many reactions reactants cannot react with each other to form desired product in this reaction catalyst plays important role. However, once the catalyst interacts with them, the reactants become compatible and can subsequently react together. The desired product is formed and the catalyst is regenerated to its initial stage to continue interacting with the remaining reactants to produce more product yield.

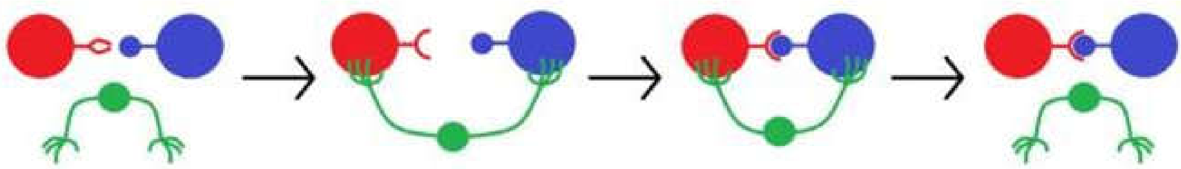

Figure 5. Catalyst's react with both reactants and helpful forformation of desired product (Fig adopted from google).

Design for Degradation

Chemical products should be designed in such a way that, after completion of reaction product become break down into innocuous degradation and do not persist in the environment.In our daily life we use lot of the chemicals lives need to be stable to perform their function. For example, if your milk mug dissolved when you poured your sugar into it, it wouldn't be very helpful! But lubricants degraded under high temperature and pressure, they may not work well in the engines of our cars or planes which is very harmful.

After chemicals are done providing their main function, they throw in a landfill or wastewater treatment plant after they can enter the waters, soil and air of our environment, or be taken up by animals or humans. The biggest challenge in recent year is making chemicals that are stable during usage, but don't persist in the environment or chemicals that can be degraded. Another important thing we want the breakdown products to also be non-toxic and not affect environment. It's important to remember that there are different reasons a chemical can break down.To breakdown productsby using with light (photo degradation), water (hydrolysis) or biological species and enzymes (biodegradation).

A common example is biodegradation, especially with the well-known biodegradable soaps.In this example design soaps, or detergents, to break down more easily in the environment.

Real-time Analysis for Pollution Prevention

Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances. As chemists, we conduct several experiments every day. When we put reaction it is necessary to use various analytical techniques to monitor the reaction. For example in highway if car don't have any mirror then some sort of accident is possible. Windows and rearview mirrors provide the driver with means to monitor their surroundings in real time and allow them to react and adjust. Thus we have to design of analytical methodologies to monitor chemical reactions in real time and allow for adjustments. In many industries it's essential to have suitable analytical method to monitor reactions in real time. We can think of the windows and rearview mirrors as examples of such "analytical methodologies".

Inherently Safer Chemistry for Accident Prevention

Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires. This principle is also known as the "Safety Principle".

Although this principle, specifically about the avoidance of using or producing hazardous compounds. In last few decades we are seen in research lab and industries about explosion. The reason behind this explosion is storing chemicals that are reactive together, such as oxidizers and flammable materials, leads to a risk of release and reaction. If these compounds leak from their containers and react, they will create a large fire. To avoiding this fire, all these chemical are store in separately. Another hazard in the lab is liquid spills. Anything that has been spilled should be immediately cleaned up to prevent people from slipping on it or receiving chemical burns from an unknown substance. If someone comes across an acid spill, but does not know what it is they could easily be burned in attempting to clean it up. The unfortunate driver could be injured as a result of faulty brakes, just as another lab member could be injured by your spill in the lab. We are seen some years ago, in a factory in Bhopal, water entered the tank of Methyl Isocyanate. Methyl Isocyanate is a highly toxic compound. It instantly started producing the toxic gases, which killed more than 2000 peoples.

Conclusion

The idea of "green chemistry" is based on twelve principles that describe how to lessen or eliminate potentially harmful or hazardous substances from the synthesis, production, and use of chemical products. This lessens or eliminates the use of substances that are harmful to both human health and the environment. While it is impossible to adhere to all twelve of the processes principles while creating synthetic techniques, some of them are attempted to be used. It is our duty to use natural resources wisely, and the introduction of green chemistry may help with both economic development and environmental preservation. Therefore, create chemical procedures and products that are safe for the environment and human health.

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