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Green Chemistry: Principle and its Application

Mohd Wahid
Department of Chemistry, Aligarh Muslim University, Aligarh, UP, India
Faizan Ahmad*
Department of Post Harvest Engineering and Technology, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh, UP, India.
Nafees Ahmad
Department of Chemistry, Aligarh Muslim University, Aligarh, UP, India

ABSTRACT:
Green Chemistry is the design of chemical processes and products which reduce or eliminate the use and generation of toxic, poisonous, hazardous and bio-accumulative chemical substances. It is a new approach to scientifically based environmental protection and play a vital role in controlling global warming, acid rain and climate change. Its principle plays a fundamental tool in pollution prevention, increasing efficiency, selectivity and minimizes waste production.

***KEY WORDS**:*
Green Chemistry, Hazardous Substances, Waste production, Environmental protection.

INTRODUCTION:

Green Chemistry is a pre-science approach to design of chemical processes and products that reduce or eliminate the anthropogenic use and generation of hazardous, toxic and bio-accumulative chemical substances [1].

It means designing of the material in the chemicals that will use in the future and are better for human health and our environment.

It helps the scientist and researchers to design an efficient planet where human being utilizes everything through bio-geo-chemical cycle, so that every human life will be better and will achieve a sustainable development.

Green chemistry is different from environmental chemistry because environmental chemistry identifies source, elucidates mechanism and quantifies problems in the earth environment while green chemistry seeks these environmental problems by creating alternative and safe technology**.**

12 PRINCIPLES OF GREEN CHEMISTRY [2]:

1. Prevent Waste.
2. Atom Economy.
3. Less hazardous synthesis.
4. Design Benign Chemicals.
5. Benign Solvents and auxiliaries.
6. Design for energy efficiency.
7. Use of renewable feedstock's.
8. Reduce derivatives.
9. Catalysis
10. Design for degradation.
11. Real time analysis for pollution prevention.
12. Inherently benign chemistry for accident prevention.

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PREVENTION/PREVENT WASTE:
It is better to check or avoid the synthesis of hazardous, toxic, explosive, bio-accumulative and waste chemical product rather than to treat or clean up[3].

For example:

(a) Check or avoid over manufacturing/synthesis of nuclear and non-nuclear weapons, explosive and harmful bio-chemical substances from various developed and developing countries because it create various type of environmental pollution and human diseases [4].

(b) Check or avoid over exploitation of natural resources like coal and petroleum because its burning produces various harmful gases like oxides of carbon and oxides of nitrogen and sulphur which result into global warming and acid rain respectively[5].

(c) Check or avoid the over production of bio-accumulative, bio-transforming, non-biodegradable substances like polythene, Aldrin, Chlordane, DDT, and methyl mercury compounds[6].

ATOM ECONOMY:
Design the chemical processes in such a way that the final product contains maximum proportion of the reactant or the starting raw materials and leaving a few numbers of atoms of raw materials[7].

Example:
Calculation of atom economy

When one mole of Benzene react with 4 ½mole of oxygen molecule then it produced one mole of maleic anhydride and 2 mole of carbon dioxide and 2mole of Water [8].

Atom economy= (mass of atom in desired product/mass of atomic reactant)*100

= (98/222)*100

= 44.1%

LESS HAZARDOUS CHEMICAL SYNTHESIS:
Design the chemical processes/product in such a way that use and generation of chemical substances should not exceed the critical limit of toxicity to avoid environmental deterioration and harmful for human being.

Example:

(a) Avoid the synthesis of chemicals like organ mercurial's compounds; which caused minamata disaster[9].

(b) Avoid the synthesis of methyl isocynate (MIC); which caused Bhopal gas tragedy[10].

DESIGN BENIGN CHEMICALS:
Chemical processes and products should be designed in such a way that, it is highly selective in nature and affect their desired functions and minimizing their toxicity, bio-accumulation and bio- transformation.

Example:

2, 4-D: It is a selective pesticide which selectively kills only broad leaf weeds[11].

BENIGN SOLVENTS AND AUXILIARIES:
The use of auxiliaries substances in the form of solvents, separating agent, extractive agent should be non-toxic, non- explosive, non-hazardous, non- cancer causing, non-bio accumulated and non- mutation inducing.

Example:

Super critical Carbon dioxide is a better solvent because it is a non-toxic and non- explosive fluid[12].

DESIGN FOR ENERGY EFFICIENCY:
It is necessary to design the chemical processes /products in such a way that it utilizes less energy to form desired product, this can accompanied by keeping the chemical processes at ambient temperature and pressure in the presence of suitable catalyst.

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Example:

Formation of ammonia from Haber's process[13]

$N_2 + 3H_2 \rightarrow 2NH_3$

Temperature = 673-723 Kelvin, pressure = 200 atm, catalyst = Iron

USE OF RENEWABLE FEEDSTOCK'S:

For sustainable development, it is better to avoid exploitation of non-renewable natural resources like petroleum, coal and natural gas etc.

But use of renewable resources for its sustainable development did not create much problem because it is restored by natural processes and biogeochemical cycle.

Example:

Formation of furfural from bagasse and waste biomass of wheat and rice plant etc[14]

REDUCE CHEMICAL DERIVATIVES:

During a chemical processes, waste product are formed or generated if additional chemical reagent are used to block or protect any groups, so avoid such type of blocking, protecting groups or even any modifications, if possible.

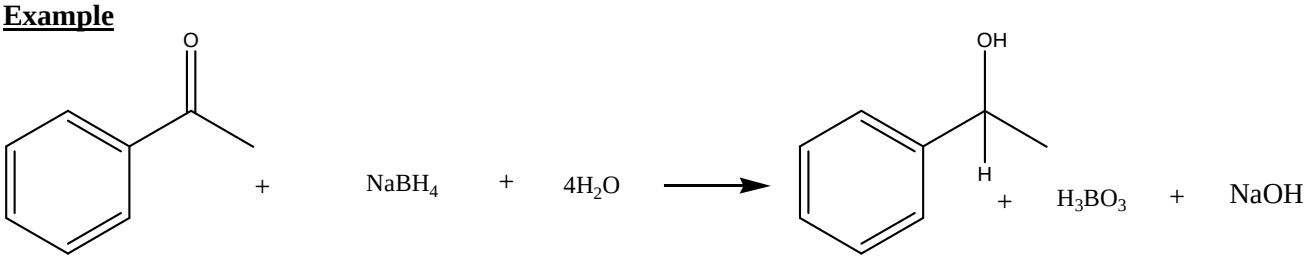
Example:

Use of enzymes to avoid protecting groups and cleanup process is the industrial synthesis of semi synthetic antibiotics such as ampicillin and amoxicillin[15].

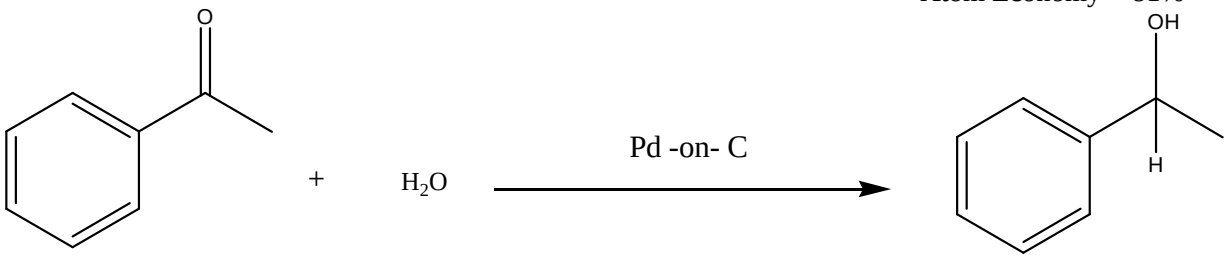
CATALYST:

Catalyst is the chemical substance which is used in small quantities, enhance the rate of reaction by decreasing activation energy and regenerate itself at the end of reaction[16]. But the stoichiometric reagent are used in large quantities and do not generate at the end of reaction[17].

Example



Atom Economy = 81%



Atom Economy = 100%

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DESIGN FOR DEGRADATION:

The chemical processes and products should be design in a way that the desired products and waste product formed by the process are biodegradable in natural environment.

The desired products are break down into harmless small substances by physical, chemical and biological means and do not persist in the natural environment.

The product should not be bio accumulative in nature and do not show biomagnifications

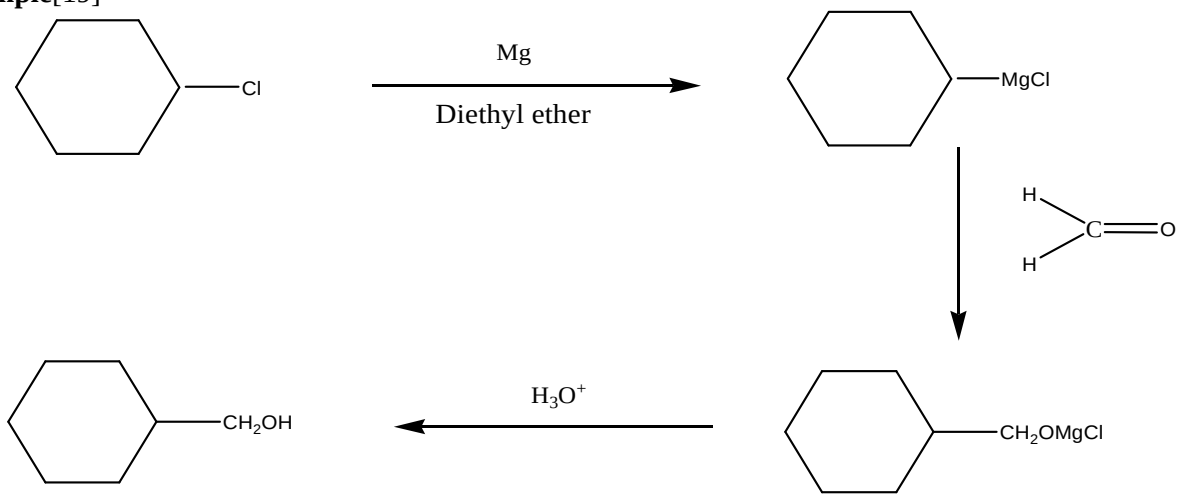
Example:

Biodegradable and bioactive thermoplastic aliphatic polyester polylactic acid (PLA)[18]

REAL TIME ANALYSIS FOR POLLUTION PREVENTION:

It is important to know the event's or the products formation during a chemical processes at different temperature, pressure, and time to control the formation of desired products and to avoid formation of any hazardous substances or waste substances as byproduct.

Example[19]



INHERENTLY BENIGN CHEMISTRY FOR ACCIDENT PREVENTION:

Design chemical processes and products and their physical states like solid, liquid and gaseous form to minimize or eliminate the potential of chemical accident's including explosion, fire, and smoke produce due to chemical and release into the natural environment.

Hazardous Substances are:

- Corrosive
- Flammable
- Explosive
- Reactive
- Toxic

To prevent accidents and injuries the following right steps should be taken before handling any hazardous substances:

- Read labels and SDSs to learn about hazardous and required safety precautions.
- Check for adequate ventilation.
- Remove items from the work area that could ignite or react with the hazardous materials.
- Know the location of fire extinguisher, emergency alarms, eyewash stations and first-aid kits[20].

CONCLUSION:

Green chemistry and application of its 12 principle in the design of chemicals processes and product help us to achieve sustainable development with an efficient bio-geochemical cycle with reduction in waste production and check the environmental deteriotion. It is basically a sustainable chemistry which makes our planet pollution free from harmful toxic, hazardous substances.

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