

# Green Chemistry

Dr. Lalan Chandra Mandal  
Dept. of Chemistry  
Krishna Chandra College, Hetampur

**In our Real life, Chemistry Contributes a lot to human Civilization for making their modern, long and comfortable life . Some of the important things which Chemists make are as given below:**

**The Drug Discovery Programme in the Medicinal World is directly related to Chemistry,**

**Materials: Plastics, metals,**

**Coatings: paint, lacquers,**

**Electronics: cell phones and computers**

**Oil, minerals , cosmetics and so many fields are directly related to Chemistry.**

**The major investigations by Chemists are: To understand unexplored things or events in the world around us.**

**Chemists are also Concerned about :**

- **Global problems: The ozone layer in the atmosphere**

- **Natural processes: What is in a flower that makes it's petals a particular color**

# Green Chemistry

For the fulfilment the demand of modern human civilization chemists are bound to prepare various types of chemical products in chemical industries. Maximum of the chemical products are hazardous substances. To minimize or prevent the production and use of such hazardous substances, it is important task for chemist to develop some novel technologies for inspiring the new generations. This branch of chemistry which motivates the generations to follow the principle PREVENTION IS BETTER THAN CURE is the **Green Chemistry**.

**The motive of this branch to design the chemical processes and products that will minimize or eliminate the use and formation of Hazardous substances.**

**The main aims of the Green Chemistry  
are:**

- **Ecofriendly Chemical Technology**
- **Replacement of Organic Solvents and to minimize the waste Product**
- **Use of Renewable feedstocks**
- **To Minimize energy Consumption**
- **Use of more ecofriendly chemical products**
- **Four R's (4R's) and integrated Waste Management(IWM) :**  
**These 4 R's are : Reduction(at Source), Recycling, Reuse and recovery.**

# 12 Principles of Green Chemistry

According to the formulation of Anastas and Warner, there are Twelve principles of Green Chemistry to save the environment and can be considered as blueprint for practicing Green Chemistry. These are given below:

- 1. Pollution Prevention**
- 2. Atom Economy**
- 3. Less Hazardous Chemical Synthesis**
- 4. Designing Safer Chemicals**
- 5. Safer Solvents and Auxiliaries**
- 6. Design for Energy Efficiency**
- 7. Use of Renewable Feedstocks**
- 8. Reduce Derivatives**
- 9. Catalysis**
- 10. Design for Degradation**
- 11. Real-time analysis for Pollution Prevention**
- 12. Inherently Safer Chemistry for Accident Prevention**

# 1. Pollution Prevention

How we can prevent pollution?

**By minimizing waste product Formation**

## Zero waste Technology

- Drive smaller, more efficient cars
- Take the commuter train
- Riding a bike
- Fix a leaky faucet
- Recycle paper or compost leaves

## 2. Atom Economy

- **Atom economy is a measure of the proportion of reactant atoms which are incorporated into the desired product of a chemical reaction.**
- **So, Synthetic methods should be designed in such a way that maximize the incorporation of all materials used in the Process into the final product.**
- **Minimise the formation of by Product**
- **Waste not, want not!**
- **A chemical reaction:**  
$$A + B \rightarrow \text{Product} + C + D$$
- **Ingredients in  $\rightarrow$  product out (any by-products??)**
- **Atom Economy = (FW of Product  $\div$  FW of Reactants) x 100%**

### 3. Less Hazardous Chemical Synthesis

**To Avoid the use and Formation of Toxic Material**

**The methodologies should be ecofriendly so that it will show little or no toxicity to human health and environment.**



## 4. Designing Safer Chemicals:

- **Use of non Toxic chemical products**
- **Chemical products should be designed to preserve efficacy of the function while reducing toxicity.**
- **Chemists are molecular designers; they design new molecules and new materials.**
- **In Green Chemistry: Function is NOT related to hazard.**
- **Making safe, non-toxic products is the goal!**

## 5. Safer Solvents and Auxiliaries:

- ❖ **The use of auxiliary substances (solvents, separation agents, etc.) should be avoided.**
  - ❖ **We use solvents for all kinds of things:**
    - \* **Cooking**
    - **Nail polish (lots of fumes!)**
    - **Paints**
    - **Cleaning products**
    - **Decaffeinated coffee**
    - **Chemical reactions**
- Among them, Many solvents are hazardous and toxic. There are safer alternatives!**
- ❖ **The principle aims to use Green solvents i.e. water, supercritical CO<sub>2</sub>**

## 6. Design for Energy Efficiency:

### Minimum energy consumption

- It is the concept of Green energy
- Synthetic methods should be conducted at ambient temperature and pressure.
- It needs suitable Catalysts .
- We use lots of energy:
  - Driving our cars
  - Heating and cooling our houses
  - Cooking food
  - Drying our hair
- Chemists also use lots of energy:
  - Heating
  - Drying
  - Cooling
- ❖ Energy is not only expensive – most of the time the power plant that creates the energy contributes to pollution.

## 7. Use of Renewable Feedstocks:

- ❑ It is technically and economically possible .

Why are gas prices so high?

- ❑ One reason is that oil is not a renewable resource.

- ❑ 90-95% of the products we use (plastic bottles, pharmaceuticals, paint, non-stick coatings, fabrics, etc.)  
Come from oil?

**\* \*What will happen when we run out of oil and petroleum?**

- ❑ Green chemists look for alternative sources for making materials. Renewable feedstocks (corn, Potatoes, biomass) can be used to make many products: fuels (ethanol and bio-diesel), plastics and more.

- ❑ **Use of sustainable and renewable resources is required.**

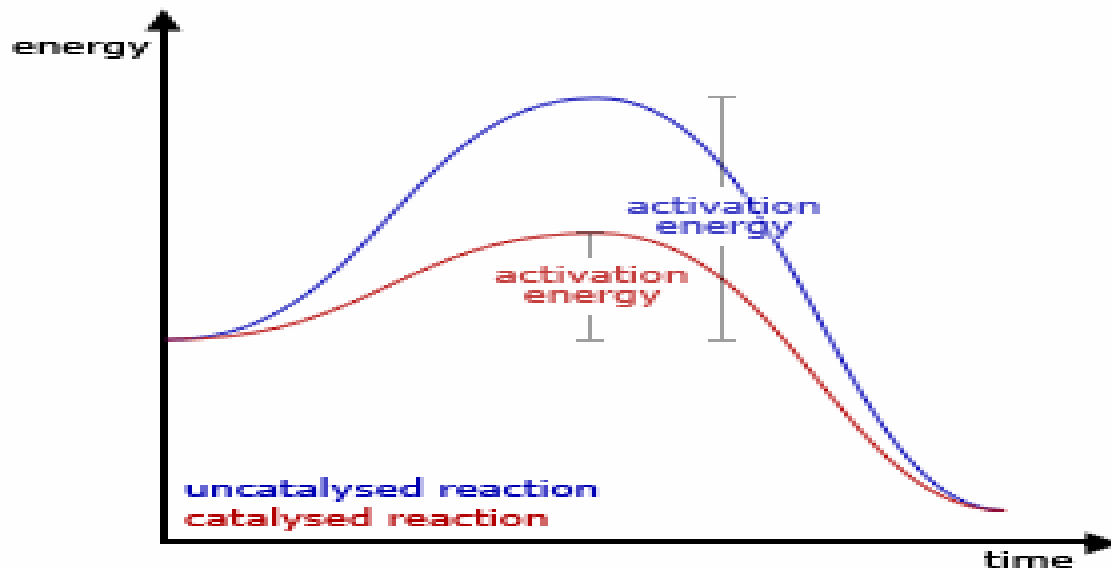
## 8. Reduce Derivatives:

**i.e. Minimisation of steps**

- Unnecessary derivatization (blocking group, protection/deprotection, temporary modification of physical/chemical processes) should be avoided whenever possible.
- Natural systems – Low energy, self-assembly
- Chemistry – Traditionally high energy, high toxicity  
Covalent versus non-covalent bonds

# 9. Catalysis

**Catalysis** is the acceleration (increase in rate) of a chemical reaction by help of a substance, called a **catalyst**, which is itself remain unaffected after the completion of overall reaction.



## 9. Catalysis

**The use of Catalysis is preferred due to following reason:**

- ❖ 100% atom economy
- ❖ Energy save is possible.
- ❖ Better reaction yield.
- ❖ Maximum use of Starting material.
- ❖ Reduces waste product formation

# 10. Lifetime for Chemical Product

**Chemical products should be designed so that at the end of their function they should degrade easily to harmless products**

**Recycling is one way of reducing waste... but, can we recycle everything?**

**What happens when we throw things away?**

**Design for degradation means that when green chemists design a new chemical (i.e., a pharmaceutical drug or medicine) or material (i.e., a new plastic) – they design it so that it breaks down at the end of its useful lifetime and degraded product should not be toxic.**



## 11. Monitoring Generation of Hazardous substances

- Analytical methodologies need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances.
- Real time analysis for a chemist is the process of “checking the progress of chemical reactions as it happens.”
- Knowing when your product is “done” can save a lot of waste, time and energy!

## **12. Use of chemically Safer substances for Accident Prevention**

**Substance and the form of a substance used in a chemical process should be selected in such a way so that they can minimize the occurrence of chemical accidents, including explosions, fires and emissions. In other words substances should not be hazardous.**

**we know the tragedy in Bhopal, India - 1984**

**It was a worst industrial accident in history, 40 tons of methyl isocyanate (MIC) were accidentally released when a holding tank overheated at a Union Carbide pesticide plant, located in the heart of the city of Bhopal. 15,000 people died and hundreds of thousands more were injured.**

**Chemists should have to try to avoid things that explode, light on fire, are air-sensitive, etc.**

**Its our responsibility to save our sweet world from unwanted occurrences.**