

# Unit 5

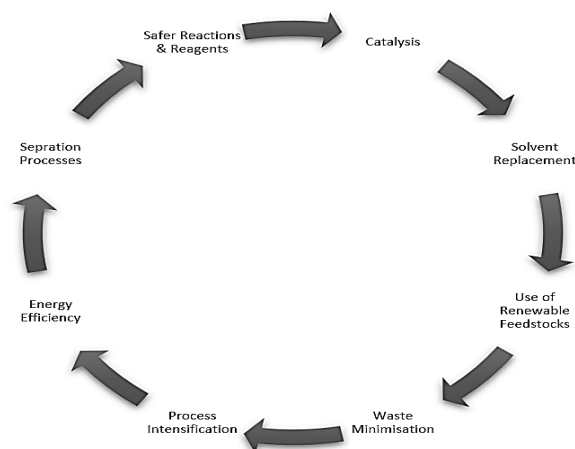
## Green Chemistry

### DEFINITION AND CONCEPTS OF GREEN CHEMISTRY

#### Definition

Green Chemistry is the branch of chemistry that focuses on designing products and processes that minimize the use and generation of hazardous substances. It aims for pollution prevention at the molecular level.

*Goal:* To make chemistry more sustainable, safe, and efficient while protecting human health and the environment.



#### Concepts of Green Chemistry

Paul Anastas and John C. Warner discovered these concepts are:

1. *Prevention at the Source:* Green chemistry prevents pollution from the beginning.
2. *Life Cycle Assessment:* It considers the environmental impact of a chemical (raw material/product formed/waste disposal) throughout entire life cycle.
3. *Hazardous Substance Minimization:* It aims to reduce or eliminate the use of hazardous substances in chemical processes and products.
4. *Renewable Resources:* It promotes the use of renewable raw materials and energy sources in chemical synthesis.
5. *Sustainable Processes:* Green chemistry looks for developing more sustainable and environmentally friendly chemical processes, reducing waste and emissions.
6. *Non-Toxic Products:* It helps the design of chemicals that are inherently non-toxic to both humans and the environment.

### PRINCIPLES OF GREEN CHEMISTRY

Developed by Paul Anastas and John Warner, the 12 Principles are:

- *Prevention:* Avoid waste rather than treating it after formation.
- *Atom Economy:* Maximize the incorporation of all materials used into the final product.
- *Less Hazardous Chemical Syntheses:* Use and generate substances with minimal toxicity.
- *Designing Safer Chemicals:* Design products that are effective but have low toxicity.
- *Safer Solvents and Auxiliaries:* Avoid or use safe solvents, separation agents, etc.
- *Energy Efficiency:* Carry out reactions at ambient temperature and pressure to save energy.

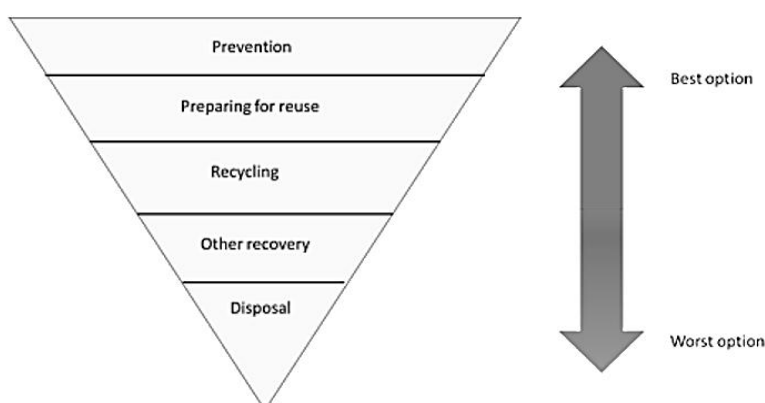
- *Use of Renewable Feedstocks:* Use raw materials from renewable sources (e.g., plants).
- *Reduce Derivatives:* Minimize steps like protection/deprotection which generate waste.
- *Catalysis:* Prefer catalytic reactions over stoichiometric ones.
- *Design for Degradation:* Design products to break down into non-toxic substances.
- *Real-Time Analysis:* Monitor reactions in real-time to prevent pollution.
- *Inherently Safer Chemistry for Accident Prevention:* Use substances and methods that minimize risks.

## WASTE OR POLLUTION PREVENTION HIERARCHY

Understanding the waste hierarchy, generally done in 5 steps, helps individuals and businesses make more eco-friendly choices.

A step-by-step approach to handling pollution:

1. Reduce: Use fewer materials and energy.
2. Reuse: Use materials again without reprocessing.
3. Recycle: Process materials to use again.
4. Treatment: Detoxify or neutralize waste before disposal.
5. Disposal: Safely dispose of materials when no other option exists.



## GREEN CHEMISTRY AND SUSTAINABILITY DEVELOPMENT

Green Chemistry is the future of chemical science. It combines innovation and responsibility, promoting processes that are safer, cleaner, and more efficient for sustainable development.

Sustainability involves using resources to meet current needs without harming future generations.

Green Chemistry supports this by:

- Reducing greenhouse gas emissions
- Lowering water and energy consumption
- Preventing hazardous waste
- Using renewable materials

## USE OF ALTERNATIVE FEEDSTOCK (BIOFUELS)

Biodiesel is a liquid fuel produced from renewable sources, such as new and used vegetable oils and animal fats and is a cleaner-burning replacement for petroleum-based diesel fuel. Biodiesel is nontoxic and biodegradable. It is produced by combining alcohol with vegetable oil, animal fat, or recycled cooking grease.

Green Chemistry encourages the use of biomass-based feedstocks like:

- Bioethanol (from sugarcane or corn)
- Biodiesel (from vegetable oils or animal fats)
- Biogas (from organic waste)

#### **Advantages**

- Renewable
- Biodegradable
- Lower CO<sub>2</sub> emissions

## **GREEN SOLVENTS**

Solvents used in chemical processes often cause pollution and health hazards. Green Chemistry promotes:

- Water - Universal, Safe and Eco-Friendly
- Supercritical CO<sub>2</sub> - Reusable, Non-Toxic
- Ionic Liquids - Low Vapor Pressure, Recyclable

Example:

Using water instead of benzene or toluene for chemical reactions.

## **ALTERNATIVE SOURCES OF ENERGY: USE OF MICROWAVES AND ULTRASONIC ENERGY**

Green Chemistry promotes the use of clean energy to reduce carbon footprint and improve efficiency:

#### **Microwave Energy**

- Increases reaction rate
- Saves energy and time
- Promotes uniform heating

#### **Ultrasonic Energy (Sonochemistry)**

- Uses sound waves to enhance chemical reactions
- Reduces reaction time
- Useful in nanoparticle synthesis and emulsification

#### **Importance of Alternative Sources of Energy**

The importance of alternative sources of energy are discussed below:

- Protects the Environment
- Helps in Providing Sustainable Fuel Systems
- Helps in Reducing the Dependence on Imported Fuels
- Helps in Enhancing Income
- Useful in Conserving Fossil Fuels
- Useful in Slowing and Reversing Climate Change
- Useful in Economic Growth