**Green Chemistry for Sustainable Development**

**Ms. Pratibha Garg**

**Assistant Professor**

**Army Institute of Education**

**Greater Noida, U.P.**

**Contact number: 9971199021**

**Email: aiepratibha@gmail.com**

**ABSTRACT**

In this paper an effort has been made to throw some light that green chemistry plays a major role in sustainable development. Green chemistry, also known as sustainable chemistry, is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Eminent international experts present research on and the application of green chemistry and engineering in addressing current issues of an environmental and social nature.

Green chemistry has brought a relatively prompt and positive paradigm shift in the overall use and management of natural resources and raw materials for the development of society with a subtle promise to cause far less pronounced harm to the environment. It provides up-to-date information on selected fields where the principles of green chemistry are being embraced for safeguarding and improving the quality of the environment. Chemistry students need to be encouraged to consider the principles of green chemistry when designing processes and choosing reagents. Green chemistry can be the next social movement that will set aside all the world’s differences and allow for the creation of an environmentally commendable civilization and will be a great help in sustainable development.

Key words: Green chemistry, sustainable chemistry, hazardous substances, environmentally commendable socialization.

**GREEN CHEMISTRY**: Green chemistry, also known as sustainable chemistry, is the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances. Green chemistry applies across the life cycle, including the design, manufacture, and use of a chemical product. Before going into the details one should know the famous quote

*“The significant problems we face today cannot be solved at the same level of thinking we were at when we created them.*” **Albert Einstein**

On one side **Green chemistry**, is an area of chemistry and chemical engineering focused on the designing of products and processes that minimize the use and generation of hazardous substances Whereas on the other side [**Environmental chemistry**](https://en.wikipedia.org/wiki/Environmental_chemistry) focuses on the effects of [polluting](https://en.wikipedia.org/wiki/Pollutant) chemicals on nature, green chemistry focuses on technological approaches to preventing [pollution](https://en.wikipedia.org/wiki/Pollution) and reducing consumption of non-renewable resources.

**Goals of Green Chemistry**:

The overarching goals of green chemistry

* more resource-efficient.
* inherently safer design of molecules, materials, products, and processes.

# **ORIGIN OF GREEN CHEMISTRY**

The idea of green chemistry was initially developed as a response to the Pollution Prevention Act of 1990, which declared that U.S. national policy should eliminate pollution by improved design (including cost-effective changes in products, processes, use of raw materials, and recycling) instead of treatment and disposal.  Although the U.S. Environmental Protection Agency (EPA) is known as a regulatory agency, it moved away from the “command and control” or “end of pipe” approach in implementing what would eventually be called its “green chemistry” program.
By 1991, the EPA Office of Pollution Prevention and Toxics had launched a research grant program encouraging redesign of existing chemical products and processes to reduce impacts on human health and the environment.  The EPA, in partnership with the U.S. National Science Foundation (NSF), then proceeded to fund basic research in green chemistry in the early 1990s.
The introduction of the annual Presidential Green Chemistry Challenge Awards in 1996 drew attention to both academic and industrial green chemistry success stories.
The mid-to-late 1990s saw an increase in the number of international meetings devoted to green chemistry, such as the Gordon Research Conferences on Green Chemistry, and green chemistry networks developed in the United States, the United Kingdom, Spain, and Italy.
The 12 Principles of Green Chemistry were published in 1998, providing the new field with a clear set of guidelines for further development.  In 1999, the Royal Society of Chemistry launched its journal *Green Chemistry*.
In the last few years, national networks have proliferated, special issues devoted to green chemistry have appeared in major journals, and green chemistry concepts have continued to gain traction.  A clear sign of this was provided by the citation for the 2005 Nobel Prize for Chemistry awarded to Chauvin, Grubbs, and Schrock, which commended their work as “a great step forward for green chemistry”

**GREEN CHEMISTRY IS ABOUT**

• **Waste Minimisation at Source**

• **Use of Catalysts in place of Reagents**

• **Using Non-Toxic Reagents**

• **Use of Renewable Resources**

• **Improved Atom Efficiency**

• **Use of Solvent Free or Recyclable Environmentally Benign Solvent systems**

**WHY DO WE NEED GREEN CHEMISTRY?**

• Chemistry is undeniably a very prominent part of our daily lives.

• Chemical developments also bring new environmental problems and harmful unexpected side effects, which result in the need for **‘greener’** chemical products.

• A famous example is the pesticide DDT.

• **Green chemistry** looks at pollution prevention on the molecular scale and is an extremely important area of Chemistry due to the importance of Chemistry in our world today and the implications it can show on our environment.

• The **Green Chemistry** program supports the invention of more environment friendly chemical processes which reduce or even eliminate the generation of hazardous substances.

• This program works very closely with the twelve principles of **Green Chemistry.**

**PRINCIPLES OF GREEN CHEMISTRY:**

In 1998, [Paul Anastas](https://en.wikipedia.org/wiki/Paul_Anastas) (who then directed the Green Chemistry Program at the US EPA) and [John C. Warner](https://en.wikipedia.org/wiki/John_Warner_%28chemist%29) (then of [Polaroid Corporation](https://en.wikipedia.org/wiki/Polaroid_Corporation)) published a set of principles to guide the practice of green chemistry. The twelve principles address a range of ways to reduce the environmental and health impacts of chemical production, and also indicate research priorities for the development of green chemistry technologies.

THE PRINCIPLES OF GREEN CHEMISTRY ARE AS FOLLOWS:

1. **Maximize atom economy:** Design syntheses so that the final product contains the maximum proportion of the starting materials. There should be few, if any, wasted atoms.

2. **Use safer solvents and reaction conditions:** Avoid using solvents, separation agents, or other auxiliary chemicals. If these chemicals are necessary, use innocuous chemicals.

3. **Increase energy efficiency:** Run chemical reactions at ambient temperature and pressure whenever possible.

4. **Design chemicals and products to degrade after use:** Design chemical products to break down to innocuous substances after use so that they do not accumulate in the environment.

5. **Analyse in real time to prevent pollution:** Include in-process real-time monitoring and control during syntheses to minimize or eliminate the formation of by-products.

6. **Minimize the potential for accidents:** Design chemicals and their forms (solid, liquid, or gas) to minimize the potential for chemical accidents including explosions, fires, and release to the environment.

7. **Prevent waste:** Design chemical syntheses to prevent waste, leaving no waste to treat or clean up.

8. **Design safer chemicals and products:** Design chemical products to be fully effective, yet have little or no toxicity.

9. **Design less hazardous chemical syntheses:** Design syntheses to use and generate substances with little or no toxicity to humans and the environment.

10. **Use renewable feedstocks:** Use raw materials and feedstocks that are renewable rather than depleting.

11. **Use catalysts, not stoichiometric reagents:** Minimize waste by using catalytic reactions. 12. **Avoid chemical derivatives:** Avoid using blocking or protecting groups or any temporary modifications if possible. Derivatives use additional reagents and generate waste.

Attempts are being made not only to quantify the *greenness* of a chemical process but also to factor in other variables such as [chemical yield](https://en.wikipedia.org/wiki/Chemical_yield), the price of reaction components, safety in handling chemicals, hardware demands, energy profile and ease of product workup and purification.

Green chemistry is increasingly seen as a powerful tool that researchers must use to evaluate the environmental impact of nanotechnology. As [nanomaterials](https://en.wikipedia.org/wiki/Nanomaterials) are developed, the environmental and human health impacts of both the products themselves and the processes to make them, must be considered to ensure their long-term economic viability.

As human beings --- we are part of the environment, the way in which we interact with our environment influences the quality of our lives.

In 1999 EPA **Green Chemistry** Award for non-competitive for treating epilepsy and neuro- degenerative diseases was given to **Lilly Research Labs for producing Talampanol.**

**Pfizer, Inc, 2002** for while doing the **SERTRALINE** Process made the following changes which resulted into saving energy, waste minimization and greener Technology.

During this production process following things were eliminated

Use of 140 metric tons/year of titanium tetrachloride

Generation of 440 metric tons/year of solid titanium dioxide waste

150 metric tons/year of 35% HCl waste

Need for 100 metric tons/year of 50% NaOH

Some aqueous washes

**Dramatically reduced** the number and & volume of solvents used and made it a greener technology.

Therefore, we can say that **Green chemistry** is **Not** a solution to all environmental problems **but** the most fundamental approach to preventing pollution.

In 2005 Nobel Prize Committee recognized the importance of green chemistry and since then, this relatively new science came into its own. Although no concerted agreement has been reached yet about the exact content and limits of this interdisciplinary discipline, there seems to be increasing interest in environmental topics that are based on the chemistry embodied in this subject. Linking green chemistry practice to environmental sustainability, **Green Chemistry for Environmental Sustainability** illustrates the efforts being made to remediate a scathed environment into a pristine one.

**Links Green Chemistry Practice to Environmental Sustainability**

Eminent international experts present research on and the application of green chemistry and engineering in addressing current issues of an environmental and social nature.

Green chemistry has brought a relatively prompt and positive paradigm shift in the overall use and management of natural resources and raw materials for the development of society with a subtle promise to cause far less pronounced harm to the environment. It provides up-to-date information on selected fields where the principles of green chemistry are being embraced for safeguarding and improving the quality of the environment.

In January, 2007 a Workshop on Green Chemistry was held in Johannesburg. John Warner and Amy Cannon (University of Massachusetts, Lowell) were the “guiding spirits” for this effort, while funding came from the South African Paper and Pulp Industry(SAPPI).

At this meeting Professor Paul N dalut from Daniel Arap Moi University wisely observed. “Green Chemistry is a good idea. But Africa has many burdens, including poverty, war and the epidemics of HIV, malaria and tuberculosis. Green Chemistry is a priority only if it helps address these issues.”

The requirements that we make of Green Chemistry are to enable substantial progress towards equitable standards of living in a manner that is sustainable for future generations. Playing such a game of “catch up” is arduous and (evidenced by China/India) risky. Some exciting examples of green, sustainable activity are being generated within Africa. He restricted his remaining comments on Green Chemical production to the area of making medicines.

**Sustainable Development**

The Brundtland Commission (1987) defined sustainable development as “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

The importance of Sustainable Development is to protect technological resources, provide basic human needs, agricultural necessity, accommodate city development, control climate change and sustain bio-diversity. It cannot be achieved by technological solutions, political regulation or financial instruments alone. We need to change the way we think and act. This requires quality education and learning for sustainable development at all levels and in all social contexts.

**Education for Sustainable Development (ESD)** ESD is an emerging concern in the 21st century world. The necessity of ESD arises due to the depletion of finite resources, over-use of renewable resources, pollution, inequity, loss of bio-diversity etc.

ESD address three pillars of sustainable development- society, environment and economy- with culture as an essential additional and underlying dimension. By embracing these elements in a holistic and integrated manner, ESD enables all individuals to fully develop the knowledge, perspectives, values and skills necessary to take part in decisions to improve the quality of life both locally and globally, which area is most relevant to their daily lives.

ESD is a vision of education that seeks to balance human and economic well-being with cultural traditions and respect for the earth’s natural resources. It is about enabling us to constructively and creatively address present and future global challenges and create more sustainable and resilient societies.

**Green Chemistry and Sustainable Development**

Green chemistry is a tool in achieving sustainability. It’s not a solution to all environmental problems. It’s a fundamental approach to pollution prevention.

Chemistry’s unique contribution to sustainability is

* Primary pollution prevention not remediation
* Use of chemistry for improved environmental performance

***Green chemistry education:*** A key to sustain the development of new educational materials.

 **We can deal with green chemistry at our practical life by just changing our mind set and apply the concept in**

* Classrooms
* laboratory
* manufacture
* And finally the surrounding environment
* If the chemical reaction of the type
* A + B P + W
* Find alternate A or B to avoid W
* **Example 1:**
* Disinfection of water by chlorination. Chlorine oxidizes the pathogens there by killing them, but at the same time forms harmful chlorinated compounds.
* A remedy is to use another oxidant, such as O3or supercritical water oxidation
* **Example 2**:
* Production of allyl alcohol CH2=CHCH2OH
* ***Traditional route:*** Alkaline hydrolysis of allyl chloride, which generates the product and hydrochloric acid as a by-product.
* ***Greener route,*** to avoid chlorine: Two-step using propylene (CH2=CHCH3), acetic acid (CH3COOH) and oxygen (O2)
* ***Added benefit:*** The acetic acid produced in the 2ndreaction can be recovered and used again for the 1st reaction, leaving no unwanted by-product.
* **Example 3:**
* Production of styrene (=benzene ring with CH=CH2 tail)
* ***Traditional route:*** Two-step method starting with benzene, which is carcinogenic) and ethylene to form ethylbenzene, followed by dehydrogenation to obtain styrene
* ***Greener route:*** To avoid benzene, start with xylene (cheapest source of aromatics and environmentally safer than benzene).
* ***Another option,*** still under development, is to start with toluene (benzene ring with CH3 tail).

**GREEN CHEMISTRY EDUCATION**

* Chemistry students need to be encouraged to consider the principles of green chemistry when designing processes and choosing reagents.
* Interactive Teaching Units (ITU) have been developed specifically to introduce undergraduate students to study green chemistry.
* There are numerous scholarships and grants available for researchers and young scholars who are furthering the goals of green chemistry.

**CONCLUSION**

The concern for nature and natural resources is not at all a new concept for Indians. Admiration for nature and the urge to concern and protect it has always been a part of our civilization. In order to save the environment, everyone should show his or her responsibility towards environment. Common people, non-governmental organizations, voluntary agencies as well as government have made several efforts for environmental conservation. Thus, there is an urgent need to create environmental awareness among all human beings so as to conserve, protect and nurture our environmental resources.

Environmental protection starts by creating awareness among the people so that it becomes part of their lifestyle. Environmental awareness is the first step to trigger the students’ involvement in environmental movements. Thus, it becomes necessary to develop awareness and positive attitude in people since their childhood. As responsible citizens of tomorrow, students need to have a sound knowledge and a proper understanding of the contemporary issues and problems of the environment. To fulfill these objectives, the school children should be educated through environmental education.

The needs and aspirations of society are reflected in the education system. Much of the environmental problems can be prevented by proper education. In this, education of green chemistry will also play an important role.

**Green Chemistry: Preventing Pollution, Sustaining the Earth**

* Green chemistry has come a long way since its birth in 1991, growing from a small grassroots idea into a new approach to scientifically-based environmental protection.
* All over the world, governments and industries are working with “green” chemists to transform the economy into a sustainable enterprise.
* ***Who knows?*** Green chemistry may be the next social movement that will set aside all the world’s differences and allow for the creation of an environmentally commendable civilization and will be a great help in sustainable development.

**References:**

* Bhattacharya, G.C. (1997). Environmental Awareness among Higher Secondary Students of Science and Non- Science streams. School Science.35(1), 24-32.
* Byhaskaracharyulu, Y. (2003). Role of Teacher in Environmental Education. Edutrack, 2(5), 19-21.
* https://application.wiley-vch.de/books/
* [https://en.wikipedia.org/wiki/**Green**\_**chemistry**](https://en.wikipedia.org/wiki/Green_chemistry)
* https://www.crcpress.com/**Green**-**Chemistry**-for...**Sustainability**/.
* <https://www.epa.gov/sites/production/files/>
* Srivastava,P.K.(2005). Green Chemistry: Need of the future for sustainable Development. Vigyan Prasar.
* [www.rsc.org/Education/Teachers/Resources/Inspirational/resources/](http://www.rsc.org/Education/Teachers/Resources/Inspirational/resources/)
* [www.tjpr.org/vol7\_no1/711editorial.pdf](http://www.tjpr.org/vol7_no1/711editorial.pdf)
* [www.vigyanprasar.gov.in/**chemistry**.../**Green**-**Chemistry**](http://www.vigyanprasar.gov.in/chemistry.../Green-Chemistry)