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# Applications of Green Chemistry

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**Abstract**

Green Chemistry is a division of design for environment applying innovative scientific solutions to product manufacturing that means processes reducing or eliminating hazardous substances. Last three decades, Green chemistry has now been making a real difference in our world. In future all division of chemistry fully depends on green chemistry due to decreasing the amount of chemical waste released to the air, water, and soil. 12 set of values of green chemistry is important which diminish or removes the use or creation of hazardous constituents. The principles of green chemistry can be reached using environmentally responsive, inoffensive, reproducible, innocuous solvents and catalysts during manufacture of medicine, and in investigates. The use of non-traditional technique like UV-energy, Microwave irradiation etc. is also significant way to achieve the goal of green chemistry.

Keywords: Green chemistry, Environment and Chemicals

## 1. Introduction

"Green chemistry" is defined as "the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances". Green chemistry has now been around for three decades, and it has been creation an actual modification in our world. It has been extensively predictable that an evolution to a sustainable society dictates vital changes in resource and energy utilization. To efficiently use limited resources, both trans materialization and dematerialization must occur. Trans materialization is the process of shifting away from hazardous and non-renewable resources toward safer and/or renewable or recyclable materials [1-3]. Forthcoming chemicals and progressions should have chemical, physical, and toxicological properties that permit safe handling and disposal. Green chemistry aims to achieve this through the rational design of chemicals and processes according to a set of principles and metrics recognized during the past few decades. A synchronized revolution of many social, political, economic, and technological factors must focus, to achieve the full potential of green chemistry. This perspective encourages interdisciplinary design and advance of new technologies that represent principles of sustainability.

## 2. Principles of green chemistry

With the introduction of the Twelve Principles of Green Chemistry, guidelines were provided for chemists to develop clean, environmentally benign methodologies that are sustainable for the long term (1). The publication of Green Chemistry: Theory and Practice [4] in 1998 clearly explained the 12 principles of green chemistry and provides a coherent vision for the emerging green chemistry movement. Although apparently spontaneous, the design of these principles facilitated chemists to know how principles of sustainability could be suitable to their research. Title of the 12 principles are 1) Prevention, 2) Atom economy, 3) Less hazardous chemical syntheses, 4) Designing safer chemicals, 5) Safer solvents and auxiliaries, 6) Design for energy efficiency, 7) Use of renewable feed stocks, 8) Reduce derivatives, 9) Catalysis, 10) Design for degradation, 11) Real-time analysis for pollution prevention and 12) Inherently safer chemistry for accident prevention.

## 3. Application of Green chemistry

Green chemistry widely used in the chemical, pharmaceutical, paper, polymer, clothes and colour industry. It plays a key role in different energy science, and the manufacture of innovative technique to make solar cells, fuel cells, and batteries for storing energy. In nanoscience and technology, green chemistry also highly used. Since main goal of green chemistry is to minimize or eliminate waste in the chemical industry, it has inspired the creation of many green "next generation" catalysts.

### 3.1 Green chemistry in pharmaceutical industry

In pharmaceutical industry green chemistry plays an important role and makes a revolution in it. BASF, a chemical company now makes ibuprofen (painkiller) in a three-step rather than a six-step process [5]. Zocor (simvastatin), leading drug for treating high cholesterol, conventionally synthesized using a multistep method concerning huge quantities of hazardous reagents that formed a big amount of toxic waste. A bio-catalysis company, Codexis developed a new technique for synthesizing the drug using an engineered enzyme and a low-cost feedstock. The chemotherapy drug paclitaxel (marketed as Taxol) was made by take out from yew tree bark, a process that used a large amount of solvent for killing

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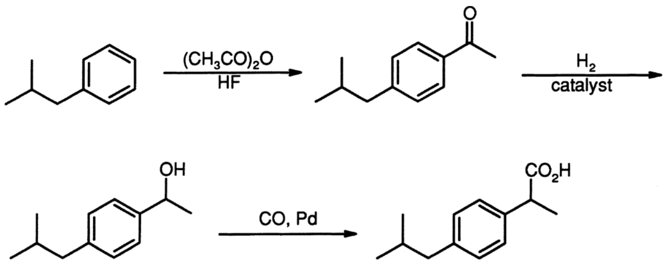
the tree. The drug is now made by growing tree cells in a fermentation vat [6].




## 3.2 Eco-Friendly Dry clean-up of Clothes

Per chloro ethylene (PERC) used for dry cleaning pollutes water and cancer-causing agent. To solve this problem, now a days super critical CO2 and a surfactant for cleaning garments was first developed by Joseph De Simons, Timothy Romark, and James. Micell Technology has likewise developed a metal cleaning framework that utilize CO2 and a surfactant accordingly replacing halogenated solvents.

## 3.3 Solution to Turn Turbid Water Clear

It has been exhibited that alum will intensify poisonous ions in treated water and will cause diseases like Alzheimer's. Municipal and industrial waste water clear and purified by using tamarind seed kernel powder, discarded as agriculture waste. Kernel powder is not poisonous and is perishable and price effective over the Al-salt to treat such water.

## 3.4 Application in nanoscience

The nano materials provide a wide range of applications in all disciplines. Researchers are engaged in developing the products of low dimensional materials that are utilized in multi-purpose technical applications. Nanotechnology is also conscious about our environment. Mechanical and chemical methods are developed for waste water treatment, air purification using nano filtration techniques. In recent years, green chemical approach is one of the important methods for synthesis of low dimensional materials. Green chemical process deserves the merit regarding reducing agent selection, avoiding surfactants, solvent choice, and improving yields, size distribution, and purity. There are chemical synthetic approaches including citrate method, tollens method, ionic liquid method, polysaccharide method, ligand exchanging method, polyoxometalate method in the light of green chemistry. The reduction of gold salts by citrate anions was established few decades before, yielding almost mono dispersed gold particles in nano range [7]. Synthesis of Ag nanoparticles using sucrose ester micellar-mediated method and NaOH is added to accelerate the formation of Ag nanoparticles [8]. Carboxy methylcellulose (CMC) derivatives were used to perform dual role, as reducing agent for silver ions and as stabilizing agent during the formation of silver nanoparticles [9].

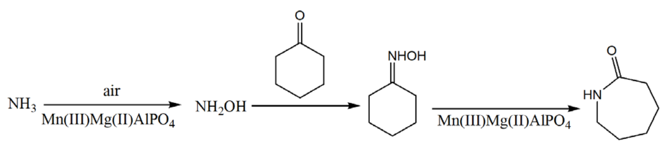
The synthesis of nanomaterials using bio inspired, eco-friendly greener methods is one of the most attractive aspects of current material science. The increasing need to develop high-yield, low cost, nontoxic, and environmentally benign procedures for synthesis of low dimensional materials is only possible to satisfy by means of biological approach. There is a vast range of biological resources available in nature including plant extract or plant biomass, microorganisms such as bacteria, fungus, algae, yeast even virus could be employed for green synthesis of low dimensional materials. There are so many plants e.g. green tea, curry leaf extract, leaf extract of Japanese rose, guava (Psidium guajava) leaf extract, extract of Ocimum sanctum (Krishna tulsi) leaf, Cinnamomum camphora leaf, Jatropha curcas latex, Jatropha curcas seed extract etc. are used for synthesis of nano/micro particles [10]. The plant fungus, Verticillum sp., was involved in the process of formation of cube-octahedral magnetite iron oxide nanoparticles with 100–400 nm size in 24 h.

## 3.5 Energy science

Low-cost and possibly environmentally gentle sources of power is Organic solar cells (OSCs). $\pi$-Conjugated molecules and polymers used for development of OSCs. The principles of green chemistry applied to the synthesis of conjugated systems. From this perspective scientist generally choose those method which has lesser steps and use of bio feed stock.

## 3.6 Next generation catalyst design

There are many opportunities for improving conventional industrial processes. For example, nanoporous aluminophosphate catalysts with a distribution of acidic and redox active sites have been used to develop a new route to the Nylon-6,6 precursor o-caprolactam. The one-step, solvent-free reaction eliminates hazardous reagents and reduces generation of waste by products.




## 4. Tools of green chemistry

The new approach introduces in green chemistry synthesis, dealing out and relevance of chemical material in such a way as to minimize the risk to environment and health of human. This advanced access is fully depending on some advance technology like photo chemical, Radiolysis, microwave irradiation, ultrasonic method, Electron beam irradiation method, ultrasound irradiation etc.

## 4.1 Microwave irradiation approach

Synthesis procedures using microwave irradiation is an advanced opportunity for synthesis of materials. Microwave radiation is known to have a faster heating rate than the conventional heating through conduction and convection. The microwave radiation heats up a material through its dielectric loss, which converts the radiation energy into thermal energy. The interaction of electric field of a microwave with dipole moment of molecules occurs during microwave heating; thus, polar solvents like water and ionic liquids are the best solvents to use in microwave synthesis. It is used in synthesis of many organic, inorganic, nanomaterials etc.

## 4.2 Sonochemical approach

Recently sonochemical method has been developed for the preparation of materials. During ultrasonic irradiation (20 kHz to10 MHz) acoustic cavitations will form and these ultrasonic cavitations are concerned with the formation, growth and implosive collapse of bubbles. The bubbles create transient localized hot spots with variety of physical and chemical effects like extremely high temperature, pressure and cooling rate which could provide a unique environment for chemical reactions under extreme conditions. Chemical bonds are ruptured under such extreme condition and different materials create from decomposition of volatile precursors within these rapidly collapsing bubbles. Sonochemical method applied on syntheses of drugs, dye etc., especially in combination with other sustainable technologies [11].

## 4.3 Ultra sound approach

The frequency range of ultrasound is 16 kHz to 10 MHz, which is just above the human threshold of audibility. Now a days ultrasound used for surface cleaning, extraction, degassing, sterilization and emulsification without the addition of emulsifying agents. The cell membrane or cell wall of micro-organisms is ruined by the flashing pressure field triggered by ultrasound. The homogenization of milk involves reducing the size of the fat molecules and disperse in throughout the milk by using ultra sound technology.

## 4. Conclusion

Green Chemistry is new philosophical approach. Application and extension of the principles of green chemistry can contribute to sustainable development. Presently it is easy to find in the literature many interesting examples of the use of green chemistry rules. Great efforts are still undertaken to design an ideal process that start from non-polluting materials. It is clear that the challenge for the future chemical industry is based on safer products and processes designed by utilizing new ideas in fundamental research. Furthermore, the success of green chemistry depends on the training and education of a new generation of chemists. Students at all levels have to be introduced to the philosophy and practice of green chemistry.

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