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Green Chemistry: Pathways to Renewable Energy and Sustainable Development

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Abstract:
A sustainable society will be constructed materially from chemical products and processes that are designed from the ground up according to principles that make them favorable to life. Early on in the design phase, it is crucial to analyze the significant intrinsic qualities of molecules to ascertain whether compounds and processes are renewable or depleting, toxic or benign, and durable or fast-degradable. Green chemistry and green engineering must be embraced by-products, feedstocks, and manufacturing processes to satisfy the requirements of an enlarged definition of performance that considers sustainability. To effect this transformation, it will be crucial to combine the most creative and productive aspects of scientific traditions with the most current developments in systems thinking and design. The world will benefit from this shift, which will begin at the molecular level.

Keywords: Food technology, green chemistry's principles, pharmacies, sustainable chemistry.

INTRODUCTION

The study of chemistry with an emphasis on creating goods and procedures that reduce the usage and production of dangerous materials is called "green chemistry," often referred to as "sustainable chemistry [1]." Reducing the detrimental effects that chemical processes have on the environment and human health is the main objective of green chemistry [2]. This field developed in response to increased knowledge of the dangers traditional chemical activities provide to human health and the environment [3]. Paul Anastas and John Warner developed twelve principles of green chemistry that provide a framework for developing more environmentally friendly chemical processes [4]. These guidelines include avoiding waste, using safer chemicals, and implementing energy-saving techniques [5]. The goal is to encourage the creation of economically, ecologically, and socially responsible goods and procedures [6]. One key aspect of green chemistry is the consideration of the entire life cycle of a chemical product. This involves evaluating not only the immediate impact of the production process but also the potential environmental and health effects during the use and disposal phases [7]. Green chemistry practitioners andthat are not only effective but also have few long-term effects by using a comprehensive approach [8].

To varied degrees, a number of sectors have adopted the concepts of green chemistry. Pharmaceutical companies are currently investigating sustainable synthesis approaches as a means of mitigating the environmental impact associated with drug manufacture [9]. Furthermore, the creation of biodegradable materials, renewable feedstocks, and green solvents is increasingly important to research and development in a variety of industries [10]. Green chemistry is essentially a mentality shift in the chemical industry that emphasizes the value of environmental stewardship, sustainability, and safety. As the area develops, it becomes increasingly important in tackling global issues including pollution, depletion of resources, and climate change [11]. Adopting green chemistry methods helps the chemical sector become more resilient and responsible, in addition to being good for the environment [12].

THE TRANSFORMATION IN GREEN CHEMISTRY

Global economic growth was accelerated by industrialization. Although industrial operations have improved living standards, their environmental effects have not been taken into account by international government regulations. Due to population growth, excessive industrialization and food production resulted in pollution and resource depletion. Environmental impact was not taken into consideration when using natural resources. First discussed at the 1949 UNSCCUR in the United States, environmental issues were brought to the forefront of international attention at the 1968 Intergovernmental Conference of Experts on the Scientific Bases for Rational Use and Conservation of Biosphere Resources, also known as the Biosphere Conference. "Silent Spring" ignited an environmental movement in the 1960s. The historical novel called for government action to alleviate the overexploitation of natural resources and increased ecological consciousness [13-15]. Some called it "the book that changed America," but John Kenneth Galbraith considered it a significant Western novel. Robert Downs agreed [16].

In Sweden in 1972, during the Stockholm Conference, representatives of non-governmental organizations and the UN discussed environmental law [17]. Following this conference, environmental dangers associated with ecosystem decline became widely known[18]. In the 1980s, there were several international conferences on the environment. The UN established the World Commission on Environment and Development in 1983 to provide reports on environmental issues and global development after reviewing ten years' worth of scheduled activities at the Stockholm Conference. In the midst of environmental pressures worldwide and awareness of unsustainable development, the group was founded [18]. In order to fulfil present demands without endangering future generations, sustainable development was suggested in the 1987 Brundtland Report, which integrated socioeconomic and environmental factors. The report emphasises the concerns posed by ozone depletion and global warming, asserting that the rapid pace of climate change prevents scientists from providing solutions [19]. The OECD Environment Ministers made decisions in 1985 about pollution prevention and control, economic development and the environment, and Environmental Information and national reviews. These rulings were in effect until 1990. These actions were crucial for reducing the risk and pollution associated with chemical products [20]. Preventing the creation of dangerous chemical compounds was emphasised in the 1991 "Alternative Synthetic Routes for Pollution Prevention" project of the US Environmental Protection Agency (EPA)21. After incorporating safer and more environmentally friendly solvents, the programme was renamed Green Chemistry in 1992. A global priority in the 1990s was environmental conservation. The 1992 UN Conference on Environment and Development was held in Brazil. Agenda [21] was developed by heads of state and binds nations to sustainable development by taking into account economic, environmental, and political aspects. Corporate environmental consciousness was lacking despite global environmental advances. Almeida asserts that businesses were compelled to abide with environmental laws by the pressure of the media and civil society. The Canadian project "Responsible Care" from 1984 has changed corporate behaviour in 68 nations.

To increase safety and quality of life, this plan made investments in energy efficiency, employee safety records, infrastructure security, and the elimination of harmful emissions. Despite environmental problems in the industrial and commercial sectors, the public detested the chemical industry, according to a 1994 European Chemical Industry Council (CEFIC) research. Due to their perceived advantages, people concentrated on the plastics and pharmaceutical industries (Pandey, 2015). According to most interviewees, sustainability was not given priority by the chemical industry. Transportation, safety, and trash were not valued as highly as oil, gas, power, wood, and paper. The Presidential Green Chemistry Challenge was established by the US government in 1995 (PGCC). Chemical industry technological advancements decreased waste in a number of manufacturing processes.

In order to advance green chemistry applications and chemical industry sustainability, the non-profit Green Chemistry Institute (GCI) was established in 1997 (ACS Chemistry, 2017). In order to address global

chemistry and environmental challenges, the GCI joined the ACS in 2001. Research on green chemistry has expanded to include conferences, businesses, sectors, and international networks (ACS Chemistry, 2017). The 1998 book Green Chemistry: Theory and Practice by Paul Anastas and John C. Warner contributed to the advancement of green chemistry. Through the 12 Principles of Green Chemistry, the book encourages environmental responsibility in academia and business (ACS Chemistry, 2017). Thirty years after Stockholm, thousands of people attended Rio + 10, the World Summit on Sustainable Development, which was held in Johannesburg, South Africa. Government and nongovernmental organisations, big businesses, sectoral associations, delegations, and the media explored Agenda 21 government and public implementation options, building on the discussions from ECO-92.
In an effort to advance green chemistry and engineering in the pharmaceutical sector, the ACS Green Chemistry Institute (GCI) and multinational pharmaceutical corporations organised a panel discussion in 2005. The panellists felt that "the green" required "continuous processing" (Contable, 2007). From 1997 to 2011, four Green Chemistry conferences were organised by IUPAC, ACS, and GCI. Lenardão claims that the symposia addressed green products, procedures, waste sources, energy sources, laws, and green chemistry education.

PRINCIPLES OF GREEN CHEMISTRY

A thorough framework for creating chemical processes and products that are both socially and environmentally responsible is provided by the Twelve Principles of Green Chemistry [20–22]. The first principle, prevention, highlights how crucial it is to, whenever feasible, refrain from producing waste. The effective use of raw materials is encouraged by the second principle, atom economy, in order to reduce byproducts and resource consumption. The third principle, less harmful chemical syntheses, emphasises the necessity of developing techniques that make use of materials with low toxicity to the environment and human health [23]. The creation of chemical products that are efficient in their function while minimising any possible harm is the emphasis of the fourth principle, safer chemical design. The fifth principle, "Safer solvents and auxiliaries," promotes the use of auxiliary compounds that are non-toxic and do not endanger the environment or human health [24]. The sixth principle of designing for energy efficiency places a strong emphasis on streamlining procedures to use less energy and favouring ambient pressure and temperature levels. The seventh principle encourages the use of sustainable and renewable raw materials by utilising renewable feedstocks. Reducing derivatives, the eighth principle, calls for the elimination of pointless derivatization processes that may contribute to waste production [25]. The ninth principle, catalysis, suggests using catalytic reagents instead of stoichiometric reagents in order to maximise reaction speeds, minimise byproducts, and consume less energy. The tenth principle, "design for degradation," advocates creating chemical products that, at the end of their useful lives, decompose into harmless degradation products, preventing persistence in the environment. The eleventh principle, "real-time analysis for pollution prevention," promotes the creation of analytical techniques for in-process monitoring in order to stop the emergence of dangerous materials. By selecting materials and shapes that reduce the likelihood of chemical accidents like releases, explosions, and flames, the twelfth principle—inherently safer chemistry for accident prevention—suggests preventing accidents [26].

When taken as a whole, these guidelines offer academics and business experts a way to include sustainability into their work, which promotes the creation of chemical processes and goods that are safer and more environmentally friendly [27].

Table 1: Principles of Green Chemistry Principle

Description	
1. Prevention	Minimize or eliminate the generation of waste products during chemical processes.
2. Atom Economy	Maximize the incorporation of all materials used in a process into the final product,

	reducing by-products and resource consumption.
3. Less Hazardous Chemical Syntheses	Design synthetic methods that use and produce substances with minimal toxicity to human health and the environment.
4. Designing Safer Chemicals	Develop chemical products that are effective while minimizing their toxicity.
5. Safer Solvents and Auxiliaries	Avoid or minimize the use of auxiliary substances, such as solvents, that are harmful to human health and the environment.
6. Design for Energy Efficiency	Optimize processes to minimize energy consumption, favoring ambient temperature and pressure conditions.
7. Use of Renewable Feedstocks	Prioritize the use of raw materials that are renewable rather than depleting.
8. Reduce Derivatives	Minimize or eliminate unnecessary derivatization steps, which can generate waste.
9. Catalysis	Prefer the use of catalytic reagents over stoichiometric reagents to increase reaction rates, reduce energy consumption, and minimize by-products.
10. Design for Degradation	Develop chemical products that break down into innocuous degradation products at the end of their functional life, avoiding persistence in the environment.
11. Real-time Analysis for Pollution Prevention	Develop analytical methods for in-process monitoring and control to prevent the formation of hazardous substances.
12. Inherently Safer Chemistry for Accident Prevention	Choose substances and forms of substances that minimize the potential for chemical accidents, such as releases, explosions, and fires.

ADVANCED GREEN CHEMISTRY APPLICATIONS

- **Medications**

Creating medicinal molecules using ecologically friendly synthesis methods. Lowering the amount of hazardous chemicals and solvents used in the production of drugs. Creating more eco-friendly ways to dispose of trash during the manufacturing of pharmaceuticals [28].

- **Agricultural chemicals**

Making fertilisers and pesticides that are safe for the environment.
Reducing the ecological impact of crop protection chemical design.
Creating sustainable agricultural methods to reduce the use of chemicals [29].

- **Materials Science**

Advances in the manufacture of composites, polymers, and plastics have a smaller negative environmental impact. Techniques for material recycling and upcycling to reduce waste.

- **Energy Production**

Creating green solutions for batteries and solar cells, two examples of renewable energy sources.
Creating catalysts to improve the efficiency and cleanliness of energy conversion processes.

- **Water Purification**

Producing ecologically friendly water filtration techniques. Producing novel materials to effectively purge water of contaminants.

- **Textile Industry**

Integrating environmentally friendly methods into the finishing and dyeing procedures.
Creating environmentally acceptable substitutes for customary textile treatments.

- **Food Industry**

Creating environmentally friendly methods for packaging and preserving food. Creating sustainable agricultural and food processing methods [30].

- **Cleaning Products**

Designing environmentally friendly cleaning agents with reduced toxicity.
Innovating in the production of detergents and other household products.

- **Waste Management**

Applying the concepts of green chemistry to the handling and elimination of hazardous waste. Designing procedures that encourage recycling and reduce trash production.

- **Education and Research**

Incorporating the concepts of green chemistry into university curricula.
Conducting research to identify and advance sustainable chemical processes.

- **Policy and Regulation:**

Influencing and forming laws to promote the use of green chemistry techniques.
Backing programs that encourage ethical and sustainable chemical production.

PHARMACEUTICALS

In addition to supporting sustainability objectives, the pharmaceutical industry's use of green chemistry helps create efficient and reasonably priced drug manufacturing procedures. The incorporation of green chemistry concepts is anticipated to have a growing impact on the future of pharmaceutical manufacturing as the industry develops [31].

SAFER SOLVENTS AND REACTION CONDITIONS

Substituting safer, more environmentally friendly solvents like water or bio-based solvents for conventional, dangerous solvents [32].
Reaction conditions are optimised to use less energy and have a less environmental impact.

Catalysis

Application of catalytic processes to lessen the requirement for high pressures and temperatures and to improve reaction efficiency.
Creation of sustainable and recyclable catalysts to reduce waste.

Atom Economy

A focus on reducing waste formation by optimising the integration of reactant atoms into the end product. Reduction of adverse effects and byproducts using effective synthetic pathways.

Green Synthesis of Active Pharmaceutical Ingredients (APIs)

Creating synthetic approaches for the synthesis of ecologically friendly pharmaceuticals.

Biocatalysis

The use of biocatalysts, such as enzymes, in pharmaceutical production can improve selectivity and lessen the requirement for severe reaction conditions. Less byproducts and softer reaction conditions are frequently the outcomes of enzymatic processes [33].

Microwave and Ultrasound-Assisted Synthesis

Utilizing microwave and ultrasonic radiation to synthesize medicinal molecules quickly and efficiently. Decreases in energy usage and reaction times.

Continuous Flow Chemistry

Implementing continuous flow procedures to improve reaction control and lessen the effect on the environment. Makes it possible to synthesize medications more effectively and with less waste.

Ecological Analytical Methods

Use of ecologically friendly analytical techniques for process monitoring and control in the pharmaceutical industry.
Application of methods like spectroscopy and green chromatography.

Waste Reduction and Recycling
Creation of procedures that reduce the output of waste byproducts.
Investigation of techniques for solvent and material recycling and reuse [34].
Eco-friendly Packaging
Packaging for pharmaceuticals is designed and produced with consideration for green chemistry.
Investigation of biodegradable and sustainable packaging materials.

Life Cycle Assessment (LCA)
Utilizing life cycle thinking helps pharmaceutical companies evaluate and reduce their environmental impact, from the extraction of raw materials to their disposal.
Regulatory Compliance
Pharmaceutical procedures that adhere to rules and regulations that support the use of green chemical techniques.
Cooperation with regulatory agencies to advance environmentally friendly pharmaceutical production.
Agrochemicals
The integration of green chemistry principles into agrochemicals results in more environmentally friendly and sustainable farming methods that safeguard ecosystem health and advance the welfare of farmers and consumers alike [35].

ATOM ECONOMY
Creating agrochemical synthesis pathways that reduce the amount of waste produced while maximising the use of raw resources.
This encourages resource efficiency and lessens the impact on the environment.
Solvent Selection: Selecting water-based pesticide formulations or solvents that are favorable to the environment. This reduces the amount of hazardous solvents used, protecting ecosystems and enhancing farm workers' safety.
Catalysis: Applying catalytic techniques to the agrochemical manufacturing process. By improving reaction rates, boosting effectiveness, and removing the need for high temperatures, catalysis can minimize its negative effects on the environment and use less energy.
Renewable Feedstocks: Combining bio-based feedstocks and other renewable raw materials to create agrochemicals. This encourages sustainability and lessens reliance on scarce fossil fuels.
Safer Chemicals: Creating agrochemicals that are less harmful to organisms that are not intended targets, such as beneficial insects and people. This reduces the possible harm to ecosystems and the influence on the environment
[36].
Biodegradable Formulations: Developing readily biodegradable agrochemical formulations to lessen their environmental persistence and minimise long-term ecological effects.
Ecological Analytical Methods: employing ecologically acceptable analytical techniques to track and evaluate pesticide residues in crops, water, and soil. This minimises damage to the environment while ensuring accurate assessment.
Integrated Pest Management (IPM): Encouraging the application of agrochemicals in IPM. This method integrates chemical, cultural, and biological control techniques to provide a comprehensive and long-lasting approach to pest. Management [33-36].
Effective Delivery Methods: Creating cutting-edge delivery methods to improve the targeted distribution of agrochemicals, such as controlled-release formulations. As a result, less waste is produced and fewer chemicals are used overall.
Science of materials: Its main goals are to create goods and procedures that have the least negative effects on the environment, employ fewer dangerous materials, and encourage sustainability. Green chemistry ideas can be used to materials science to provide creative and environmentally sustainable solutions for material creation and production.

Biodegradable Polymers: The use of biodegradable polymers as a substitute for conventional, nonbiodegradable plastics is encouraged by green chemistry. The spontaneous breakdown of these polymers lessens the load of persistent plastic waste on the environment. Medical devices, disposable goods, and packaging are among the industries that can use biodegradable materials.

Renewable Resources: The use of renewable resources, such as plant-based feedstocks, in the manufacturing of materials is emphasised by the field of green materials science. This strategy lessens dependency on fossil fuels, which promotes sustainability and lessens the negative environmental effects of extracting and processing nonrenewable resources.

Safer Solvents: Conventional solvents can be hazardous to human health and the environment when employed in the synthesis of materials. Water or bio-based solvents are safer and more environmentally friendly solvents that are supported by green chemistry. This lessens the amount of hazardous materials that employees are exposed to and the amount of volatile organic compounds (VOCs) that are released into the atmosphere.

Energy-Efficient Manufacturing: In order to lessen the carbon footprint of material production, green chemistry encourages energy-efficient manufacturing techniques. To improve the sustainability of materials synthesis, methods such as microwave-assisted synthesis, which can drastically reduce reaction times and energy usage, are being investigated.

Catalysis: The application of catalysis to improve reaction selectivity and efficiency is encouraged by green chemistry. By lowering the requirement for high pressures and temperatures, catalytic processes save energy and minimise the generation of byproducts. This method is very pertinent to the synthesis of many materials, including catalysts [37].

Recyclable Materials: One of the main tenets of green chemistry in materials science is the design of materials with recyclability in mind. This entails creating materials that are simple to recycle, separate, and disassemble.

Decreased Toxicity: The goal of green chemistry is to employ as few harmful ingredients as possible while creating new materials. The effects of materials manufacturing on the environment and human health can be greatly minimised by choosing less dangerous components and avoiding harmful byproducts.

Life Cycle Assessment (LCA): The integration of life cycle assessment principles into materials science enables a thorough examination of a material's environmental impact, spanning from the extraction of raw materials to their disposal. Researchers and business experts can make wellinformed decisions about the sustainability of materials thanks to this comprehensive methodology [38].

GENERATION OF ENERGY

Utilizing green chemistry concepts in energy generation necessitates a comprehensive strategy. It includes the creation of sustainable materials, procedures, and technologies in a range of energy-related fields, resulting in a more sustainable and green energy landscape.

RENEWABLE ENERGY SOURCES

Solar Energy: Using renewable resources is emphasized in green chemistry. This could apply to solar energy and involve creating sustainable materials for PV cells. Researchers are looking at abundant, non-toxic, and energyefficiently produced materials that are inspired by nature and biology.

Wind Energy: Materials for wind turbines can be manufactured using green chemistry. This covers the creation of eco-friendly coatings and lubricants as well as the utilization of recyclable materials in the building of turbines.

Bioenergy: The sustainable production of biofuels can be guided by the concepts of green chemistry. This entails utilising feedstocks other than food, consuming as little water and energy as possible throughout the production process, and lessening the negative environmental effects of producing biofuel.

Energy Storage

Batteries: Green chemistry promotes the creation of materials for batteries that are safe for the environment. Investigating non-toxic electrolytes, recyclable components, and substitute electrode materials are some examples of this. One of the main components of green chemistry in energy storage is designing batteries with a smaller environmental impact.

Hydrogen Storage: The creation of secure and effective materials for hydrogen storage is aided by green chemistry. This entails investigating materials that are readily available, safe, and able to store hydrogen at lower pressures—thereby lowering the energy needed for storage
[39–40].

FUEL PRODUCTION

Production of Hydrogen: Green chemistry encourages environmentally friendly ways to produce hydrogen. Green chemistry applications in hydrogen production include the use of catalysts derived from naturally occurring materials and electrolysis powered by renewable energy sources.

Biofuel Production: The development of sustainable biofuel production processes is guided by the concepts of green chemistry. This entails choosing feedstocks with less of an impact on the environment, maximising reaction conditions to reduce waste, and employing ecologically friendly solvents.

CARBON CAPTURE AND UTILIZATION

Carbon Capture: By utilising the concepts of green chemistry, effective and sustainable techniques for sequestering carbon emissions from power plants can be created. This entails the application of energy-saving procedures and environmentally friendly solvents.

Carbon Utilisation: The utilisation of captured carbon dioxide is also aided by green chemistry. This involves using eco-friendly catalytic techniques to transform CO2 into useful items like chemicals or fuels [41].

MATERIALS INNOVATION

Green chemistry is centred on creating catalysts that are more effective, less harmful, and composed of renewable materials. This is essential to many energy-producing processes, such as the creation of clean energy and fuel synthesis.

Materials for Infrastructure: By employing recyclable and sustainable materials, green chemistry may help build energy infrastructure, such as transmission lines and power plants. This also applies to the planning of structures and amenities that use less energy.

WATER TREATMENT

The application of green chemistry principles in water treatment procedures can successfully tackle environmental issues and foster sustainable behaviours [42].

Alternative Water Treatment Agents: Chemicals that may be hazardous to the environment are frequently used in traditional water treatment techniques. Green chemistry promotes the creation and application of less hazardous and more ecologically friendly substitute water treatment agents. In water treatment, for instance, natural coagulants and biobased polymers can be used in place of conventional coagulants.

Reducing Chemical Waste: Green chemistry places a strong emphasis on the necessity of reducing waste production. This idea can be utilised to water treatment by optimising chemical dosages to make sure that only the required amount is used. Furthermore, lessening the environmental impact is achieved by using recyclable or biodegradable components in water treatment methods.

Energy-Efficient Treatment Procedures: Energy-efficient procedures are encouraged by green chemistry. Modern technologies that can be more energy-efficient than conventional techniques, like membrane filtration, ultraviolet (UV) disinfection, and electrochemical treatment, can be used in the treatment of water. Energy-efficient procedures lower total resource use, which promotes sustainability.

Green Solvents: In a number of water treatment procedures, solvents are essential. The application of solvents that are safe for the environment and human health is promoted by green chemistry. To lessen the need for organic solvents in some treatment applications, this involves investigating the use of water as a solvent [43].

Biological Treatment Methods: Green chemistry concepts are aligned with biological treatment techniques like phytoremediation and biofiltration, which use natural processes to eliminate pollutants from water.

Utilising plants and microorganisms to break down or absorb contaminants provides a practical and affordable method of treating water [44].

Food Technology: In the field of food technology, green chemistry concepts can significantly improve sustainability and lessen environmental effect.
Sustainable Agriculture: Green chemistry encourages the application of environmentally friendly and sustainable farming methods. This covers the creation of biopesticides, organic fertilisers, and farming techniques that are safe for the environment. These methods help lessen the negative effects of food production on the environment.
Waste Reduction: The processing of food produces less waste thanks to green chemistry. This entails creating procedures that produce less byproducts and coming up with creative uses for leftover materials. Reducing waste helps create a food production system that is more efficient and sustainable.
Alternative Energy Sources: Using renewable energy sources in food processing processes is part of putting green chemistry principles into practice. This involves lessening reliance on non-renewable resources and the food industry's carbon footprint by using biomass, solar, or wind energy to power industrial facilities.
Green Ingredients and Additives: Using renewable resources and reducing the usage of hazardous chemicals are key components in the creation of green ingredients and additives. This involves investigating naturally occurring preservatives, antioxidants, and antimicrobials that don't harm people or the environment [44].
Water Conservation: Green chemistry highlights how crucial it is to preserve water when processing food. The food sector adopts sustainable practices when it uses watersaving technologies, like water recycling and process optimization.
Applications in Biotechnology: Green chemistry encourages the production of food ingredients through biotechnological processes. This includes substituting conventional chemical processes with fermentation processes, microbes, and enzymes, which use less energy and have a less environmental effect.
Carbon Footprint Reduction: Green chemistry contributes to reducing the food industry's carbon footprint by streamlining supply chains and production procedures. This entails optimising resources overall, cutting energy use, and improving transportation efficiency.
Life Cycle Assessment (LCA): Green chemistry integrates life cycle theory into food manufacturing, taking into account a product's environmental impact from the extraction of raw materials to its disposal at the end of its useful life. LCA directs the creation of more sustainable food items and assists in identifying areas that require improvement.
Educational Initiatives: Programmes for scientists and food technologists incorporate the ideas of green chemistry. This guarantees that next experts will have the know-how to use sustainable methods in the food sector.

CONCLUSION

Through investments in environmentally sound analytical and policy methodologies, research progress has over time supported the development of sustainable processes in accordance with worldwide conventions since 1968. We are unable to fully utilise this approach, though, because businesses need to determine whether integrating green chemistry into their operations is financially feasible. Future developments depend heavily on investments in and advocacy for the importance of green chemistry and its direct bearing on pharmaceutical analysis, worker satisfaction, patient health, and environmental sustainability.

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