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# The application of renewable materials in green chemistry

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**Abstract.** Natural substances that are capable of being replaced or renewed over the course of a human lifetime or over a relatively short amount of time through natural processes are referred to as material that is renewable. Due to the fact that these materials are both sustainable and favorable to the environment, they are frequently used in a variety of industries, including the building industry, the textile industry, the energy industry, and the packaging industry. Given the circumstances, it is quite probable that this will have a profound effect on the future of humanity. Renewable materials commonly encompass biomass, bio-based polymers, natural fibers, wood, and lumber. The main focus of the study is to explore the utilization of renewable materials in green chemistry, namely biomass-sourced renewable materials, as well as other renewable materials such as food waste, recyclable plastics, and paper. This paper provides an in-depth review of the advantages and challenges related to renewable materials in the realm of green chemistry.

**Keywords:** Renewable Materials, Green Chemistry, biomass sources

## 1. Introduction

Renewable materials are compounds obtained from natural resources that can be renewed or regenerated reasonably quickly within a time range that is important to humans. These materials are obtained via renewable or regenerative processes and are commonly utilized in diverse industries because of their environmentally beneficial and sustainable characteristics. The key characteristics of renewable materials encompass sustainability, biodegradability, low environmental impact, reduced dependence on finite resources, diversity in sources, versatility and applications, lifecycle consideration, regenerative processes, and eco-friendly properties. Renewable resources are vital elements of sustainable development and environmentally friendly practices. Their attributes aid in lessening the environmental effect, diminishing reliance on limited resources, and promoting a more sustainable and circular economy.

Green Chemistry is a discipline that concentrates on creating chemical goods and procedures that minimize or eradicate the use and production of dangerous substances. The concepts of Green Chemistry, as established by Paul Anastas and John Warner, prioritize sustainability, efficiency, and environmental responsibility in the domains of chemical research, development, and manufacture. These principles serve as directives for developing chemical processes that are safer, less hazardous, and more sustainable. Preventing waste generation is more preferable than the subsequent cleanup or treatment of garbage. Developing strategies to limit trash generation is crucial; Efficiently synthesize compounds by utilizing

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all the atoms in the reactants, therefore reducing the production of waste byproducts; Develop synthetic methodologies to utilize and produce compounds that exhibit minimal or negligible toxicity towards human health and the environment; Create compounds with less toxicity while preserving their efficacy in their designated uses; Employ more secure solvents and auxiliary chemicals in chemical operations, while minimizing the utilization of volatile, poisonous, or environmentally detrimental elements; Integrate energy-efficient techniques into chemical processes to minimize energy usage and advance sustainability; Employ renewable raw materials or feedstocks obtained from sustainable sources to reduce dependence on non-renewable resources; Develop methodologies that reduce the utilization of superfluous derivatives, which necessitate supplementary reagents and produce waste; Employ catalytic agents in chemical processes to optimize reaction efficiency, decrease energy demands, and minimize waste generation; Create compounds that undergo complete breakdown into harmless byproducts upon usage to prevent any accumulation in the environment. Furthermore Integrate analytical approaches that enable immediate monitoring and regulation of chemical reactions to reduce the production of dangerous chemicals.

The study primarily examines the utilization of renewable materials in green chemistry, specifically focusing on biomass-sourced renewable materials, as well as other renewable materials such as food waste, recyclable plastics, and paper. This paper provides a thorough examination of the advantages and challenges related to renewable materials in the realm of green chemistry.

## 2. The application of renewable materials in green chemistry

### *2.1. Application of renewable materials from biomass sources*

The author’s objective is to categorize the use of renewable materials in green chemistry into several sections, including biomass-based recyclable materials, the repurposing of biomass waste, the utilization of food waste, the recycling of plastics and paper, and the implementation of renewable energy.

*2.1.1. Biomass-based recyclable materials.* Paper bags and paper boxes are the most often utilized items, mostly manufactured from cellulose-based materials, starch-based materials, and biodegradable plastics sourced from biomass. Based on data from the China Paper Association, the paper industry in China is comprised of around 2500 enterprises. In 2022, the production of paper and cardboard reached 124 million tons, representing approximately 30% of the global market share. The consumption of paper and cardboard in China also amounted to 124 million tons, with an average per capita consumption of 88kg [1]. Developed countries had higher per capita paper use. There is no doubt that Bio-based Packaging constitutes a significant market globally. In China, there are multiple applications of various directions. The first component is a composite film made of paper and CNC/PEI, as shown in figure 1. The second component involves the effective incorporation of silver utilizing resin materials derived from biological sources, as depicted in figure 2. Following that is the study of materials derived from biological sources. The third category consists of bioactive materials, whereas the last category is derived from starch.

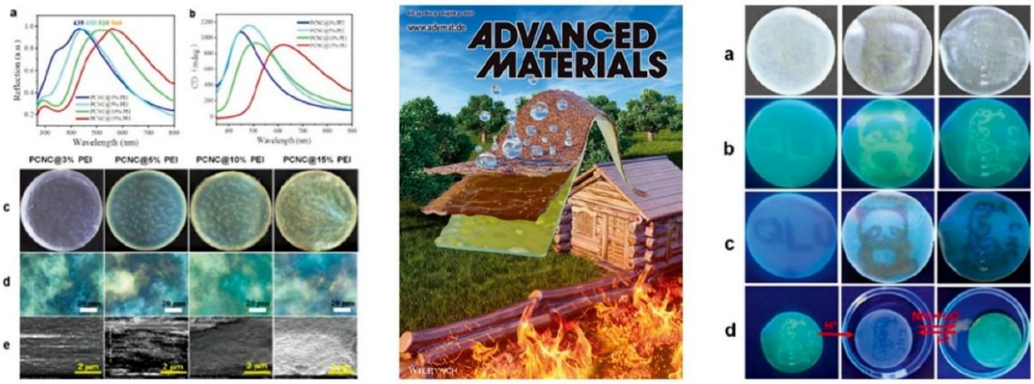


**Figure 1.** Response and anti-counterfeiting performance of composite film [1]

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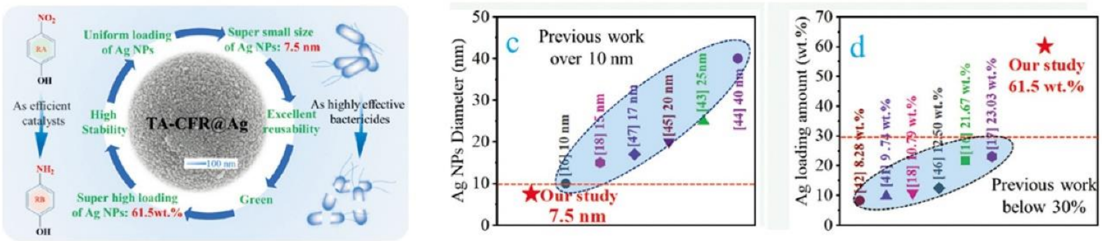


**Figure 2.** Efficient loading of silver using bio-based resin materials [1]

*2.1.2. Reuse of biomass waste.* Biomass waste reuse is transforming organic matter derived from plants, animals, and microbes into valuable commodities or sources of energy, instead of allowing them to be disposed of as waste. These waste items frequently comprise agricultural residues, food waste, wood residues, municipal solid trash, and other similar substances. Below are several techniques for the repurposing of biomass waste. Bioenergy production involves the conversion of waste plant materials, such as wood chips, straw, and maize stalks, into bioenergy sources, which include biomass fuels like pellets and biochar, as well as biodiesel. Biological fermentation is a process that can transform organic waste into valuable biochemicals such as bioethanol, acetic acid, lactic acid, and other compounds that are utilized in various industries and pharmaceutical applications. Anaerobic digestion is a process in which organic materials are broken down without the presence of oxygen to produce biogas [2]. This biogas can then be utilized for the creation of power and heating purposes. The resultant digestate can also function as an organic fertilizer. Biodegradable Plastics and Packaging Materials: Biomass waste can be employed to make biodegradable plastics and packaging materials, reducing reliance on regular plastics and lessening environmental impact. Utilizing biomass waste for the production of organic fertilizers enhances soil quality and stimulates crop development, hence fostering soil vitality and ecological equilibrium. Utilization of Biomass Waste for Biomass Chemical Production: Biomass waste can be employed to synthesize bio-based chemicals that find applications in diverse products, such as bio-based cleansers, pharmaceuticals, cosmetics, and more. Utilizing biomass waste helps decrease reliance on limited resources, mitigate environmental degradation, and promote sustainable development. However, the adoption of these reuse methods necessitates examining technological feasibility, economic viability, as well as the environmental and societal implications to ensure sustainability and efficacy [3].

*2.2. Other renewable material applications*

The predominant method of harnessing food waste appears to involve categorizing it as kitchen garbage and employing it as fertilizer. Occasionally, it also entails a degree of ingenuity. In addition, the utilization of trash in a more advanced manner has already been implemented. Kitchen garbage, also known as food waste, mostly consists of carbohydrates, dietary fiber, and animal fat. It constitutes a significant portion of municipal waste. The nutritional value of kitchen trash is utilized by using the lactic acid fermentation broth of kitchen waste as a raw material. A catalyst is employed to prepare and extract lactic acid fat from the lactic acid fermentation broth. Polylactic acid, a biodegradable polymer substance, is produced by directly synthesizing lactic acid fat through melt/solid phase polymerization [2].

Regarding plastic recycling, it is important to understand that plastics are classified using resin identification codes (RICs) ranging from 1 to 7, typically located on the bottom of containers. The most often recycled types of plastics are PET (Polyethylene Terephthalate, #1), HDPE (High-Density Polyethylene, #2), PVC (Polyvinyl Chloride, #3), LDPE (Low-Density Polyethylene, #4), PP (Polypropylene, #5), and PS (Polystyrene, #6). Recyclability of plastics varies depending on the location. Consult the local recycling standards to ascertain the specific categories of plastics that your recycling facility is capable of accepting. Plastics labeled as #1 and #2 are commonly and widely acknowledged as recyclable materials. To prevent contamination, it is advisable to thoroughly clean containers before recycling them, as any food remains present can diminish the quality of the recycled plastic. Besides, it is necessary to minimize plastic usage whenever feasible, and contemplate repurposing plastic containers for storage prior to discarding them. When recycling paper, it is important to categorize it into commonly recyclable types such as newspapers, magazines, cardboard, office paper, and corrugated cardboard boxes for subsequent processing. These can be utilized not just for reproduction, but also for several other purposes. Waste paper fibers have a beneficial coagulation assist effect when used in FeCl3 treatment of water with low turbidity. By enhancing the settling speed of flocs, they can improve the turbidity treatment effect [3].

## 3. Benefits and Challenges of Renewable Materials in Green Chemistry

Renewable materials offer several advantages over non-renewable resources, especially in the context of sustainability, environmental impact, and long-term viability.

### *3.1. Benefits of Renewable Materials in Green Chemistry*

Renewable materials are typically obtained from natural resources that have the ability to be replaced at a relatively fast rate. This helps to alleviate the pressure on limited resources such as fossil fuels. Firstly, numerous renewable materials exhibit a reduced carbon footprint in comparison to their non-renewable equivalents. Their manufacture and processing frequently result in reduced greenhouse gas emissions. Furthermore, the utilization of renewable materials frequently entails the implementation of sustainable harvesting methods that foster the conservation of biodiversity and the well-being of ecosystems.

In addition, it also offers economic benefits. Renewable resources are obtained from sources that may be sustainably grown, developed, or harvested, guaranteeing a consistent and dependable supply in the long run. Furthermore, industries that rely on renewable materials have the potential to generate job opportunities, particularly in fields such as agriculture, forestry, and other sustainable sectors, thereby making a significant contribution to local economic growth [4].

In addition, it also offers social and health advantages. For instance, numerous renewable materials possess the qualities of being non-toxic and biodegradable, hence diminishing the potential hazards of dangerous chemicals in both products and surroundings. In addition, communities can reap advantages from renewable material industries by engaging in sustainable behaviors and cultivating a feeling of accountability towards the environment.

Technological breakthroughs are the final outcome. The utilization of renewable materials stimulates creativity and investigation into manufacturing processes that are more sustainable, ultimately resulting in technological advancements. Renewable materials can be employed in diverse sectors including building, packaging, textiles, and energy generation, providing flexible and environmentally friendly alternatives.

Additionally, it possesses long-term sustainability. Using renewable materials aids in the preservation of natural resources for future generations by encouraging responsible use and decreasing reliance on limited resources. Renewable materials help combat climate change by decreasing dependence on fossil fuels and promoting the storage of carbon in natural ecosystems.

To summarize, adopting renewable materials provides a variety of advantages, including environmental preservation, economic advancement, and societal welfare. Their utilization is in accordance with sustainable development objectives and enhances a more robust and equitable interaction between human endeavors and the environment [5-6].

### *3.2. Challenges of Renewable Materials in Green Chemistry*

In addition to its promising prospects, it also endures significant challenges. The worldwide consumption of fossil fuels amounts to 9.9 billion tons (9 billion metric tons). The majority of petroleum is utilized for fuel transportation and energy generation purposes. However, around 60 million tons (54 million metric tons) of petrochemical goods that are not special to petrochemical companies are manufactured in the United States. Presently, of the overall quantity of 2.5 billion tons (230 million metric tons) of sucrose, roughly 0.75 billion tons (68 million metric tons) of inedible sucrose can be utilized for chemical production and ethanol manufacturing. If we assume that three units of sugar are transformed into one unit of a chemical product, then 100 million tons (23 million metric tons) of chemical products will be obtained from 0.25 units of sugar. Of the total 2.4 billion tons (2.2 billion metric tons) of starch, approximately 300 million tons (270 million metric masses) are allocated for industrial usage, resulting in the production of 100 million tons (90 million metric tons) of chemical goods. The worldwide production of vegetable oil amounts to roughly 170 million tons (150 million metric tons), with 80% being suitable for consumption. The remaining 30 million tons (27 million metric tons) are utilized in the production of industrial chemicals and fuel, although a significant portion is already allocated to the oil and fat chemical industry. These sources are currently embroiled in dispute on the choice between utilizing food or fuel. Annually, the global production of cellulose as an alternative amounts to around 130 billion tons (120 billion metric tons). This is sufficient to substitute the worldwide utilization of fossil fuels. Nevertheless, it is imperative that we take into account the matter of sustainable production [4].

## 4. Conclusion

In conclusion, the study discussed the utilization of renewable materials in green chemistry. These renewable materials included those that were derived from biomass, in addition to other renewable materials such as paper, recyclable plastics, and food waste. This paper provides a complete review of the advantages and challenges that are related with the use of renewable resources in the field of green chemistry. In addition, green chemistry has a promising future, but it is also confronted with a significant amount of difficulty at the same time. Due to the constraints imposed by the existing circumstances, the author of this study does not have the opportunity to conduct experiments or do additional research on papers. It is necessary for the future of green chemistry to overcome the challenge of high costs and low efficiency in order to bring about a better world for people.

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