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# Use Of Biomass and Technological Advances in Sustainable Organic Chemistry

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## Abstract

Chemistry and biology researchers are working hard to create environmentally friendly and sustainable methods for turning waste biomass into valuable chemicals, biofuels, and bioplastics in response to the pressing need to mitigate climate change. Green Chemistry, which emphasizes the effective use of renewable raw resources, waste minimization, and the avoidance of harmful compounds, is the guiding principle at the center of this endeavor. In order to better understand the process of converting biomass into commodity chemicals, this study will focus on two main methods: direct conversion to oxygenates as platform chemicals and complete deoxygenation to petroleum hydrocarbons. Various methods for converting carbohydrates to hydrocarbons and oxygenates are explored, including fermentation, biotechnological techniques, and chemical catalysis. Moreover, measures underscoring the meaning of materials proficiency, energy effectiveness, land use, and interaction costs are proposed for assessing the manageability of biomass-based processes. The final section of the study addresses the difficulties associated with logistics and economies of scale in the conversion of biomass, offering creative solutions such mobile refineries.

**Keywords: Biomass utilization, green chemistry, Biorefinery, Renewable feedstocks, Catalytic conversion, Sustainable chemical synthesis**



## 1. INTRODUCTION

Coming up with environmentally friendly and sustainable methods to turn waste biomass into valuable chemicals, biofuels, and novel bio-based materials like bioplastics is one of the great challenges facing chemistry and biology today, motivated by the urgent need to mitigate the effects of climate change.

Considerate by plan, or the making of earth harmless merchandise and systems, is the focal precept of Green Chemistry, as expressed by Anastas and Warner in their twelve standards of Green Chemistry. To put it momentarily, green chemistry is the successful utilization of unrefined components (preferably renewable ones), squander decrease, and staying away from the utilization of dangerous or potentially harmful solvents and reagents in the creation and utilization of chemical products. There are three fundamental components to it. Initially, reducing waste by using raw materials effectively.

Secondly, avoiding the use of hazardous and/or poisonous materials, such as solvents, in order to avoid health, safety, and environmental concerns. Third, substituting non-renewable fossil feedstocks like coal, natural gas, or crude oil with renewable biomass. Green chemistry, as opposed to waste cleanup at the end of the pipe, is mostly about preventing pollution. It's interesting to take note of that there is no monetary part to "green chemistry." Sustainable turn of events, then again, includes the social, ecological, and financial parts known as the "three mainstays of maintainability": individuals, planet, and benefit. It is depicted as fulfilling current believes that without forfeiting the capacity of people in the future should fulfill their own requirements, and it perceives the need of sustainable modern and cultural development. Put another way, we shouldn't utilize our regular assets at a rate that makes them run out and we shouldn't deliver extras at a rate quicker than the ecosystem can ingest them. Green chemistry should be visible as an empowering innovation. An innovation should meet the necessities in light of the three mainstays of individuals, planet, and benefit to be long haul sustainable.

Although the phrase "green chemistry" did not yet have a name when it first appeared in the early 1990s, it does not imply that green chemistry did not exist prior to that time. A development toward more efficient and less inefficient chemical production was well in progress in the 1980s, when the expression "clean chemistry" was generally utilized. Still, the expression "green chemistry" and the foundational theories of "particle economy" and "E factors" (kilograms of waste per kilogram of item) gave it a decent lift in the mid-1990s.

## 2. LITERATURE REVIEW

**Varma, R. S. (2019)** Biopolymers like cellulose, chitin, and chitosan are widely found in our biosphere and have several beneficial properties, the most notable of which are their biodegradability and renewability. Notwithstanding nitrogen-enhanced carbonaceous materials, the amino gatherings in chitin and chitosan furnish these central polysaccharides with a large group of advantages that guide in the synthesis of chemical elements with unmistakable and positive utilitarian properties. This Viewpoint article features a portion of the thrilling open doors that these biopolymers present because of the latest mechanical progressions in the area of nanotechnology, which range from laid out catalysis to recently grew high-esteem merchandise. A couple of occasions of harmless to the ecosystem chemical changes and natural remediation that utilize the copious biomass, extras from horticulture, and marine garbage are given. The regular utilization of chemicals created from petroleum products is tried not to by present customary biomass-inferred stage chemicals as an expected wellspring of renewable feedstocks from these carbon-based materials. These chemicals offer different opportunities for the assembling of sustainable products.

**Fiorentino, G., et.al., (2017)** In the context of a more sustainable economy, industries are finding it more and more appealing to invest in the manufacturing of chemicals from renewable feedstocks. In fact talking, a huge part of modern chemicals and materials got from non-renewable energy sources can be traded out for their profile based counterparts. In any case, due to more effective creation strategies and less expensive expenses, fossil-based chemistry keeps on being transcendent. Processing biological feedstocks in integrated biorefineries, which function similarly to a standard petroleum refinery but can also create bio-based chemicals and energy carriers, is the greatest way to optimize the value of biomass. The issue is to exhibit the environmental viability of a lower impact all through the entire production chain, in addition to the technological and economic viability. Potential renewable substrates, conversion courses, and target atoms are entirely examined in this review while taking into account the latest improvements in innovation. Throughout a product's life cycle, potential advantages and effects on the environment are also examined. While technological and economic feasibility can—and occasionally have—been achieved, the same cannot be said for environmental feasibility, where a number of questions remain to be answered and the possibility of burden shifting is not insignificant. This survey means to offer a wide outline of the chances and difficulties related with the shift from oil to biomass chemistry. It likewise draws a guide of the most encouraging biomass esteem chains and sustainable advances, screening their ecological ramifications simultaneously, to push toward the commercialization of bio-based chemistry. Copyright 2016 John Wiley & Sons, Ltd. and the Society of Chemical Industry.

**Lakó, J., et.al., (2008)** These days, biotechnology and the energy use of biomass are very visible from an environmental perspective, as well as from a social, political, and economic one. According to the European Parliament and European Council's Directive 2003/30/EC, utilizing bioethanol made from a corn-based manufacturing process rather than fuels based on crude oil can reduce greenhouse gas emissions by 49%. Moreover, as of July 1, 2007, just gas with a base 4.4% bioethanol content is considered commercialization in Hungary. This article gives explicit occasions of effective biomass projects created or potentially executed in Hungary, including the development of bioethanol by the organizations Hungrana and Győr Refinery, the development of bioethanol by MOL Pls. Danube Treatment facility, research on

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new age of biofuels, and creation cordial manufactured material at the "Nitrokémia" chemical plant. The essential advantages and disadvantages, as well as the purposes behind additional review and development in Hungary's profile modern and bio-shopper areas, are covered.

**Sheldon, R. A. (2011)** A review is conducted on the several catalytic approaches that can be used to use renewable biomass for the sustainable manufacture of commodity chemicals and liquid fuels. Focus is on the environmentally friendly aspects of these innovative processes, as well as second generation methods that use lignocellulose as a sustainable feedstock to avoid the conflict between fuel and food. The necessity of developing a set of criteria for evaluating the sustainability of various procedures and goods is also emphasized. It is found that evaluating the sustainability of platform commodity chemicals and biofuels using a single set of measures is probably not enough. The latter can be evaluated by taking into consideration the amount of carbon dioxide gas produced by energy and water consumption, as well as by doing a life cycle assessment and applying E factors (kgs waste/kg product). Biofuels, on the other hand, bring up other issues, such land utilization, due to their massive volume requirements, and their goal is different: to sustainably produce a certain energy density at a commercially viable cost.

## 3. CONVERSION OF BIOMASS TO COMMODITY CHEMICALS

There are essentially two approaches to converting cellulosic biomass and the building components that make it up:

- Conclude the deoxygenation process to obtain "drop-in" petroleum hydrocarbons, and then use the existing reactors to carry out further processing in order to create commercial chemicals using tried and true petrochemical technologies.
- Direct conversion into platform chemicals, such as oxygenates and nitrogenates. In a conventional oil refinery, petroleum hydrocarbons are converted into a large number of "oxygenating" commercial chemicals, often through catalytic aerobic oxidation. On the other hand, certain oxygen-containing functions are already present in the building blocks of carbohydrates. Therefore, it does not seem to make sense to produce petroleum hydrocarbons by first eliminating all of these oxygens and then oxidatively reintroducing oxygen functions. In fact, this serves as the foundation for the idea of redox economy, which holds that avoiding oxidation state transitions during a multi-step process is energetically more economical. Amino acids obtained from proteins may also make advantageous building blocks for compounds that include nitrogen (see below).

### 3.1. Carbohydrates to hydrocarbons

Hexoses and pentoses, which are structural components of hemicellulose and cellulose, can be converted to oil hydrocarbons in a variety of methods. A possible approach is to convert lower alcohols (such as propanols, butanols, and ethanol) into olefins so they may be easily integrated into petrochemical supply chains. For sure, bioethanol might be best utilized as a stage chemical as opposed to a biofuel. Allegedly, Braskem in Brazil makes the vast majority of its polyethylene from bioethanol.

As a second-age alcoholic fuel with higher energy thickness and lower instability than ethanol, 1-butanol is standing out. Recombinant microorganisms that make butanols in modern amounts have been created utilizing metabolic pathway designing. In excess of twelve firms, including the DuPont/BP joint endeavor, Butamax Cutting edge innovations, Cobalt Advancements, and Green Biologics, market bio-1-butanol. DuPont and later Gev portrayed maturation based isobutanol synthesis. The two products dry out effectively to 1-butene and isobutene. Bioethylene and biobutene would empower olefin metathesis to deliver biopropylene, finishing the C2, C3, and C4 triangle of the petrochemical business. It could be more productive to make

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biopropylene from bioisopropanol. There is no business cycle, even though it has the potential to grow in the near future. A gas-stripping E. coli strain that has undergone metabolic changes can produce 67% isopropanol at a concentration of 143 g $L^{-1}$ in 240 hours. Butadiene, one more C4 petrochemical building part, can be got dried out from 1,4-or 2,3-butane diol from C5 and C6 sugar maturation (see later). Bioethanol, a biofuel and platform chemical, can be used to make butadiene and other commodity chemicals.

Fermentation can straightforwardly make hydrocarbons without the energy-escalated detachment of water-miscible lower alcohols from the fluid fermentation medium. In microbes and yeast, metabolic designing is re-designing the isoprenoid pathway or unsaturated fat biosynthesis to make hydrocarbons straightforwardly. Global Bioenergies is developing fermentation-based isobutene manufacturing. Genencor and Amyris created fermentation methods for isoprene fabricating with Goodyear and Michelin. Moreover, Amyris is commercializing the fermentation of β-farnesene utilizing hereditarily adjusted yeast. The last option can be utilized to make renewable diesel fuel and specialty chemicals. LS9 utilizes manufactured science to reengineer unsaturated fat biosynthesis to create alkanes, alkenes, alcohols, and esters.

Third, biomass-inferred oxygenates like glucose, sorbitol, and glycerol can be changed over chemocatalytically through watery stage transforming. Producing hydrogen and light alkanes in the presence of a powerful corrosive and (de)hydrogenation impulse, such as Pd or Pt. Gas, diesel, and lamp fuel range alkanes, as well as the commonly used mixture of benzene, toluene, and xylenes (BTX), are produced in petroleum processing plants using hydrotreatment or dehydrocyclization over a modified ZSM-5 zeolite catalyst. As a company, Virent Energy Systems promotes innovation. The (HMF) that is created by the corrosive catalyzed hydrolysis of hexoses, for example, fructose and glucose can be changed over into hydrocarbons in their entirety.

Aliphatic hydrocarbons can be created by fermentation, yet fragrant hydrocarbons, a large portion of which come from the BTX cycle stream in petrochemical treatment facilities, are expected to blend all item chemicals. Biorefineries can make fragrant hydrocarbons by overhauling pyrolysis oil or fluid stage transforming starch feedstocks. Lignin might be a decent wellspring of fragrant mixtures, and worldwide result is sufficient to fulfill need. The specific catalytic conversion of lignin to usable chemical mixtures by chemo-or biocatalysis stays a significant biomass conversion issue. The significant use is to make energy for processes.

### 3.2. Carbohydrates to oxygenates

Biotech practices. Biotechnological or chemical techniques can directly convert lignocellulose sugars to commodity platform chemicals. Lower alcohols, diols, mono-and di-carboxylic acids, and a host of other oxygenates can be efficiently extracted from sugars during fermentation. Products derived from fermentation, such as short-chain diols used in polymers and specialty chemicals, undergo an intensification process.85 Polyester and polytrimethylene terephthalate (PTT), which are used in filaments, plastics, films, and coatings, are only a few of the many current uses for 1,3-propane diol (1,3-PDO). A recombinant E. coli strain that manufactures 1,3-PDO was developed by a partnership between DuPont and Genencor; this is a significant accomplishment in modern biotechnology for product chemicals. The versatile 2,3-butane diol (2,3-BDO) can also be produced through fermentation and has several applications in current times. In a recent development, Genomatica88 reported the first commercial-scale production of 1,4-butane diol (1,4-BDO) using metabolic engineering of Escherichia coli. Lanxess has produced 20 tons of polybutylene terephthalate (PBT) using Genomatica biobased 1,4-BDO, which is a polyester.

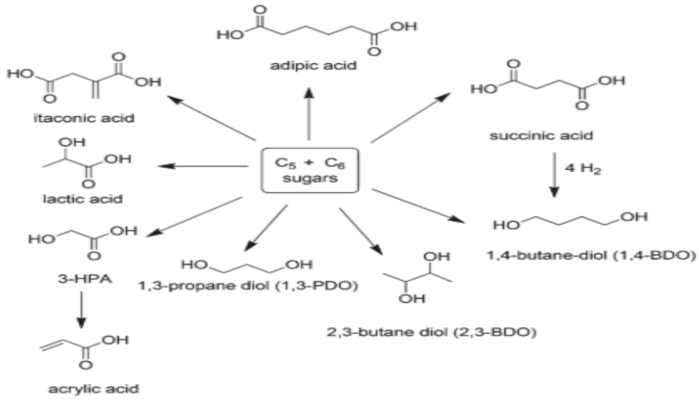


**Figure 1: Biomass-derived sugar fermentation produces commodity chemicals.**

Lactic acid is a first-generation biobased commodity chemical with several uses, including the fast rising use of polylactate as a bioplastic. Fermentation produces citric acid, another valuable molecule. Fermentation produces various second-generation carboxylic acids cost-effectively. Due to its potential for large-scale polyester and polyamide applications, succinic acid has garnered attention. Myriant Innovations, Reverdia (a DSM-Roquette joint endeavor), Bioamber with Mitsui, and Purac with BASF are creating microbial assembling. The Reverdia cycle, which has been displayed at modern scale, utilizes a changed yeast that can mature at pH 3, delivering succinic acid straightforwardly rather than a salt that should be killed and stoichiometric measures of an inorganic chloride or sulfate as waste.

The process of drying and maturing 3-hydroxypropionic acid (3-HPA) yields bio-acrylic acid.In their bioacrylic acid turn of events, Novozymes, BASF, and Cargill recently demonstrated pilot-scale 3-HPA creation. Appropriately, OPXbio94 is working with Dow Chemical and Evonik to create a modern bioacrylic acid synthesis utilizing Efficiency Directed Genome Engineering (EDGE). A few firms guarantee to have found new bio-adipic acid pathways. Adipic, sebacic, and 1,12-dodecane dioic acids were developed by Verdezyne95 using feedstock-freethinker techniques that make use of alkanes, vegetable oils, or sugars.96 The interplay of chemical forces. Furfural and hydroxymethylfurfural are byproducts of acid hydrolysis of pentoses and hexoses.

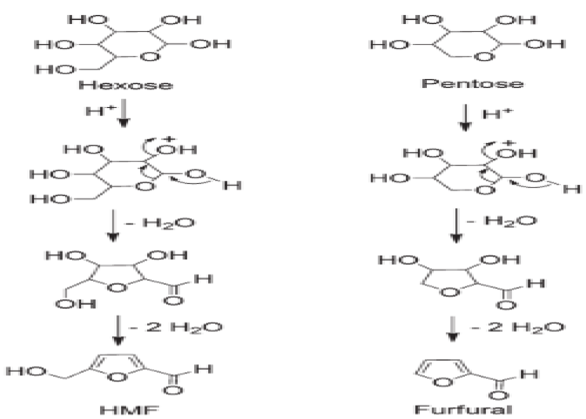


**Figure 2: Using xylose and fructose to make furfural and hydroxymethyl furfural.**

(HMF), both significant platform chemicals. Furfural is broadly utilized and mechanically delivered for quite a long time. Interestingly, HMF has incredible potential as a natural substance for chemicals, polymers, and biofuels, however its creation is as yet uncommercialized. Fig. 7 demonstrates the way that HMF can be changed over completely to levulinic acid (LA), γ-valerolactone (GVL), or furan-2,5-dicarboxylic acid (FDCA), a potential

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polyester building block. Hydrocarbon fuel and item chemical antecedents HMF, LA, and GVL are of interest. To switch carb feedstock over completely to hydrocarbon powers, acid catalyzed drying out and catalytic hydrogenation are utilized. Catalytic fluid transforming produces hydrogen. Hydrogenation of 5-ethoxymethylfurfuryl liquor, delivered by an acid-catalyzed HMF-ethanol technique, can be utilized to make a diesel fuel additive from two renewable feedstocks and hydrogen. An interaction that Lange and partners created to deliver valeric powers involved hydrolyzing hexoses to LA, hydrogenating to GVL and valeric acid, and esterifying with ethanol. This was undeniably finished under acid catalysis. Over Ru-on-H-ZSM5104 or Ru/SBA-SO3H bifunctional impetuses, LA can be hydrogenated directly to valeric acid or valerate esters.

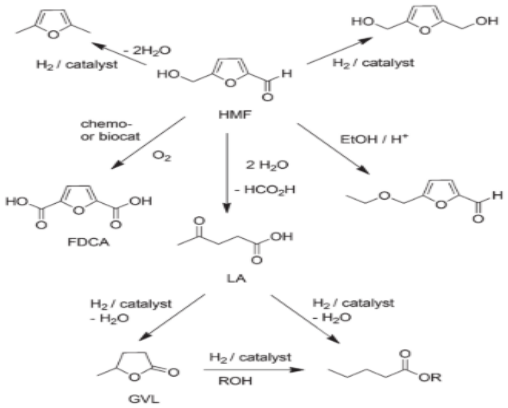


**Figure 3: Catalytic hydroxymethyl furfural conversions to products.**

The acid catalyzed dehydration of hexoses to (HMF) with economically meaningful selectivities is challenging, in any case, because of HMF's acidic reaction propensity. Dumesic and colleagues107 tracked down that acid catalyzed dehydration in a biphasic watery DMSO environment yielded 90% fructose conversions and 80% HMF selectivities, however glucose feedstock yielded lower selectivities. Upstream processing is still an issue, yet ongoing improvements recommend that these dehydrations can be achieved all the more selectively in ionic liquids as reaction media108 with acids or metal chlorides as impetuses. It is possible to switch to a more stable derivative on the spot during acidic HMF synthesis to eliminate byproducts. Chloromethyl furfural (CMF) was converted to glucose, fructose, cellulose, and maize stover in a 70-90% yield by reacting them with fluid HCl at 100 °C. Depending on the temperature, a large amount of either hydrochloric acid (HCl) or levulinic acid (LA) was produced after combining CMF with water. Tragically, the reaction was finished in 1,2-dichloroethane, yet a greener dissolvable might be utilized. HMF can likewise be acid-catalyzed to shape a more steady alkyl ether with a primary liquor. Avantium fostered a technique for acid-catalyzed dehydration of hexoses to HMF ethers using methanol or ethanol.A nanogold-ontitania impetus in methanol can catalyze aerobic oxidation of HMF and HMF methyl ether to the dimethyl ester of furan-2,5-dicarboxylic acid (FDCA) in high yield.

Under acidic circumstances, HMF responds with water to deliver levulinic acid (LA) and eliminate formic acid. LA is a popular platform chemical, and hydrogenation yields GVL. The creation of γ-valerolactone (GVL) with one hundred percent selectivity was demonstrated by Poliakoff and colleagues through the hydrogenation of fluid LA under a ruthenium impulse in supercritical CO2. GVL goes through a carbon dioxide phase and LA a fluid phase. The selective hydrogenation of LA to GVL over a Ru/Sn-on-C impetus was carried out by Dumesic and colleagues. Formic acid, a byproduct of LA derived from HMF, might stand in for the hydrogen. The GVL platform chemical and sustainable liquid fuel are highly recommended. As an example, methyl pentenoate is produced by ring opening with methanol followed by dehydration. This compound is thought to be an antecedent of dimethyl adipate and an intermediary of nylon-6,6. Acids gluconic and glucaric are byproducts of catalytic glucose oxidation. That subsequent one is among the twelve primary renewable building block chemicals listed by the United States Division of Energy. It shows promise as a monomer for novel biodegradable polyamides. Due to its high price and limited supply, glucaric acid is not selling well in the market. Due to the lack of selectivity in glucose oxidation.

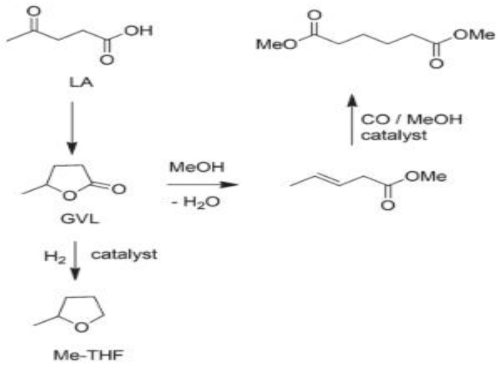


Figure 4: Levulinic acid hydration to γ-valerolactone

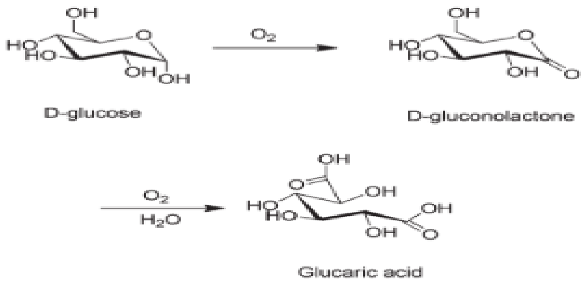


**Figure 5: Glucose oxidation to glucaric acid.**

Rivertop Renewables is bringing glucaric acid to market as a platform chemical and has successfully accomplished selective aerobic oxidation in nitric acid. Glutaric acid can result from fermentation. Jones Prather and colleagues developed a biosynthetic route in recombinant E. coli that synthesizes glucaric acid at low yields by using proteins from three different sources. Isosorbide is one more platform chemical created from sugar that can possibly be an industrial monomer. It is made by hydrogenating sucrose to sorbitol and then dehydrating it with an acid impetus to deliver sorbitan and isosorbide. According to a new paper, cellulose can be immediately changed over into isosorbide using a hydrogenation impetus, ZnCl2 as a Lewis acid impetus, and a liquid salt reaction medium.

## 4. THE METRICS OF SUSTAINABILITY

There are several interesting catalytic methods, including biological and chemical catalyses, enabling sustainable platform commodity chemical manufacture from waste biomass. How can we tell if a procedure is sustainable? Metrics are essential for analyzing the sustainability of future biorefinery technologies for basic chemical synthesis. E factors and particle economies are insufficient to contrast petrochemical and bio-based pathways with commodity chemicals, as we have noticed. In light of lignocellulose's status as renewable biomass, UBIOCHEM, a 2009 Expense Action, seeks to strengthen Europe's scientific and technology investigation to aid in the shift from an economy dependent on fossil fuels to a sustainable bioeconomy. The goal of this action is to create useful indicators for an efficient and quick assessment of interaction sustainability. Cycle costs, land usage, energy efficiency, and materials efficiency were chosen for this. The aforementioned bounds were employed to examine the sustainability of producing eight target commodity compounds using petrochemicals as opposed to biomass.

Methionine, acrylonitrile, isoprene, lactic acid, succinic acid, 1,2-propane diol, and 1,4-butane diol. There will be repercussions from this probe.

Raw petroleum and, less significantly, flammable gas are feedstocks that are highly thought and simple to assemble and move. Collecting and transporting low-density squander biomass is different. This will require rethinking biomass conversion logistics and economies of scale. We could foster mobile refineries that go to the biomass source instead of the reverse way around. Lateral thinking is required.

## 5. CONCLUSION

Sustainable organic chemistry using biomass could reduce fossil fuel use and climate change. Transforming biomass into important commodity chemicals has advanced thanks to Green Chemistry and technology. There are still issues with optimizing operations, lowering prices, and handling biomass collecting and transportation logistics. Biomass-based process sustainability measures are crucial for future research and development. Mobile refineries may help overcome logistical issues and maximize biomass conversion. To fully utilize biomass as a sustainable organic chemistry resource, interdisciplinary collaboration and innovation are essential.

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