BIO-BASED CHEMICALS AS SUSTAINABLE ALTERNATIVES TO PETROCHEMICALS

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Abstract. *The increasing demand for sustainable industrial development has accelerated the transition from fossil-based chemicals to renewable bio-based alternatives. Bio-based chemicals, produced from renewable biomass such as agricultural residues and organic waste, offer significant environmental and economic advantages, including reduced greenhouse gas emissions, lower dependence on non-renewable resources, and support for circular economy principles. Uzbekistan possesses abundant biomass resources generated from its agricultural sector, particularly cotton production, wheat cultivation, fruit processing, and livestock farming. These resources represent valuable feedstocks for producing bioethanol, lactic acid, furfural, pectin, biochar, and biogas.*

Keywords: *bio-based chemicals, biomass, petrochemicals, Uzbekistan, green chemistry, agricultural waste, sustainable development.*

Petrochemicals are fundamental raw materials for manufacturing plastics, solvents, fertilizers, pharmaceuticals, and numerous industrial products. However, their production relies heavily on fossil fuels, resulting in greenhouse gas emissions, environmental pollution, and depletion of finite natural resources. Growing environmental concerns and international climate commitments have encouraged many countries to seek renewable alternatives that minimize ecological impacts.

Bio-based chemicals are produced from renewable biological resources such as agricultural residues, forestry biomass, food-processing waste, and organic municipal waste. Compared with conventional petrochemicals, bio-based products generally exhibit lower carbon footprints and contribute to the development of a circular economy by converting waste into valuable products.

Uzbekistan is well positioned to develop a bio-based chemical industry because agriculture contributes significantly to the national economy. Large quantities of cotton stalks, wheat straw, fruit-processing residues, grape pomace, livestock manure, and other biomass are generated annually. Much of this biomass remains underutilized or is disposed of through open burning, creating environmental problems. Converting these renewable resources into bio-based chemicals represents an attractive strategy for sustainable industrial development.

Biomass Resources in Uzbekistan. Agricultural biomass is the primary renewable resource available in Uzbekistan. Cotton remains one of the country's most important agricultural crops, producing considerable quantities of cotton stalks and cotton gin waste after harvest. Wheat cultivation also generates large amounts of straw, while extensive fruit production creates substantial volumes of processing residues.

These biomass resources are rich in cellulose, hemicellulose, lignin, starch, and organic compounds that can serve as feedstocks for various chemical products.

Table 1. Major biomass resources and potential bio-based chemicals in Uzbekistan

Biomass resource	Main components	Potential products
Cotton stalks	Cellulose, hemicellulose	Bioethanol, furfural, biochar
Wheat straw	Cellulose, lignin	Bioethanol, xylitol
Fruit processing waste	Sugars, pectin	Pectin, citric acid, ethanol
Grape pomace	Polyphenols, cellulose	Bioethanol, antioxidants
Livestock manure	Organic matter	Biogas, organic fertilizer
Rice husks	Silica, lignin	Biochar, silica materials

The utilization of these renewable feedstocks can reduce agricultural waste while creating value-added chemical products for domestic industries and export markets.

Among various bio-based chemicals, bioethanol is one of the most promising products for Uzbekistan. Agricultural residues such as cotton stalks and wheat straw contain abundant lignocellulosic material that can be converted into fermentable sugars through pretreatment and enzymatic hydrolysis. The resulting ethanol can be used as a renewable fuel, industrial solvent, or raw material for chemical synthesis.

Another important product is furfural, which is produced from hemicellulose-rich agricultural residues. Cotton stalks represent an excellent feedstock due to their high pentosan content. Furfural is widely used in resin production, petroleum refining, pharmaceuticals, and polymer manufacturing.

Lactic acid is another valuable bio-based chemical produced through microbial fermentation of carbohydrate-rich biomass. It serves as the primary precursor for polylactic acid (PLA), a biodegradable polymer increasingly replacing conventional petroleum-based plastics in packaging and medical applications.

Uzbekistan's fruit-processing industry also generates considerable quantities of apple, apricot, and grape residues. These by-products contain pectin, natural antioxidants, and fermentable sugars suitable for producing food additives, pharmaceuticals, and cosmetic ingredients.

Conclusion. Bio-based chemicals represent a sustainable alternative to conventional petrochemical products and offer considerable environmental, economic, and social benefits. Uzbekistan possesses abundant agricultural biomass resources that remain largely

underutilized despite their significant industrial potential. Cotton residues, wheat straw, fruit-processing waste, and livestock manure can serve as renewable feedstocks for producing bioethanol, furfural, lactic acid, pectin, biochar, and biogas. Developing a national bio-based chemical industry would reduce dependence on fossil resources, improve agricultural waste management, decrease greenhouse gas emissions, and create new economic opportunities in rural regions. Although technological and financial challenges remain, coordinated efforts involving government, industry, and academic institutions can facilitate the transition toward a sustainable circular bioeconomy. Investment in modern biorefinery technologies and continued scientific innovation will be essential for realizing Uzbekistan's potential in green chemical manufacturing.

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