CHAPTER 1

Introduction to Biomass Conversion

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1.1 LIGNOCELLULOSIC BIOMASS: A PROMISING AND SUSTAINABLE RESOURCE

Biomass refers to any organic material derived from living materials that contains chemical energy which is converted from solar energy obtained from the sun (Turgeon & Morse, 2022). Lignocellulosic biomass emerges as a highly promising and viable alternative energy source, poised to address the pressing challenges associated with energy and material production security. In this context, biomass plays a significant role in advancing the attainment of sustainable development objectives (Triwahyuni et al., 2015).

Over recent decades, researchers have diligently explored an array of methodologies aimed at harnessing biomass and its attendant derivatives. Similar to fossil fuels, these compounds release their stored energy to the environment when they are burned (Shi et al., 2019). Since biomass is easily acquired, it has been considered as one of the most promising sources of renewable energy (Ma et al., 2018). Apart from biofuel, biomass can also be converted into higher value-added products including biochemicals and biomaterials.

1.1.1 Global Biomass Trends

Annually, about 200 billion tons of lignocellulosic biomass waste are produced around the world (Ahmed et al., 2020), primarily encompassing agricultural and forestry waste, residues from horticulture, and economically significant crops (Ufodike et al., 2020). However, only 4.52% of the biomass are utilized; in which 7 billion tons are from agriculture, grass, and forest, whereas another 1.2 billion tons came from agriculture waste (Dahmen et al., 2019). As of 2021, some of general trends in global biomass production includes forest, agricultural, bioenergy and aquatic biomass.

For agricultural crops, only 3% are contributed to the energy production, whereas another 23% are served as food for human and the rest is to feed animals (Mr. Sustainability, 2020). As depicted in Figure 1.1, China holds a prominent position in the field of agriculture, resulting in the largest accumulation of agricultural waste on a global scale. This is exemplified by the yearly abandonment of over 900 million tons of straw, including rice straw, wheat straw, and corn stover (Ma et al., 2020). Similarly, in the United States, a staggering 150 million tons of corn stover is produced due to its leading corn cultivation, alongside an annual residue of 65 million tons of wheat straw (Ndayisenga et al., 2021). India, being a major hub for cereal production, contributes significantly with an annual yield of agricultural residues amounting to 605 million tons (Tripathi et al., 2019).

Beyond agricultural waste, forestry residue makes a significant contribution to the pool of lignocellulosic biomass. Forests play a significant role in global biomass production as store carbon and provide resources for various industries, including timber and pulp and paper. However, deforestation and land-use changes can impact the overall forest biomass. For instance, in Russia, the yearly generation of lignocellulosic waste from wood surpasses 287.5 million tons (Tripathi et al., 2019). Economic crops also play a notable role in the lignocellulosic landscape. Countries like Indonesia, Brazil, and the Mediterranean region hold substantial lignocellulose production capacities, with annual yields ranging from 9.6 to 530 million tons for each country. These regions cultivate a significant quantity of essential economic resources such as cocoa pods, sugar cane, and olives, contributing to the abundance of lignocellulosic feedstock (Tayeh et al., 2020; Nurika, 2019).

Bioenergy crops on the other hand are cultivated with minimal resource inputs to yield lignocellulosic biomass, offering a sustainable reservoir of renewable energy. The genetic enhancement of bioenergy crops could entail heightened biomass production, increased resistance to stressors like pathogens and drought, and the generation of cell wall constituents possessing reduced resistance to deconstruction processes (Lin & Eudes, 2020). Other than that, algae and aquatic plants are potential sources of biomass for various purposes, including food, feed, and biofuels. The global biomass production is summarized in Figure 1.1.