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Conversion of Biomass to Useful Material

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Biomass conversion processes and equipment to produce bio-fuels, power, and chemicals from biomass are now becoming very important. These processes are called as “biorefinery”. The biorefinery concept is analogous to today's petroleum refineries, which produce multiple fuels and chemical products from petroleum. Industrial biorefineries have been identified as the most promising route to the creation of a new biobased industry.

By producing not only fuels but also chemicals, a biorefinery can take advantage of the differences in biomass components and intermediates and maximize the value derived from the biomass feedstock. A biorefinery may produce one or several low-volume, but valuable, chemical products and a low-value, but high-volume liquid transportation fuel. The high- value products enhance profitability, the high-volume fuel helps meet national energy needs, and the power production reduces costs and avoids greenhouse-gas emissions.

Figure 1 shows an overview of our present projects. In our project, one of final products are carbon fiber reinforced plastic (CFRP). In the figure two routs are showing. One route is converting cellulose or starch into sugars. Then the sugars are converted into building blocks, such as 2.5-furandicarboxyric acids. From these chemical building blocks, thermosetting and thermoplastic resins are produced.

Another route is a producing the bio-based resin directly from biopolymers. Because of there was no good solvent that can be dissolve biomass or cellulose and lignin, there are only limited studies were carried out. In 2002, Rogers and co-workers reported that ionic liquids (ILs), a kind of solvents comprising of cations and anions as components, had a unique potential to dissolve cellulose under mild conditions. Triggered by this report, other biomaterials including lignin and even a raw biomass itself have been discovered to be dissolved in ILs under mild conditions. Because the above-noted biomasses were scarcely soluble in any solvents including both organic and aqueous solutions, these basic studies re-triggered a chemical treatment of biomass, which had been suppressed for long years.

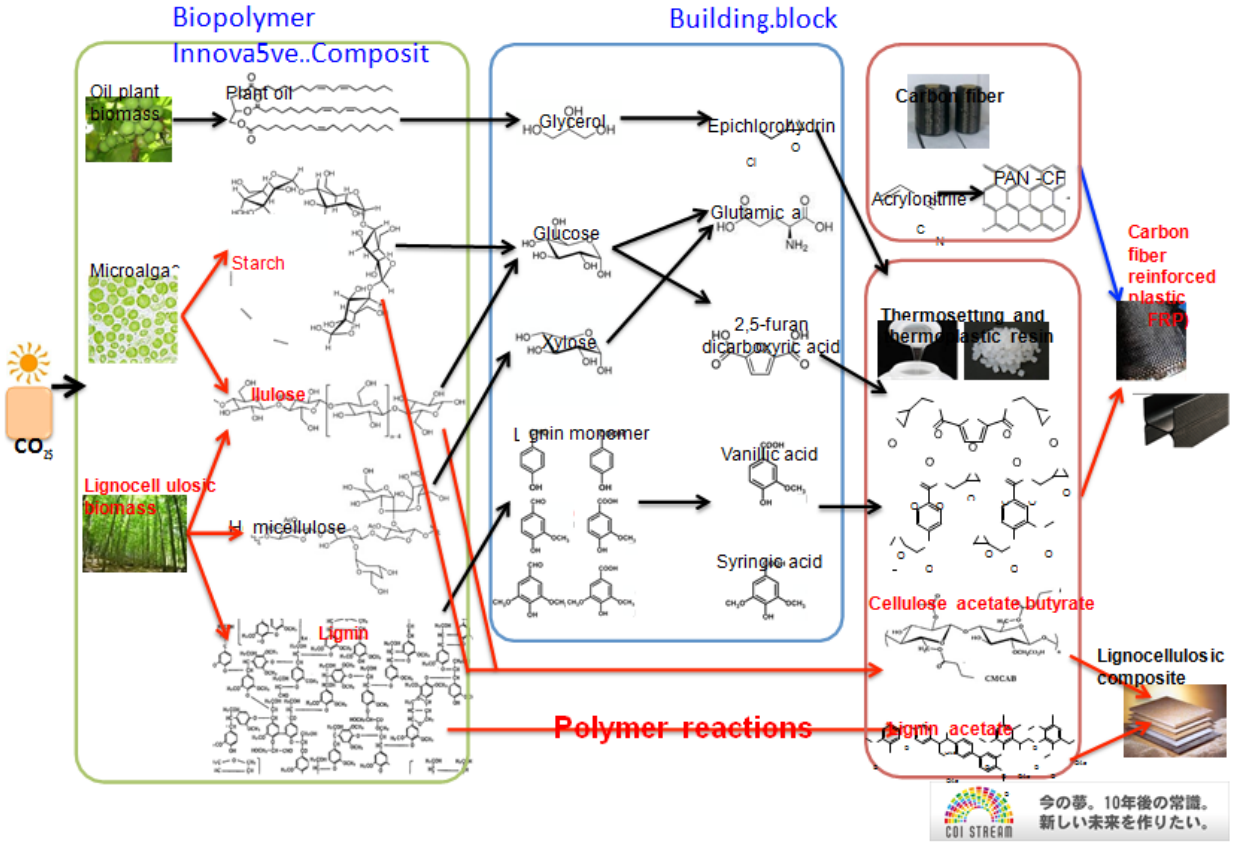

Figure 1. An overview of biorefinery project in Kanazawa University, Japan.

The ligunocellulosic biomass is made from mainly three components, namely the cellulose, the hemicellulose, and the lignin with highly sophisticated architectures (Scheme 1). Usually, utilization of biomass has been depending on the depolymerization processes of either lignin or polysaccharides. Hence, reported study of biomass application were economically and thermodynamically disadvantageous. Hence, an ideal case in application of biomass is expected to be a direct separation of the lignin and the polysaccharide segments keeping their polymeric characters because such polymeric materials can be employed for a lot of industrial applications. However, it is extremely difficult to separate directly each components in biomass structure because the lignocellulose structure showed in Scheme 1 is very complex.

Herein, now a new biomass application, essentially realizing a direct chemical derivatization and subsequent fractionation of the polysaccharide and lignin of the lignocelluloses are proposed. Our attention was turned to the common feature of lignocelluloses. To be precise, the hydroxyl group is well-known to exist in any components of biomass and thus targeted as the ubiquitous reaction point. In specific cases, organic transformation reactions in ILs were revealed to undergo with ILs as both a solvent and organo-catalyst[1]. In this presentation, 1) a direct chemical reaction of raw biomass in ILs with ILs as a organo-catalyst to afford polysaccharides and lignin derivatives without the aid of metals and strong acids and 2) subsequent separation of polysaccharides and lignin derivatives with taking advantage of differences in their solubility are described (Figure 2).

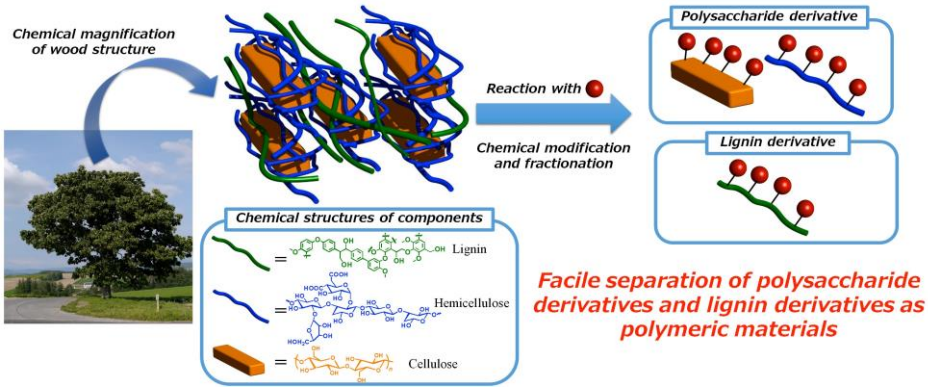

Figure 2. Schematic representation of this work.

REFERENCES

[1] Efficient and rapid direct transesterification reactions of cellulose with isopropenyl acetate in ionic liquids, RSC Adv., 2015, 5, 72071-72074