RECENT RESEARCH ACTIVITIES

Determination of the cross-linking structure of lignocellulose, and evaluation of anti-viral active substances through biomass convert reaction

(Laboratory of Biomass Conversion, RISH, Kyoto University)

Hiroshi Nishimura, Chihiro Kimura, Ruibo Li, and Takashi Watanabe

Promoting the utilization of plant biomass for a sustainable society is an urgent task. Plant biomass is the most abundant organic resource on earth. The secondary plant cell wall is mainly composed of cellulose, hemicellulose, and lignin. Hemicellulose surrounds cellulose microfibrils and is filled with lignin. Each component is properly packed, and there are covalent linkages between the lignin and hemicellulose. However, direct evidence of those linkages has been under the question for many years. We have established a highly efficient separation/extraction method for the lignin-carbohydrate complex (LCC) and succeeded in the first direct proof of lignin-polysaccharide linkages by using the multi-dimensional NMR spectroscopy (Figure 1). 2D-NMR, such as ^{1}H-^{13}C HSQC, HMBC, and 3D TOCSY-HSQC, clearly demonstrated the covalent bond between glucomannan and lignin and elucidated the entire cross-linked structural unit. [1]

We have been researching to obtain bioactive substances from lignocellulosic biomass. By conducting an artificial conversion reaction of lignocellulose and fractionating, we have found the anti-viral active ingredient. Catechol, 3-methyl-, 4-methyl-, 4-ethyl-, and 3-methoxycatechol, and 2-methyl-1,4-benzenediol were identified as the main anti-viral compounds from pyroligneous acid of pine and clarified structure-activity correlations. [2]

Twenty-five phenolic derivatives were identified from pyroligneous acid of hardwood, softwood, and bamboo and evaluated as anti-viral active ingredients. [3]

Recently, we have found a lignin-derived anti-viral substance from sugarcane bagasse by microwave heating at 200 ℃ in aqueous glycerol containing 0.5 % H_2SO_4. It has no cytotoxicity and showed potent inhibition towards encephalomyocarditis virus (EMCV) replication as a result of cell experiments. [4]

These results will contribute to protecting infections and human health care in our globalized society, Sustainable Humanosphere.

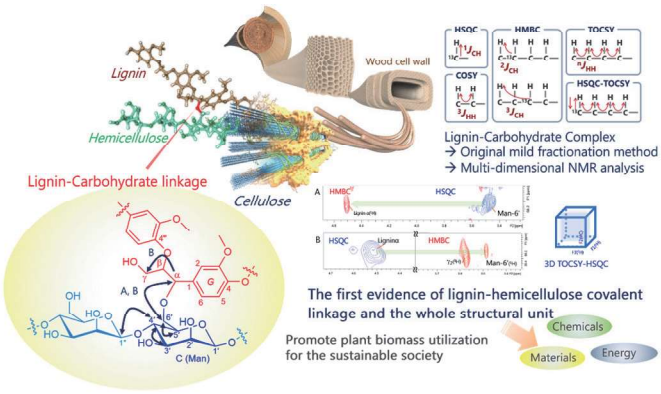

Figure 1.

Chemical structure of the lignin-carbohydrate linkage and typical NMR correlation spectra and future prospects [1]

References

[1] Nishimura, H., Kamiya, A., Nagata, T., Katahira, M., Watanabe, T. "Direct evidence for α ether linkage between lignin and carbohydrates in wood cell walls" *Sci.Rep.* 8:6538, 2018.

[2] Li, R., Narita, R., Ouda, R., Kimura, C., Nishimura, H., Yatagai, M., Fujita, T., Watanabe, T. "Structure-dependent anti-viral activity of catechol derivatives in pyroligneous acid against the encephalomycarditis virus" *RSC Adv.* 8:35888-35896, 2018.

[3] Li, R., Narita, R., Nishimura, H., Marumoto, S., Yamamoto S., Ouda, R., Yatagai, M., Fujita, T., Watanabe, T. "Anti-viral Activity of Phenolic Derivatives in Pyroligneous Acid from Hardwood, Softwood, and Bamboo" *ACS Sustain Chem Eng.*. 6:119-126, 2018.

[4] Kimura, C., Li, R., Ouda, R., Nishimura, H., Fujita, T., Watanabe, T. "Production of Antiviral Substance From Sugarcane Bagasse by Chemical Alteration of Its Native Lignin Structure Through Microwave Solvolysis" *ChemSusChem*, doi: 10.1002/cssc.202000490., 2020.