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Editorial

Analysis of Biomass, Today and Tomorrow

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Editorial

Lignocellulosic biomass has been introduced as a promising resource for alternative fuels and chemicals. It is the most abundant renewable resource and does not compete with food sources; therefore, it is considered to be a competitive feedstock. Biomass has different compositions and physicochemical characteristics depending on its species (hardwood, softwood, agricultural residues, and energy crops) and environments. It is a complex biopolymer composed of cellulose, hemicelluloses, and lignin, with minor constituents such as protein, ash, and other extractives. Due to its variety and complexity, it is difficult to utilize and characterize the biomass as it is.

For better understanding and efficient utilization of biomass, various analysis methods have been developed. Biomass analysis can be generally categorized to two approaches: non-degradative and degradative methods. Non-destructive analysis such as Ultraviolet (UV) spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, and Nuclear Magnetic Resonance (NMR) enables to reveal compositional and structural information of biomass with minimal structural modification and relatively shorter time, but are limited and/or time consuming in providing qualitative and/or semi-quantitative analyses.

Degradative analysis such as wet chemical analysis with Liquid Chromatography (LC), pyrolysis with Gas Chromatography (GC), and Gel Permeation Chromatography (GPC), is the other type of biomass analysis. Chromatographic methods are powerful technologies for separation, identification, and quantitation of samples; thus, they have been widely utilized in many degradative biomass characterizations. Wet chemical compositional analysis developed in paper and pulping industry is among the most popular biomass compositional analyses. This analysis does not only quantify sugars derived from cellulose and hemicellulose, but also measure lignin content (Klason lignin) through a two-step sulfuric acid hydrolysis. Hydrolyzed monosaccharides from biomass are separated and quantified using High Performance Liquid Chromatography (HPLC). Choices of column types and detectors are determined according to the isolation procedure and sample conditions. Gas chromatography is another analysis technology for biomass characterization. However, this method still needs prior steps including decomposition of cell walls, derivatization of carbohydrates and aromatic compounds, particle size reduction, and/or removal of metal contents in the biomass. Gas chromatography can be combined with mass spectrometry and pyrolysis (i.e., PyGCMS) to analyze lignin content and syringyl to guaiacyl (S/G) ratios, but the analysis is limited to lignin characterization.

Gel Permeation Chromatography (GPC) is another chromatographic method that measures the molecular weights and degree of polymerization of cellulose, hemicellulose, and lignin. Cellulose and hemicellulose are isolated through holopulping with peracetic acid followed by sodium hydroxide extraction. The isolated cellulose is derivatized by tricarbanilation and analyzed by GPC to estimate the cellulose molecular weights and degree of polymerization. Molecular weights of hemicellulose can be obtained through a similar process, but without derivatization step. For lignin molecular weight analysis, diverse methods using vapor pressure osmometry, ultra-filtration, light scattering, mass spectroscopy, and GPC are developed. So far, GPC stands out among these methods because of its broad detection range, availability of small quantity sample analysis, and relatively short processing time. Even though degradative methods require many pre-steps like sample preparation,

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isolation, and derivatization, these chromatographic technologies are powerful for quantitative analysis compared to the non-degradative methods.

Current challenges for chromatographic analysis for biomass characterization occur primarily in the pre-analysis steps for deconstruction and/or isolation of constituents from cell walls. Efforts have been made to minimize/avoid undesirable changes and/or decomposition of biomass compositions and linkages that occur during the deconstruction and isolation. In addition, multi-pre-analysis steps need longer time and more labor intensive. Recently, high-throughput biomass composition analysis methods were developed using Near Infrared (NIR) spectroscopy and Partial Least Squares (PLS) multivariate analysis. However, this method still needs calibration model by wet chemical composition analysis. Pyrolysis Molecular Beam Mass Spectroscopy (pyMBMS) is also designed for high-throughput biomass screeningforlignin contents and S/G ratio, but it has limitation for carbohydrates analysis. Moreover, additional variation from instrumental drift caused by clogged orifice or fouled mass spectrometer quadruple rods with pyrolysis products needs to be addressed.

While some methods using NMR and NIR were already developed for whole cell wall biomass, there is no whole cell wall biomass analysis using chromatography. Chromatography is a common but powerful identification and quantification tool, thus chromatography analysis with whole cell wall biomass could be a potential solution for the existing barriers in biomass analysis. For instance, whole cell wall biomass analysis using Ionic Liquids (ILs)-HPLC could possibly reduce pre-steps for chromatographic analysis, since ILs can dissolve whole cell wall biomass under mild conditions. Although efforts to find and develop proper column resins, detectors, and pre-dissolution conditions are still being made, this consolidated chromatographic method has great potentials for enhancing biomass analysis in both high throughput and quality. Development of chromatography will be one of the keys for future biomass characterization and also for biomass utilization in the wide-view.

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