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The Composition of Biooil during Biomass Pyrolysis at Various Temperatures

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Abstract : Extraction of the energy content of lignocellulosic biomass is one of the possible pathways to reduce the greenhouse gas emission derived from the burning of the fossil fuels. The application of the bioenergy can mitigate the energy dependency of a country from the foreign natural gas and the petroleum. The diversity of the plant materials makes difficult the utilization of the raw biomass in power plants. This problem can be overcome by the application of thermochemical techniques. Pyrolysis is the thermal decomposition of the raw materials under inert atmosphere at high temperatures, which produces pyrolysis gas, biooil and charcoal. The energy content of these products can be exploited by further utilization. The differences in the chemical and physical properties of the raw biomass materials can be reduced by the use of torrefaction. Torrefaction is a promising mild thermal pretreatment method performed at temperatures between 200 and 300 °C in an inert atmosphere. The goal of the pretreatment from a chemical point of view is the removal of water and the acidic groups of hemicelluloses or the whole hemicellulose fraction with minor degradation of cellulose and lignin in the biomass. Thus, the stability of biomass against biodegradation increases, while its energy density increases. The volume of the raw materials decreases so the expenses of the transportation and the storage are reduced as well. Biooil is the major product during pyrolysis and an important by-product during torrefaction of biomass. The composition of biooil mostly depends on the quality of the raw materials and the applied temperature. In this work, thermoanalytical techniques have been used to study the qualitative and quantitative composition of the pyrolysis and torrefaction oils of a woody (black locust) and two herbaceous samples (rape straw and wheat straw). The biooil contains C5 and C6 anhydrosugar molecules, as well as aromatic compounds originating from hemicellulose, cellulose, and lignin, respectively. In this study, special emphasis was placed on the formation of the lignin monomeric products. The structure of the lignin fraction is different in the wood and in the herbaceous plants. According to the thermoanalytical studies the decomposition of lignin starts above 200 °C and ends at about 500 °C. The lignin monomers are present among the components of the torrefaction oil even at relatively low temperatures. We established that the concentration and the composition of the lignin products vary significantly with the applied temperature indicating that different decomposition mechanisms dominate at low and high temperatures. The evolutions of decomposition products as well as the thermal stability of the samples were measured by thermogravimetry/mass spectrometry (TG/MS). The differences in the structure of the lignin products of woody and herbaceous samples were characterized by the method of pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS). As a statistical method, principal component analysis (PCA) has been used to find correlation between the composition of lignin products of the biooil and the applied temperatures.

Keywords : pyrolysis, torrefaction, biooil, lignin
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