Pyrolysis Characteristics of Thai-agricultural Residues of Rice Straw, Rice Husk, and Corncob by TG-MS Technique and Kinetic Analysis

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The pyrolysis behaviors of several Thai agricultural residues have been investigated by using thermogravimetric analysis paying an attention to the pyrolysis pathway of their own cellulose in the biomass. The evolving rates of the gaseous products during the pyrolysis such as H_2, CH_4, H_2O, CO and CO_2 were also measured by the TG-MS techniques. The weight decreasing profiles and the gas formation rates were significantly different among the samples although their elemental compositions were almost the same. It was found that H_2O is the main product formed for all the samples. The differences in the gas formation rates were found to be due to their differences in the composition of hemicellulose, cellulose, and lignin. There were significant interactions between cellulose and lignin during the pyrolysis. The interactions between cellulose and lignin during the pyrolysis contributed to a decrease in tar yields but an increase in char yields. As for the kinetic analysis, without any assumption and mathematical fitting, we could obtain the very proper kinetic parameters (the distribution curve of activation energy, $f(E)$, and the activation energy dependent frequency factor, $k_0(E)$), of biomass pyrolysis by utilizing the distributed activation energy model (DAEM) proposed by Miura *et al.* (K. Miura and T. Maki, Energy Fuels 1998;12:864). The peaks of $f(E)$ curve for rice straw, rice husk, corncob and cellulose were found to be 170 kJ/mol, 174 kJ/mol, 183 kJ/mol, and 185 kJ/mol, respectively. The k_0 value increased from an order of 10^{13} to an order of 10^{18} s^{-1}, while E increased from 150 to 250 kJ/mol. The variation of $f(E)$ curve among different biomass was probably due to the differences in chemical and physical structures of the biomass. The interactions among hemicellulose, cellulose, lignin and minerals during the pyrolysis influenced the pyrolysis pathway of their own cellulose accompanying with decreasing the activation energy. It was found that the kinetic parameters obtained can predict not only global devolatilization of biomass pyrolysis but also can predict the pyrolysis pathway of cellulose in the target biomass.

Key words

Pyrolysis, Biomass, Kinetic, TG-MS