Characterization and prediction of tar formation from fast pyrolysis of lignin

Anna Trubetskaya[1*], Kentaro Umeki[2]

[1]*Department of Applied Physics and Electronics, Umeå University, 90187 Umeå, Sweden*

[2]*Division of Energy Science, Luleå University of Technology, 97187 Luleå, Sweden*

[*]*anna.trubetskaya@umu.se*

Abstract

Lignocellulosic materials are abundant, and have the potential to replace fossil fuels in the production of liquid hydrocarbons for the transportation sector [1]. Entrained flow gasification (EFG) is a promising technology, which generates high quality syngas with little or no tar due to the high operating temperatures. At high temperatures and long residence times, tar cracking reactions affect significantly the yields and composition of products. At temperatures below 1000°C, secondary reactions of volatiles produce mainly tars and small amounts of soot. A number of studies on gaseous and liquid fuel combustion have revealed that polycyclic aromatic hydrocarbons (PAHs) are precursors of soot [2-4]. In order to reduce the yield of soot during gasification, it is necessary to understand how primary tar properties are correlated with fuel composition and operating conditions since soot is formed as a result of the reactions between PAHs.

The aim of this work is to obtain knowledge about lignin type (softwood and wheat straw), holocelluloses and potassium influence on the tar and soot yields during high-temperature fast pyrolysis, relate the conversion and product distribution of tar compounds to the soot yields at three different residence times in the temperature range of 800-1250°C, and to group tar species in lumps in order to make gasification models relevant to the industrial-scale while maintaining a minimum number of tar species. Fast pyrolysis experiments on holocelluloses and two types of organosolv lignin (softwood and wheat straw) were carried out in a drop tube furnace. The quantitative and qualitative analysis of tars was performed using GC-FID and GC-MS systems.

The present results indicated that the soot and tar yields from pyrolysis of potassium impregnated lignin at 1250°C were significantly lower than that of non-treated lignin samples indicating the catalytic influence of potassium. Tar composition and yield remained only slightly changed with the increasing particle residence time. No tars were detected at 1250°C during pyrolysis of holocelluloses and lignin. The tar composition of both lignin samples was similar. The total yield of tar was simplified by lumping the different compounds into groups represented by catechol, acetol, toluene, benzene and naphtalene to predict the volatile yields in both gas phase and over char surfaces. The catalytic effect of potassium on the product yields was related to the concentration of catechol which is higher in the wheat straw compared to wood samples. The conversion and product distribution of tar compounds were related to the yield and morphology of soot particles. In this study, the kinetic model was validated against the own experimental results. Results showed that the proposed kinetic

model for the fast biomass pyrolysis and gas phase reactions is relatively simple and predicts the tar and soot yields from pyrolysis of holocelluloses and lignin reasonably accurately.

References

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