MODELLING OF THE MASS LOSS AND THE GAS RELEASE DURING TORREFACTION OF WOODY BIOMASS AND ITS CONSTITUENTS

T. NOCQUET[1*], C. DUPONT[1], J.M. COMMANDRE[2], M. GRATEAU[1], M.H.NGUYEN[1], S. SALVADOR[2]
[1]CEA Grenoble - LITEN/DTBH/LTB, 17 rue des Martyrs, 38054 Grenoble Cedex 9, France
[2]CIRAD, 73 avenue Jean-François Breton ; 34398 Montpellier Cedex 5, France
[2]MINES ALBI, RAPSODEE, FRE CNRS 3213, France
*Corresponding author: timotee.nocquet@cea.fr, 33-(0)4 38 78 54 69

In the present energy context, there is a growing interest for the development of entrained-flow processes that produce synthesis gas (H_2 and CO) from biomass gasification. However, a major technical barrier in this process is the size reduction to 100-300 μm and the subsequent transport of the biomass powder into the gasifier, which are difficult with raw biomass due to the fibrous structure of the material. Thus, torrefaction, which enables the partial destruction of the fibrous structure of the biomass through a mild thermal treatment (typically around 280°C during a few tens of minutes in an atmosphere in default of oxygen), appears as an attractive option. The industrialisation of this process requires a better knowledge of the gases and condensibles released versus operating conditions and biomass feedstock, since these products can be damaging for the units. This work aims therefore at modelling woody biomass torrefaction.

Up to now, only very few experimental studies deal with this. Moreover, the mechanisms of the reaction are still poorly understood and the models are only focused on solid mass loss. None tries to describe the kinetics of formation of the gas species released by torrefaction.

Models adapted from biomass pyrolysis may be used for this. All are based on the addition of the kinetics of degradation of each component of the biomass (cellulose, hemicellulose and lignin). This assumption has been discussed under pyrolysis conditions because of possible interactions between biomass constituents but it has never been checked under torrefaction conditions.

For this reason, an experimental study has been performed on beechwood (several milligrams samples) in a TGA device to determine the mass loss kinetics under fixed operating conditions: temperature between 250°C and 300°C, and N_2 atmosphere. The results are compared with those obtained with cellulose, hemicellulose and lignin extracted from the same beechwood sample. Then, experiments have also been launched on beechwood and its extracted components in a laboratory scale device connected with a gas analyser (FTIR) to quantify (in function of time) the gas species produced for different conditions of torrefaction. The mass balance is closed. The results of these experiments have been used to build a kinetic model able to predict the mass loss and the gas composition during torrefaction.

In a further work, experiments with other biomass feedstock will be launched to extend the validity domain of the model.