

# Calculation of Thermochemical Kinetic Parameters of Several Types of Biomass Using Friedman Isoconversional method

Soyoung Han<sup>1\*</sup>, Yeon-Seok Choi<sup>1</sup>, Sang-Kyu Choi<sup>1</sup>, Yeon-Woo Jeong

1: Korea Institute of Machinery and Materials, 156 Gajeongbuk-Ro Yuseong-gu Daejeon, Korea

\*corresponding author: syhan@kimm.re.kr

**Keywords:** thermochemical kinetics, Biomass pyrolysis, isoconversional method

## INTRODUCTION

Generally, pyrolysis produces liquid biomaterials containing high-density energy from biomass under appropriate temperature, temperature heating rate, and pressure conditions. The biofuel obtained through appropriate following treatment processes or as gaseous fuel can be used in combustion engines and gas turbines. The biomass pyrolysis is a complex reaction that is influenced by many factors such as type and size of biomass material, reaction temperature, heating rate, pressure, residence time, and moisture content. However, an appropriate pyrolysis model is needed to better understand the optimization of pyrolysis production and power generation facilities and the operation of an engine using pyrolysis products as fuel. In line with this, numerous studies have applied the most commonly used technology, thermogravimetric analysis to elucidate the pyrolysis dynamic process. In this paper, after going through the overall data process with the mass change data through the thermal decomposition of the sample through the TGA for several different types of waste biomass, the effective kinetic parameter of the pyrolysis reaction, derived using the Friedman differential isoconversional method, was determined for the waste biomass after available data processing was employed.

## MATERIALS AND METHODS

### Materials for TGA

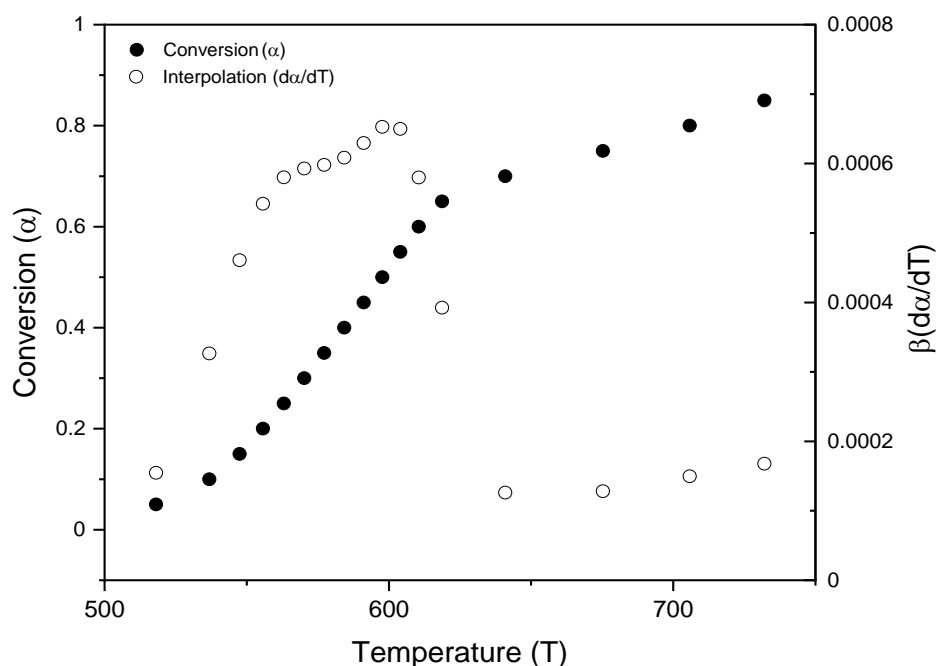
In this study, several waste biomass samples such as corn stalk, corn stem, Napier grass, Narra, rice straw, sugarcane, and tobacco leaf were collected from Vigan City, Ilocos Sur in Southeast Asia and dried in a dryer at 105°C (AJEON, ATT 1000, Korea) for about a day.

### Methods for kinetic analysis

In this study, biomass pyrolysis experiments were performed in a thermogravimetric analyzer (Shimadzu, DTG-60AH), which could measure the mass loss of a sample with time and temperature during a continuous heating process.

## RESULTS AND DISCUSSION

In the case of seven types of biomass from Philippine in Southeast Asia, the Friedman model used after several stages of data processing was applied to calculate the effective activation energy value from TGA data. The activation energy of the cornstalk was 138.62-227.60 kJ/mol, the corn stem 72.02-205.44 kJ/mol, the Napier grass 77.77-149.35 kJ/mol, the Narra 77.76-167.72 kJ/mol, the rice straw 99.95-206.10 kJ/mol, the sugarcane 66.82-173.60 kJ/mol, and the tobacco leaf 75.08-243.10 kJ/mol at each conversion rate.



**Figure 1** Temperature ( $T_\alpha$ ) and derivative conversion  $(d\alpha/dT)_\alpha$  at various conversion rate of 0.05-0.85 obtained from cubic spline interpolation (corn stem pyrolysis at  $5 \text{ K min}^{-1}$ )

## CONCLUSION

In this study, processing data of biomass thermogravimetric analysis can help the estimation of kinetic parameters by reducing the error caused by the differential values of the reaction conversion rate at each operating temperature. In the case of the Kissinger model, the calculation method was simple and the activation energy value could be obtained in a short time, but the activation energy value was found to be low in the case of different pyrolysis characteristics as influenced by temperature. Since the Friedman model was able to obtain the activation energy value at each conversion rate change, it was suitable for biomass kinetic analysis.

## REFERENCES

- Friedman, H.L. Kinetics of thermal degradation of char-forming plastics from thermogravimetry. Application to a phenolic plastic. *J. Polym. Sci. Part C Polym. Symp.* 6, 183–195, 2007.
- Flynn, J.H.; Wall, L.A. General treatment of the thermogravimetry of polymers. *J. Res. Natl. Bur. Stand. Sect. A Phys. Chem.* 70A, 487–523, 1996.
- Vyazovkin, S. Modification of the Integral Isoconversional Method to Account for Variation in the Activation Energy. *J. Comput. Chem.* 22, 178–183, 2001.