

Abstract

Thermo-gravimetric analysis was carried out on a vitrinite-rich coal (VC), highveld grass (HG) and pine wood (PW) chars, and coal-biomass char blends of each. The analysis was carried out on combustion and gasification tests using air and CO₂ respectively. The blends were modeled by the application of a distributed activation energy (DAE) based model. The DAE based model is a modification of an algorithm developed by Scott et al. for the pyrolysis of complex fuels obeying linear kinetics (Scott et al., 2006). The modified DAE model was able to derive the activation energy, E , the grouped pre-exponential factor, A , and the number of reactions occurring in the thermal conversion process. Furthermore, the mass fraction associated with each unique reaction was obtained. The ability to determine multiple reactions distinguishes the DAE based model as a unique and robust method for kinetics determination.

The first order and the random pore reaction models (RPM) were applied to describe the reaction profiles. The conversion of all the coal and biomass blends were successfully modeled using the RPM to high accuracy. During combustion, E 's and A 's in the range of 180-255kJ/mol and $5.34E+8$ to $2.80E+15$ s⁻¹m⁻¹ were determined for the PW char. E 's and A 's in the range of 125-138kJ/mol and $5.38E+4$ to $3.94E+5$ s⁻¹m⁻¹ were determined for the rest of the chars and blends during combustion. For gasification, E 's and A 's in the range of 222 -304kJ/mol and $5.36E+5$ to $3.96E+9$ s⁻¹m⁻¹ were determined for all the chars and blends. The structural parameters (φ) obtained lie in the range of 8.3 to 18.9. The φ determined during combustion were sufficient for modeling the same material during gasification. Multiple reactions were identified for most of the chars during both gasification and combustion.

Kinetic analysis showed that PW char was the most reactive char, followed by the HG and VC chars respectively. For the 50:50 heat input ratio coal-biomass blends during combustion, synergetic behavior and a decrease in E was observed.