List of Abbreviations

ANSI	American National Standards Institute	RT	Retention time
ANOVA	Analysis of variance	RSM	Response surface methodology
ASTM	American Society for testing and materials	SEM	Scanning electron microscope
AC	Ash content (wt %)	SGF	Sweeping gas flow rate
BBD	Box-Behnken design	TGA	Thermogravimetric analysis
BD	Bulk density	HR	Heating rate
BL	Biomass loading	V_p	Volume of biomass (m^3)
BET	Brunauer–Emmett–Teller	V_c	Sample cell volume (m^3)
C	Cohesion coefficient	V_R	Reference volume (m^3)
CCD	Central composite design	V_L	Volume of measuring cylinder (m^3)
CCI	Carr compressibility index	VCT	Vapour cooling temperature
CI	Combustibility index (MJ/kg)	T	Temperature
CrI	Crystallinity index (%)	TAN	Torrefied *Acacia nilotica*
CHNS	Carbon Hydrogen Nitrogen Sulphur	TANX-Y-Z	Torrefied biomass at optimum condition
Db	Dry basis	X	Optimum temperature
d_{gm}	Geometric mean diameter (mm)	Y	Optimum retention time
DAN	Dry *Acacia nilotica*	Z	Optimum heating rate
DTG	Differential thermogravimetry	XRD	X-Ray diffraction (XRD)
d_i	Aperture diagonal of i^{th} screen	ρ_b	Bulk density (kg/m^3)
d_{i-1}	Aperture diagonal of next larger screen	ρ_{Tb}	Tapped density (kg/m^3)
EY	Energy yield (%)	ρ_p	Particle density (kg/m^3)
EDX	Energy dispersive X-ray (EDX)	k	Scherrer constant (0.90)
FC	Fixed carbon (Wt %)	λ	X-ray wavelength (0.15406 nm)
Fr	Feed rate	β	FWHM of peak
FR	Fuel ratio	k	Rate constant
FTIR	Fourier transform infrared spectroscopy	α	fractional conversion
FWHM	Full width at half maximum	m_0	Initial mass of the sample (mg)
HHV	Higher heating value (MJ/kg)	m_t	Mass of sample at any time t (mg)
HR	Hausner ratio	m_f	Final mass of the sample (mg)
I_{002}	Crystalline intensity of diffraction	E_a	Activation energy

	plane (002)
I_{am}	Amorphous intensity of diffraction plane (002)
L_{002}	crystal size
M_i	Mass retained on i^{th} screen (kg)
M_1	Initial mass of sample (kg)
m_c	Mass of empty cylinder
m_p	Mass of geometrical shape (kg)
P_1	Pressure after pressurizing the reference volume (Pa)
P_2	Pressure after including V_C (Pa)
m_g	Total mass of cylinder with sample (kg)
m_t	Total mass of cylinder with sample after tapping (kg)
GC-MS	Gas chromatography-mass spectroscopy
PO-DAN	Pyrolysis oil from raw biomass pyrolysis at optimum condition
PO-TAN	Pyrolysis oil from torrefied biomass pyrolysis at optimum condition

	(kJ/mol)
E_α	Activation energy at different conversion (kJ/mol)
A	Pre-exponential factor (s^{-1})
R	Universal gas constant
β	Heating rate (K/min)
T	Temperature (K)
T_α	Temperature at different conversion (K)
T_p	Peak temperature in the DTG curve (K)
ΔH	Change in enthalpy (kJ/mol)
ΔG	Change in Gibbs free energy (kJ/mol)
ΔS	Change in entropy (J/mol.K)
K_B	Boltzmann constant ($1.381*10^{-23}$ J/K)
h	Plank constant ($6.626*10^{-34}$ J.s),