Co-gasification of Waste Tyres, Bamboo and Refuse Derived Fuel (RDF) using Carbon dioxide

By

B.Oboirien and S. Bada

12th ECCRIA Conference, (The European Conference on Fuel and Energy Research and its Applications), Wednesday 5th to Friday 7thSeptember 2018 at Cardiff University, UK.

UNIVERSITY OF JOHANNESBURG

Presentation Overview

- Introduction /Motivation
- Aims and Objectives
- Methodology
- Results and Discussions
- Conclusion

Introduction

- There is a worldwide drive to dispose tyres effectively;
- This is due to the huge number of waste tyres produced annually;
- 2.7 billion units of tyres were produced in 2017 and 1 billion units were disposed;
- The disposal of waste tyres is currently a challenge,
- Dumping of tyres in landfills is no longer permitted in some countries

Motivation

- Energy recovery from waste tyre through gasification is an alternative process for the effective disposal of tyres;
- Gasification of tyres is a process in which air, oxygen and or steam reacts with tyres in an endothermic reaction to produce mainly syngas (CO and H_2) and other byproducts are CO_2, light hydrocarbons and char

- *Tyres* $\rightarrow$ *heavy hydrocarbons* + *light hydrocarbons* + *char*
- *chars* $\longrightarrow$ $CO + H_2$

Problem Statement

- One challenge is the low rate of tyre char gasification; this leads to a lower overall efficiency of the tyre gasification process
- One way of increasing the rate of tyre char gasification is by co-gasification with fuels that have a higher rate of gasification
- Lahijani et al (2013) co-gasified tyre and Palm empty fruit bunch and Almond shell.
- They reported that the rate of tyre gasification was increased in the blends with the Tyre+ Palm fruit having the highest gasification rate.
- The was observed by the reduction of the activation energy in the tyre-char/ Palm fruit blend
- There have not been any report on the co-gasification of tyre and bamboo and tyre and Refuse Derived fuel (RDF) from Municipal Solid Waste .
- This study aims to evaluate the co-gasification tyre of bamboo and RDF and determine its kinetic parameters such as Activation energy (Ea) and pre-exponential factor (A).

Methodology

- Waste tyre was shredded to remove steel cords and cut into small granules of 500 micron
- Bamboo (Dendrocalamus asper) was also shredded into 500 micron
- Refuse derived fuel was obtained from MSW (Paper +Plastics) was also shredded into 500 micron

Sample	Waste Tyre (WT)	Bamboo (BA)	Refuse Derived Fuel (RDF)
Proximate- Analysis (wt%)			
Inherent Moisture Content	0.7	5.45	2.38
Volatile Matter Content	65.6	71.93	87.67
Ash	5.6	3.71	3.15
Fixed Carbon(by difference)	28.1	18.91	6.81
Gross Calorific Value (MJ/kg)	37.83	17.87	30.42
Ultimate Analysis (wt%)			
Carbon	83.8	45.80	64.50
Hydrogen	8.18	6.14	11.17
Nitrogen	0.24	0.68	3.92
Total Sulphur	1.58	0.93	0.18
Oxygen (by difference)	6.2	47.38	14.70

Methodology

- Gasification experiments were carried out in a thermogravimetric analyser and carbon dioxide was used as the gasifying agent.
- At 800^{o}C, 850^{o}C,900^{o}C and 950^{o}C

Sample
100% Tyre
100% Raw Bamboo
100% RDF
20% B + 80% T
40% B + 60% T
50% B + 50% T
60% B + 40% T
80% B + 20% T
20% RDF + 80% T
40% RDF + 60% T
60% RDF + 40% T
80% RDF + 20% T

B:Dendrocalamus Asper Bamboo

T: Tyre; RDF: Refuse Derived Fuel

Data Analysis

- DTG – Weight loss per min (%/min)
- Carbon Conversion

$$X = \frac{m_o - m_t}{m_o - m_{ash}}$$

- X is carbon conversion, m_o is the initial sample mass, m_t sample mass at time t and m_{ash} is the mass of the residual ash
- Rate of gasification

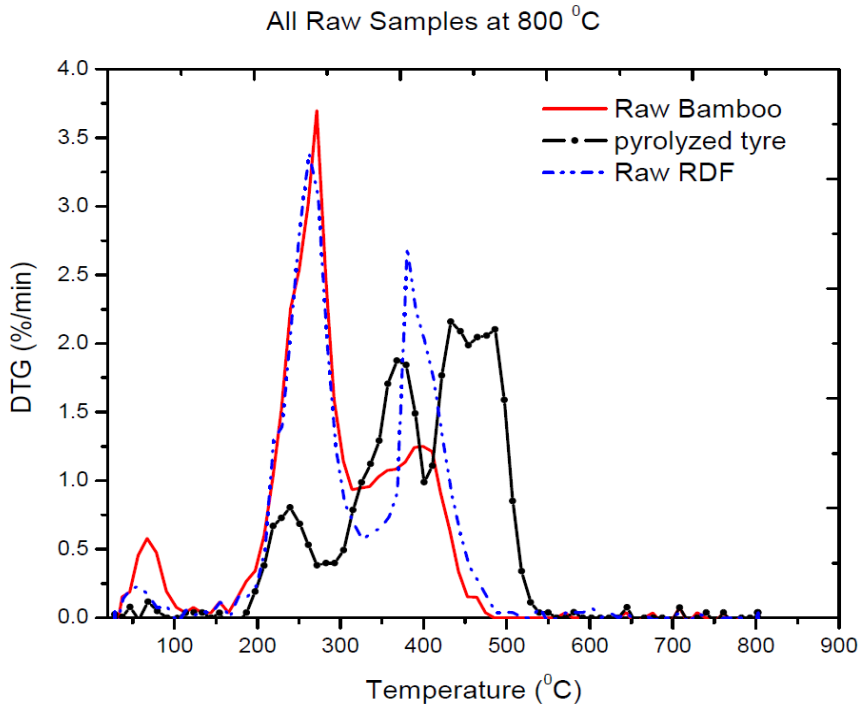
$$R = \frac{dX}{dt} = k(T)\, f(X).$$

- where k is the apparent gasification rate constant and function of carbon conversion and temperature (T)

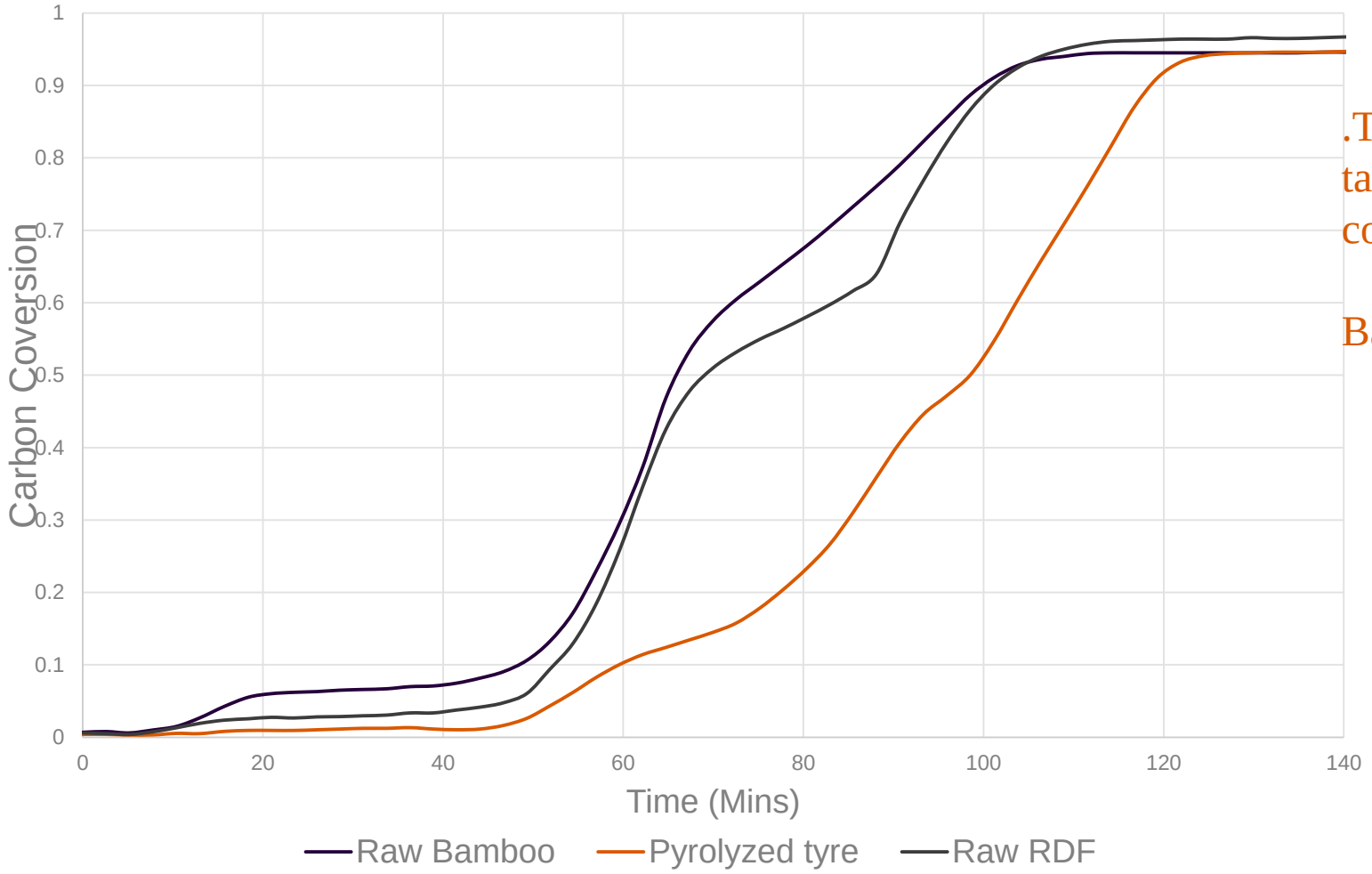
$$k = koe^{-E/RT}$$

- Ko is the pre-exponential factor, E is the activation energy and R is universial gas constant.

Results and Discussion



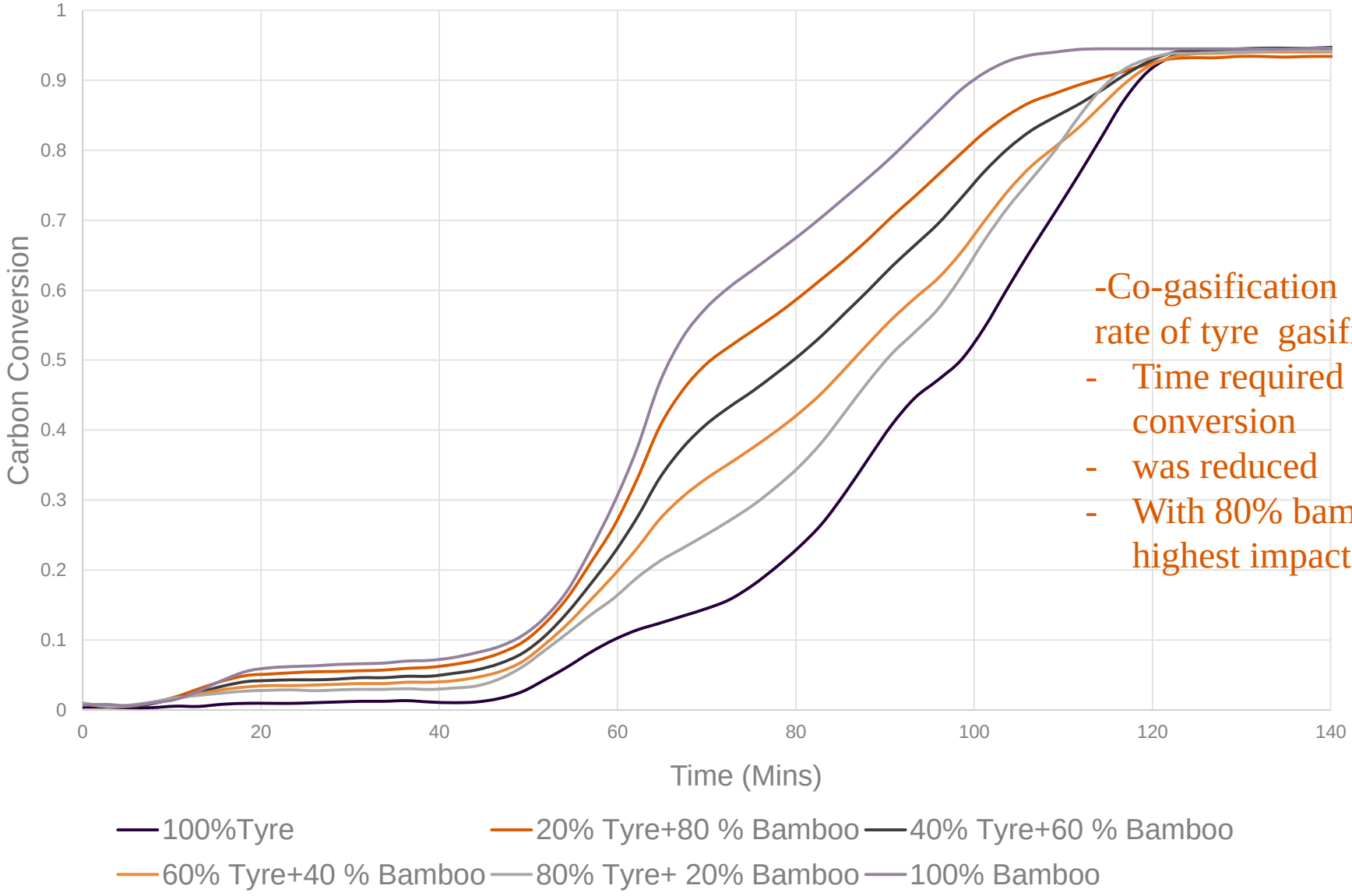
- Based on DTG Curve for the fuel samples(Raw Bamboo, Pyrolyzed Tyre and Raw RDF) , there are three main stages of gasification ; firstly drying and then devolatilisation and lastly char gasification
- The degree of weight loss for each of the stages were different for the different fuel samples
- Drying ; Raw Ramboo (~10%), Raw RDF(~5%), Pyrolyzed char(~2%)
- Devolatisation; Ramboo (~76%), Raw RDF(~74%), Pyrolyzed char(~48%)
- Char gasification; Ramboo (~10%), Raw RDF(~7%), Pyrolyzed char(~2%)



.This was evident in the time taken to achieve complete carbon conversion

Bamboo> RDF> Tyre

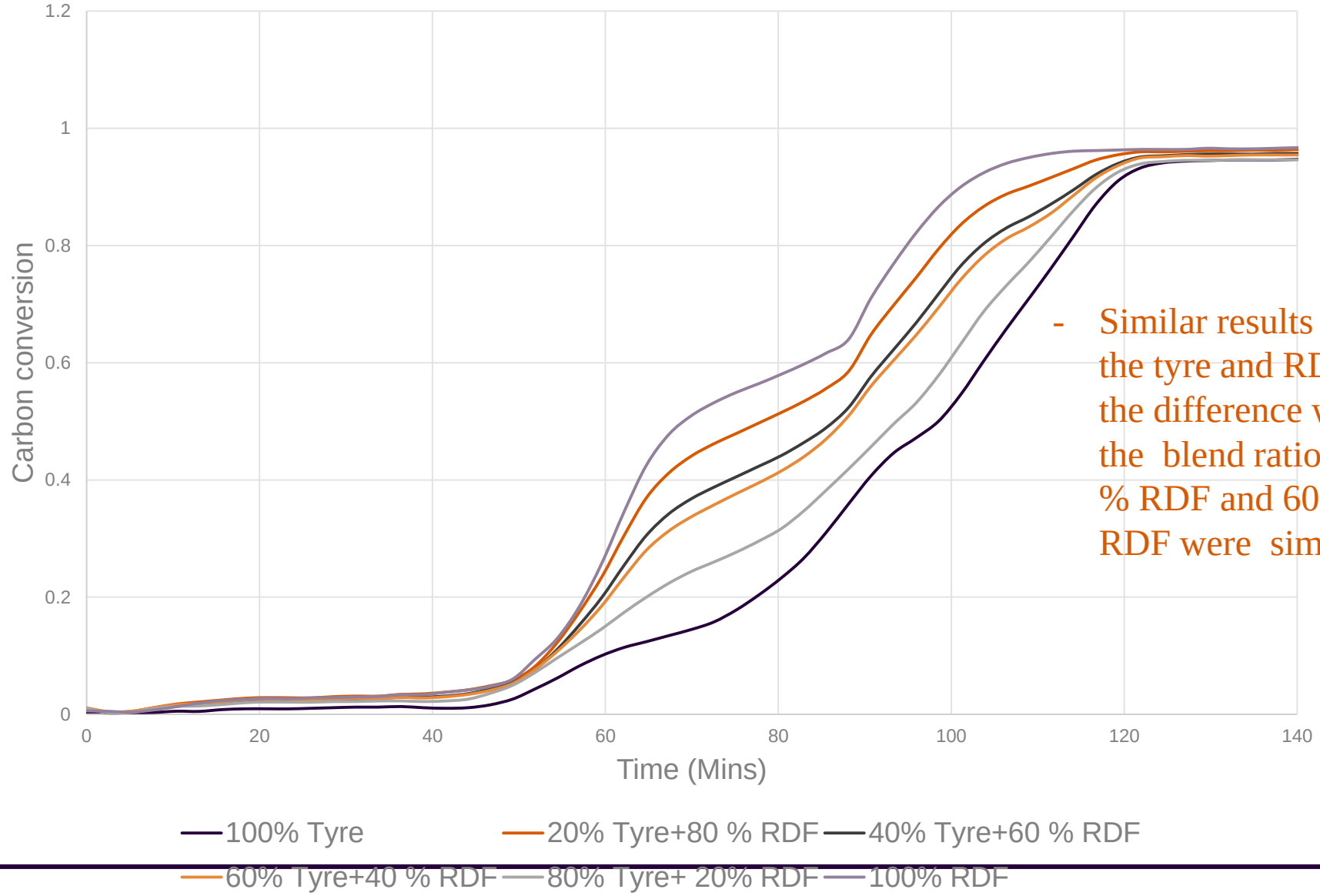
Blends of Tyre and Bamboo



-Co-gasification of increased the rate of tyre gasification

- Time required to achieve complete conversion
- was reduced
- With 80% bamboo /20 % have the highest impact

Blends Tyre and RDF



- Similar results were observed for the tyre and RDF blend , the only the difference was that the results of the blend ratios of 40 % tyre+ 60 % RDF and 60 % tyre and 40% RDF were similar.

Kinetic parameters of the samples during gasification

Sample	R^2	Ea (kJ/mol)	A $(min)^{-1}$
100% Tyre	0.9726	41.10	7.23E+02
100% Raw Bamboo	0.9182	27.01	1.70E+02
100% RDF	0.9095	31.40	2.72E+02
20% B + 80% T	0.9875	29.80	1.22E+02
40% B + 60% T	0.9684	27.04	8.15E+01
60% B + 40% T	0.9451	26.00	7.75E+01
80% B + 20% T	0.9055	25	7.62E+01
20% RDF + 80% T	0.9809	31.70	1.54E+02
40% RDF + 60% T	0.9555	30.90	1.62E+02
60% RDF + 40% T	0.9399	30.50	1.57E+02
80% RDF + 20% T	0.9205	30.50	1.87E+02

- There was a reduction in the activation energy for tyre co-gasification with the co-gasificaton of bamboo having the highest reduction.
- The highest reduction in activation energy of the tyre–char gasification was from 41kJ/mol to 30 kJ/mol in tyre-RDF blend; to 25 Kj/ mol in tyre-bamboo blend

- At 80 % Bamboo + 20% Tyre and 80% RDF + 20% for both types of blends
-
- In the RDF + tyre blend the activation energy at 40% RDF+ 60% tyre; 60% RDF+ 40 tyre and 80% RDF + 20% tyre were similar.

Conclusions

- Bamboo had the highest rate of gasification followed by RDF and lastly tyre
- The co- gasification of tyre and bamboo and RDF increased the rate of tyre-char gasification by reducing its activation energy during gasification
-
- The highest reduction in activation energy of the tyre–char gasification was from 41kJ/mol to 30 kJ/mol in tyre-RDF blend; to 25 Kj/ mol in tyre-bamboo blend was obtained at 80 % Bamboo + 20% tyre and 80% RDF + 20% tyre for both types of blends .

- The effect of blend ratio on activation energy was slightly different for the two different blends.

- In the RDF + tyre blend the activation energy the blend ratios of 40% RDF+ 60% tyre; 60% RDF+ 40 tyre and 80% RDF + 20% tyre were similar, while it was different for the Bamboo- tyre blend

Thank you!!!