Process simulation of plastic waste to environmental friendly fuel

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INTRODUCTION

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- Since plastics appeared in the 1950s they have changed our world forever
- Option proposed, and used to a certain degree, is to recycle plastics is pyrolysis
- Experimental results have shown that the final composition of products is highly dependent on the purity and type of polymer(s), temperature and residence time

- This presentation describes the results of a thesis (Andersen, 2017) where one of the main aims was to find methods to model such a process, to implement and simulate these, and to compare them with experimental data.

- The experimental data were obtained from reported pyrolysis experiments using virgin HDPE and PP (Azuibuke, 2017).

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Materials and methods

2.1 Kinetic Models

The commonly used polyethylene and polypropylene are stable molecules

An equation for the reaction for the decomposition rate can be written as follows, assuming an Arrhenius mechanism:

$$\frac{dX_P}{dt} = -X_p * A_0 \cdot e^{-\frac{Ea}{R \cdot T}}$$

Where,
Xp: mass fraction of the polymer,
A0: pre-exponential factor
Ea : activation energy for the reaction

2.2 Three Lump model for HDPE and PP/PE mix

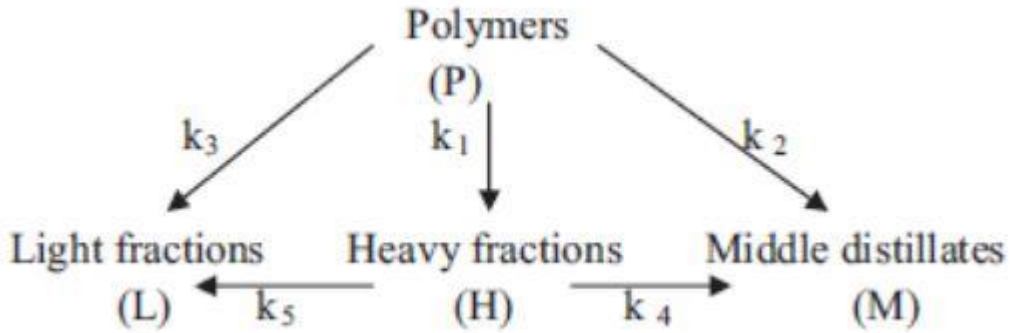

Figure 1 - Proposed reaction pathway by (Ding et al, 2012).

$$\frac{dX_P}{dt} = -X_p * (k_1 + k_2 + k_3) \quad (2)$$

$$\frac{dX_H}{dt} = X_p * k_1 - X_H * (k_4 + k_5) \quad (3)$$

$$\frac{dX_M}{dt} = X_p * k_2 + X_H * k_4 \quad (4)$$

$$\frac{dX_L}{dt} = X_P * k_3 + X_H * k_5 \quad (5)$$

Where k_1 - k_4 are expressed as:

$$k_i = A_{0i} \cdot e^{-\frac{Ea_i}{R \cdot T}} \quad (6)$$

2.3 Six Step model for Polypropylene

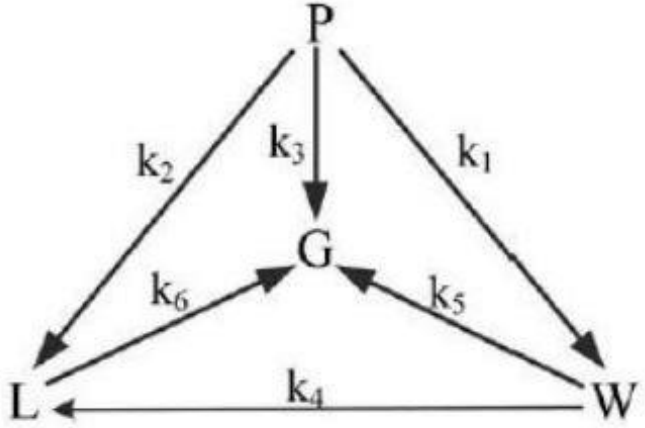

Figure 2 Reaction pathway for PP suggested by (Zhang et al, 2015)

$$\frac{dX_P}{dt} = -X_p * (k_1 + k_2 + k_3) \quad (7)$$

$$\frac{dX_L}{dt} = X_p * k_2 + X_W * k_4 - X_L * k_6 \quad (8)$$

$$\frac{dX_W}{dt} = X_p * k_1 - X_W * (k_5 + k_6) \quad (9)$$

$$\frac{dX_G}{dt} = XP * k3 + XL * k6 + XW * k5 \quad (10)$$

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Results and Discussions

Kinetic Models

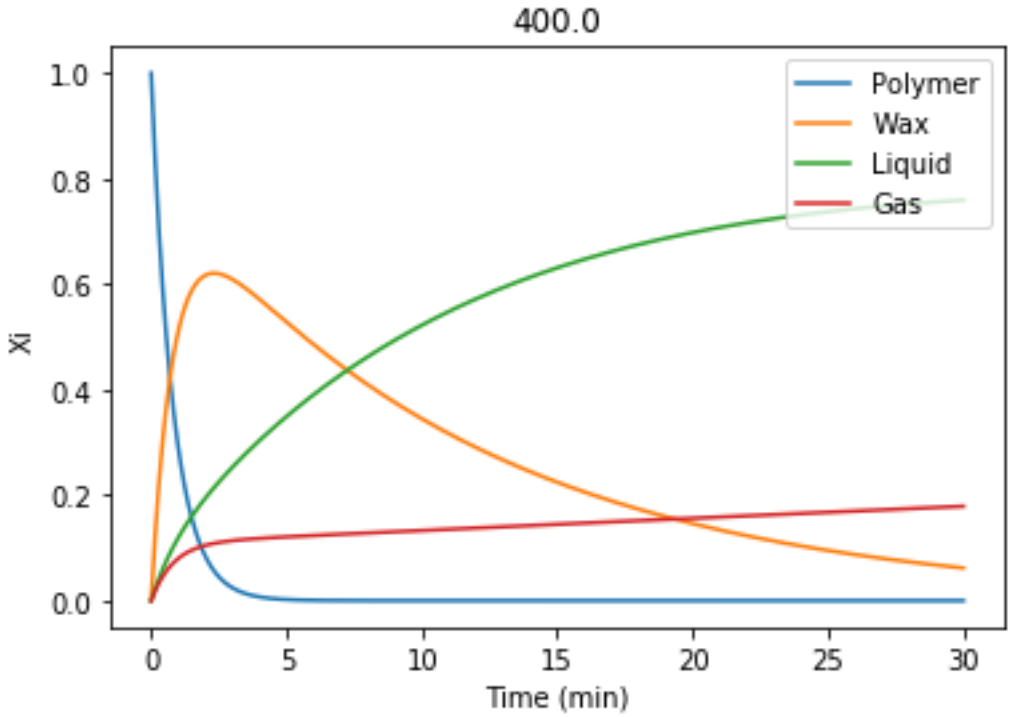

Figure 3 - Results of kinetic models for PP at 400 C.

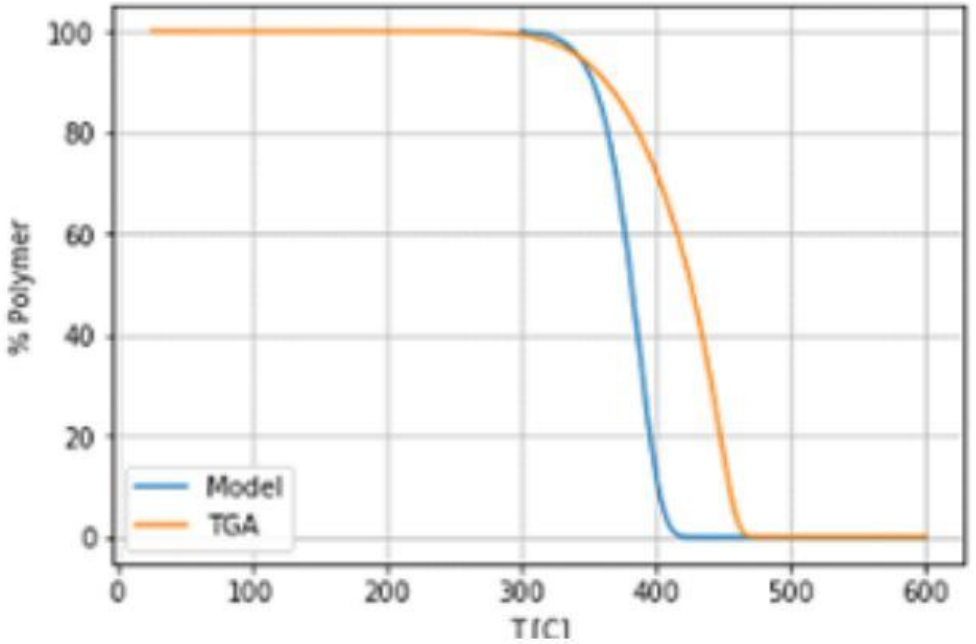

Figure 4 - Comparison between PP model and TGA. 10°C/min rate.

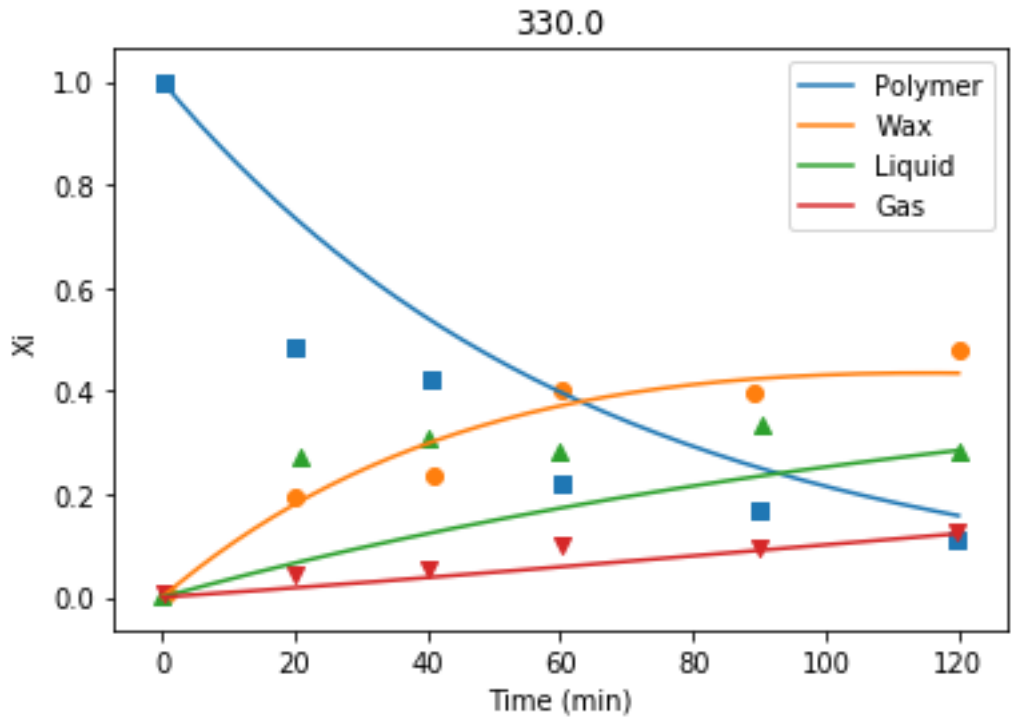

Figure 6 – Results of kinetic models for PP at 330 C.

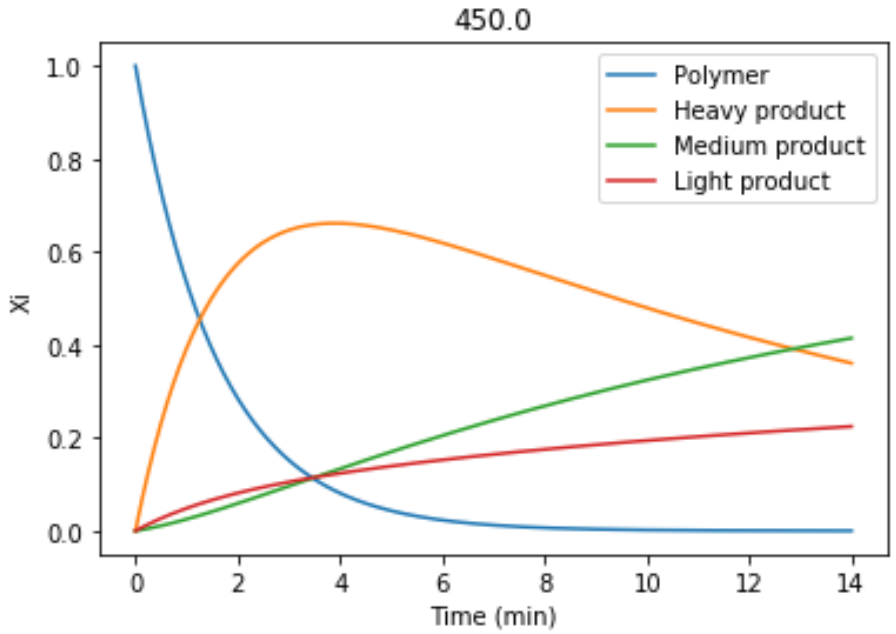

Figure 7 - Results of kinetic models for HDPE at 450 C.

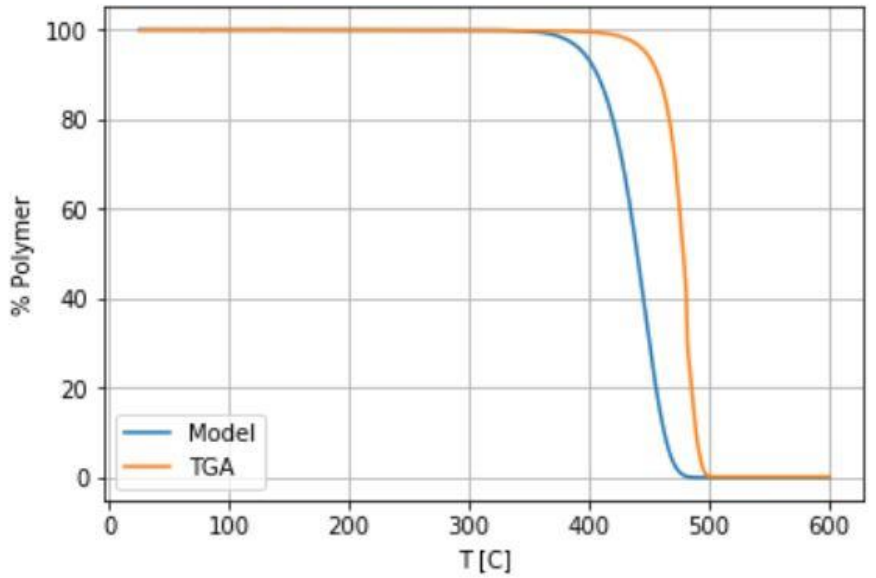

Figure 8 - Comparison between HDPE model and TGA. 10°C/min rate.

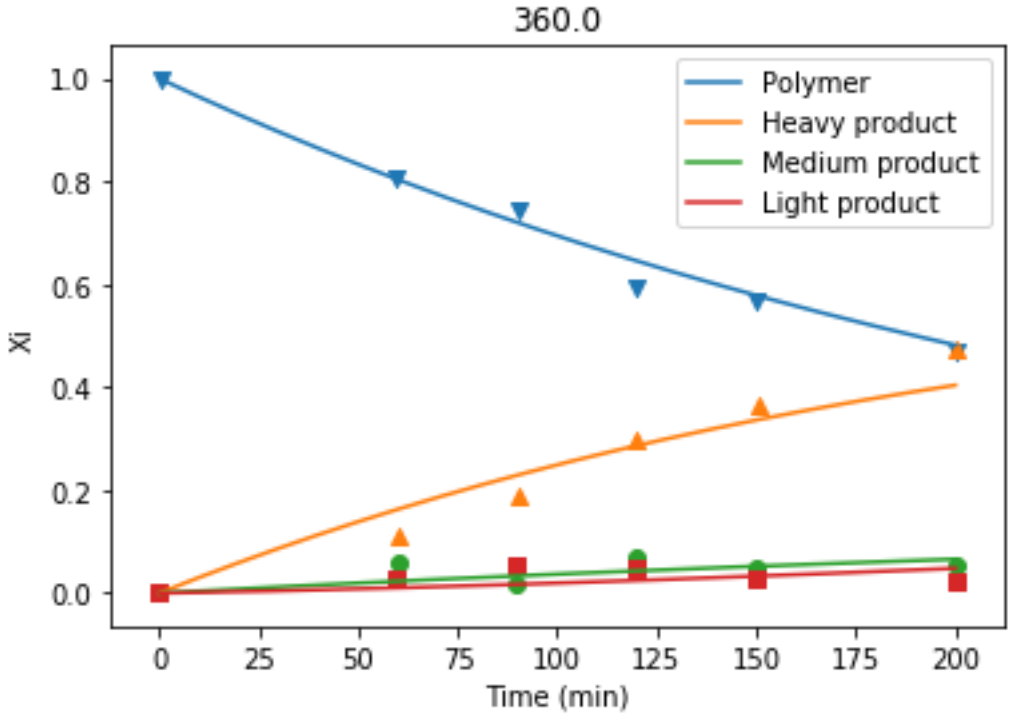

Figure 9 - Results of kinetic models for HDPE at 330 C.

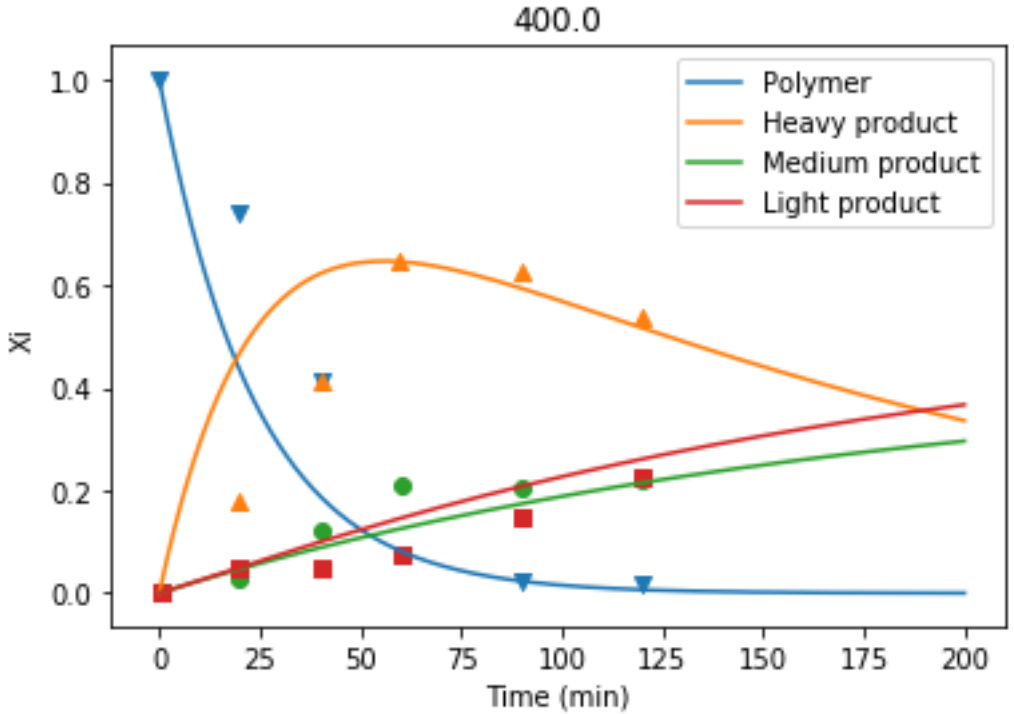

Figure 10 - Results of kinetic models for HDPE at 330 C.

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CONCLUSION

1. It can be concluded that the decomposition of pure polymers by pyrolysis can be modelled with a good (~90-95%) accuracy using models.

2. The models presented in this presentation could be used together with the energy balance, operation cost estimations and products values, to find the optimal residence time that maximizes the profit for the pyrolysis process.