MODELLING THE EFFECT OF PARTICLE CHARACTERISTICS AND PROCESS PARAMETERS DURING FAST PYROLYSIS OF BIOMASS ANISOTROPIC PARTICLES WITH INTRAPARTICLE TRANSPORT PHENOMENA AND DETAILED KINETICS

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Introduction

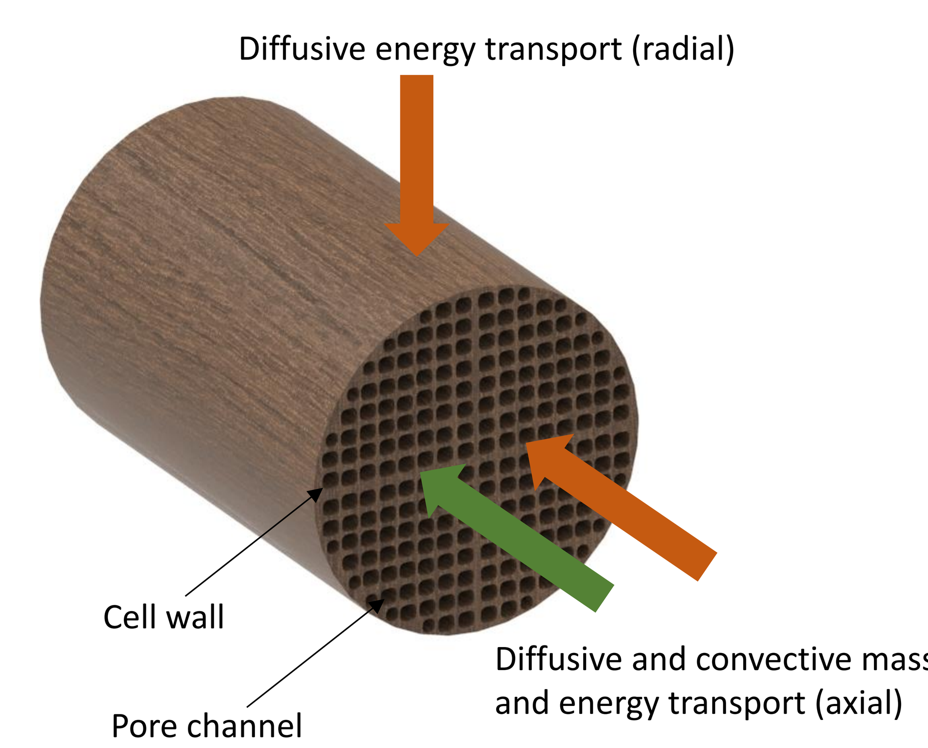
A model to study the effect of particle characteristics and process parameters during biomass fast pyrolysis conversion was developed. The pyrolysis model considers simultaneously the effect of particle anisotropy and shrinking, intra-particle energy and mass transport, a detailed reaction mechanism with biomass pseudo-components, the appearance of liquid intermediate compounds, and secondary intraparticle reactions of volatiles.

Considerations were made to obtain a low computation cost tool, with a 95% reduction on calculation time, with negligible effect on the estimation of particle mass loss and main products yields.

Methods

The mass transport perpendicular to the direction of the pores was considered negligible and Darcy law for intraparticle velocity estimation was used. The different species of permanent gases were grouped in a single component and the same is done for the different volatile species. Thermal properties, such as thermal conductivity anisotropy, were estimated as a function of particle conversion and temperature, and the local concentration of each component.

Particle conversion and products yields were estimated for millimeter-sized particles, model results were validated against previous experiments in a Frontier micropyrolyzer for a particle of 3 mm diameter and 12 mm long.



Results

The effect of particle size and shape, initial moisture content, lignocellulosic composition, and reactor temperature on particle conversion time and products yields was studied. A reduction of 95% in computational cost against CFD simulations was obtained due to modelling strategy and assumptions such as intraparticle velocity estimation using Darcy law, negligible radial mass transport, and grouping of volatile and gaseous species in the reaction mechanism.

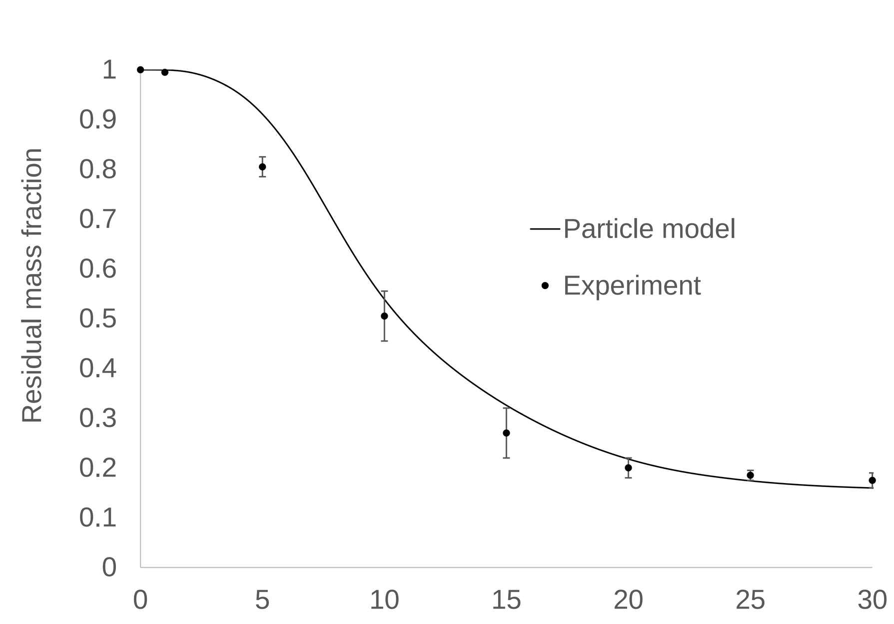


Figure 1. Model validation against mass loss rate experiments for oak particle (D= 3 mm, L = 12 mm)

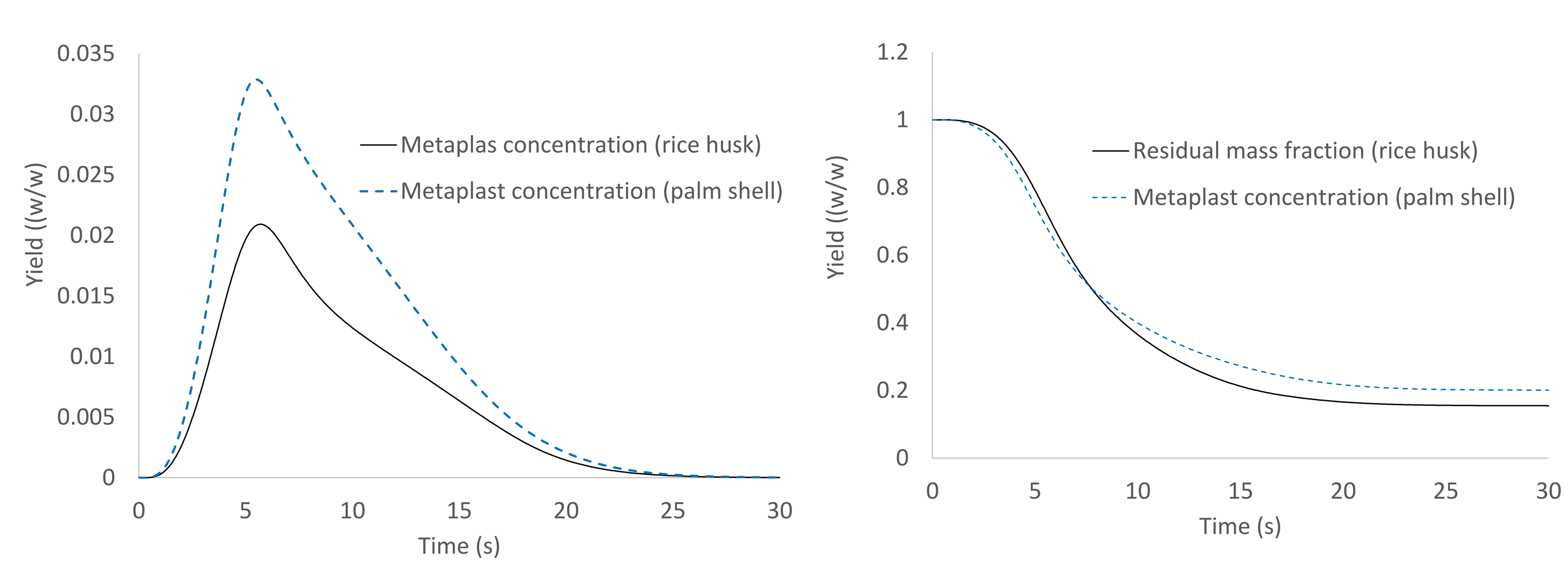


Figure 2. Effect of lignocellulosic composition on liquid intermediates concentration (left) and mass loss rate (right)

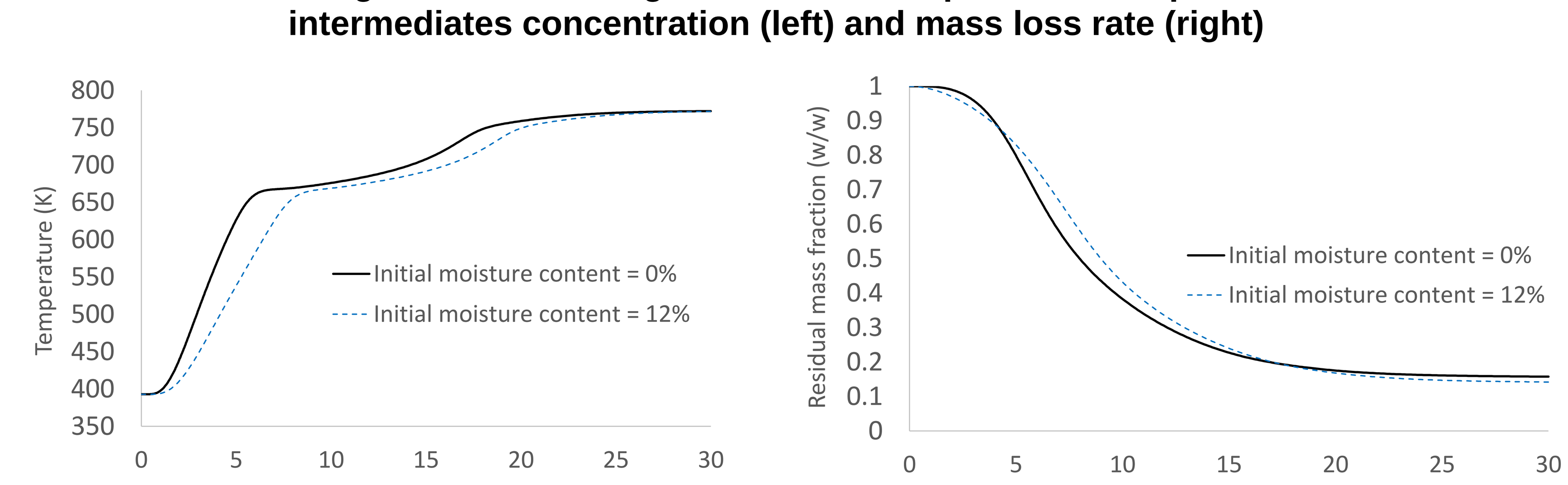


Figure 2. Effect of initial moisture content on particle heating rate (left) and mass loss rate (right)

Table 1. Effect of lignocellulosic composition on product yields

	Rice husk (CEL 43%, HCE 32%, LIG 25%)	Palm shell (CEL 27%, HCE 23%, LIG 50%)
Yield volatiles	0.613	0.561
Yield water	0.065	0.057
Yield char	0.158	0.202

Table 2. Effect of initial moisture content on product yields (rice husk)

	Initial moisture (0%)	Initial moisture (12%)
Yield volatiles	0.613	0.546
Yield water	0.065	0.166
Yield char	0.158	0.142

Conclusions

Validation of the model showed that the modelling strategy and considerations such as using Darcy law for intraparticle velocity estimation, considering negligible mass transport in the radial direction, and grouping of volatiles and gaseous species significantly reduce computational cost when estimating particle conversion time and main products yields.

The characteristics and phenomena considered in the model such as particle shape and anisotropy, intraparticle transport phenomena, and detailed kinetics allow to study the effect of particle characteristics and process parameters in millimeter-sized anisotropic particles, and therefore the model represents a powerful low computational cost tool to model biomass pyrolysis.

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