



# Proposal of an Empirical Kinetic Model of Steam Gasification Valid for Various Biomass Chars between 750 and 900°C

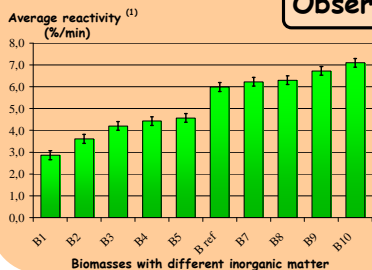
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**Objective:** Development of a kinetic model able to describe the gasification of various woody biomasses

## Observations



Significant variation of the reaction rate

Up to 2.5 !

Assumption: influence of the inorganic matter

## Influence of the inorganic matter



Catalytic effect?

Steric or dilution effect?

## Experiments

### Biomasses



- 10 woody biomasses
- With a large range of  $m_k/m_{Si}$  ratio (0.3-3.3)

### Slow pyrolysis (oven)



Heating rate: 15°C/min  
Atmosphere: N<sub>2</sub>  
T<sub>reaction</sub> = 450°C for 4h

### Gasification (thermobalance)



Operating conditions

T<sub>reaction</sub> = 800°C  
P<sub>total</sub> = 1 atm  
P<sub>H<sub>2</sub>O</sub> = 0.3 bar

t<sub>convection</sub> = 1.6 s  
t<sub>diffusion</sub> = 0.04s

Char layout

d<sub>char particle</sub> < 50µm  
d<sub>crucible</sub> = 7mm  
h<sub>bed</sub> ~ 3mm

Under these experimental conditions

Kinetically controlled reaction

t<sub>reaction</sub> ~ 2000 s

## Determination of a kinetic model on one reference biomass

- Gasification at different temperatures of beech char: 750°C, 800°C, 850°C, 900°C

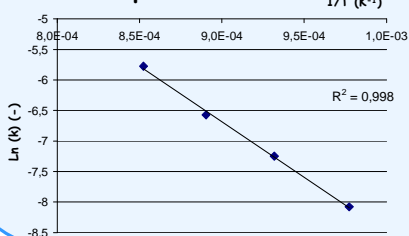
- Model suitable for our study: shrinking core model

Hypothesis: reaction on char particles, whose radius decreases with the conversion ratio X

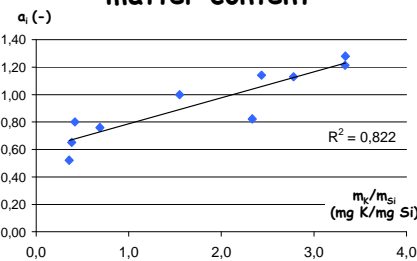
$$r = k(1-X)^{2/3}$$

(k: Arrhenius constant)

### Determination of the kinetic parameters



## Correlation of a<sub>i</sub> with the inorganic matter content



Clear trend for the ratio  $m_k/m_{Si}$

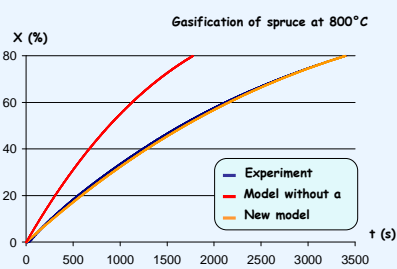
## Model adjustment

- Gasification at 800°C of chars (with different inorganic content)
- Introduction of a new parameter in the model: a<sub>i</sub>

a<sub>i</sub> = constant during the reaction

a<sub>i</sub> function of  $m_k/m_{Si}$

$$r = a_i k (1-X)^{2/3}$$



Performance of the model improved (average error: 2%)

## Conclusion

New model: 
$$\frac{dX}{dt} = k_0 \exp\left(\frac{-E_a}{RT}\right) \left(0.1891 \frac{m_k}{m_{Si}} + 0.5989\right) (1-X)^{2/3}$$

Validity domain:  $\begin{cases} 750^\circ\text{C} < T < 900^\circ\text{C} \\ P_{H_2O} = 0,3\text{bar} \end{cases}$  With:  $\begin{cases} k_0 = 1.62 \cdot 10^4 \text{ s}^{-1} \\ E_a = 151 \text{ kJ/mol} \end{cases}$

Validation on 2 other woody biomasses Error < 12%

## Further Work

- Study of P<sub>H<sub>2</sub>O</sub> influence
- Validation on a larger range of woody biomasses (~50) with different inorganic contents
- Adaptation of the model on other kinds of biomasses (agricultural)
- Study of the inorganic influence mechanisms