

Introduction - Context

High temperature **gasification of biomass** in Entrained Flow Reactor (EFR) is one of the most promising technologies to produce syngases or H₂. These operating conditions requires a **fine grinding of biomass**, which is energy costly. Biomass **torrefaction** is a pre-treatment process allowing to **reduce grinding energy consumption**.

⇒ **Aim of our work** : Influence of **nature of biomass** on **torrefaction products**?

↳ **Objectives of this study** : Characterization of products and grinding energy after torrefaction of **3 types of biomass** : softwood (pine), agricultural residue (wheat straw) and perennial feedstock (miscanthus).

Biomasses

Biomass	Proximate analysis (wt.%)				Ultimate analysis (wt.% da)				LHV (MJ/kg db)	
	Moisture	Ash (db)	VM (db)	FC (db)	N	C	H	O		
Raw	raw wheat straw	8,0	6,4	73,5	20,2	1,0	48,9	6,1	43,0	18,4
	raw miscanthus	8,2	2,2	80,9	16,9	0,3	40,2	6,2	44,3	18,0
	raw pine	11,9	0,3	85,2	14,5	0,2	49,7	6,1	44,0	18,1
Torrefied	torrefied wheat straw	4,7	8,9	67,3	23,9	1,1	55,0	6,0	37,9	20,8
	torrefied miscanthus	4,1	2,5	78,5	19,1	0,3	52,1	6,0	41,7	19,0
	torrefied pine	5,1	0,2	84,5	15,3	0,1	51,6	6,0	42,3	18,9

db: dry basis
daf: dry ash free basis

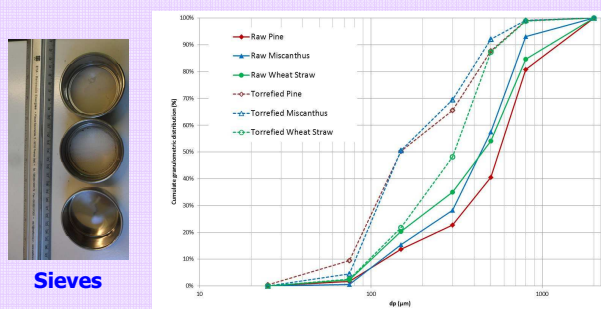
Torrefaction device

Temperature	250°C
Gas atmosphere	N ₂
Gas flow	100 mL.min ⁻¹
Pressure	atmospheric
Sample mass	-1.5 g

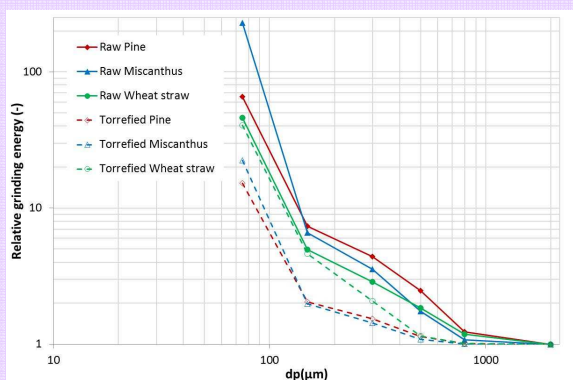
Heating rate: 10°C.min⁻¹
250°C
T_{amb}
45 min
Time (min)

To exit
N₂
Glass balls
Sample
26 mm
Cooling bath (-10°C)
Collection for GC-MS analysis
Crossed fixed bed reactor (ALIGATOR)

Grindability



Particle size distribution



Relative grinding energy consumption

Grinding device

Ball mill

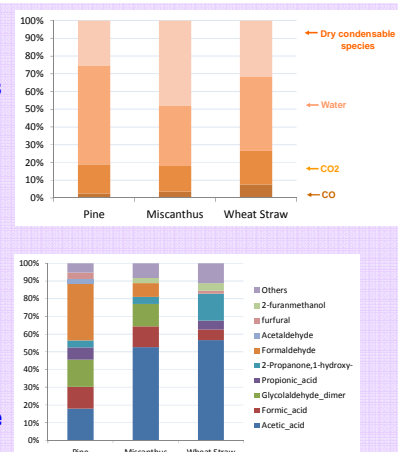
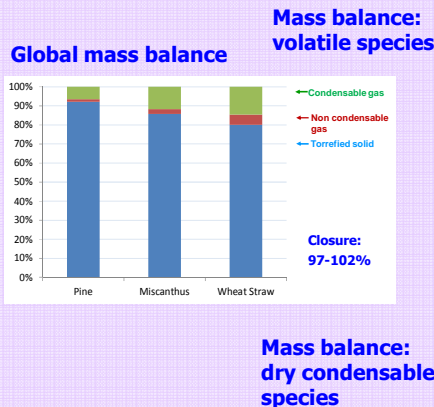
Experimental conditions:

- Same weight loss (~17 %) for different torrefied biomasses
- Same grinding protocol (residence time, volume of sample)

Hypothesis:

- Relative energy before grinding = 1
- Shape of particles after grinding: sphere
- Energy proportional to the surface created

Mass balance



Conclusions

- Strong influence of nature of biomass on mass loss during torrefaction
- Similar non condensable gases, but differences in condensable species composition
- After grinding: torrefied particles are significantly smaller than raw biomass particles
- Grinding energy is reduced by 4 to 6 for particle size of 100μm after torrefaction of Pine and Miscanthus
- Low impact of torrefaction on grindability for wheat straw