


Operation of biomass boilers: Particles, Ash and Slagging

Training material for B4B seminars
Prepared by: Wolfgang Stelte
Danish Technological Institute
2016

Overview

- Particle emissions from biomass boilers
 - Smokeformation
 - Smoke particles
 - Reduction of particle emissions
 - Ash and slagging in biomass boilers
 - Characterization of slagg
 - Ash-melting behaviour
 - Ash formation in biomass boilers
- 

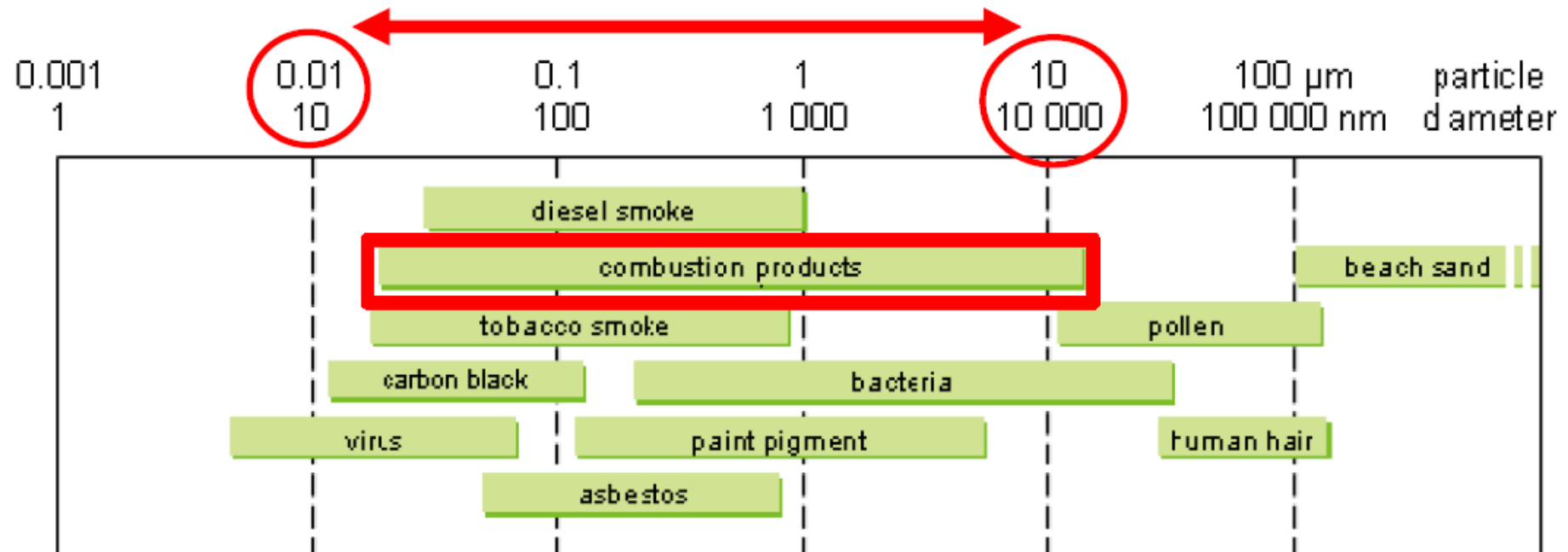
Particle emissions from biomass boilers

- Smoke?

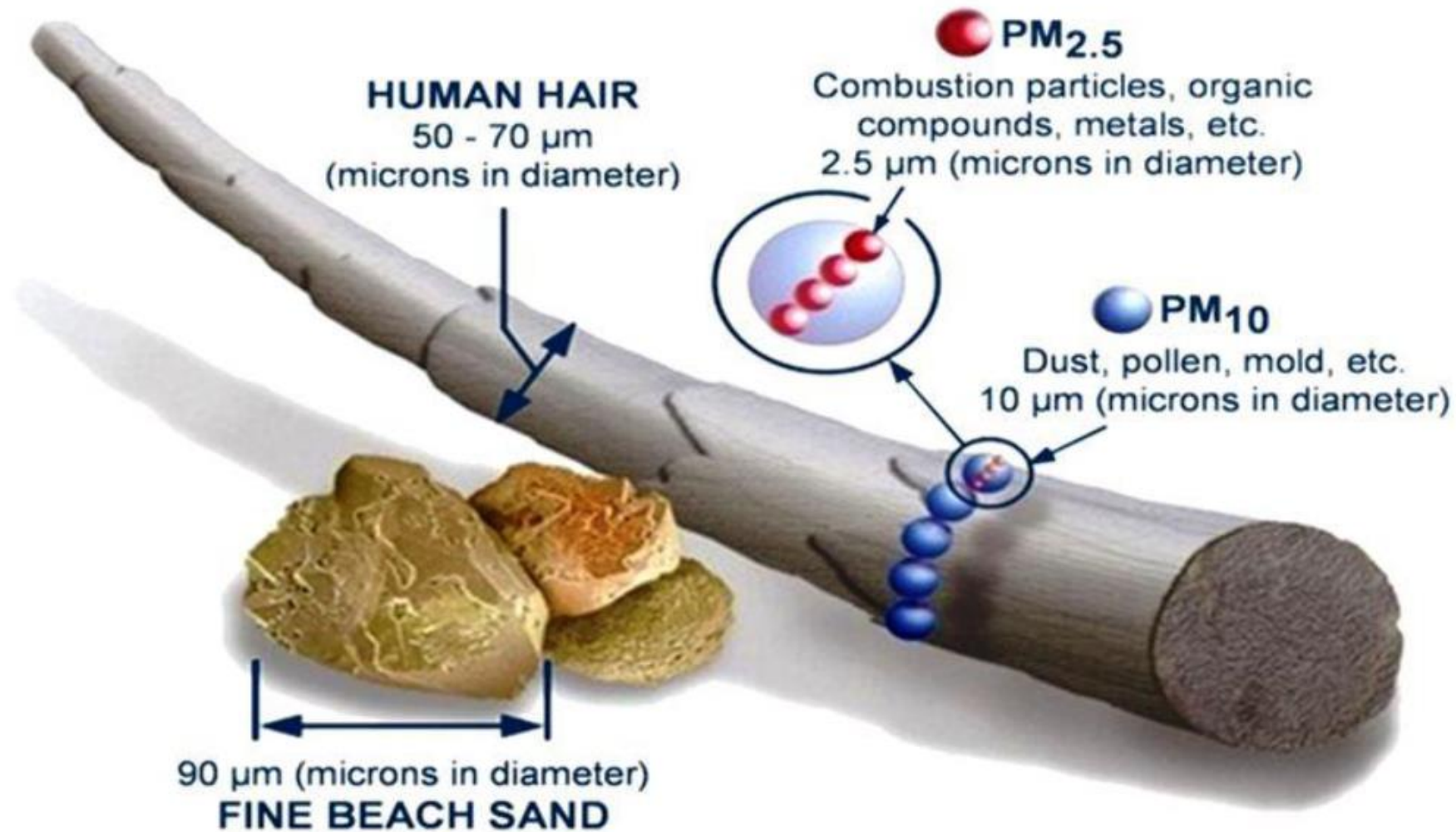


→ **Particles + droplets of water**

Particle emissions from biomass boilers

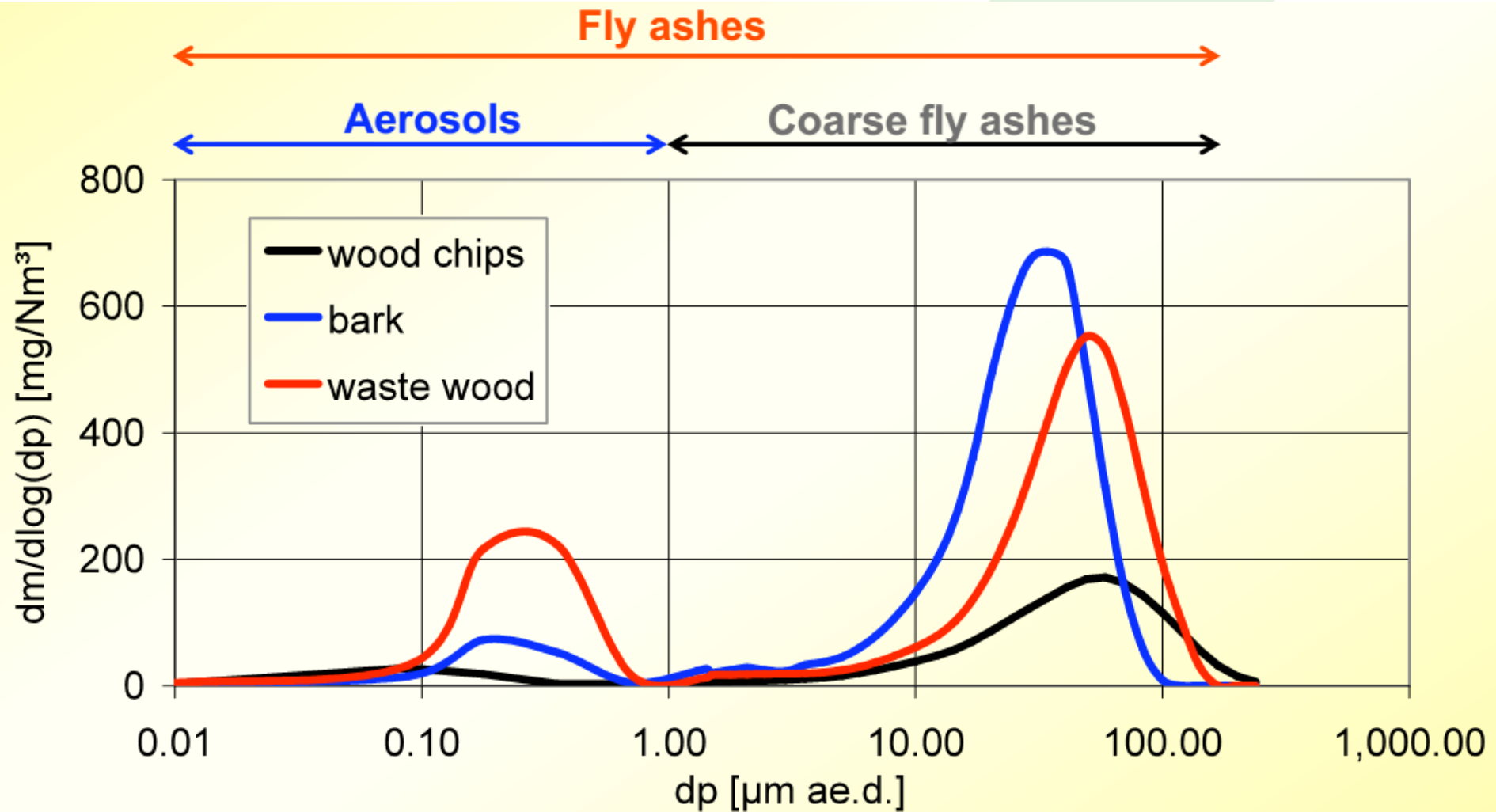


Particle emissions from biomass boilers



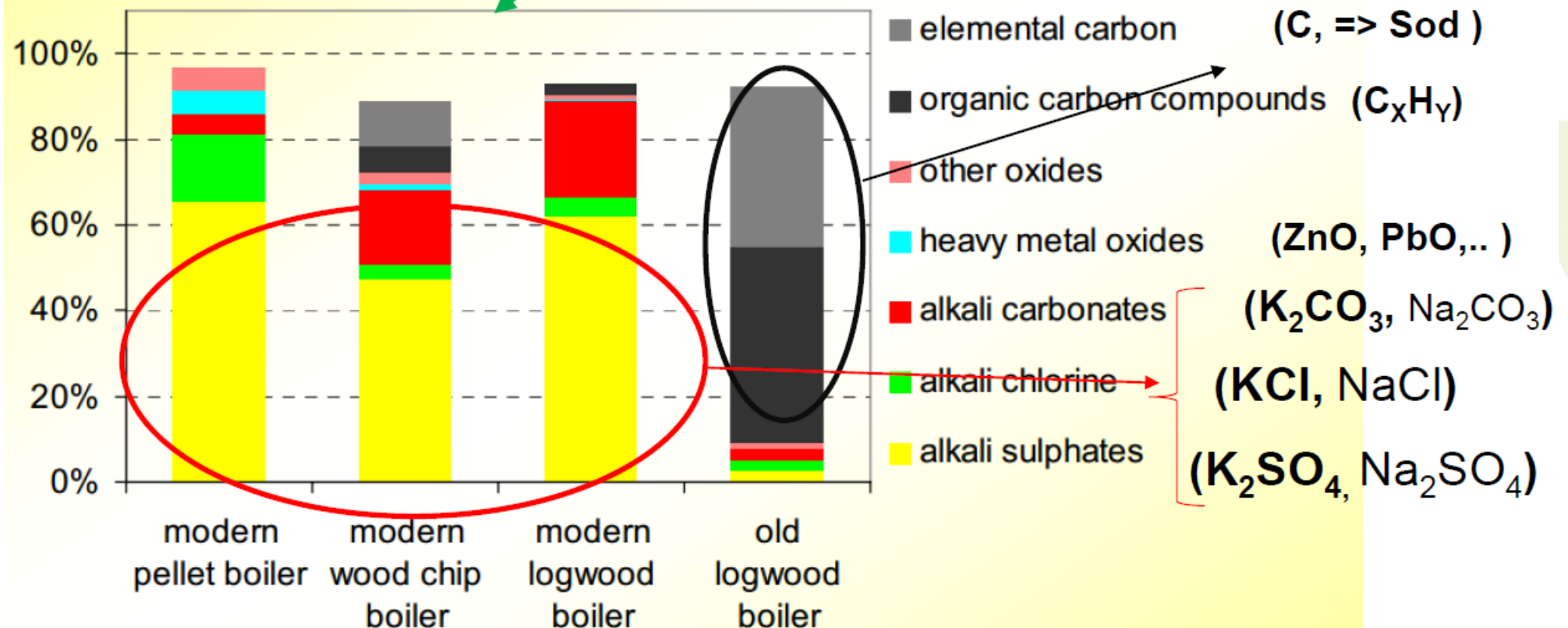
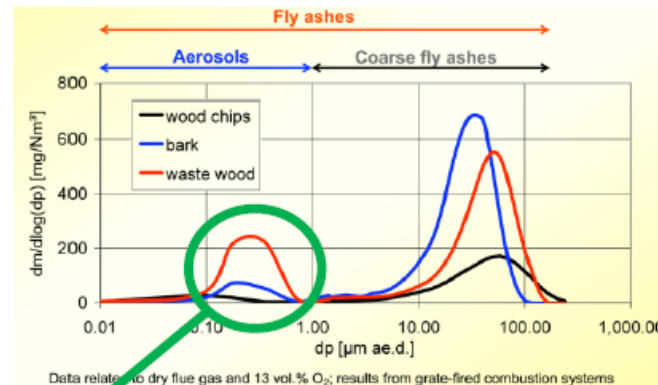
PM₁₀ og PM_{2,5} = **P**articulate **M**atter < 10 μm og < 2,5 μm

Bi-modal size distribution of smoke particles from biomass combustion

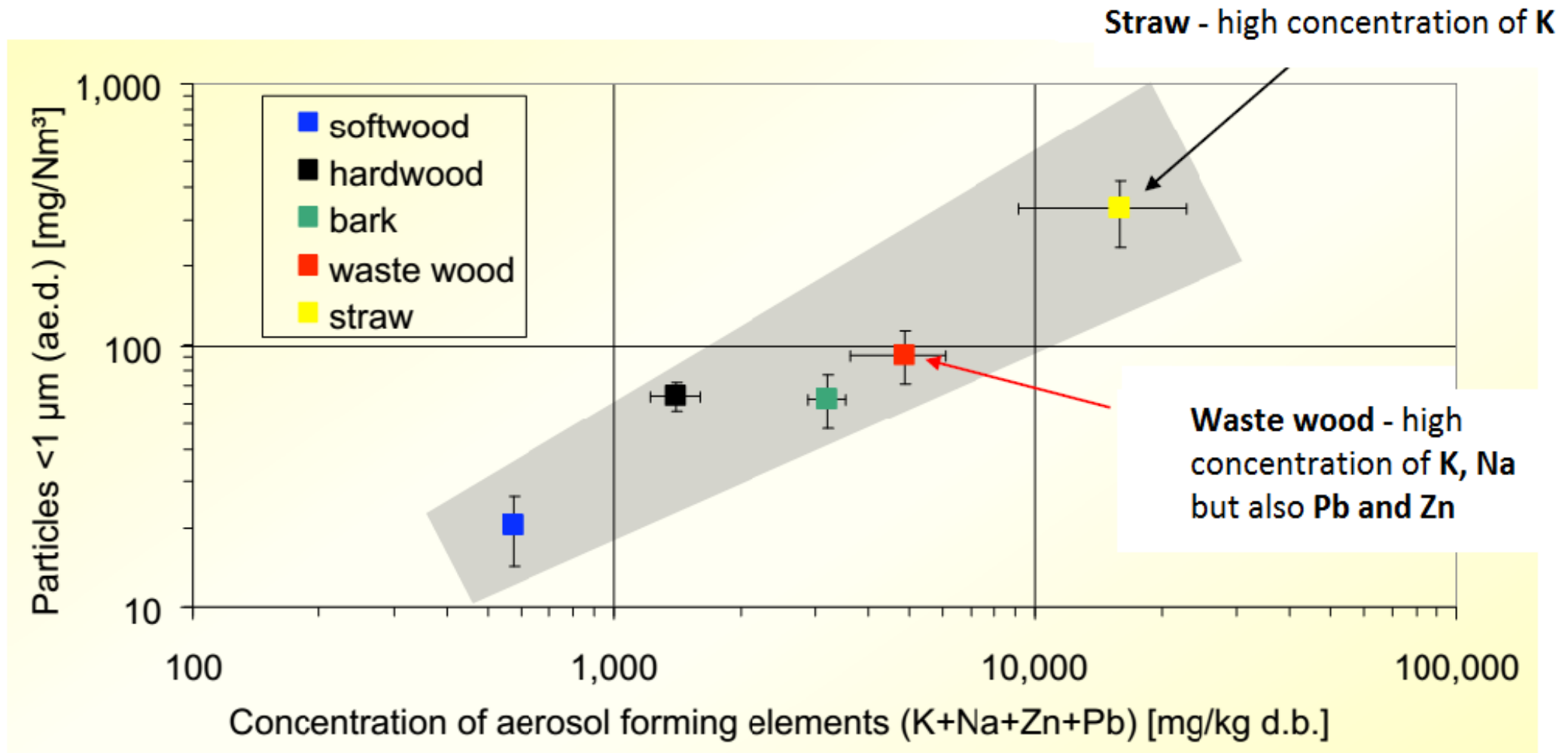


Data related to dry flue gas and 13 vol.% O_2 ; results from grate-fired combustion systems

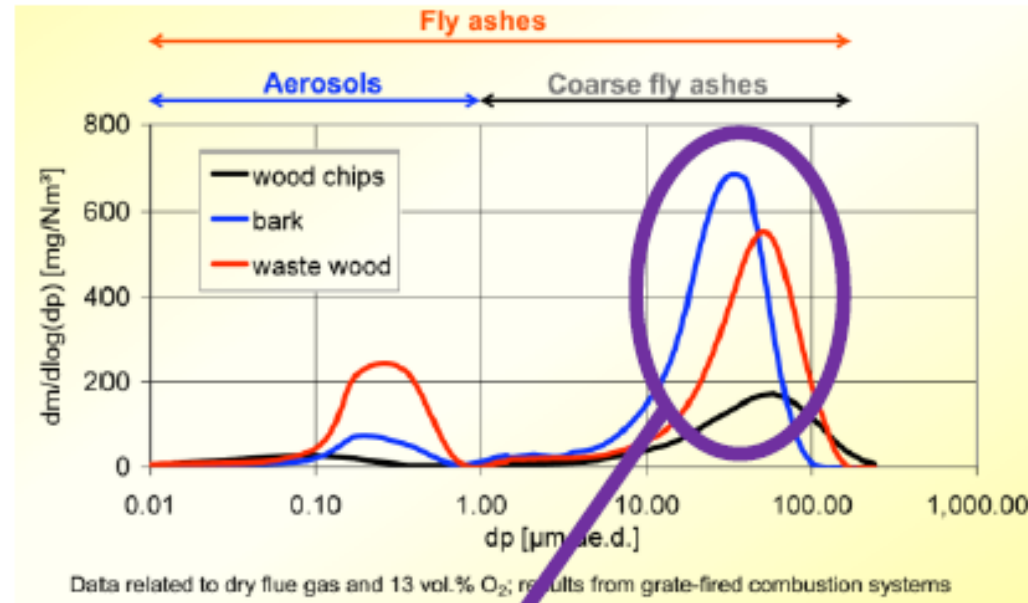
Composition of particles (PM < 1µm)



Amount of aerosol in relation to biomass composition



Composition of particles (PM > 5 μ m)

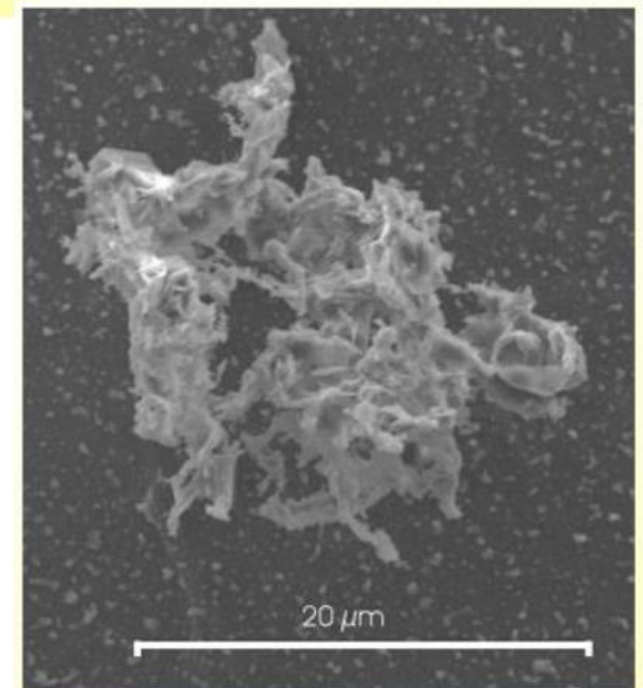
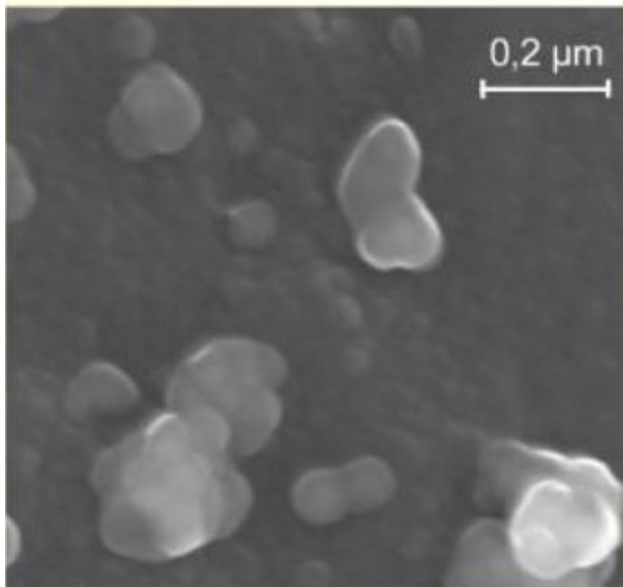
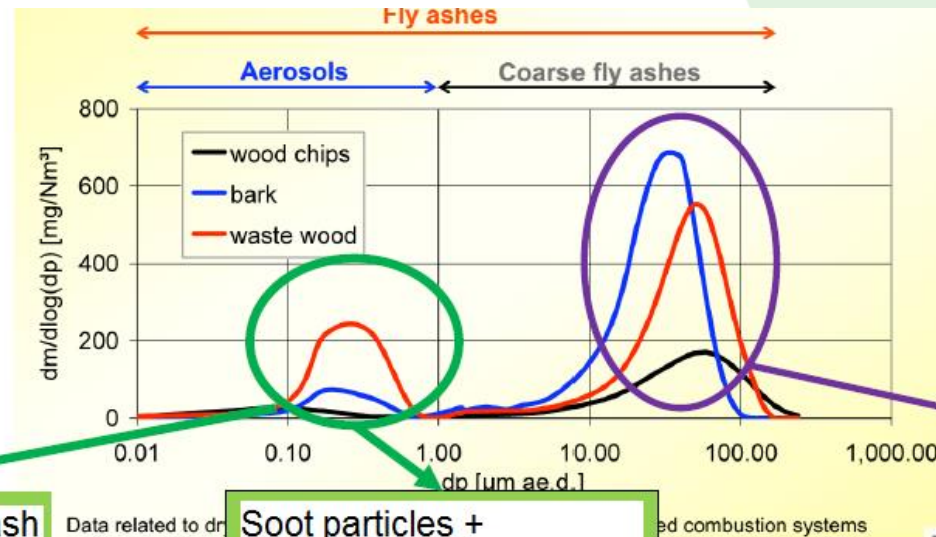


Ca, Si, Mg, P, Fe, Mn, Al, ..

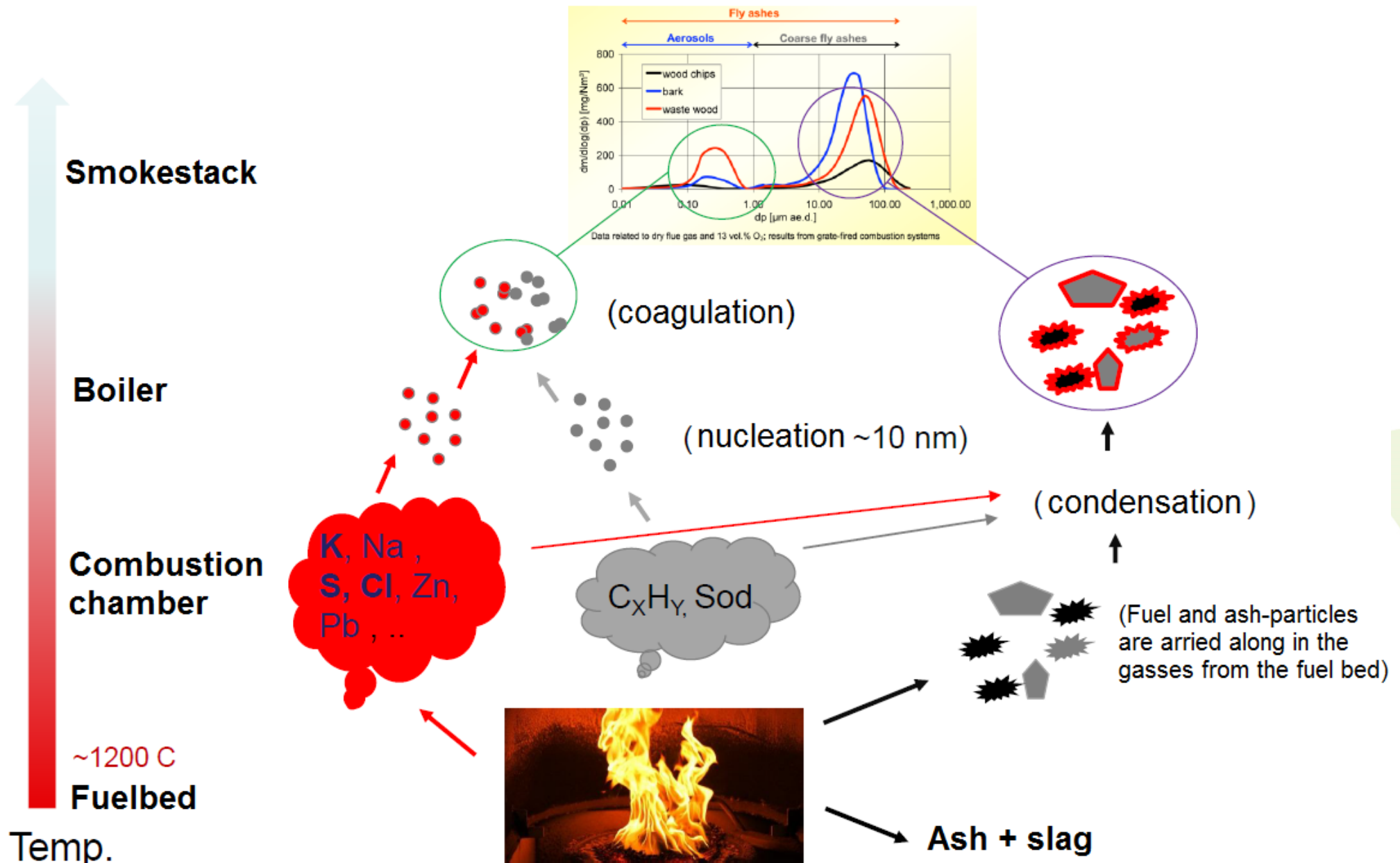
K, Cl, S, Na...

uncombusted C

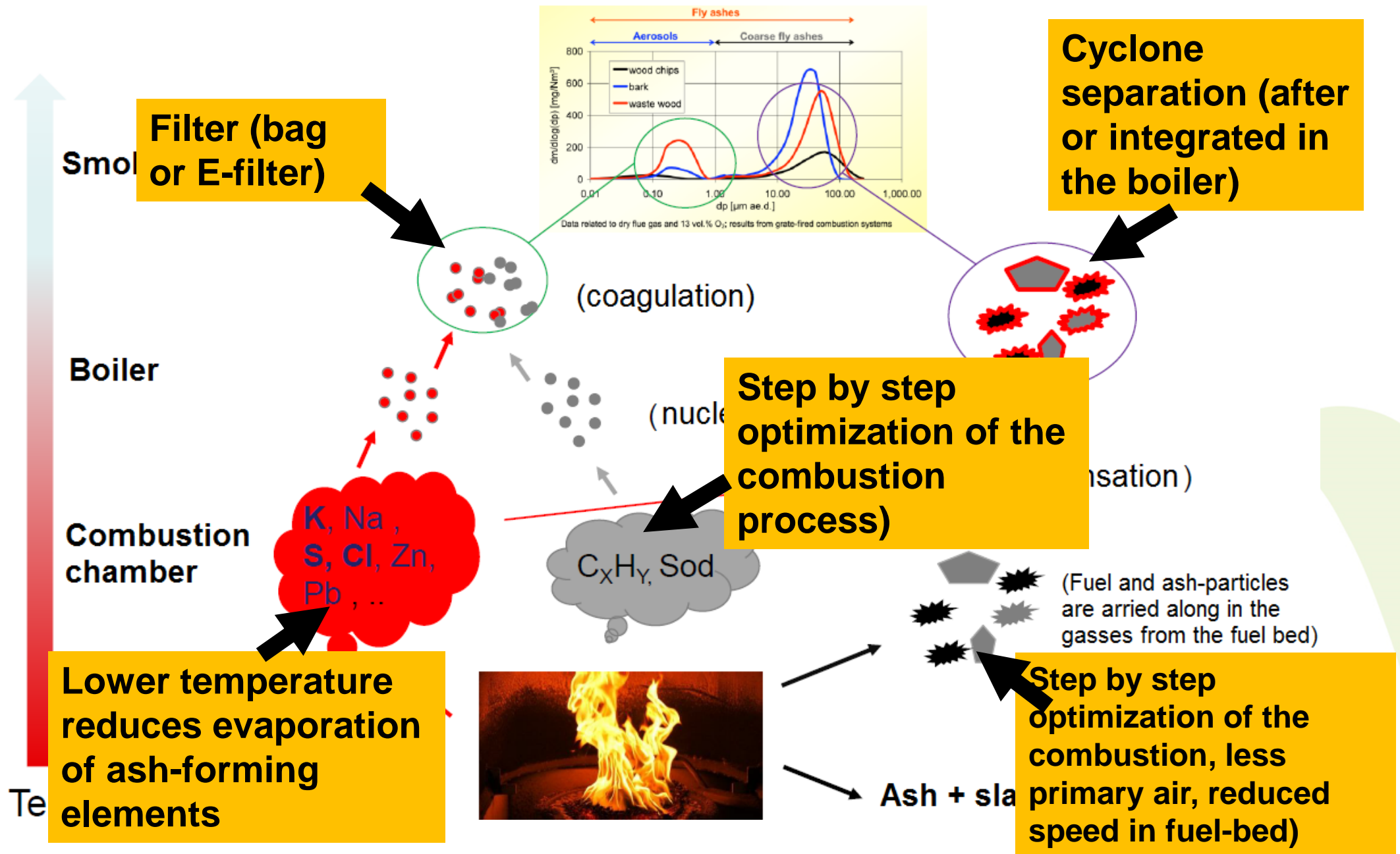
Composition of particles (PM > 5 μ m)



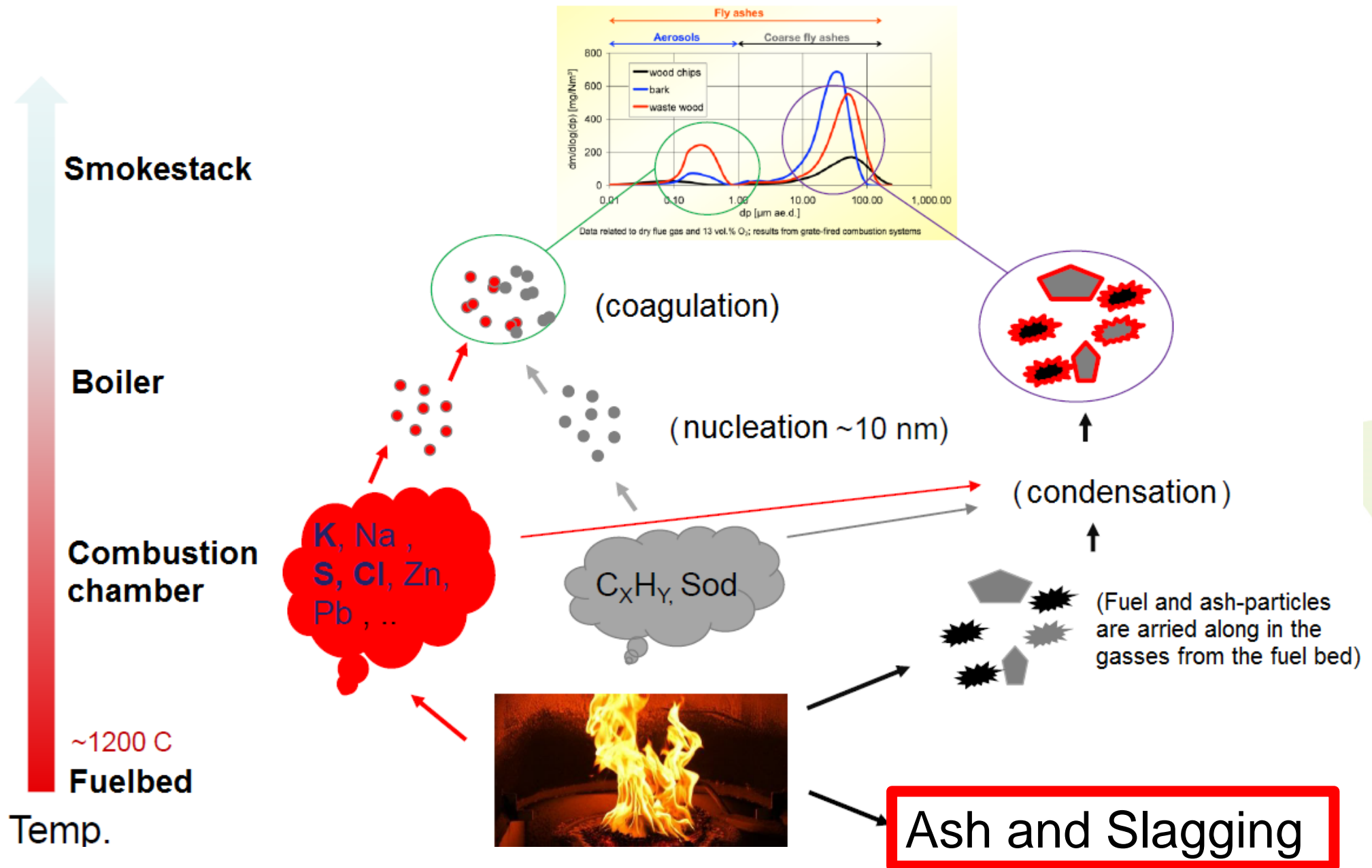
Principles of ash formation in biomass-boilers



Possibilities to reduce PM emissions



Principles of ash formation in biomass-boilers



Ash and slagging



Slag characterization

Slag = molten ashes



Light sintered

crushable

non-crushable

Glas



Standard analysis for ash melting temperature

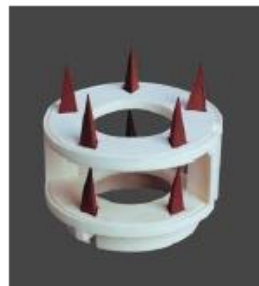
– The ash fusion test



300 g ,
milled (< 2mm)

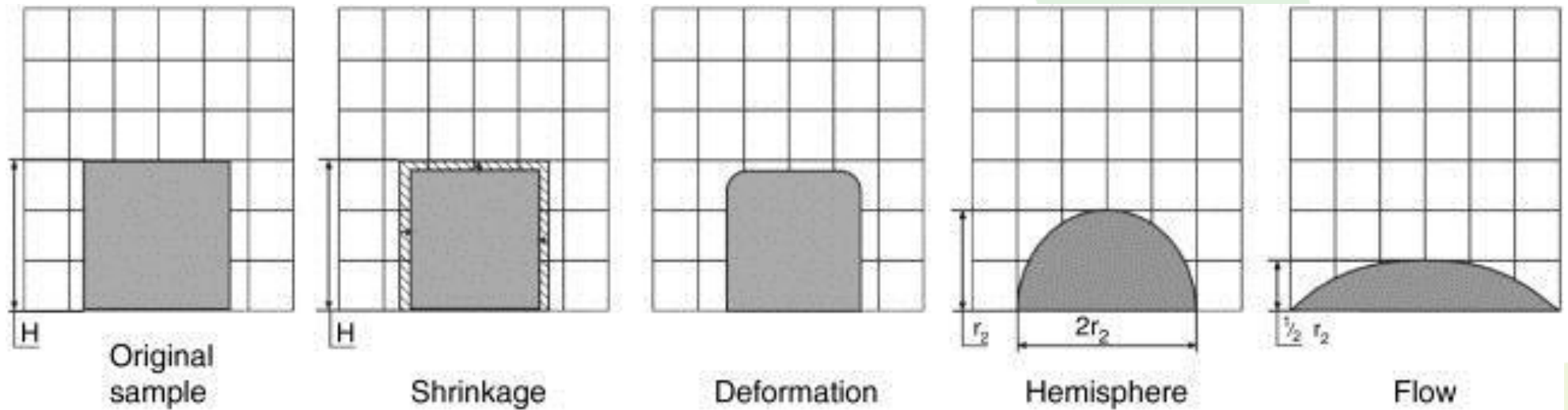


T = 550 eller 830 C,
over natt (~8h)



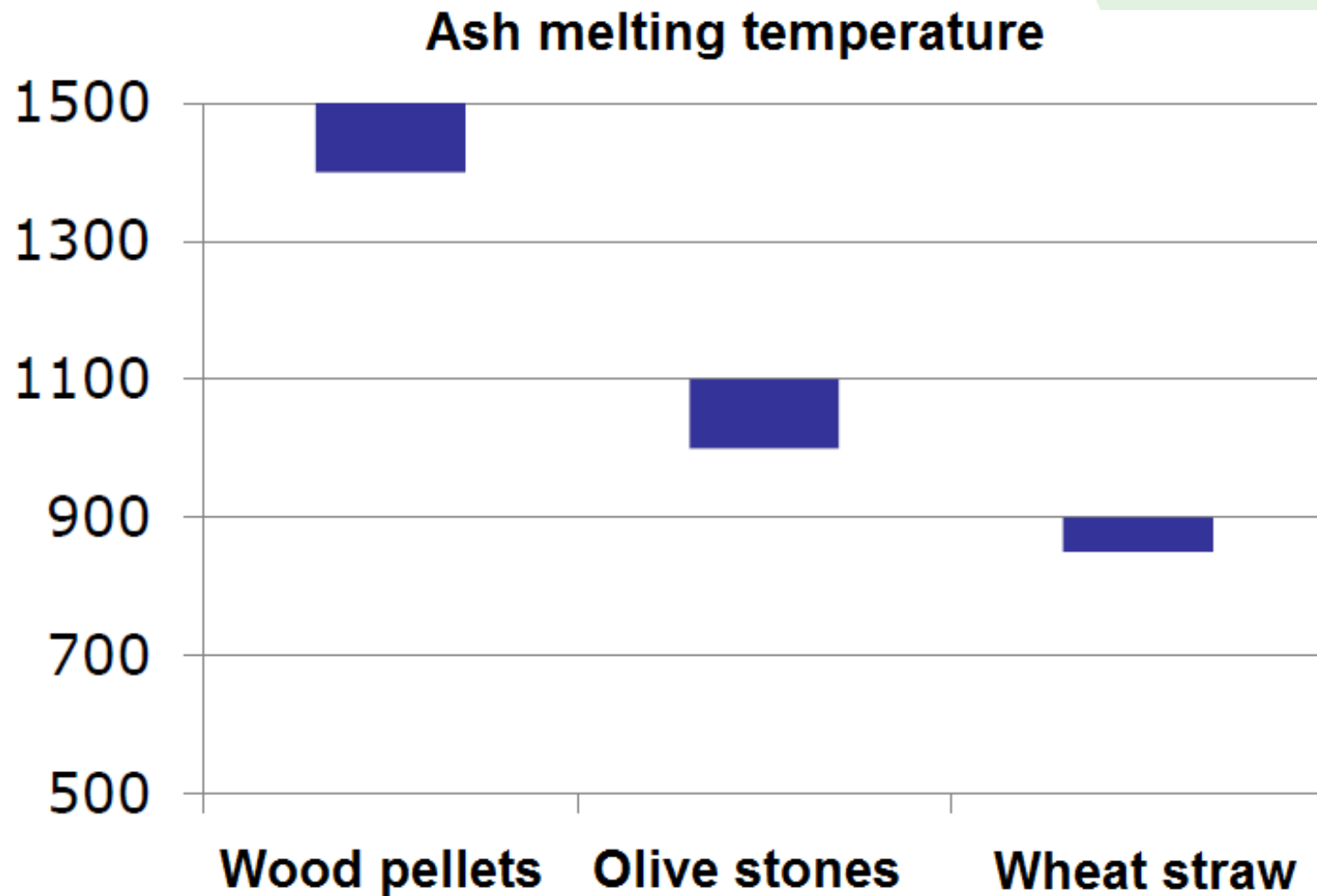
T = 100 => 1600 C,
4 h + cool = ~8 h

At what temperature does ash melt



Increasing Temperature

Differences between biomass types

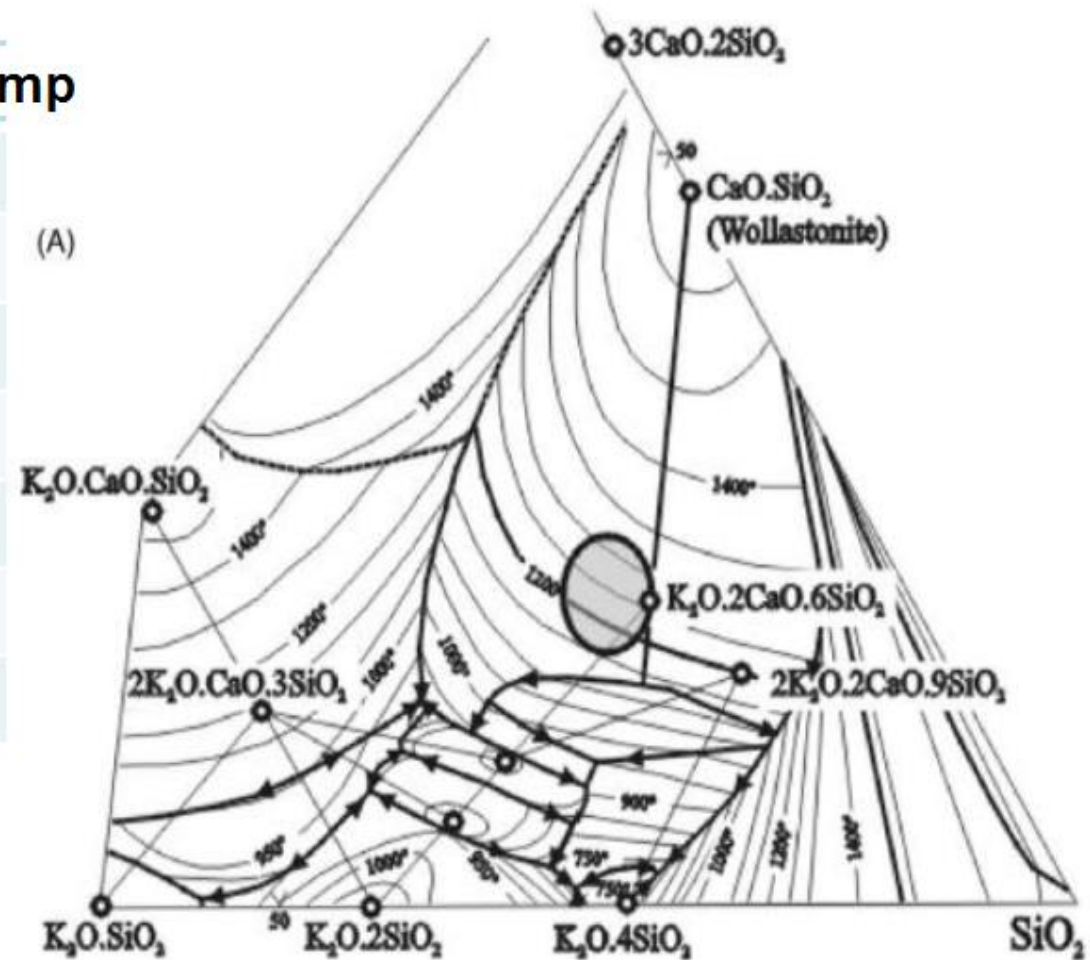


Different ash composition → different melting point

What is the reason for different melting temperatures

	Wood	Straw	Coal	Melting Temp
SiO₂	17	56	53	↓
CaO	26	13	5	↑
K₂O	11	16	0,4	↓
Na ₂ O	1	2	0,5	↓
MgO	5	3	2	↑
Al ₂ O ₃	5	4	29	↑
Fe ₂ O ₃	1	2	4	

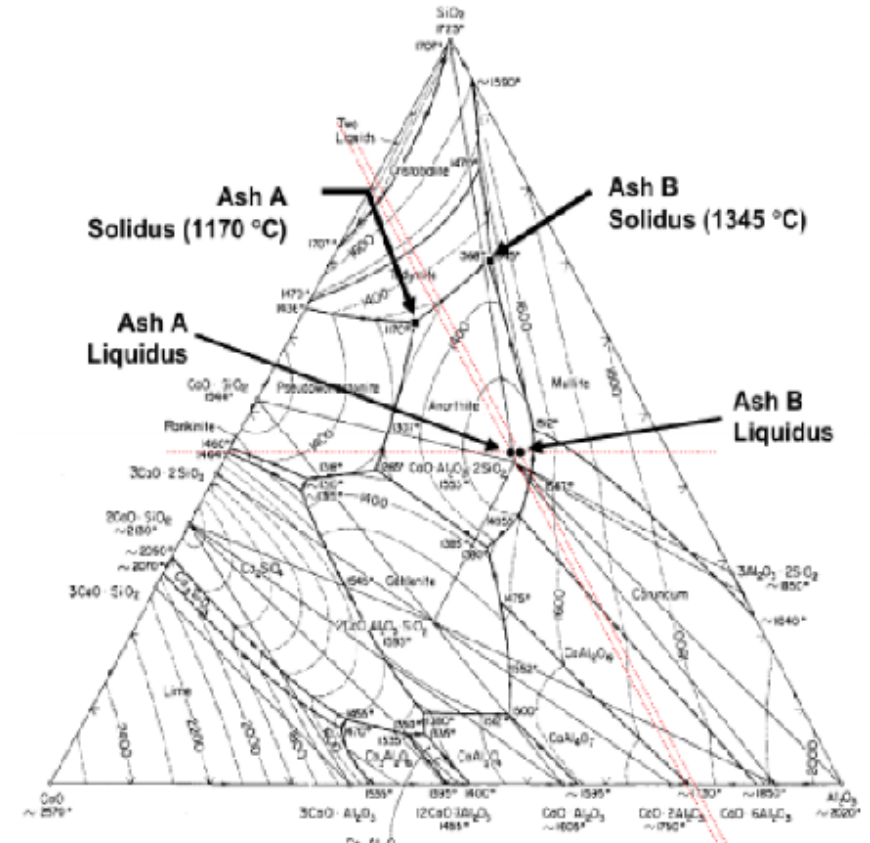
*Ash composition in %



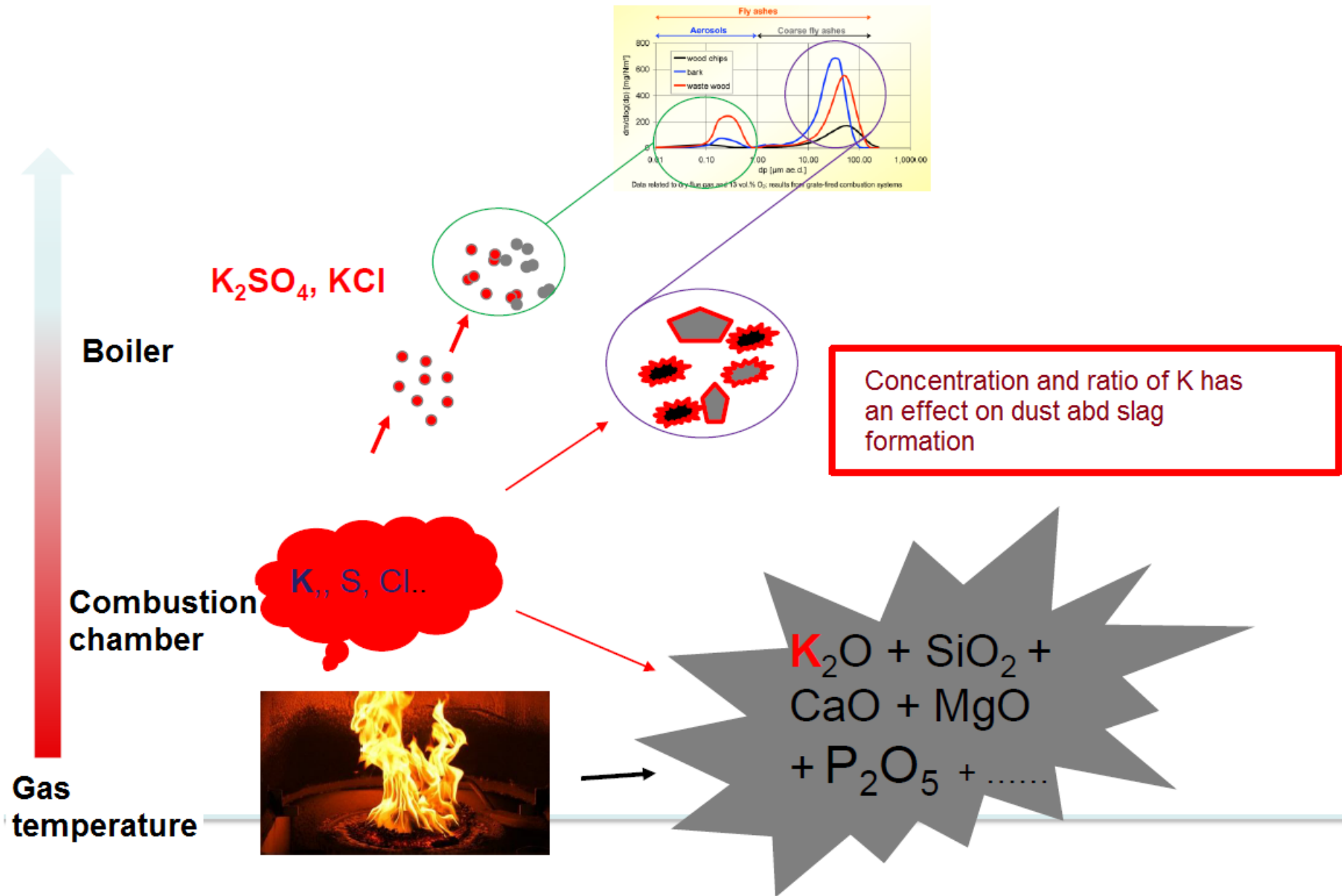
What is the reason for different melting temperatures

	Wood	Straw	Coal	Melting Temp
SiO ₂	17	56	53	↓
CaO	26	13	5	↑
K ₂ O	11	16	0,4	↓
Na ₂ O	1	2	0,5	↓
MgO	5	3	2	↑
Al₂O₃	5	4	29	↑
Fe ₂ O ₃	1	2	4	

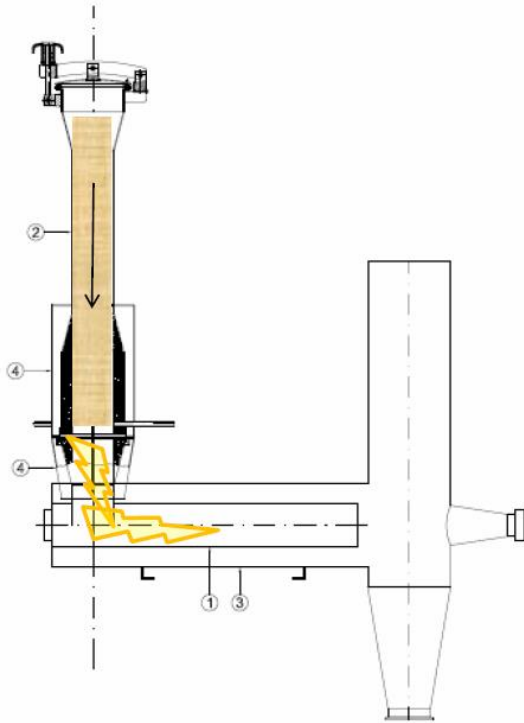
*Ash composition in %



Principles for ash-formation in biomass boilers



How to determine slagging of biomass fuels



Experimental analysis of slagging properties at DTI



References and further reading

- Obernberger et al. www.bios-bioenergy.at