Fly ash and aerosol formation in biomass combustion processes – an introduction

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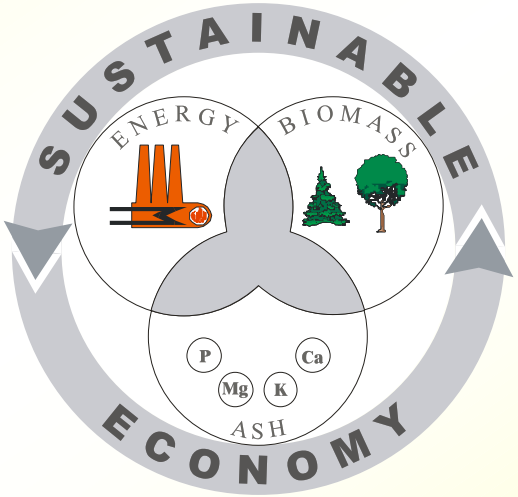

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Content

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  - **aerosols**
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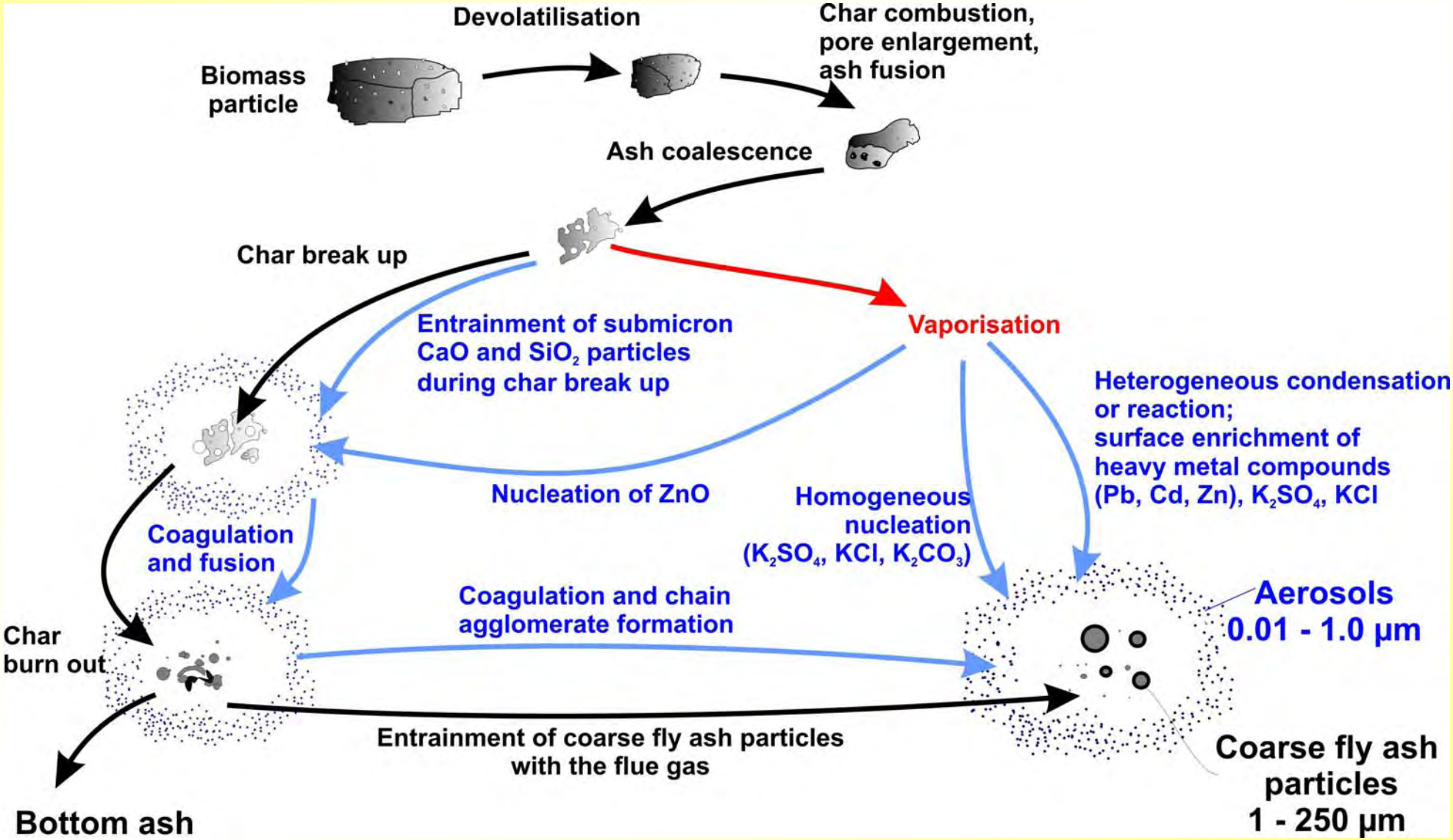
  - **prediction of aerosol formation**
  - **plant internal problems due to aerosols**
  - **aerosol emissions and health risks**

Ash formation

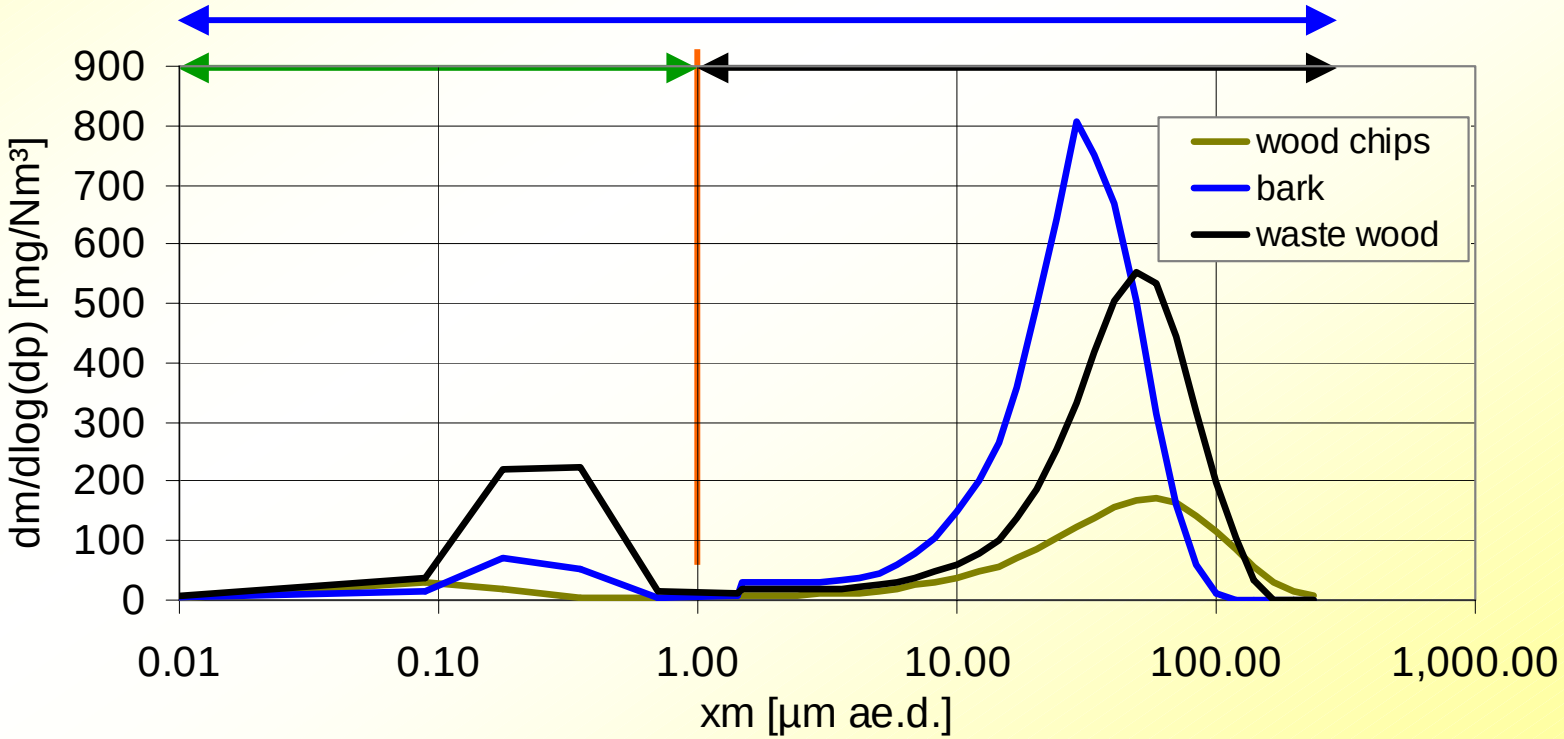


Nomenclature for particle emissions used within this presentation

aerosols — the particle fraction < 1 µm

coarse fly ash — particles > 1 µm

fly ash — total of aerosols and coarse fly ash



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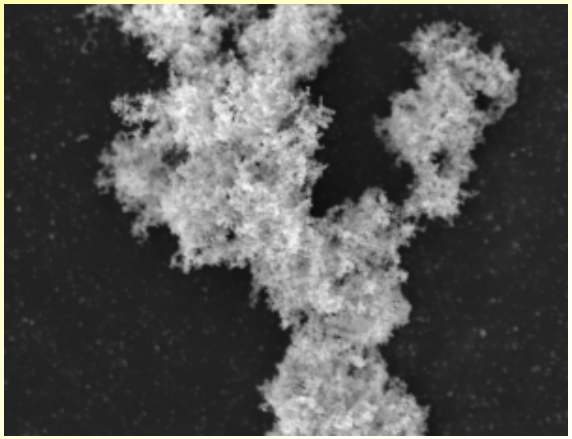
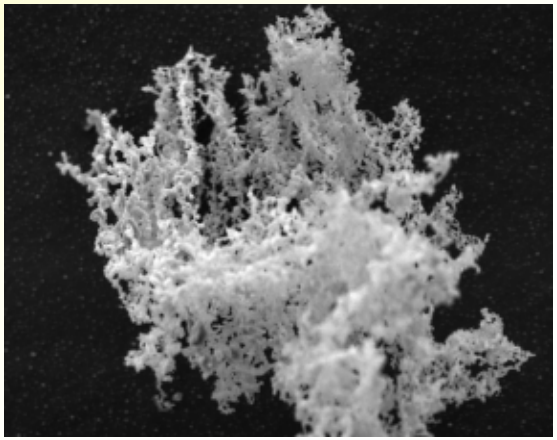
Coarse fly ashes – shape and chemical composition

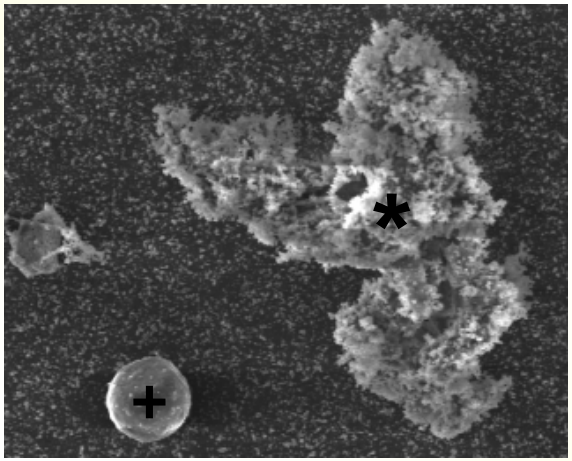
Spruce
(picture width: 20 µm)



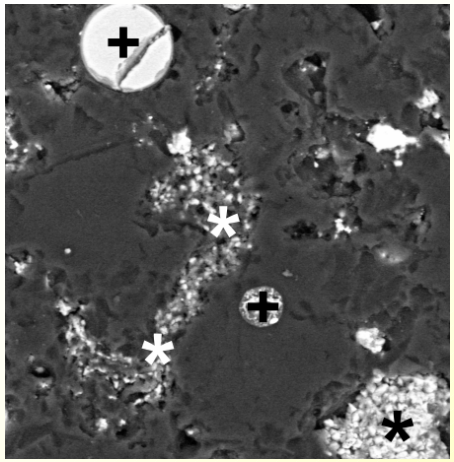
Beech
(picture width: 35 µm)



Bark
(picture width: 38.2 µm)



Waste wood
(picture width: 110 µm)



Spruce, beach, bark, waste wood (*):

- non volatile inorganic matrix of the biomass fuel, which has been left over after the release of the volatile compounds and a complete burnout of the charcoal
- the particles mainly consist of Ca, K and O as well as smaller amounts of Mg, P, S, Cl and heavy metals

Bark, waste wood (+)

- mineral impurities
- The particles mainly consist of Ca, Si, Mg, Al and O

Coarse fly ashes – summary

Formation

- **Entrainment of ash particles from the fuel bed with the flue gas**

Characteristics

- **particle size: up to 250 µm (ae.d.) with a peak at 30 - 70 µm (ae.d.)**
- **concentration: from about 100 mg/Nm³ up to 1,000 mg/Nm³**
- **chemical composition: Ca, Si, Mg and K are the main ash matrix elements**

Parameters influencing coarse fly ash formation

- **the characteristics of the fuel used**
- **combustion technology** (fixed bed, fluidised bed, entrained flow)
- **load of the combustion unit**
- **conditions in the fuel bed**
  (combustion air distribution over the fuel bed, distribution of fuel over the grate)

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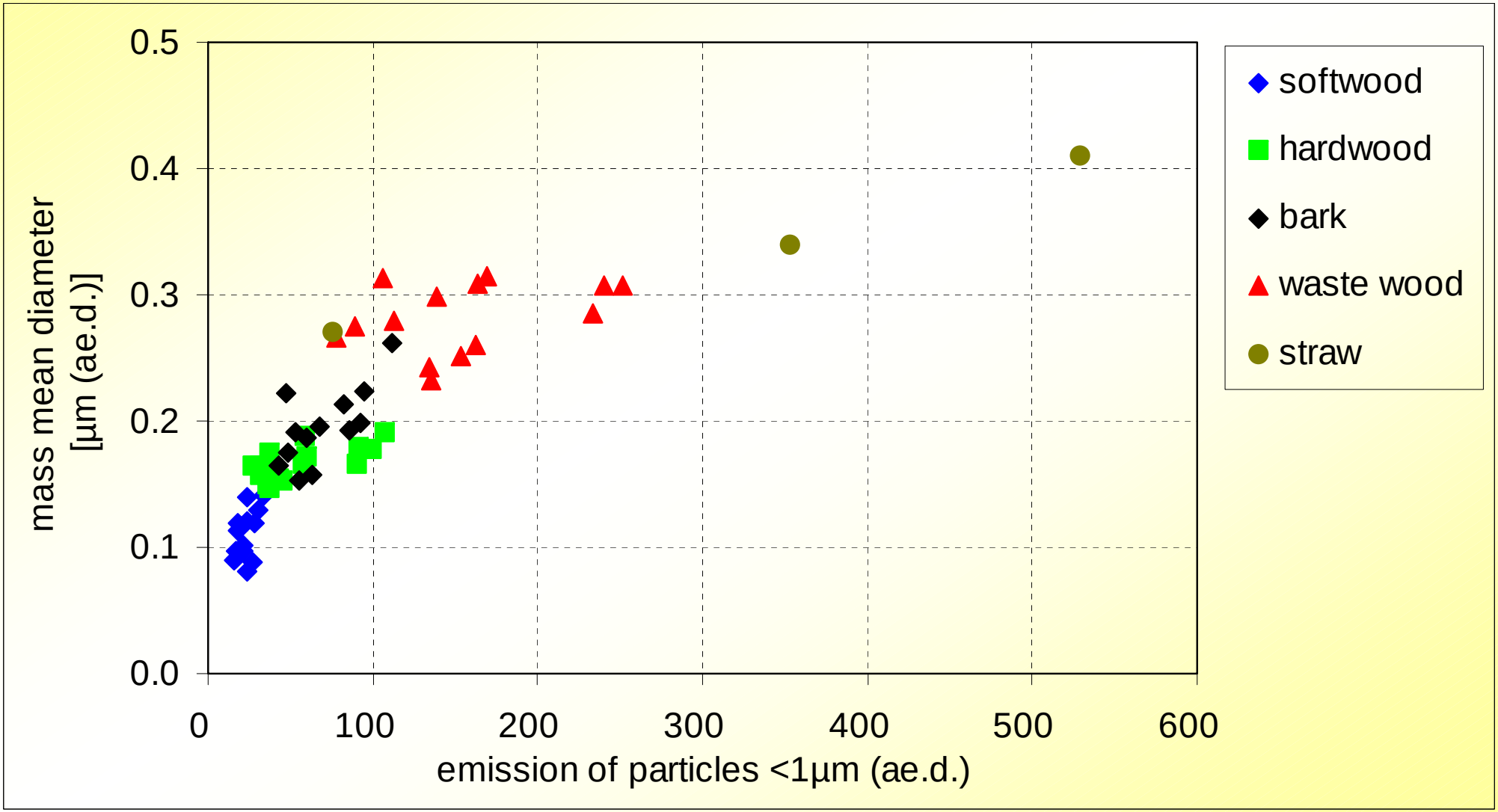
Aerosols – mass mean diameter vs. emissions



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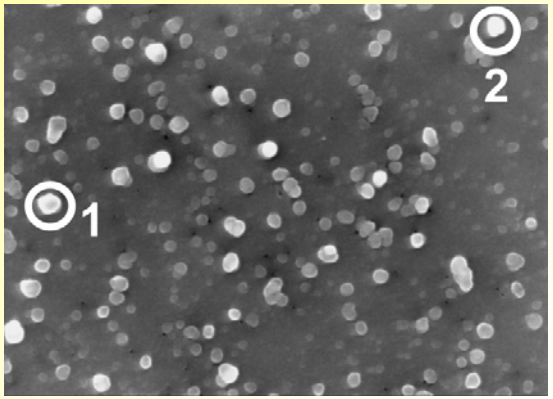
Aerosols – shape and chemical composition

Softwood (spruce)

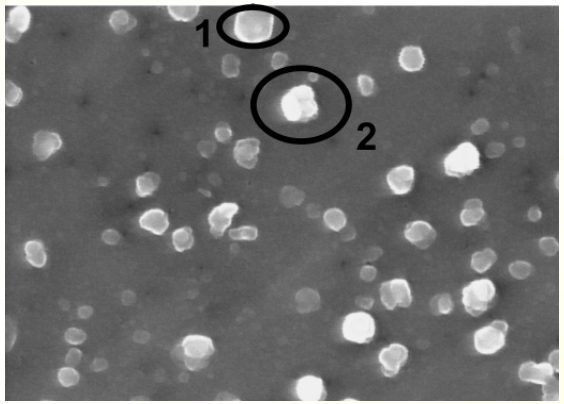
(picture width: 4 µm)



	1	2
	atom%	
K	28.5	27.1
Na	2.7	7.6
S	9.0	9.2
Cl	1.6	5.4
Zn	7.3	2.8
O	50.4	47.8

Hardwood (beech)

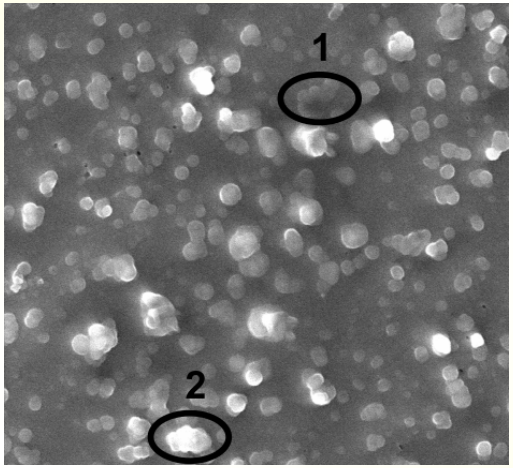
(picture width: 2.9 µm)



	1	2
	atom%	
K	34.6	38.9
Na	1.5	5.1
S	9.7	5.7
Cl	5.7	8.8
O	47.8	40.3

Bark

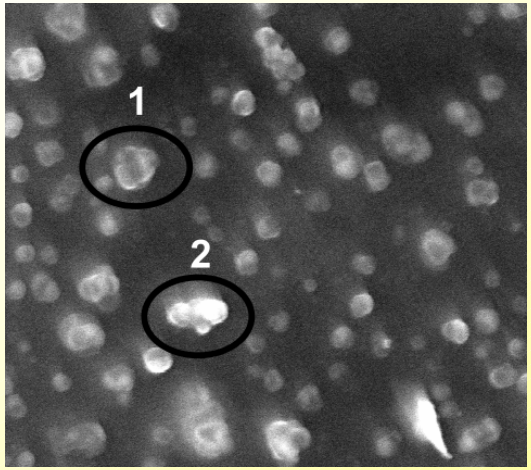
(picture width: 4 µm)



	1	2
	atom%	
K	27.3	37.1
S	8.7	4.7
Cl	18.1	34.5
Zn	3.4	2.4
Ca	1.3	0.0
O	40.7	21.3

Waste wood

(picture width: 2 µm)



	1	2
	atom%	
K	8.7	13.1
Na	4.4	0.0
S	0.0	3.2
Cl	36.6	44.6
Zn	12.6	10.4
Pb	25.2	6.5
O	12.6	22.5

Aerosols – summary

Formation

- **Release of volatile ash forming compounds from the fuel followed by nucleation and condensation of ash vapours and subsequent coagulation of particles**

Characteristics

- **particle size: <1 µm**
- **concentrations: 20 - 50 mg/Nm³ (softwood)**
  50 - 100 mg/Nm³ (hardwood and bark)
  >100 mg/Nm³ (straw, waste wood)
- **chemical composition: K, S, Cl, Na, Zn and Pb are the main constituents**

Parameters influencing aerosol formation

- **The amount of aerosols formed as well as their chemical composition mainly depend on the chemical composition of the biomass fuel used**

Relevant aerosol related topics – prediction of aerosol formation

- Appropriate simulation models to describe vapour to solid conversion already exist
- However, the release behaviour of aerosol forming compounds as well as the governing mechanisms behind are not well known yet
- Models and secured data concerning this release behaviour represent the basis for a correct prediction of aerosol formation based on mathematical modelling
- Therefore, additional research in this field is urgently needed to increase the preciseness of aerosol formation prediction tools

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Relevant aerosol related topics – Plant internal problems due to aerosols

- Aerosols from biomass combustion contain high amounts of alkali metals, S, Cl as well as varying amounts of heavy metals
- These elements and their respective compounds have comparatively low melting points
- Therefore, aerosols may influence the melting behaviour of ashes and therefore substantially contribute to deposit formation problems
- For fuels like straw and waste wood, the high Cl-content of the aerosols may additionally cause corrosion problems

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Relevant aerosol related topics – aerosol emissions and health risks

- **Aerosol precipitation demands for highly sophisticated and therefore costly technologies such as ESPs and baghouse filters**
- **Especially for small-scale combustion units appropriate low-cost aerosol precipitation devices are needed but not yet commercially available**
- **No standard procedures for aerosol characterisation are available**
- **The impact of particulates on the human organism increases with decreasing particle size**
- **Consequently, aerosol fractions are predestined to contribute to health risks**
- **However, actually only few information about the health risks of aerosols from biomass combustion compared with fine particulate emissions from other sources is available**