Role of aerosol particles as condensation and ice nuclei in tropospheric clouds

(Aerosol-Cloud Interactions VI-ACI)

VI-ACI 2nd annual meeting

27./28. April 2009

LACIS-mobile and DMT-CCNC

Results from IN-11 and ACI-02

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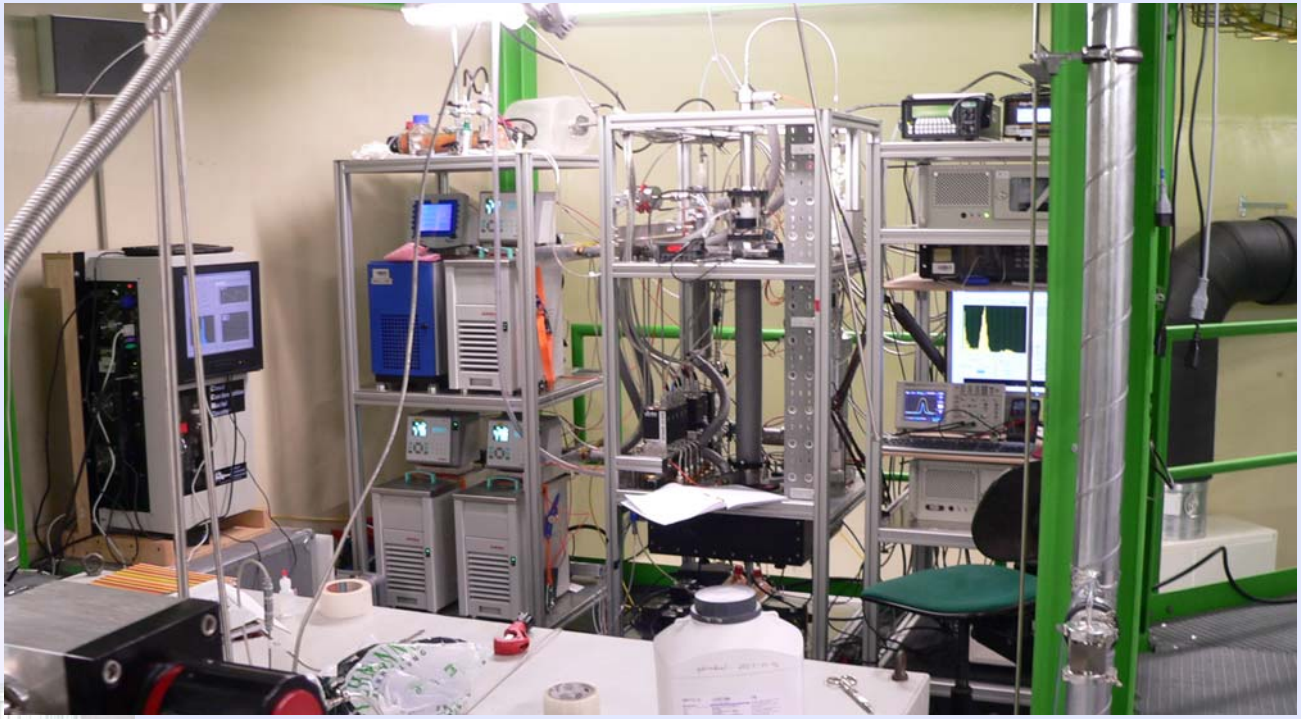
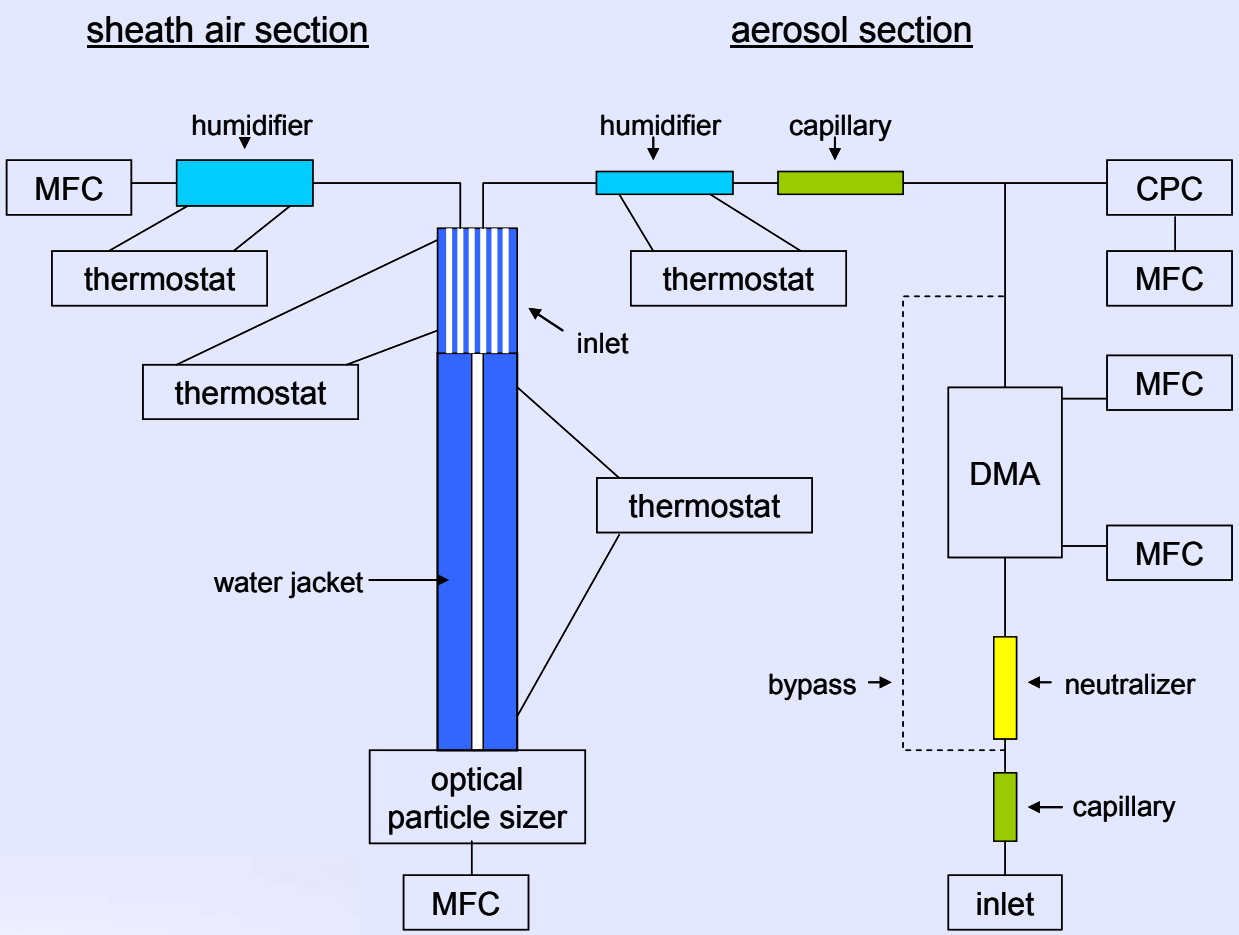
Work packages

- L2A - Achievement of CCN closure for selected aerosol systems and provision of validated microphysical models / expressions and parameterizations
- M1C - Validated microphysical models, expressions and parameterizations regarding CCN activation for selected aerosol systems

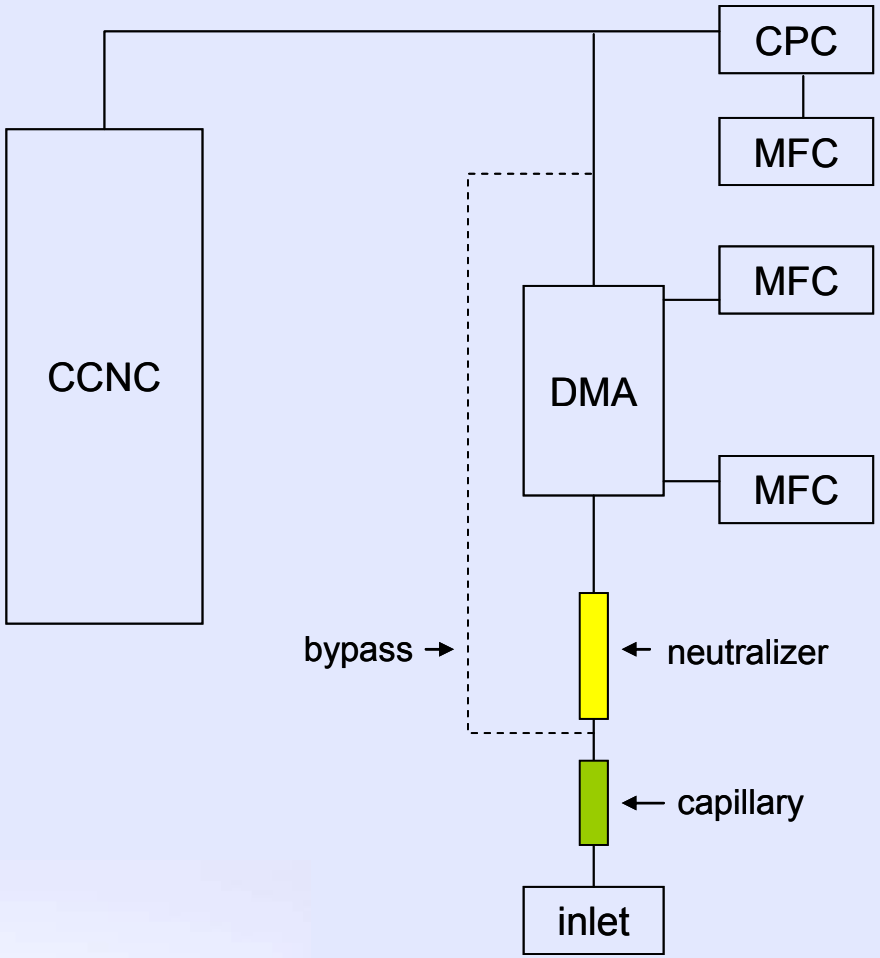


Set-up LACIS-mobile



- RH: up to 99.3%
- particle size: 200nm @ n=1.59
- measurement: at constant dry particle diameter varied relative humidity

Set-up DMT-CCNC

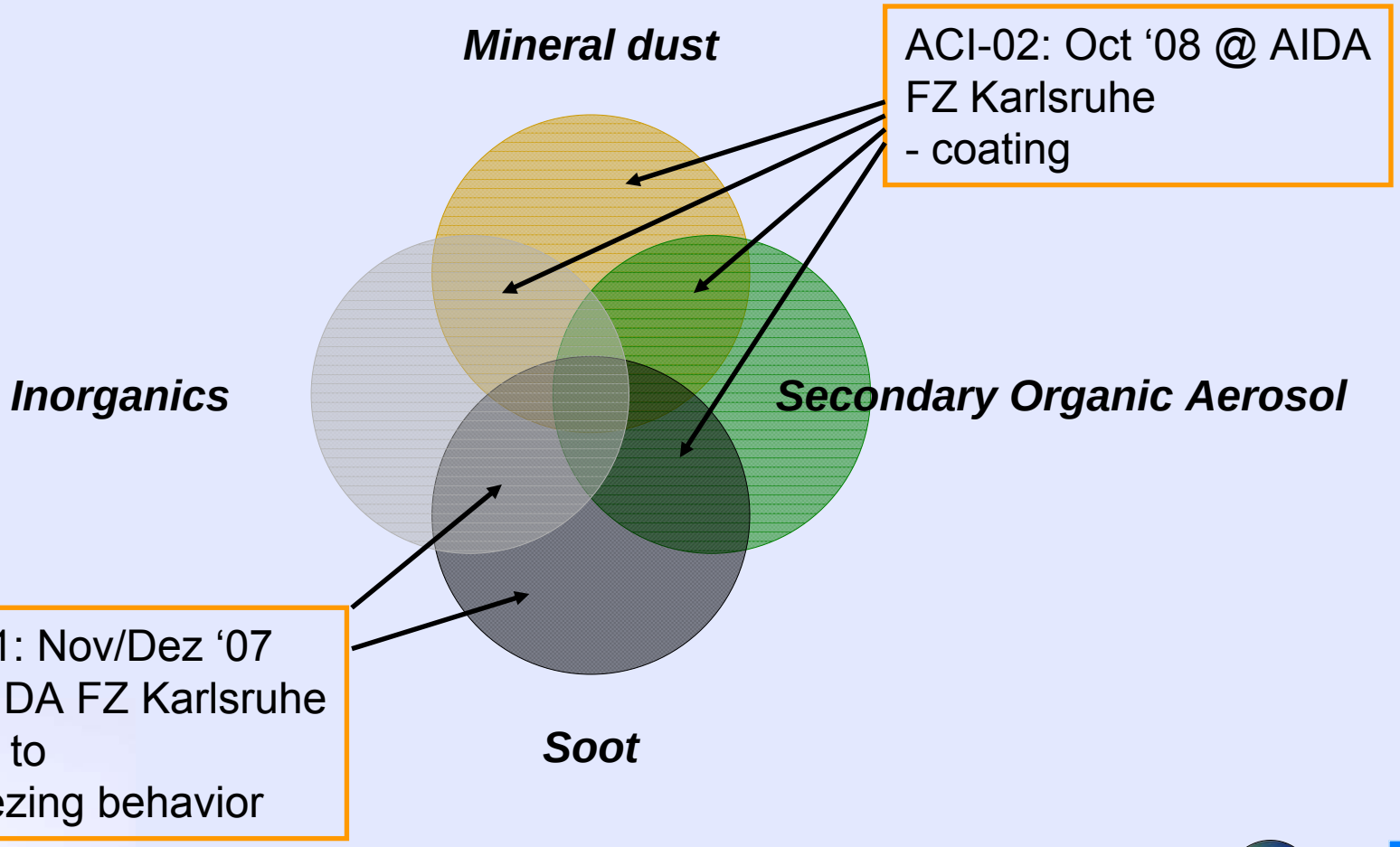


- Supersaturation range: 0.07% - 1.1%

- measurements:

  diameter scans and saturation scans

Investigated aerosol types – IN-11 & ACI-02



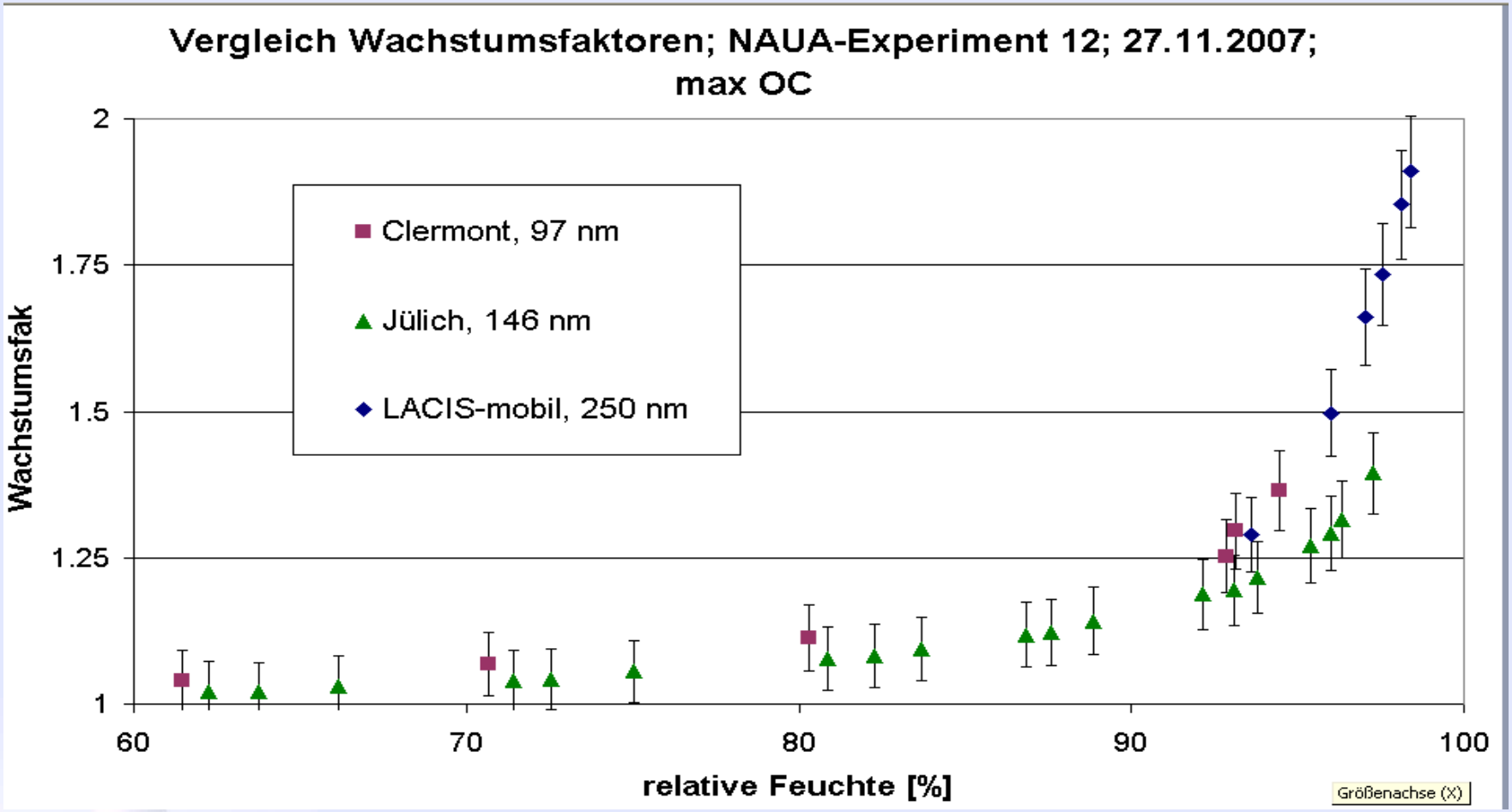
IN-11

Results

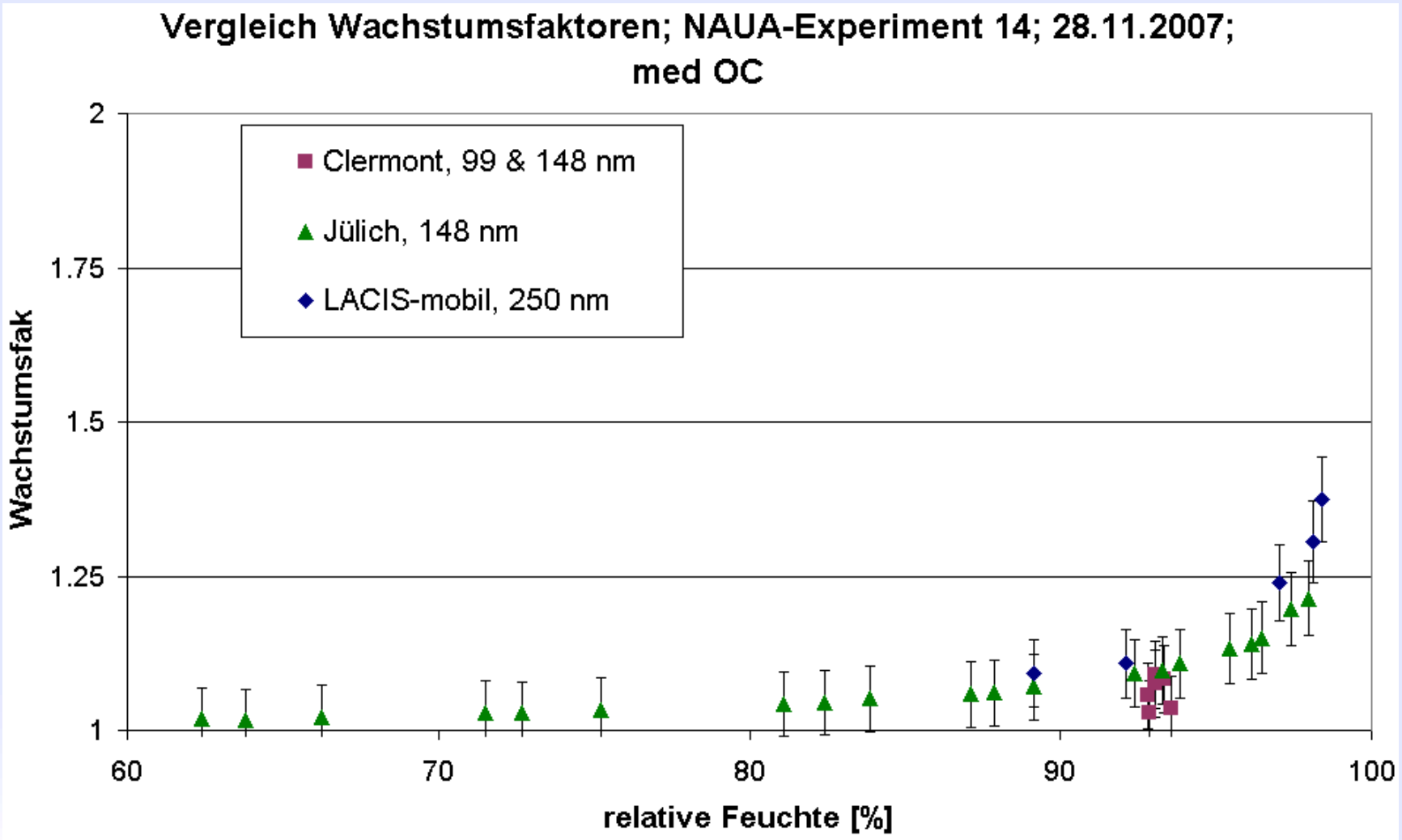
Summary IN-11

Soot type	Hygroscopic growth	Activation
GFG Ar	✓	✓
GFG N_2	o	o
GFG + succinic	✓	o nf
GFG + oxalic	o	o
CAST	✓	o
CAST + succinic	✓	o nf
CAST + sulfuric	✓	✓

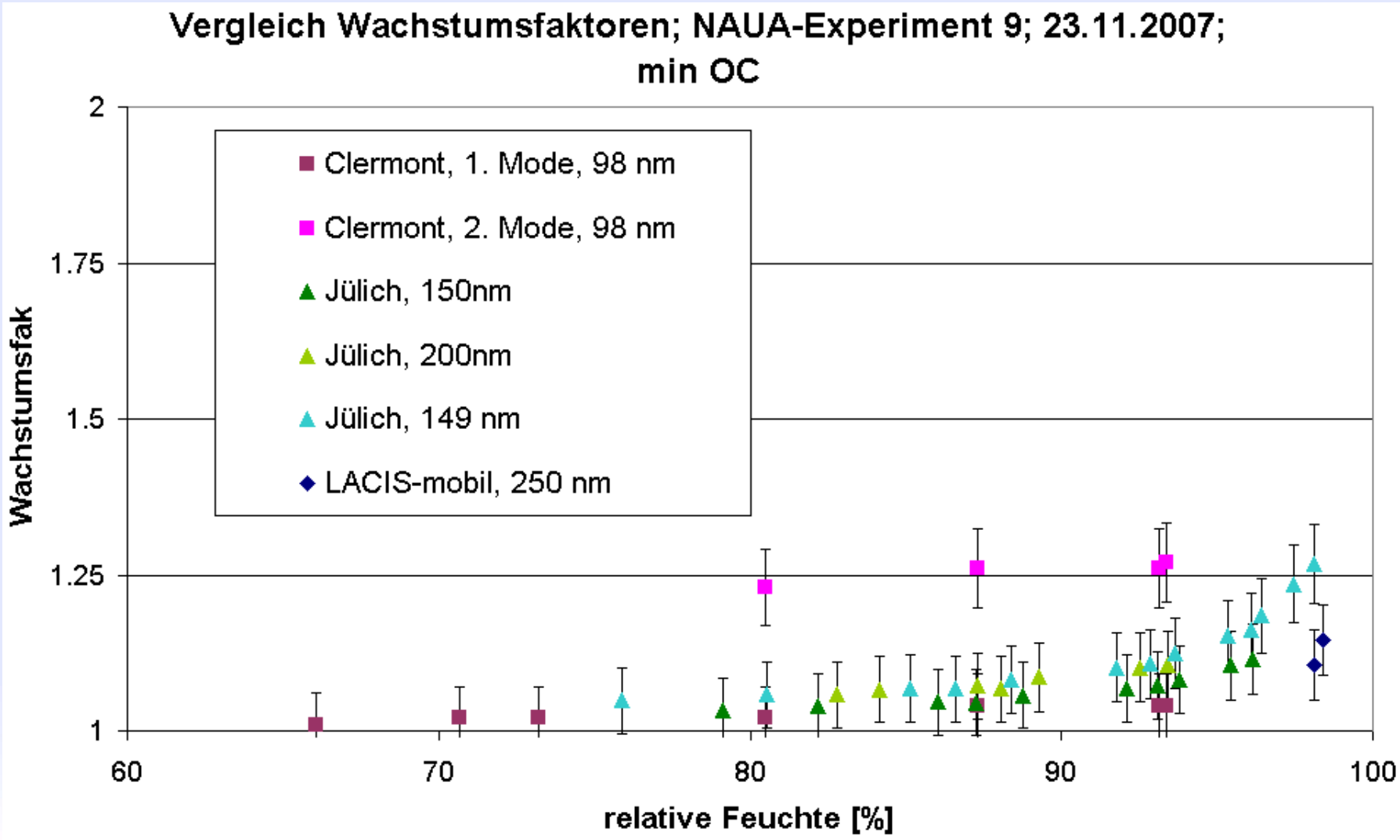
Growth factor Max OC



Growth factor Med OC

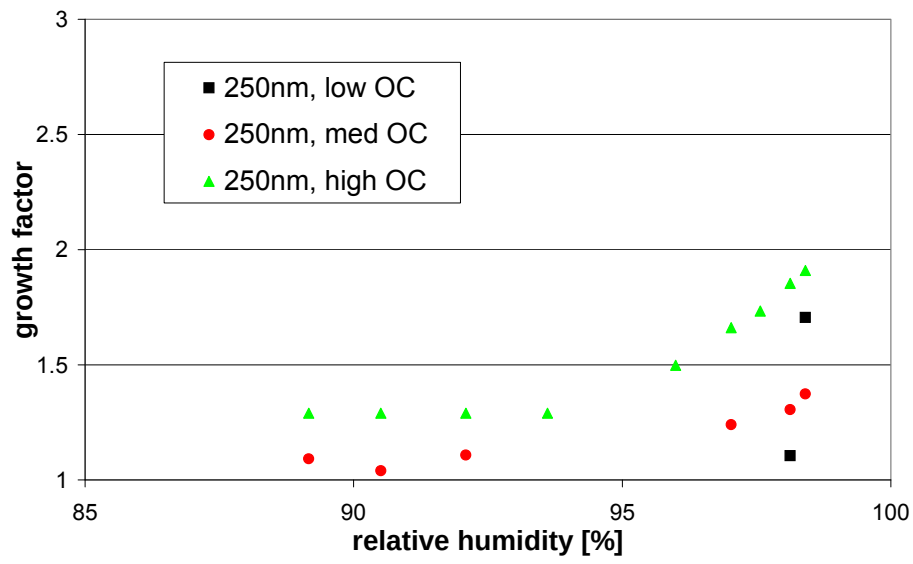


Growth factor Min OC

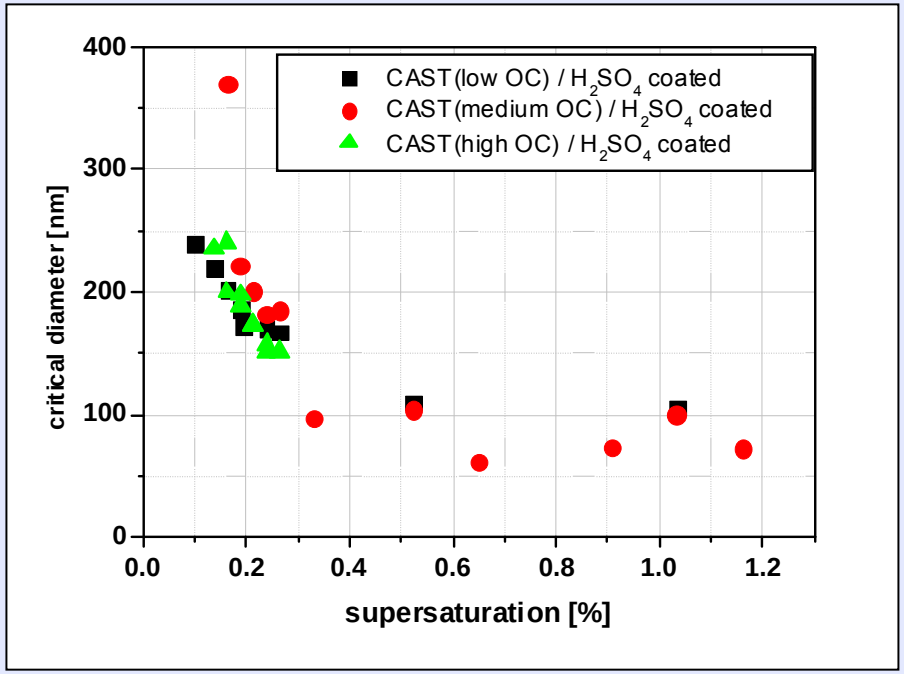


CAST-soot coated with sulfuric acid

hygroscopic growth



activation

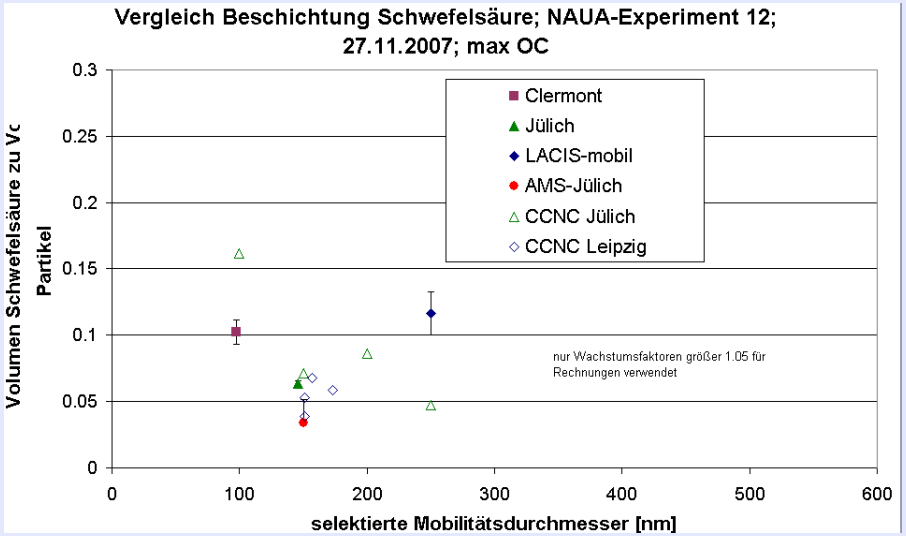


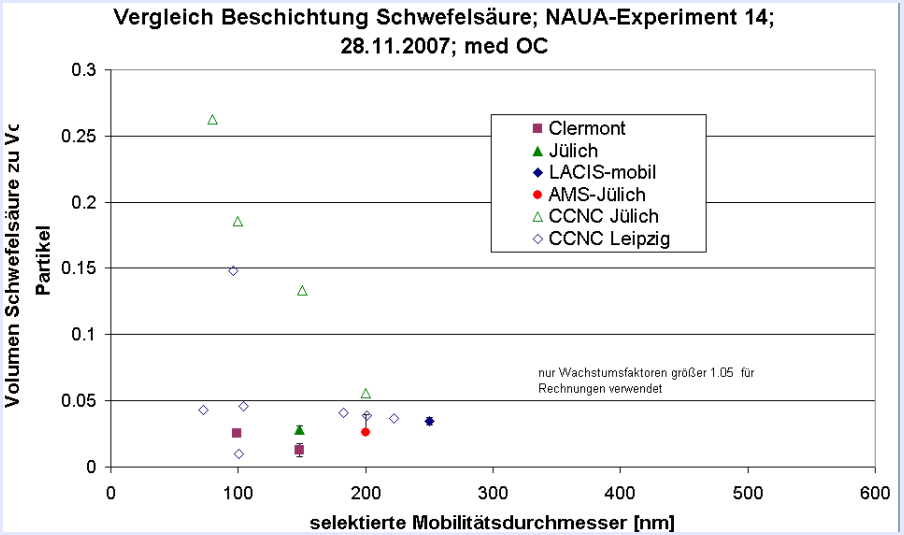
- hygroscopic growth increase with increasing OC-content
- activation independent from OC-content

Possible explanations for observations

CAST-soot coated with sulfuric acid

(1) Does coating thickness of sulfuric acid dictate hygroscopic behavior?

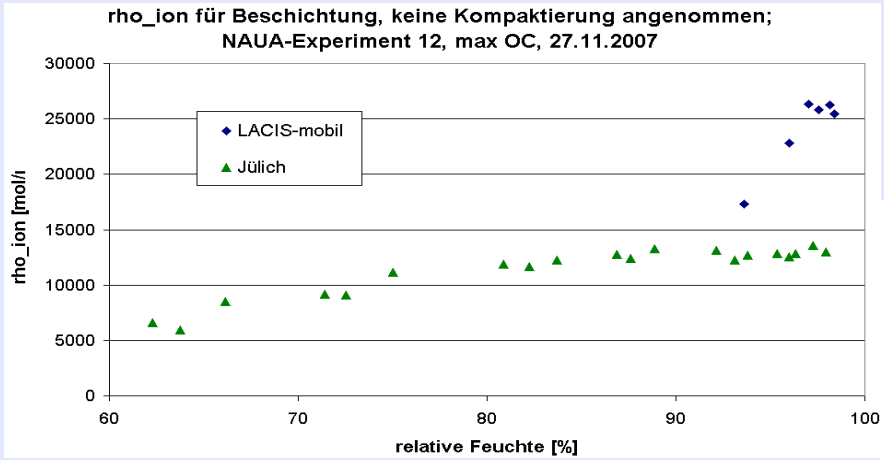


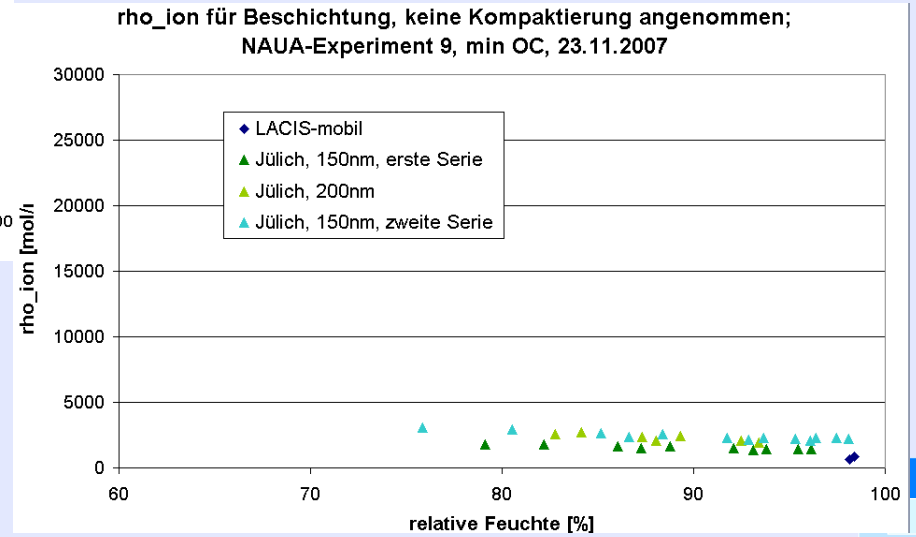


Possible explanations for observations

CAST-soot coated with sulfuric acid

(2) Fraction of soluble OC and/or chemical composition of OC (low and medium OC-content ρion~2500 mol/m³, high OC-content ρion~26000 mol/m³)





Soot morphology

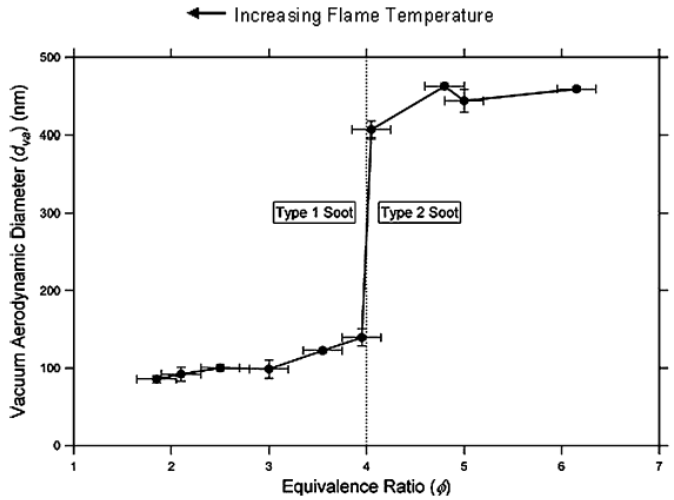


Figure 3. Vacuum aerodynamic diameter of $d_m = 350$ nm soot as a function of equivalence ratio. There is a sharp boundary between type 1 and type 2 soot, occurring at a equivalence ratio of about 4.0.

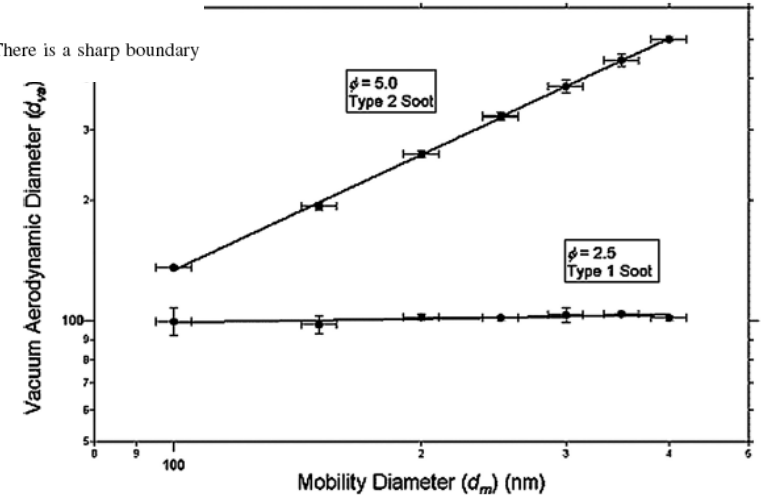


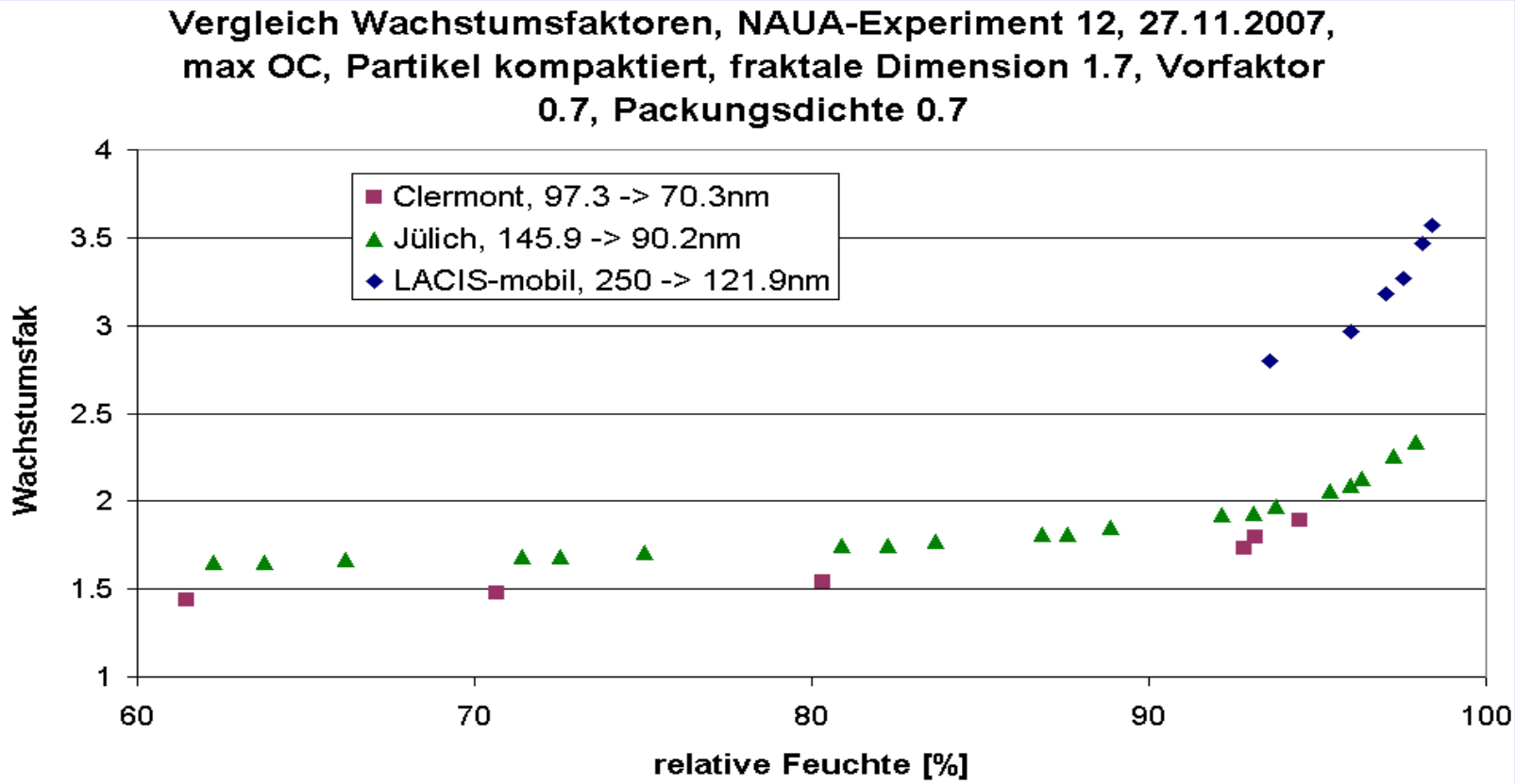
Figure 4. Vacuum aerodynamic diameter versus mobility diameter for two equivalence ratios. For $\phi = 2.5$ (type 1 soot), $d_{va} \sim 102$ nm regardless of d_m. For $\phi = 5.0$ (type 2 soot), $d_{va} = 1.3 \times d_m$.

Slowik et al. AST 2004

Possible explanations for observations

CAST-soot coated with sulfuric acid

(3) Fractal dimension of soot is the important fact and NOT the fraction of soluble material?



Possible explanations for observations

CAST-soot coated with sulfuric acid

(1) Does coating thickness of sulfuric acid dictate hygroscopic behavior?

(2) Fraction of soluble OC and/or chemical composition of OC (low and medium OC-content ρion~2500 mol/m³, high OC-content ρion~26000 mol/m³)

(3) Fractal dimension of soot is the important fact and NOT the fraction of soluble material?

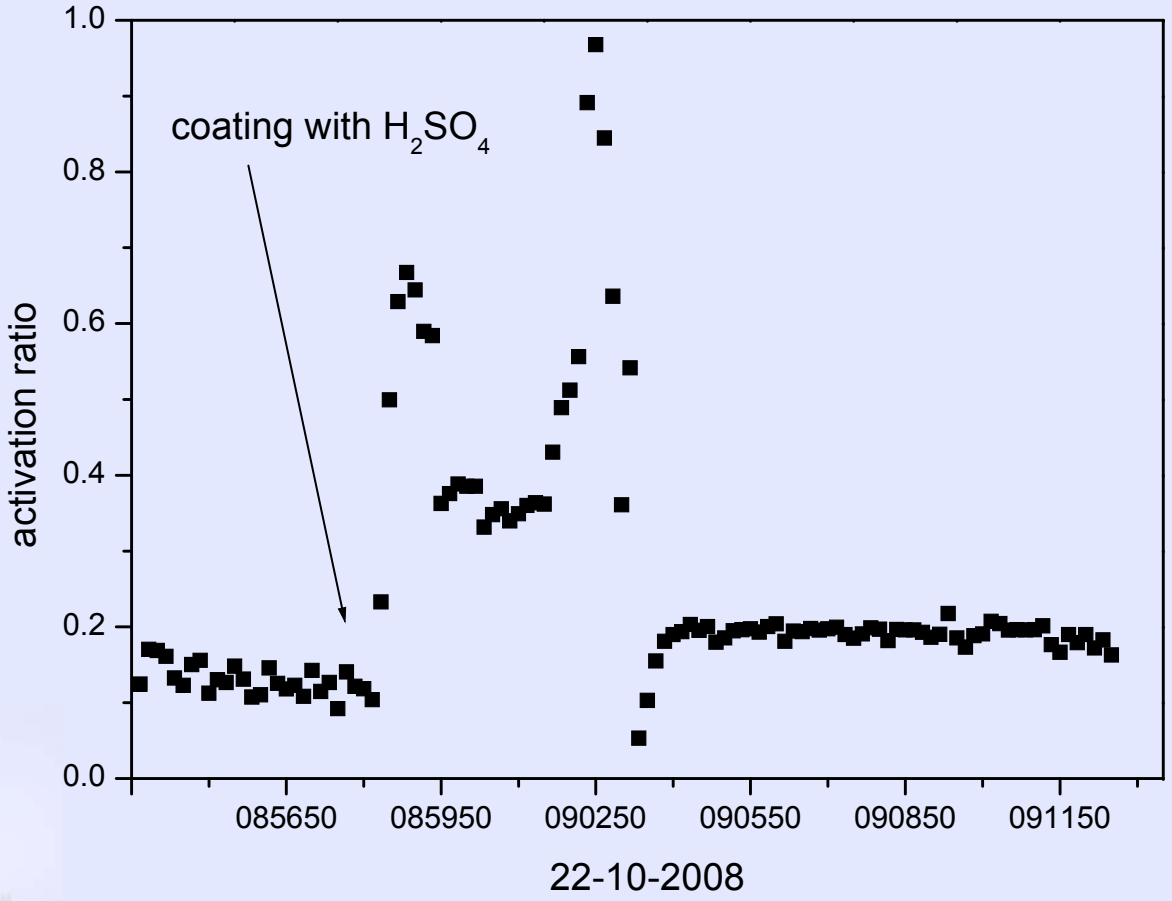
(4) Sulfuric acid might react with the OC on the soot surface to organo-sulfates

Analogies to SOA experiments → does something similar to SOA form @ soot surface?

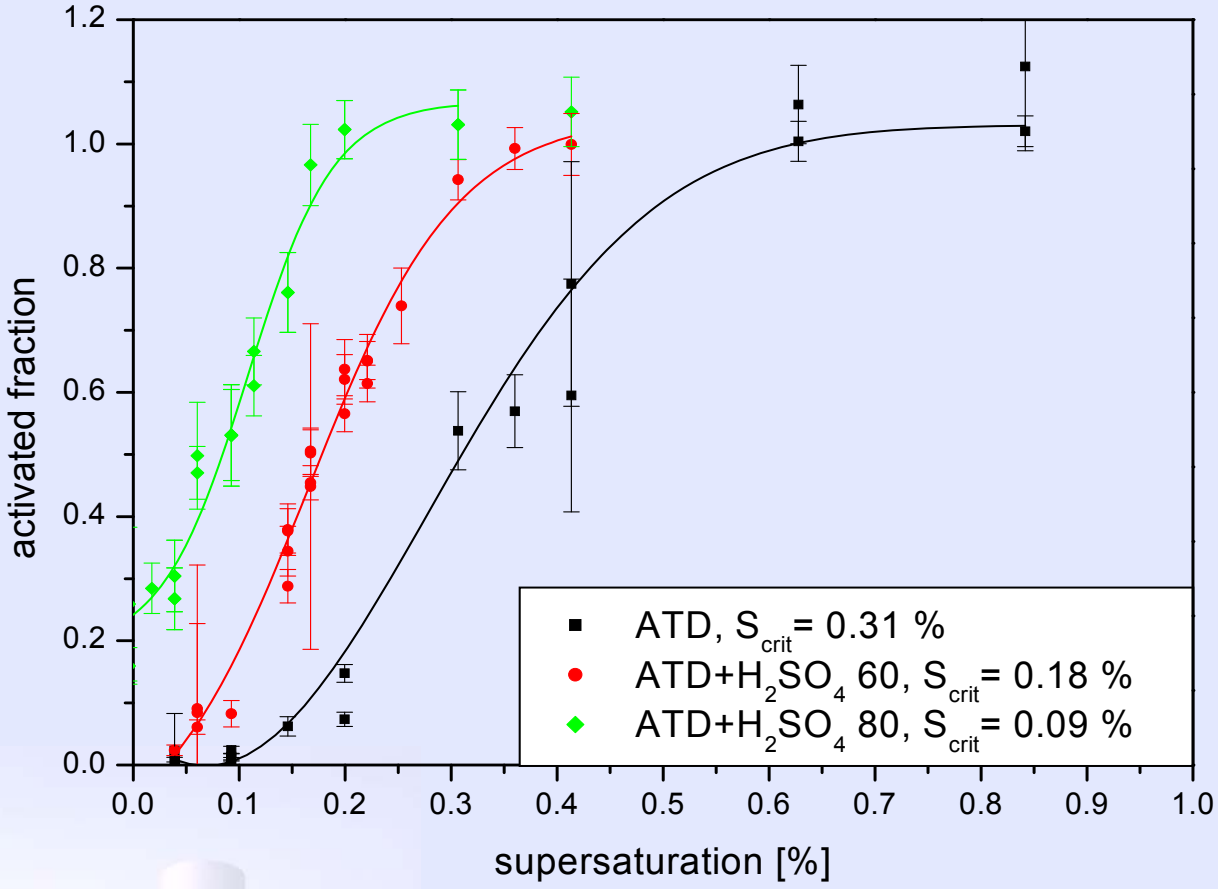
ACI02

Preliminary Results

ATD coated with H_2SO_4



CCNC: ATD + H_2SO_4

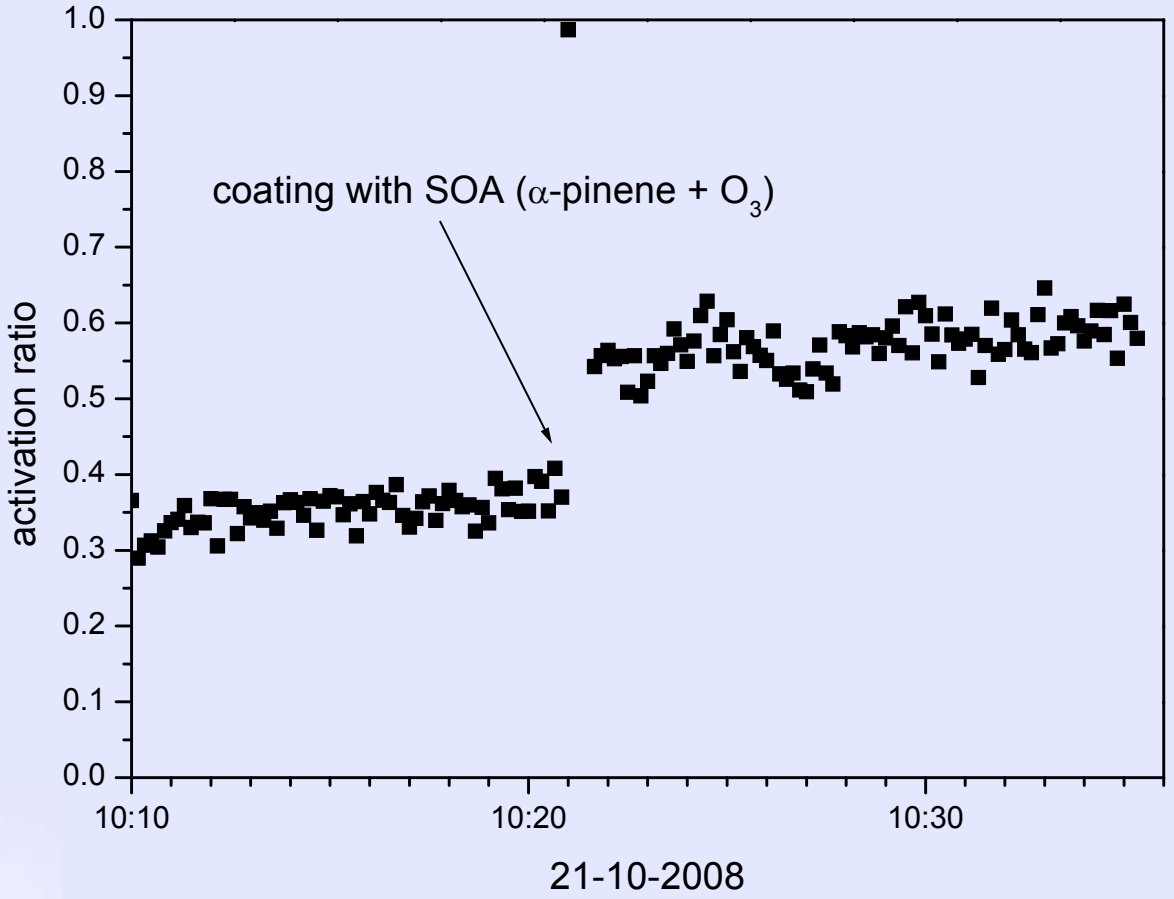


NAUA:
Exp.Nr. 17, 20, 21

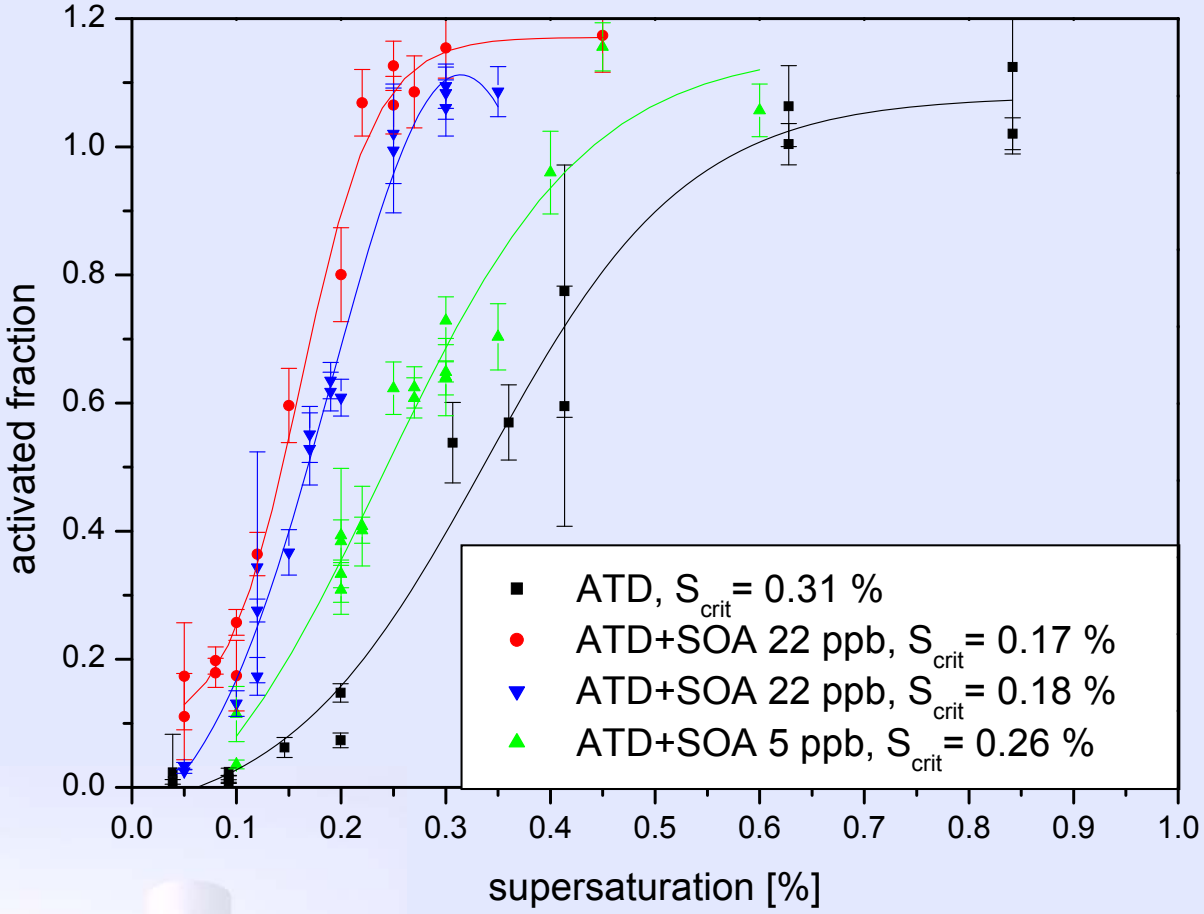
kappa:
κ ATD = 0.01
κ ATD+H_2SO_4 60 = 0.03
κ ATD+H_2SO_4 80 = 0.15

coating thickness :
dc ATD+H_2SO_4 60 = 2-3 nm
dc ATD+H_2SO_4 80 = 12-13 nm

ATD coated with SOA



CCNC: ATD + SOA



NAUA:
Exp.Nr. 16, 17, 18, 19

kappa:
κ ATD = 0.01
κ ATD+SOA22 = 0.04
κ ATD+SOA22 = 0.04
κ ATD+SOA5 = 0.02

coating thickness:
dc ATD+SOA22 = 43 nm
dc ATD+SOA22 = 40 nm
dc ATD+SOA5 = 16-17 nm

Wish list

IN-11

- TEM-pictures from ACI-02

ACI-02

- Size distributions from NAUA and AIDA
- Coating thickness from AMS

Status

IN-11

- Data analysis completed
- Data interpretation still ongoing

ACI-02

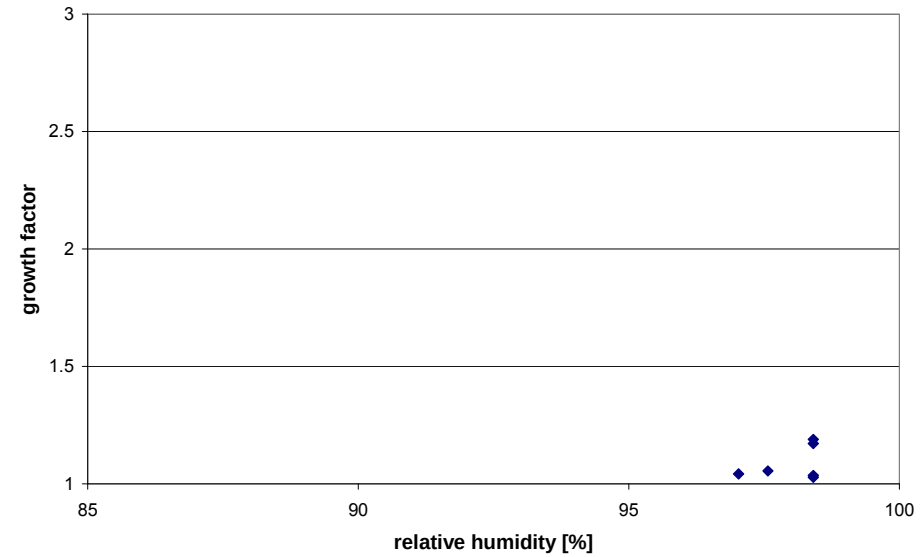
- Data analysis in progress

IN-11

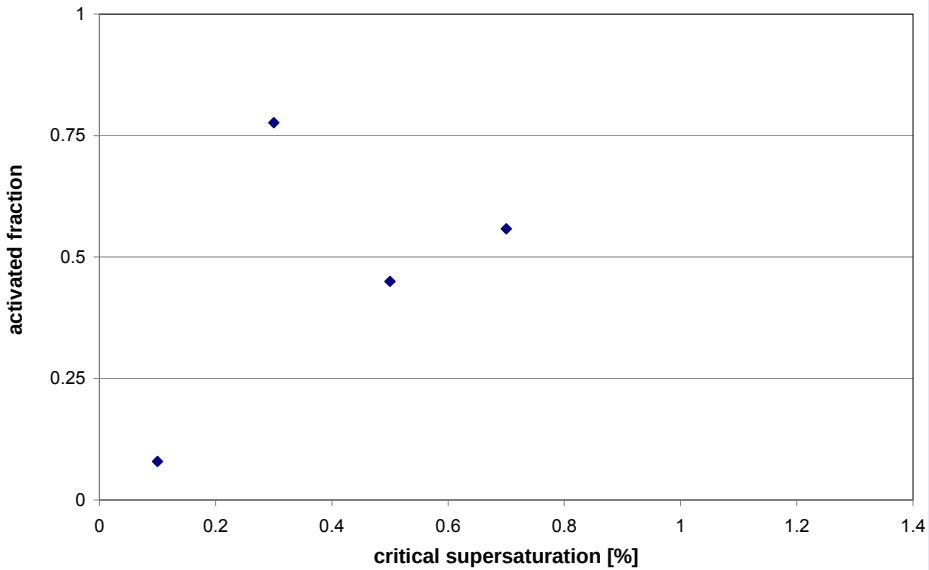
Results

GFG1000-soot & succinic acid

hygroscopic growth



activation



- no full activation observed
- evaporation of succinic acid ?

GFG1000-soot coated with oxalic acid

hygroscopic growth

activation

- neither hygroscopic growth nor activation observed
- evaporation of oxalic acid?

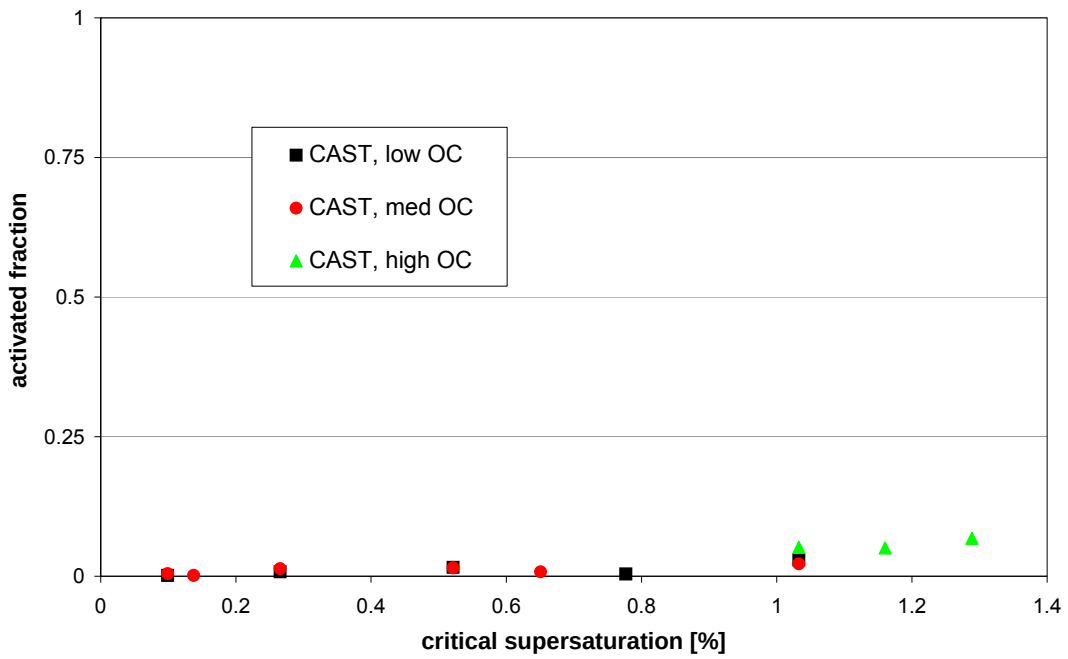
Uncoated Cast-soot

hygroscopic growth

OC	RH	GF
low	98.41	1.04
med	98.41	1.04
high	no growth observed	

- similar growth to uncoated GFG-soot

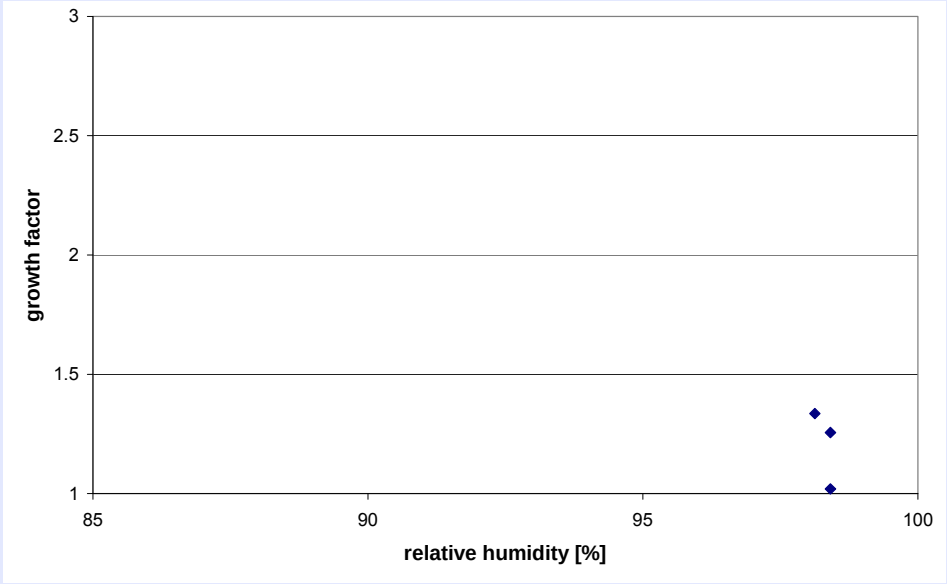
activation



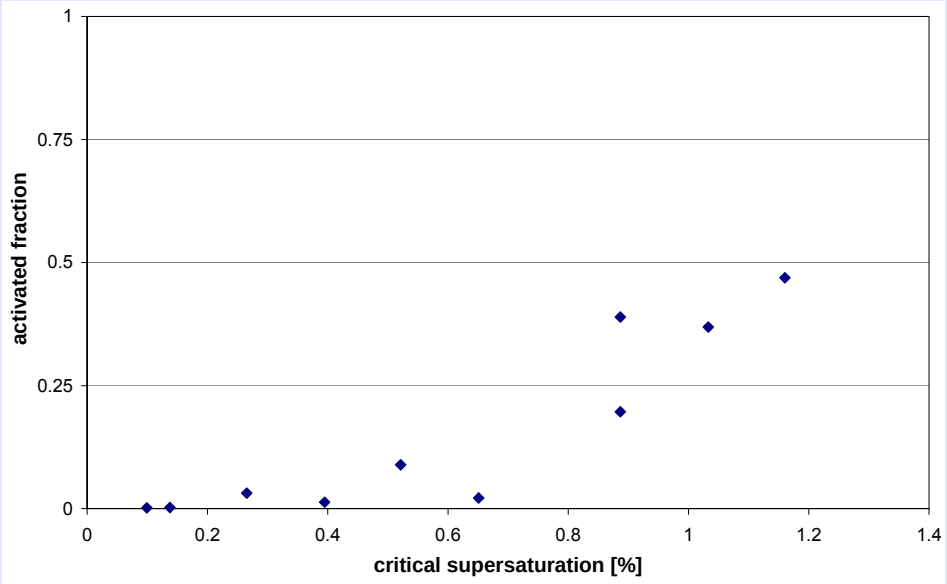
- no activation observed (all OC-contents)

CAST-soot coated with succinic acid

hygroscopic growth



activation

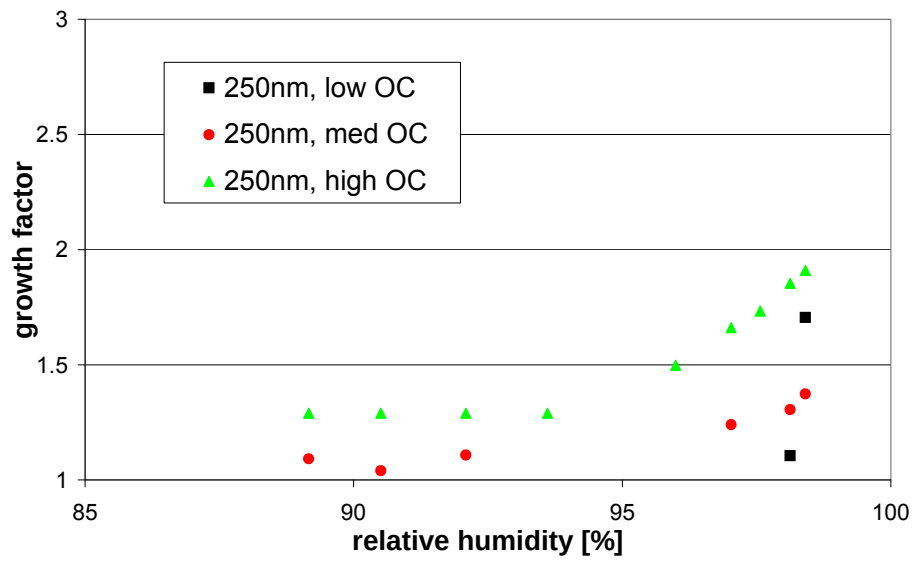


- hygroscopic growth larger than for GFG-soot coated with succinic acid

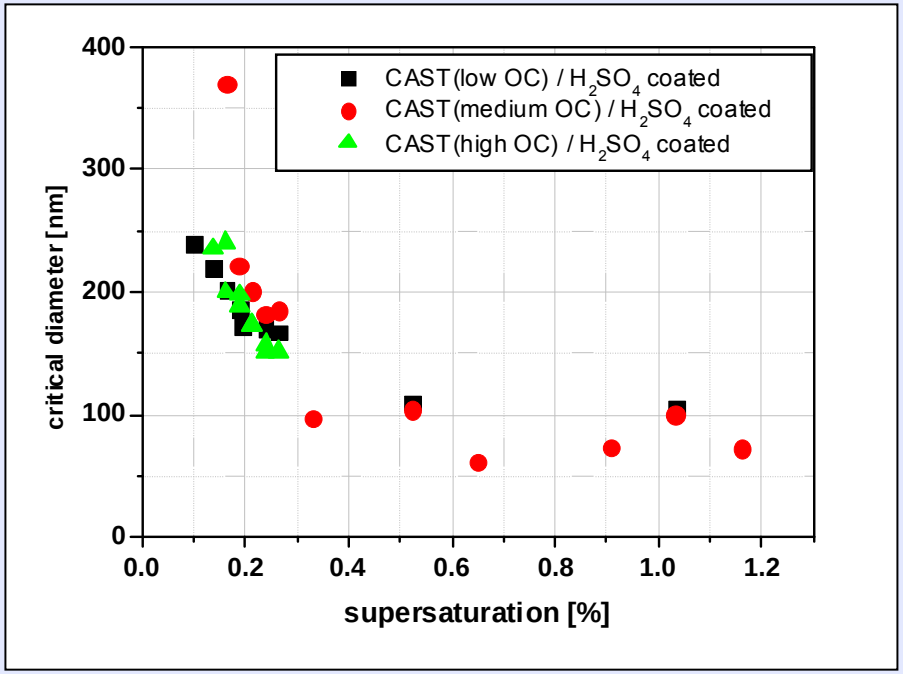
- no full activation observed
- evaporation of succinic acid ?
- activated fraction lower than coated GFG-soot

CAST-soot coated with sulfuric acid

hygroscopic growth



activation

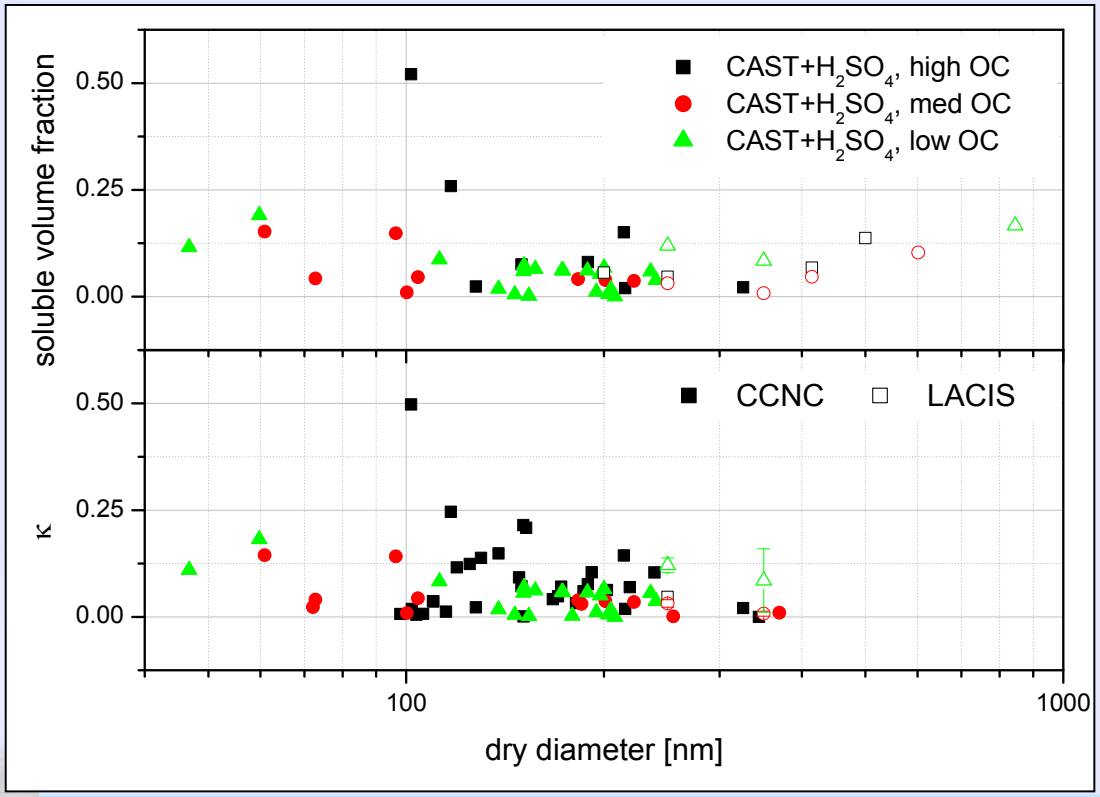


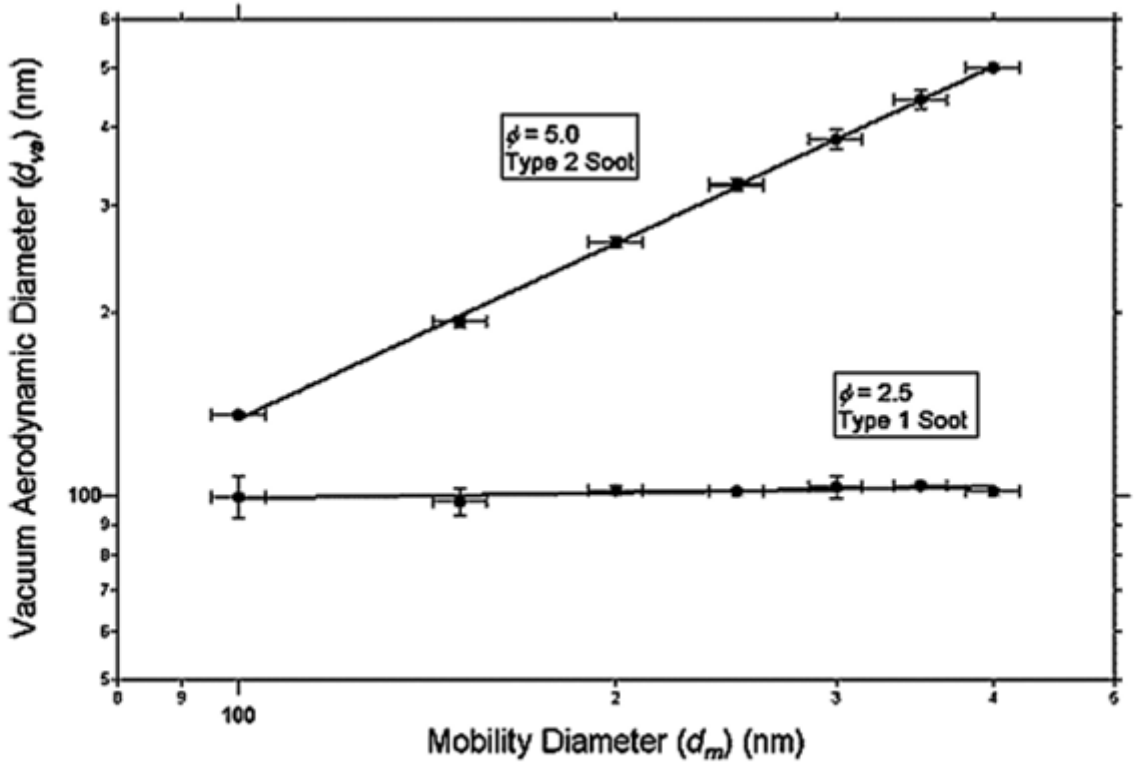
- hygroscopic growth increase with increasing OC-content or masked by sulfuric acid coating

- activation independent from OC-content or masked by sulfuric acid coating

‘Closure’ between hygroscopic growth and activation

- derived soluble volume fraction and κ from hygroscopic growth and activation measurements





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