# Activation and hygroscopic growth behavior of soot and dust coated with SOA or $H_2SO_4$: Results from IN 11 and ACI 02 campaigns, DMT-CCNC & LACIS-mobile measurements

presented by
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# Overview

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Our part in VI-ACI

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# Our part in VI-ACI

- Characterize the cloud condensation properties of soot and mineral dust particles
- Activation and hygroscopic growth measurements of coated and uncoated soot and mineral dust particles
- Closure study between hygroscopic growth and activation properties
- Studying the effect of the coating of particles on their hygroscopic growth and activation behavior

# AIDA Studies

IN 11 (measurements and analysis, Ziese et al.)

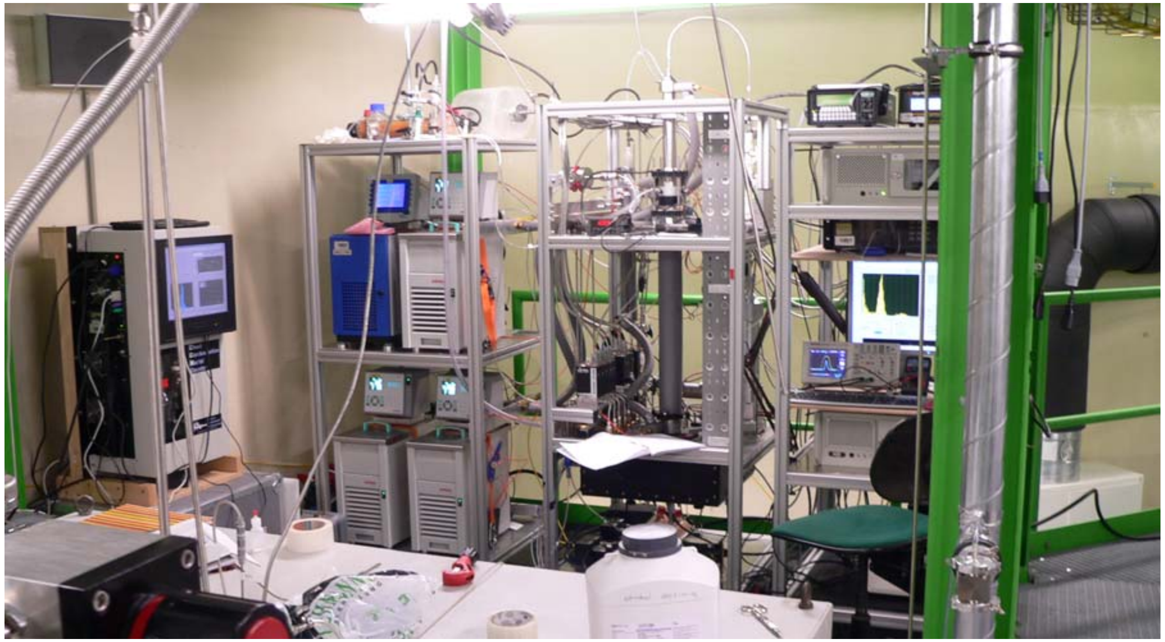
- Investigated aerosol types:
  - Uncoated GFG-soot (nitrogen or argon as carrier gas)
  - GFG-soot coated with succinic acid
  - CAST-soot with different organic carbon contents uncoated and coated with sulfuric acid or succinic acid

ACI 02 (measurements and analysis, Mildenberger et al.)

- Investigated aerosol types:
  - Uncoated mineral particles (glass spheres, BCR and ATD)
  - Coated mineral particles with SOA or sulfuric acid
  - GFG-soot coated with SOA

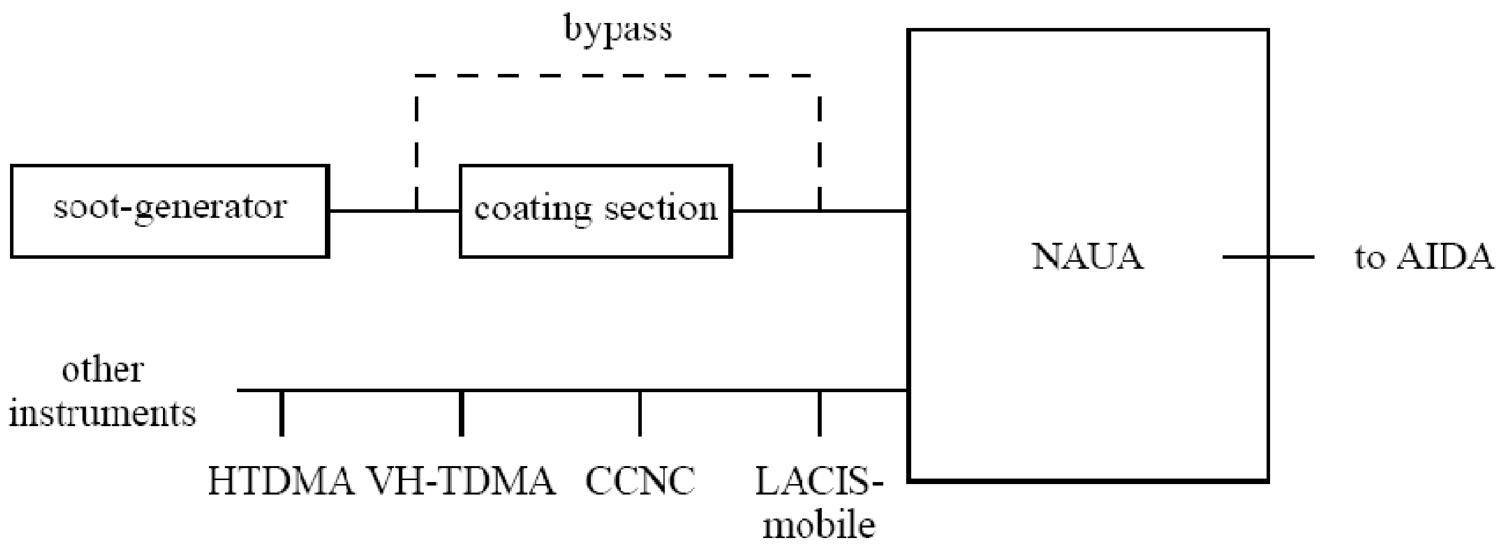
# Instrumentation

- [HTDMA, hygroscopic growth; FZ Jülich, Germany]
- [VH-TDMA,  volatilie and hygroscopic behavior; Aubire, France]
- LACIS-mobile (hygroscopic growth up to 99.39 % RH)
- Cloud Condensation Nucleus Counter (activation measurements 0.07 – 1.6 % SS)



# IN 11 - Experimental Setup

- All results for monodisperse aerosol sampled from the NAUA-chamber



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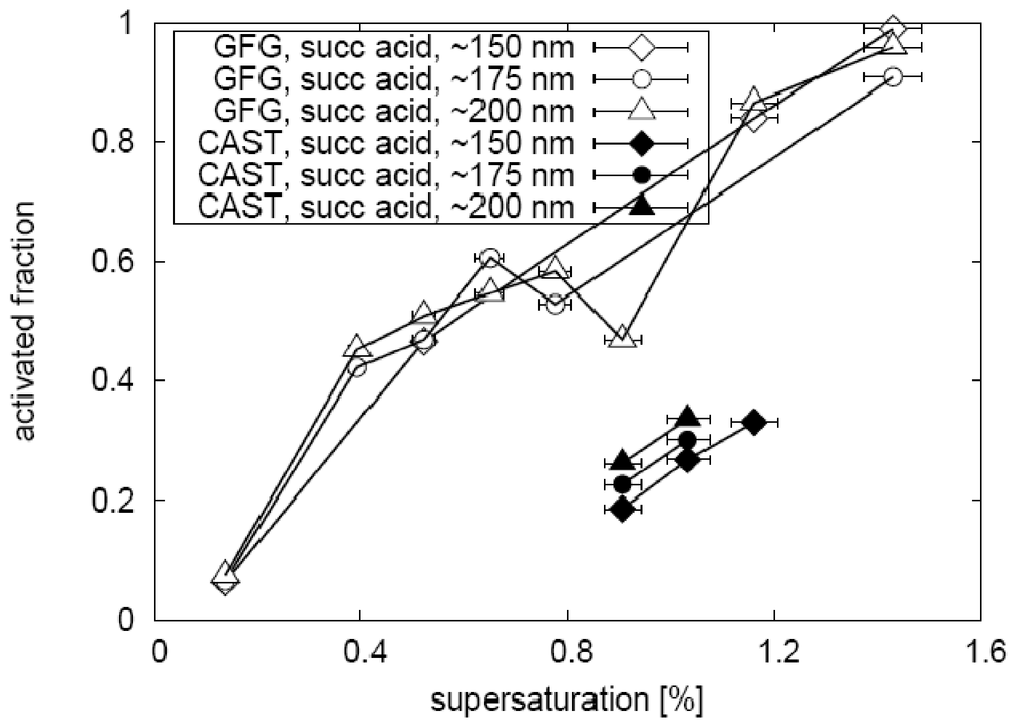
# IN 11 – Results and Discussion

- No hygroscopic growth for all pure soot types
- No activation up to 1.6% except GFG with Ar as carrier gas
- No hygroscopic growth for all soot types coated with succinic acid (after wetting shrinking of the particles was observed)
- Activation of the different soot types coated with succinic acid was observed (see Figure)
- Only 54% of the particles coated (non uniform coating)???



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# IN 11 – Results and Discussion

- Hygroscopic growth for CAST-soot coated with sulfuric acid was found
  → Hygroscopic growth increased with increasing OC content (OC content included PAHs (cf. AMS data))
  Hypothesis: insoluble PAHs reacted with sulfuric acid to smaller and more soluble molecules
  → VHTDMA, HTDMA, LACIS showed slightly different results
  Hypothesis: different coating thicknesses for different dry particle sizes as the coated particles were polydisperse
- Activation of CAST-soot coated with sulfuric acid was possible
  → no change of the activation behavior with increasing OC content

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# IN 11 – Status

Paper is in preparation:

“Hygroscopic growth and activation of soot particles: uncoated, succinic or sulfuric acid coated”

Ziese et al., 2010

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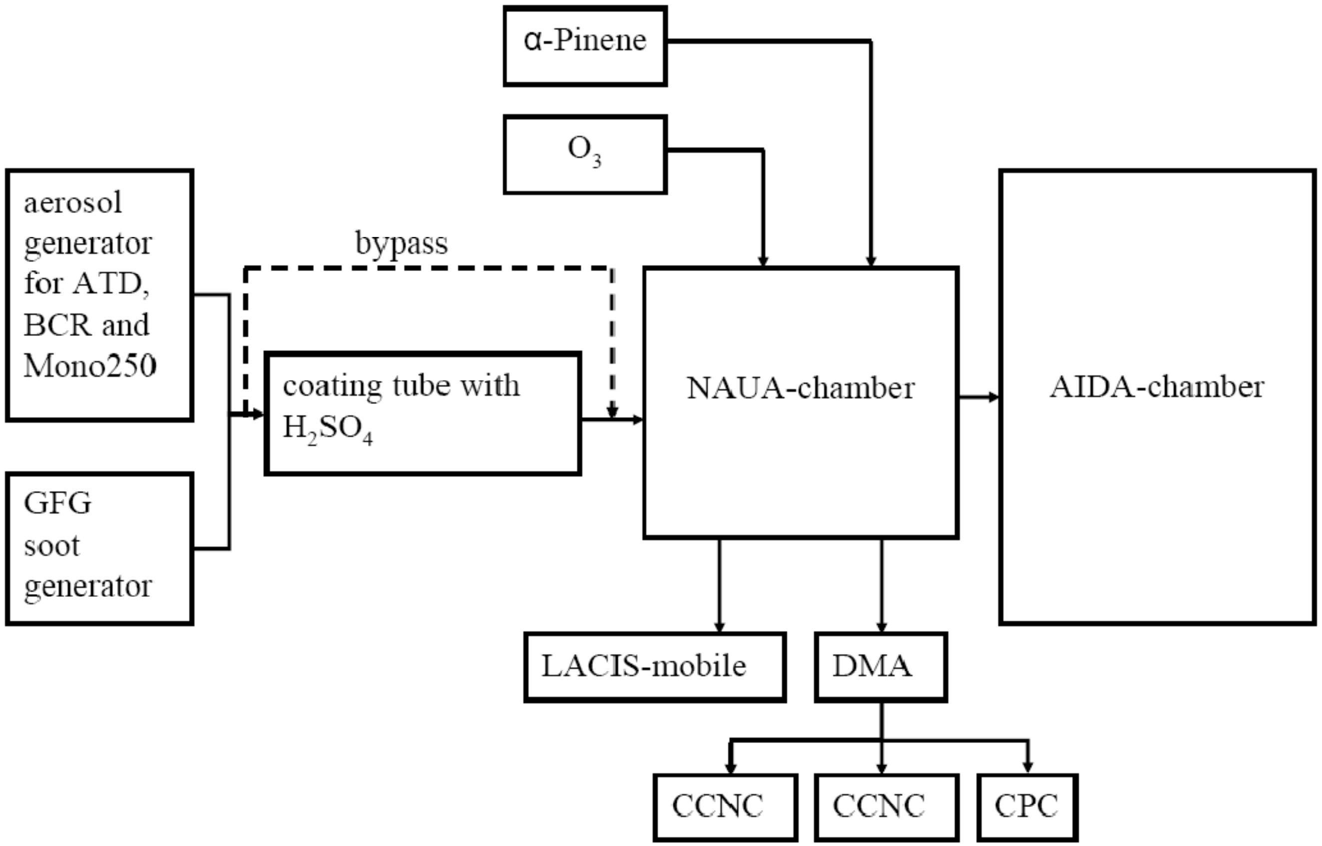
# ACI 02 - Experimental Setup

- All results for monodisperse aerosol sampled from the NAUA-chamber



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# ACI 02 – Methods

- Determination of the critical supersaturation ($S_{crit}$) from CCNC measurements

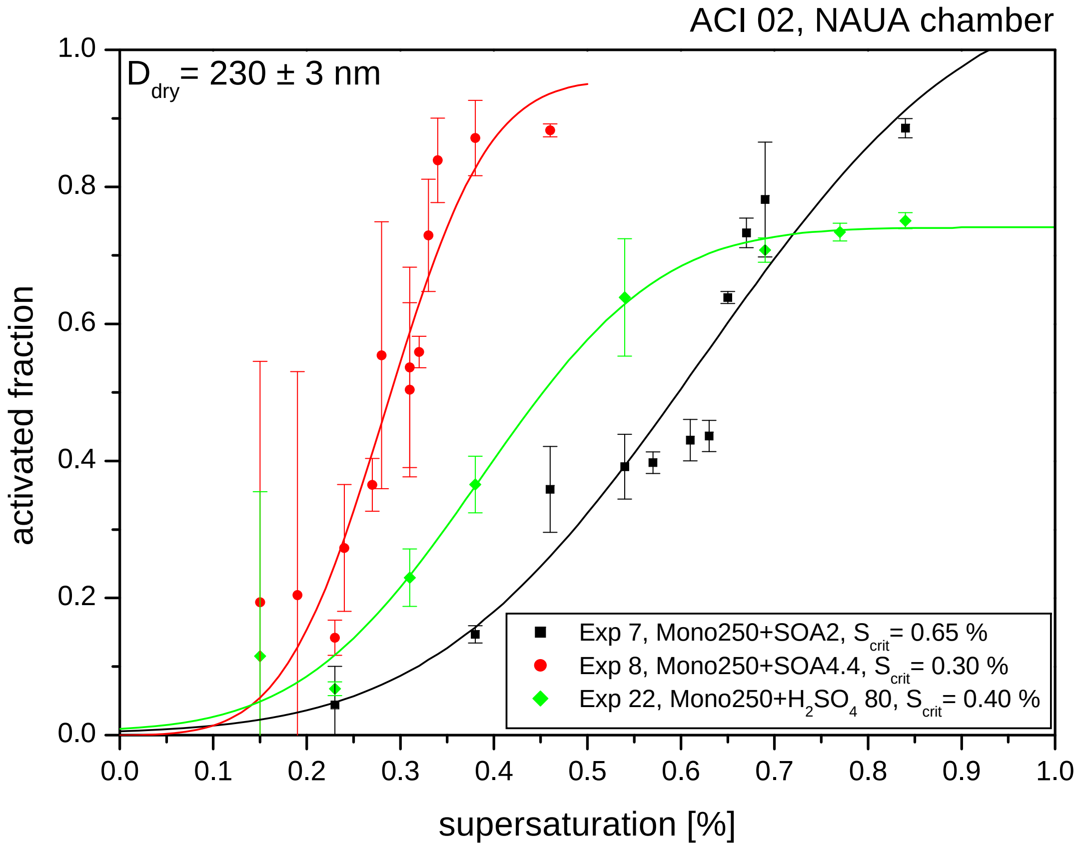
- Calculation of the coating thickness: Köhler model with insoluble core and one respectively two soluble compounds was used assuming spherical particles (T = 20°C, $\sigma$ of water)

- Closure study: Prediction of critical supersaturation using values of the hygroscopicity parameter $\kappa$ derived from hygroscopic growth measurements

# ACI 02 – Results and Discussion

## (Activation of uncoated and coated Mono250)

- No activation of pure glass spheres (Mono250) for supersaturations up to 1.31%
- After coating activation was observed

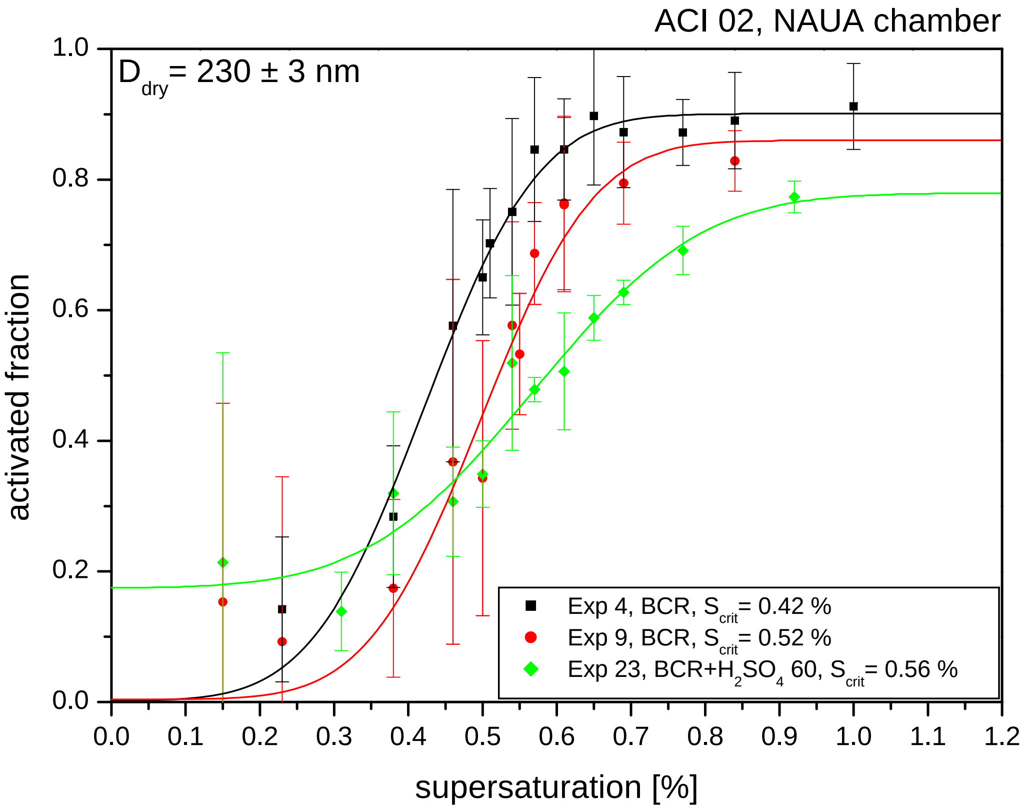



- The larger the coating thickness, the easier the particles activated
- Hygroscopicity ($\kappa$) increased with coating thickness
- Coating thickness:
  - Exp 7 → 0.3 nm
  - Exp 8 → 4.5 nm
  - Exp 22 → 0.2 nm

# ACI 02 – Results and Discussion

(Activation of uncoated and coated BCR)

- Activation of pure BCR particles was observed



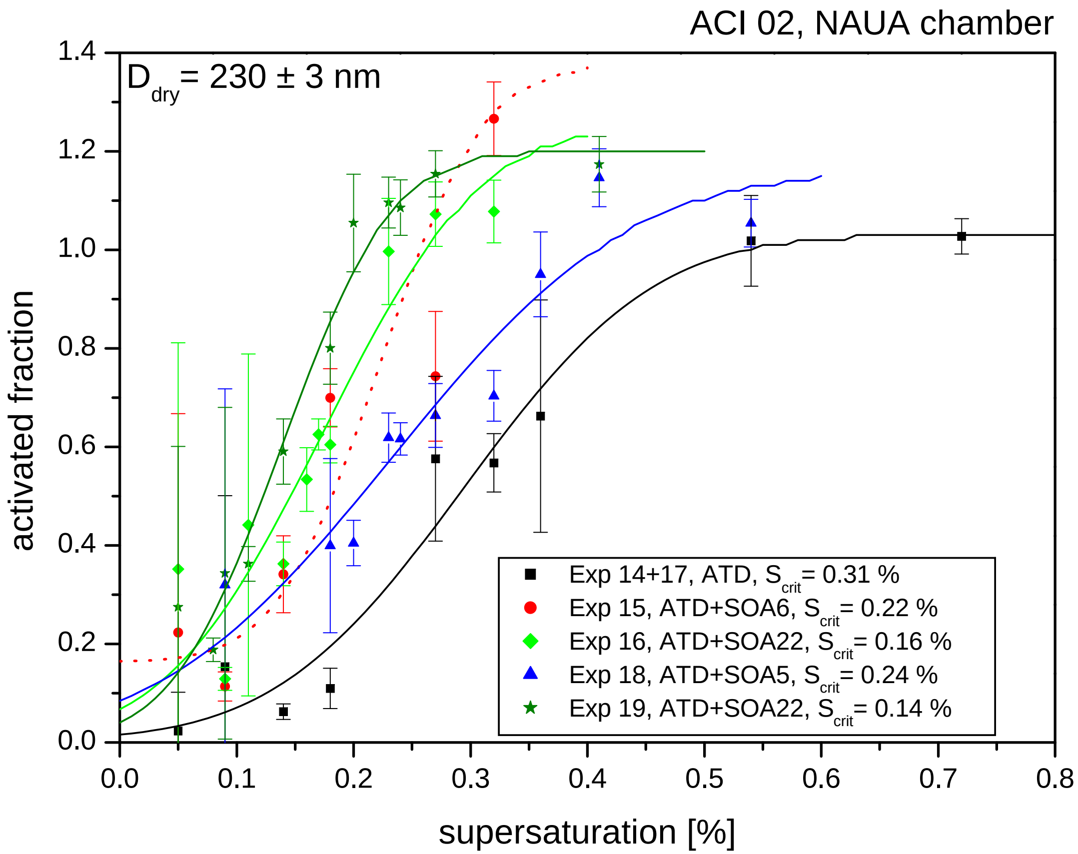

- Critical supersaturation needed for activation was higher for particles coated with sulfuric acid than for pure BCR particles

Explanation???

# ACI 02 – Results and Discussion

(Activation of uncoated and coated ATD)

- Activation of pure ATD particles was observed

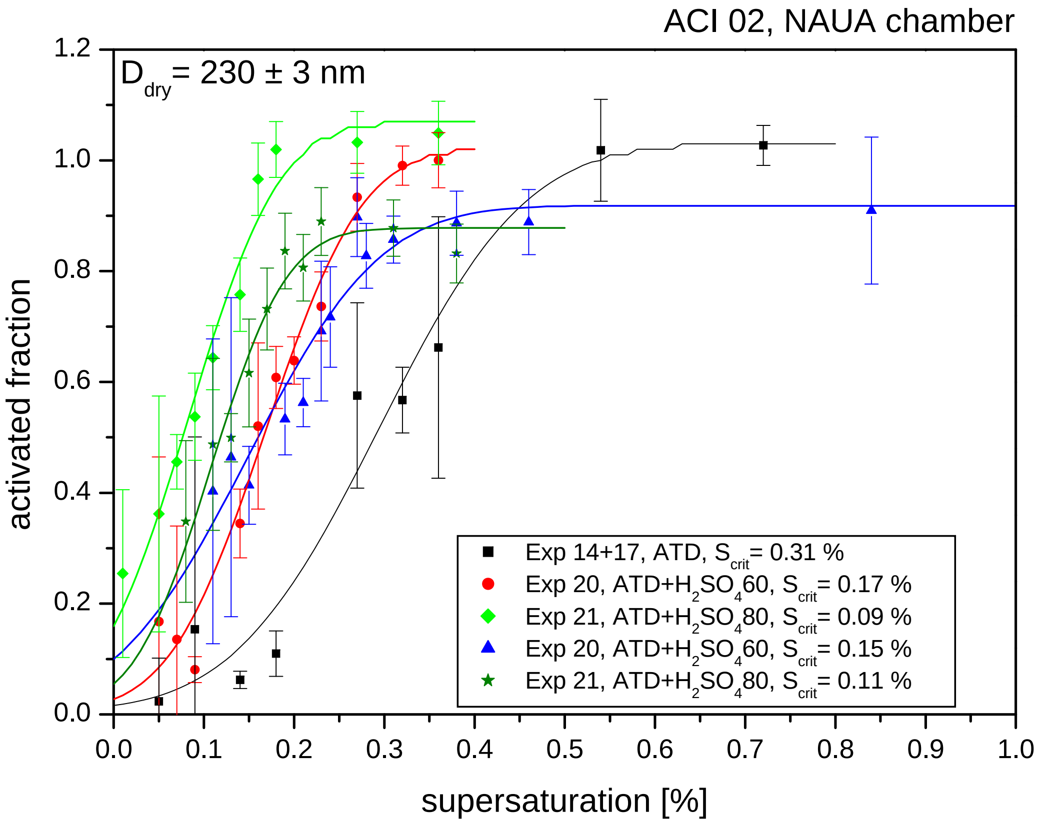



- The larger the coating thickness, the easier the particles activated
- Hygroscopicity (κ) increased with coating thickness
- Coating thickness:
  - Exp 15 → 8.9 nm
  - Exp 16 → 18.4 nm
  - Exp 18 → 7.2 nm
  - Exp 19 → 27.7 nm

# ACI 02 – Results and Discussion

(Activation of uncoated and coated ATD)

- Activation of pure ATD particles was observed

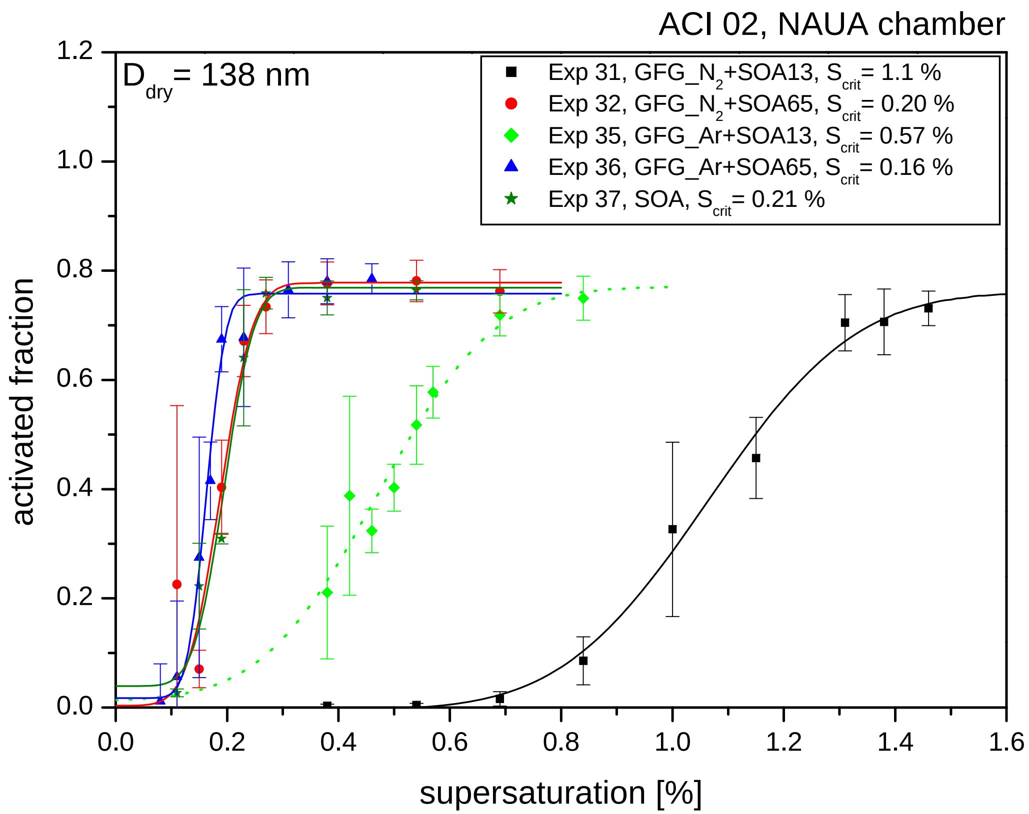



- The larger the coating thickness, the easier the particles activated
- Hygroscopicity (*κ*) increased with coating thickness
- Coating thickness:
  - Exp $20_{CCNC1}$ → 2 nm
  - Exp $21_{CCNC1}$ → 4 nm
  - Exp $20_{CCNC2}$ →1.5 nm
  - Exp $21_{CCNC2}$ → 6 nm

# ACI 02 – Results and Discussion

(Activation of uncoated and coated GFG)

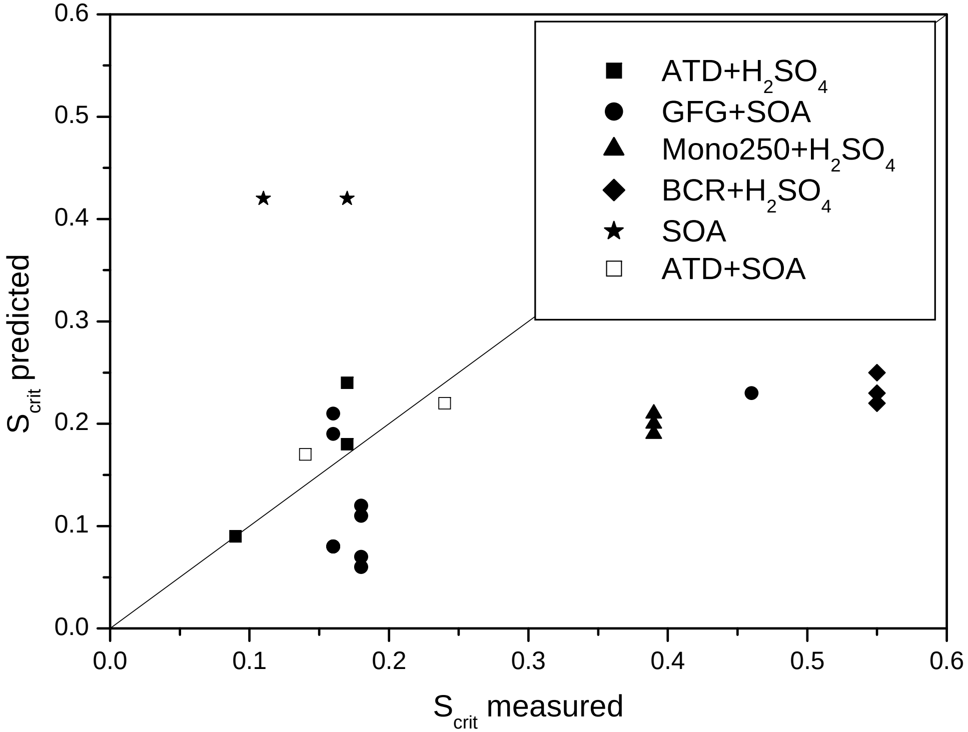
- No activation of pure soot particle (GFG) and soot particles coated with a thin layer of SOA for supersaturations up to 1.31%




- The larger the coating thickness, the easier the particles activated; In exp 32 & 36 particles activated easier than pure SOA???
- Hygroscopicity (κ) increased with increasing coating thickness
- Coating thickness:
  - Exp 31 → 0.3 nm
  - Exp 32 → < pure SOA
  - Exp 35 → 3.5 nm
  - Exp 36 → < pure SOA

# ACI 02 – Results and Discussion

- Closure study: prediction of $S_{crit}$ from hygroscopic growth measurements by using *κ*-Köhler theory




- BCR and Mono250 particles coated with $H_2SO_4$: Measured $S_{crit}$ much higher than the predicted ones
- Pure SOA: Measured $S_{crit}$ much lower than the predicted ones
- ATD coated with SOA or $H_2SO_4$: Measured and predicted $S_{crit}$ in good agreement
- GFG particles coated with SOA→ no clear trend

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# ACI 02 – Results and Discussion

Further results (not shown):

- Comparison of both CCNC → good agreement
- Additionally, for ATD the influence of dynamic shape factor (1.5) on the results was checked → absolute $\kappa$ values and coating thicknesses differed, but trends in hygroscopic growth and activation behavior remained
- For all SOA coated particles critical supersaturation ($S_{crit}$) and surface tension ($\sigma$) at the activation point was iterated following Ziese et al. (2008) based on LACIS and CCNC data → $0.026 < \sigma_{activation} < 0.060$ N m$^{-1}$ (too low)

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# ACI 02 – Summary

- Soluble coating of an insoluble particle generally made the particles more hygroscopic

  Except: The activation of pure BCR particles was better than the activation of BCR particles coated with sulfuric acid

- For GFG particles coated with a high amount of SOA the activation was better than for pure SOA particles

- Closure between hygroscopic growth measurements was only possible for ATD particles

# ACI 02 – Outlook

Further plans:

- More detailed consideration of the closure study results
- Implementation of a dynamic shape factor for BCR and GFG particles into calculation of $\kappa$ and coating thicknesses
- Further discussion of the results
- Preparation of paper

Further information needed:

- measured dynamic shape factor
- determined coating thickness from AMS measurements
- number size distributions of the aerosol particles in the NAUA-chamber

Thanks to all participants!