



A NEW WORKING FLUID FOR CONDENSATION PARTICLE COUNTERS WITH PROPRIETARY BENEFITS

ETH NANOPARTICLE CONFERENCE

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2023 | PATRICK WEBER

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Mitglied der Helmholtz-Gemeinschaft

GRIMM  AEROSOL
TECHNIK



 **JÜLICH**
Forschungszentrum

INTRODUCTION

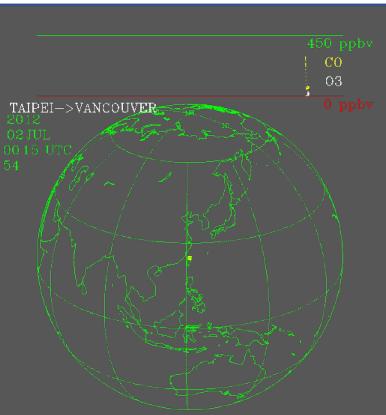
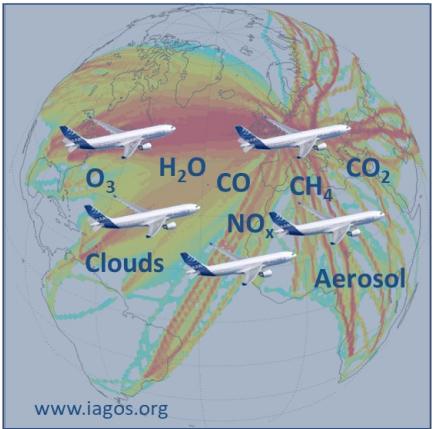
Background



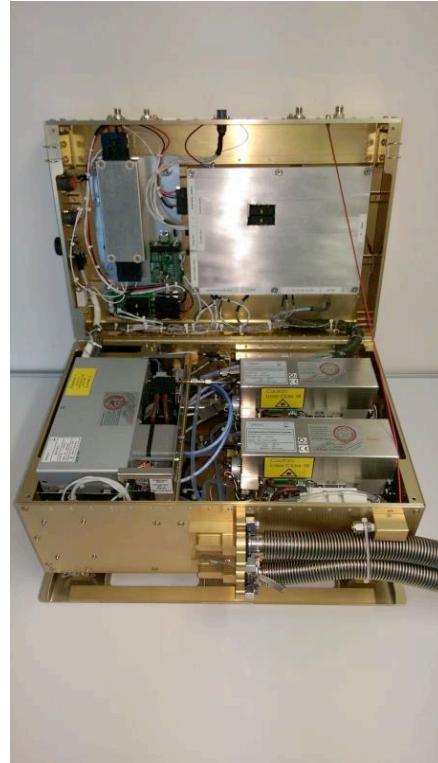
In-service Aircraft for a Global Observing System

European Research Infrastructure for atmospheric observation by passenger aircraft since 2014 (MOZAIC: 1994 - 2014)

- Regular in-situ monitoring of essential climate variables
- Provision of data in near real time for Copernicus
- Open data policy



Lufthansa AIRFRANCE CHINA AIRLINES CATHAY PACIFIC IBERIA HAWAIIAN Eurowings

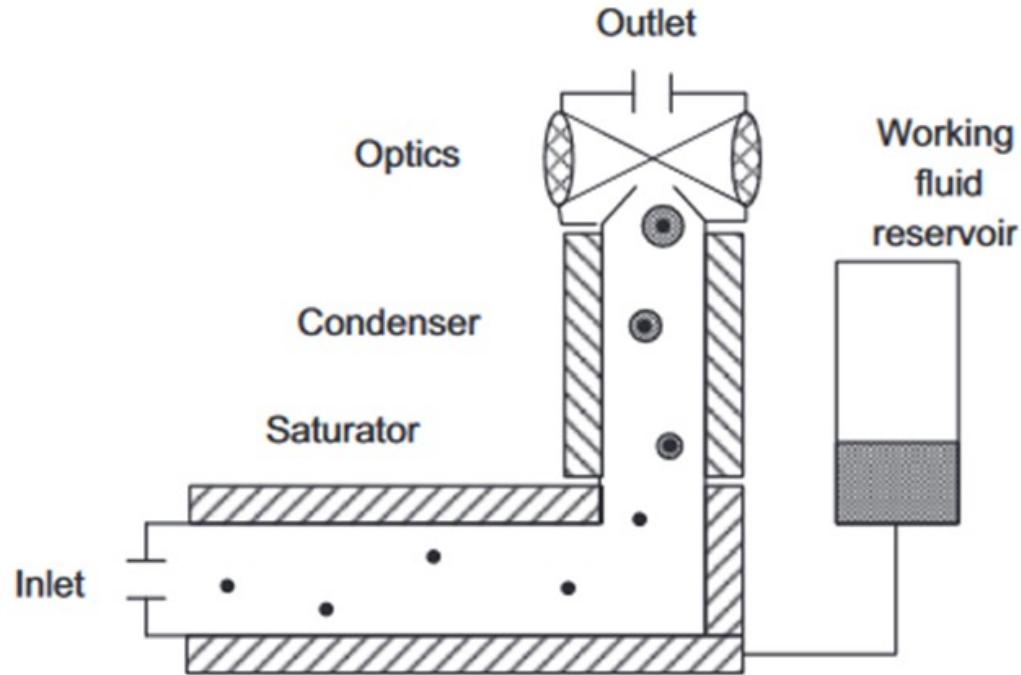


Working Fluid:

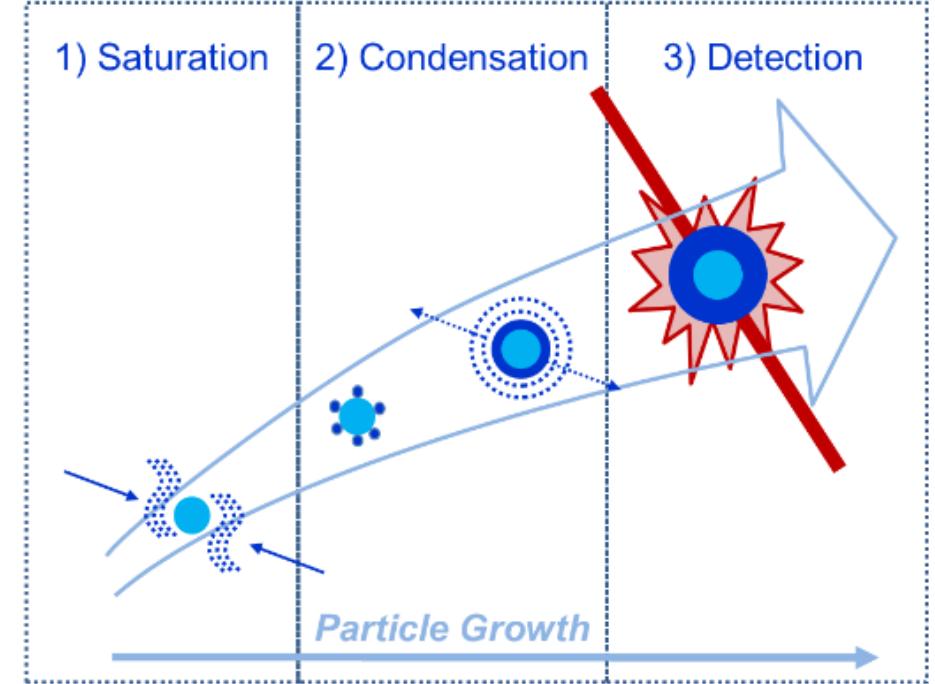
~~Butanol~~

INTRODUCTION

Condensation Particle Counter



Giechaskiel, B et al. *Journal of Aerosol Science* 2014, 67, 48-86.



Bischof, O. F. *Dissertation, Verlag des Forschungszentrums Jülich, Energie & Umwelt*, 2022, ISBN: 978-3-95806-629-8.

NEED FOR A NEW WORKING FLUID

Requirements

- Low consumption
- **Non- Toxic, Non- Flammable, Non- Corrosive, Non- Explosive...**

- No GHS symbols would be fine



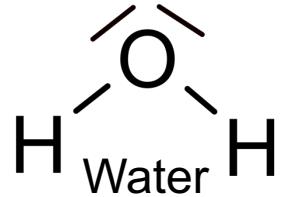
- Inexpensive
- Long-term stability

- Water?

- Should work on a regular/alcohol Condensation Particle Counter
- Same or better Cut-Off efficiencies
- Low pressure application

Water?
Page 4

SEARCHING FOR A NEW SUBSTANCE



Legende

schwarz = Feststoff
blau = Flüssigkeit
grau = unbekannt
unterstrichen = radioaktiv
Dichte
Symbol
Name
Ordnungszahl
Atomgewicht
Symbol
Elektronegativität
Dichte

Gruppe

1 H	2 He	3 Li	4 Be	5 Na	6 Mg	7 Al	8 Si	9 P	10 S	11 Cl	12 Ar	13 K	14 Ca	15 Sc	16 O	17 F	18 Ne
Wasserstoff	Helium	Alkalimetalle	Halbmetalle	Natrium	Magnesium	Aluminium	Silizium	Phosphor	Schwefel	Chlor	Argon	Kalium	Calcium	Scandium	Stickstoff	Fluor	Neon
rot = kg / dm ³	grau = kg / dm ³	schwarz = natürliche Elemente	blau = künstliche Elemente	schwarz = natürliches Element	grau = unbekannt	schraffiert = radioaktiv	untenstrichen = unbekannt	untenstrichen = radioaktiv	untenstrichen = unbekannt								

Periode

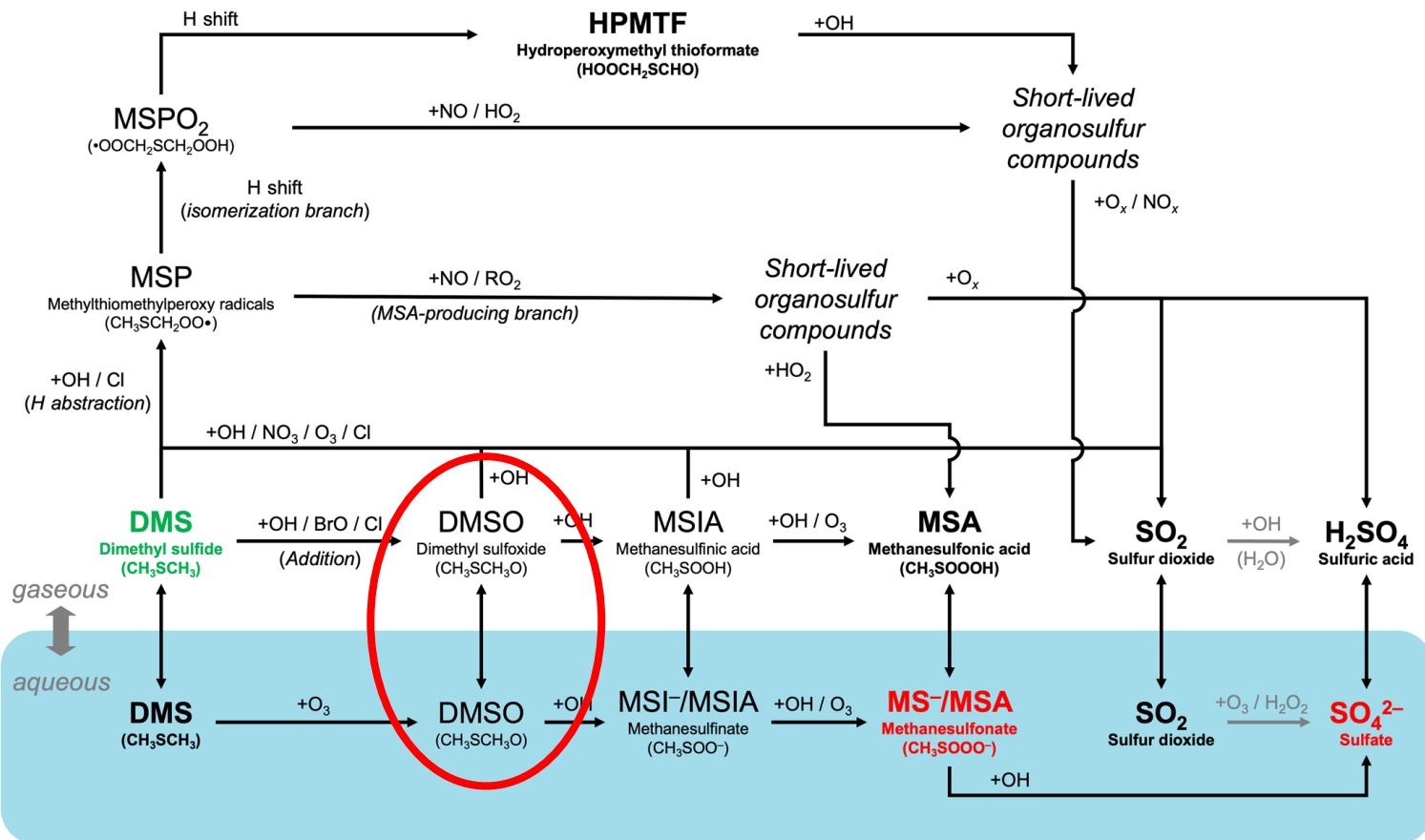
Lanthanoide

Actinoide



Substance with similar chemical/physical properties

NEW WORKING FLUID



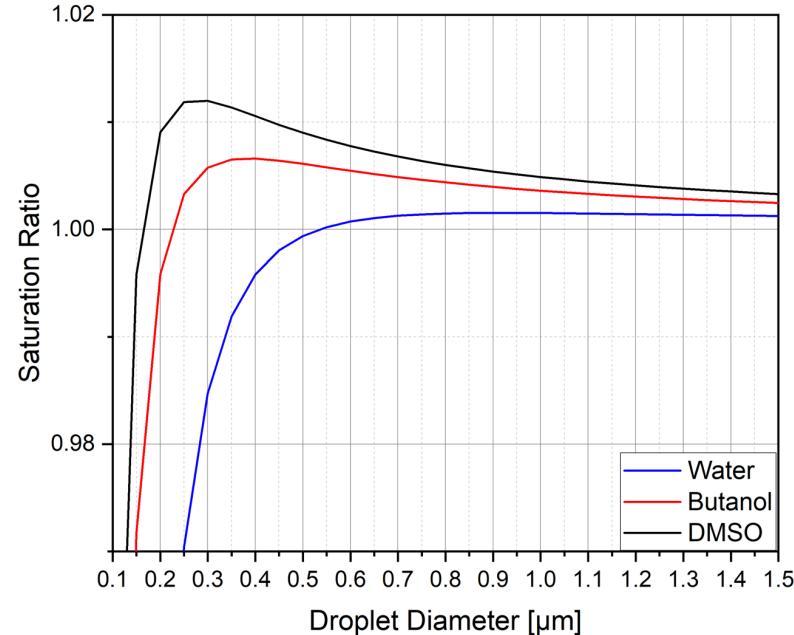
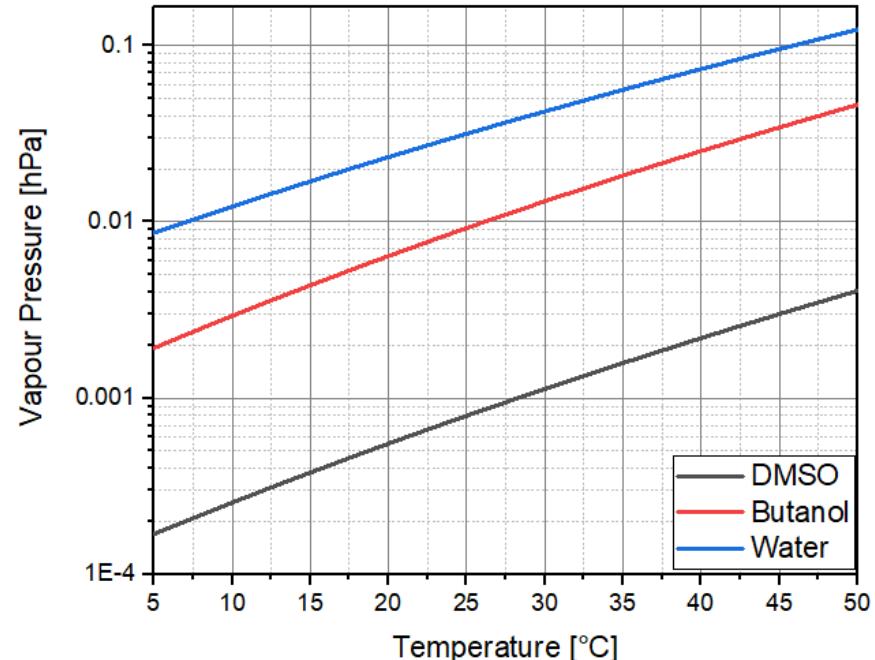
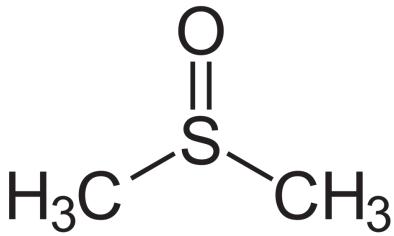
Fung, K. M., et al.: Exploring dimethyl sulfide (DMS) oxidation and implications for global aerosol radiative forcing, *Atmos. Chem. Phys.*, 22, 1549–1573, <https://doi.org/10.5194/acp-22-1549-2022>, 2022.

WORKING FLUID

Vapour Pressure

and

Particle Activation

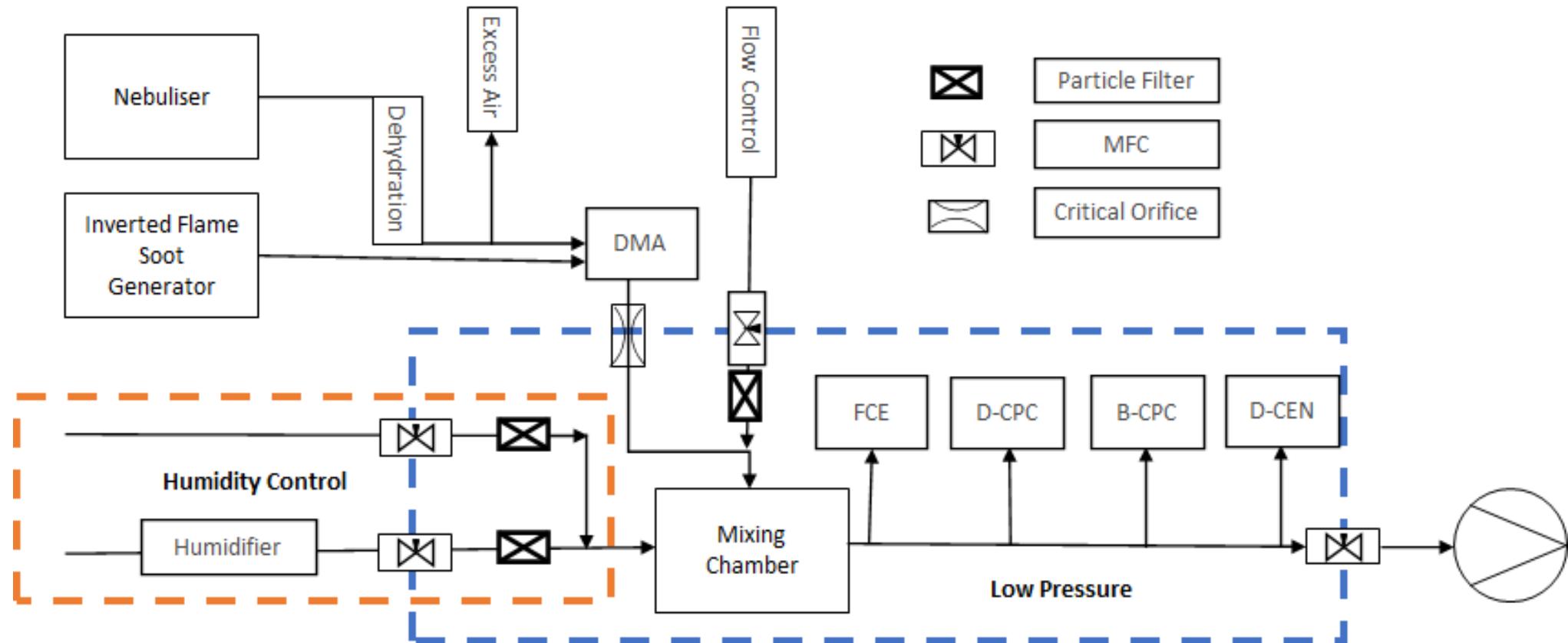


$$\log_{10} p = a - \frac{b}{c+T} \quad \text{Antonie (1888)}$$

$$\frac{p}{p_s} = \left(1 + \frac{6imM}{M_s \delta \pi d^3}\right)^{-1} \exp\left(\frac{4\sigma M}{\delta RTd}\right) = \text{saturation ratio}$$

The surface tension of the liquid σ , the molecular weight M , the density δ , the general gas constant R , the absolute temperature T and the Kelvin diameter d

MEASUREMENT SET-UP



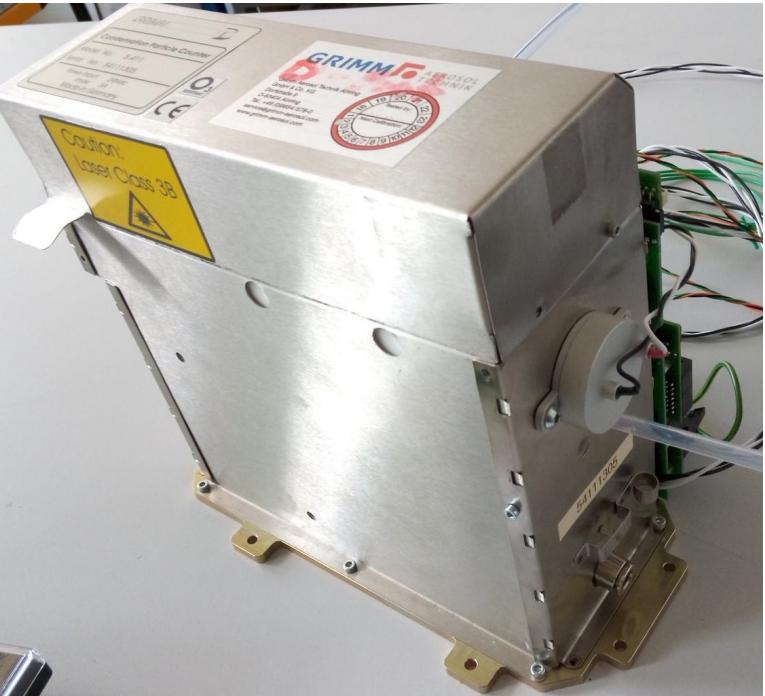
Weber, P., Bischof, O. F., Fischer, B., Berg, M., Schmitt, J., Steiner, G., Keck, L., Petzold, A., and Bundke, U.: A New Working Fluid for Condensation Particle Counters for Use in Sensitive Working Environments, Aerosol Research [preprint], <https://doi.org/10.5194/ar-2023-1>, in review, 2023.

INSTRUMENTS TESTED

CPC - Models

- 5411 Sky-CPC

GRIMM Aerosol Technik, Ainring, Germany



- CEN-3772

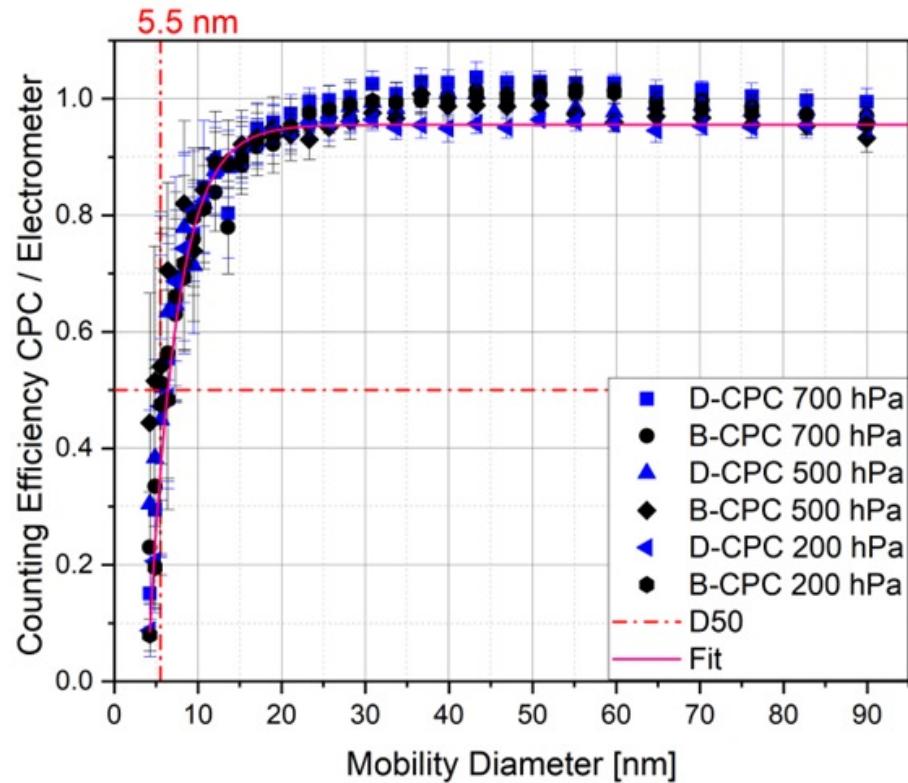
TSI Incorporated, Shoreview, MN, USA



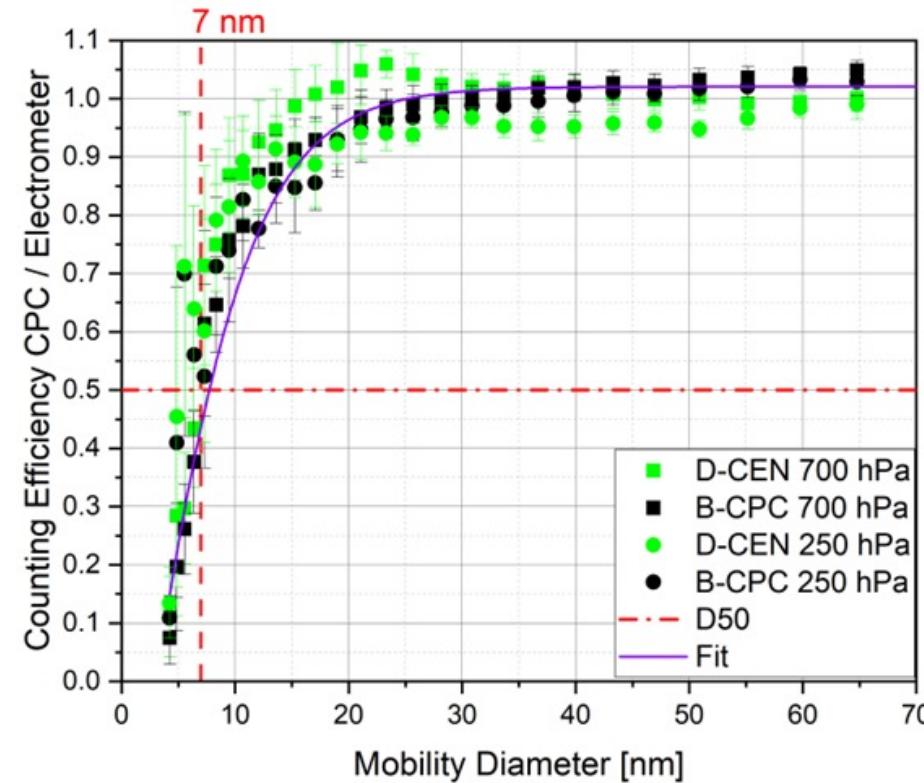
CPC COUNTING EFFICIENCY

Sodium Chloride – salt particles

■ 5411 Sky-CPC

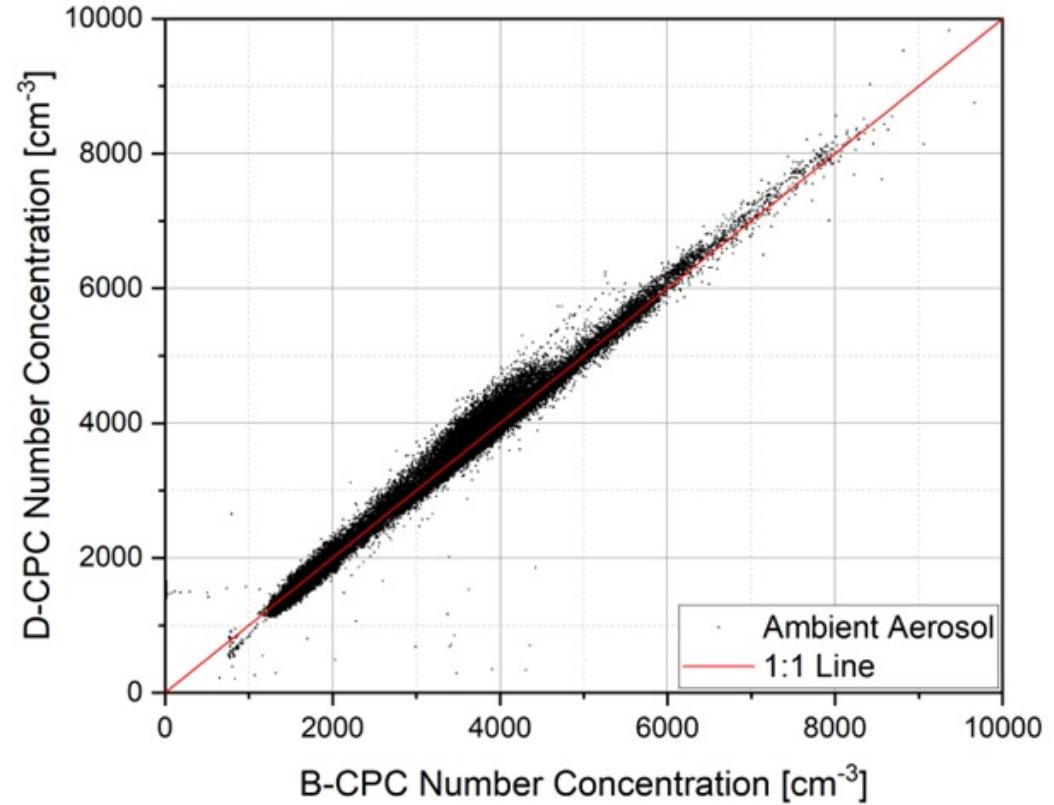
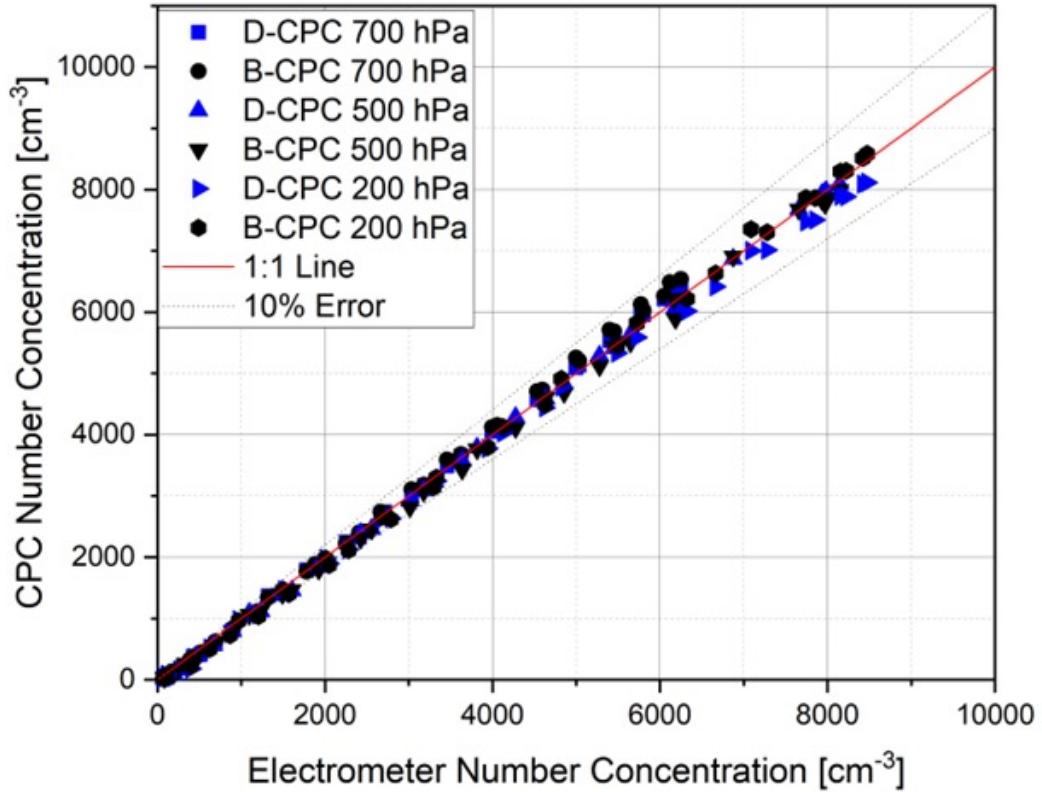


■ CEN-3772



LINEARITY OF INSTRUMENT RESPONSE

Salt and ambient aerosol



DMSO – AN EASY SUBSTITUTE?

Interaction with some rubber-like materials



O-rings and gaskets

Silicone instead of:

Polycarbonate (PC)

Polyvinylidene fluoride (PVDF) / Kynar®

Polyvinyl chloride (PVC)

SUMMARY

- **Easy substitute for butanol**
- **Suitable for ambient and low-pressure measurements**
- **Extension to sensitive working area applications**

OUTLOOK

- Pending Patent (Weber and Bundke; FZJ)
- Assessment and approval by the manufactures
- Investigation of activation of smaller particles (higher saturation ratio)

THANK YOU FOR LISTENING

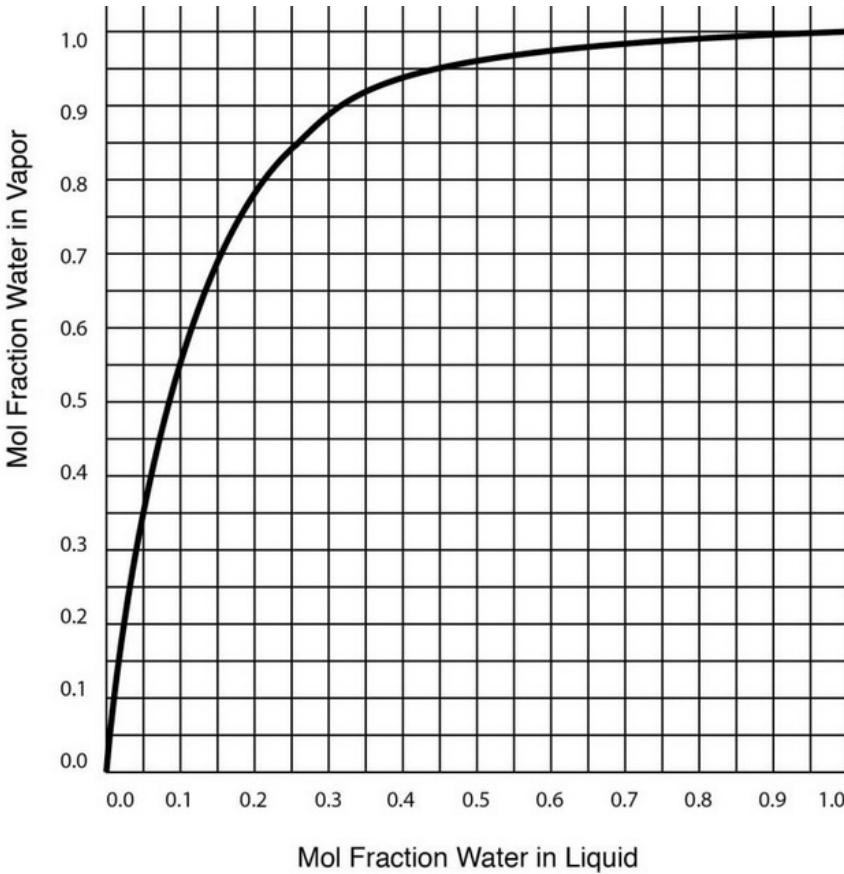
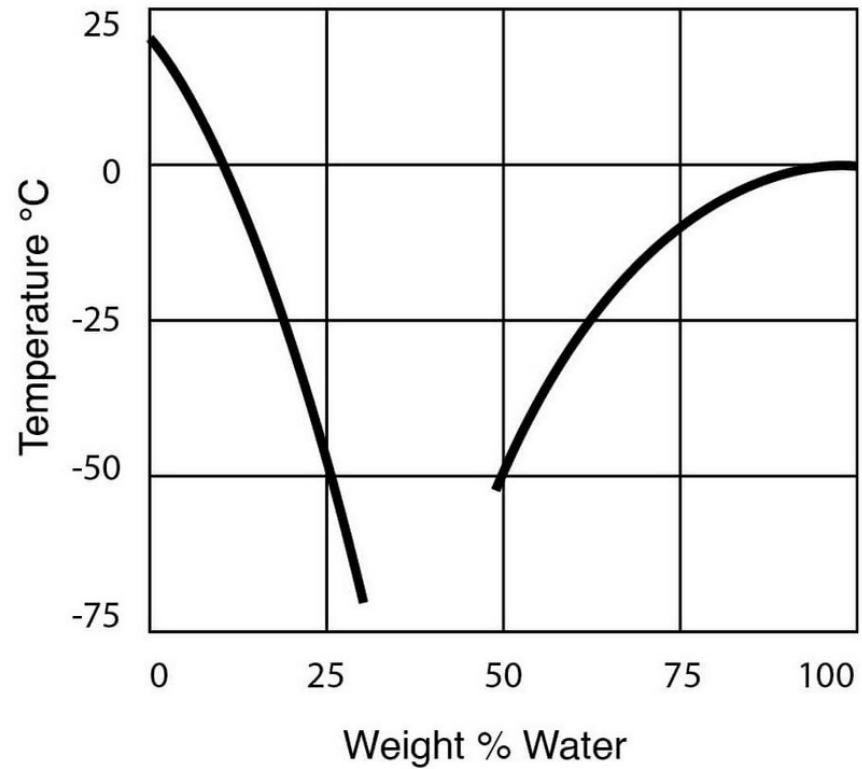
Big Thanks to the Organization Team

QUESTIONS?

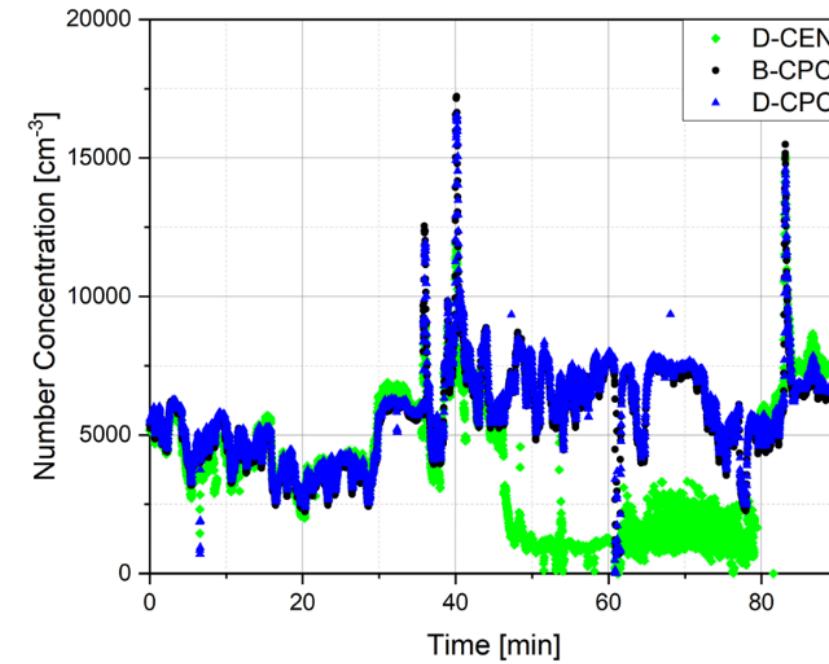
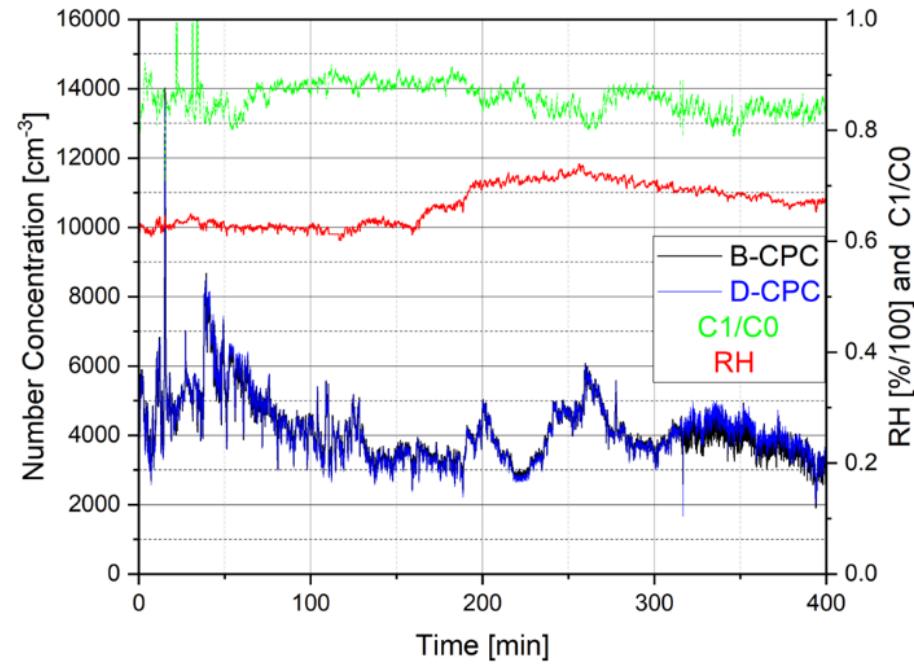
DMSO

Some more Properties

Freezing Temperature 18 °C!

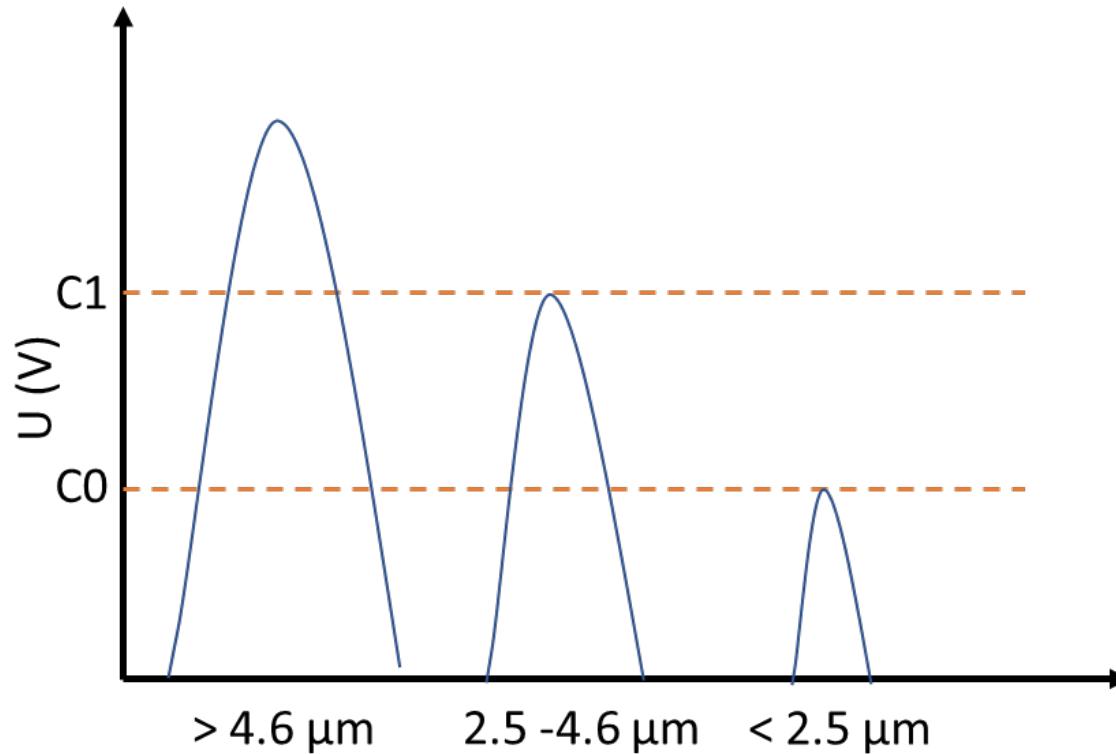


AMBIENT AEROSOL

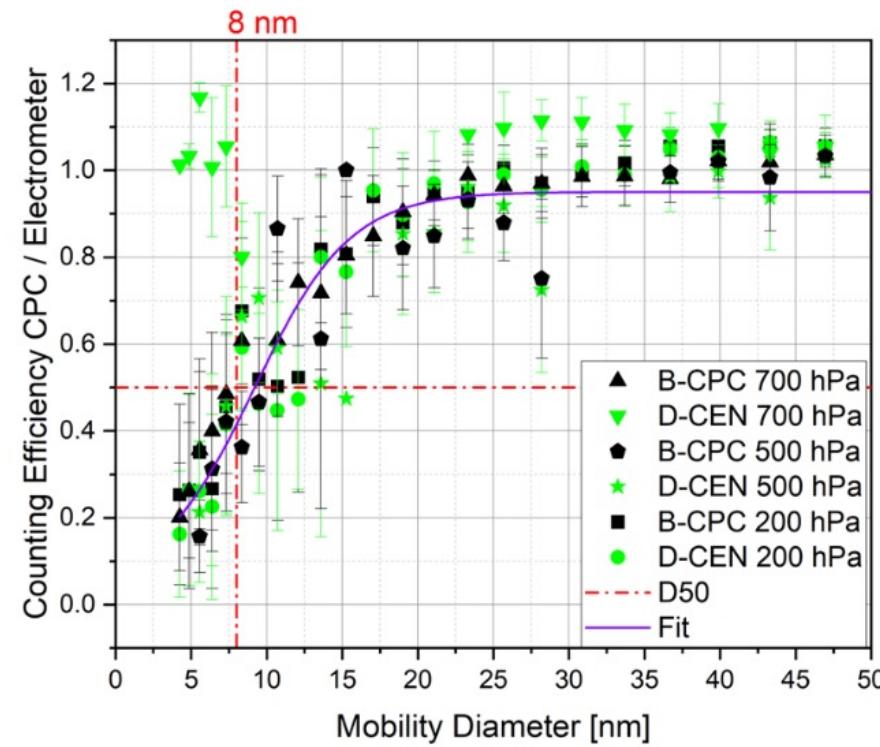
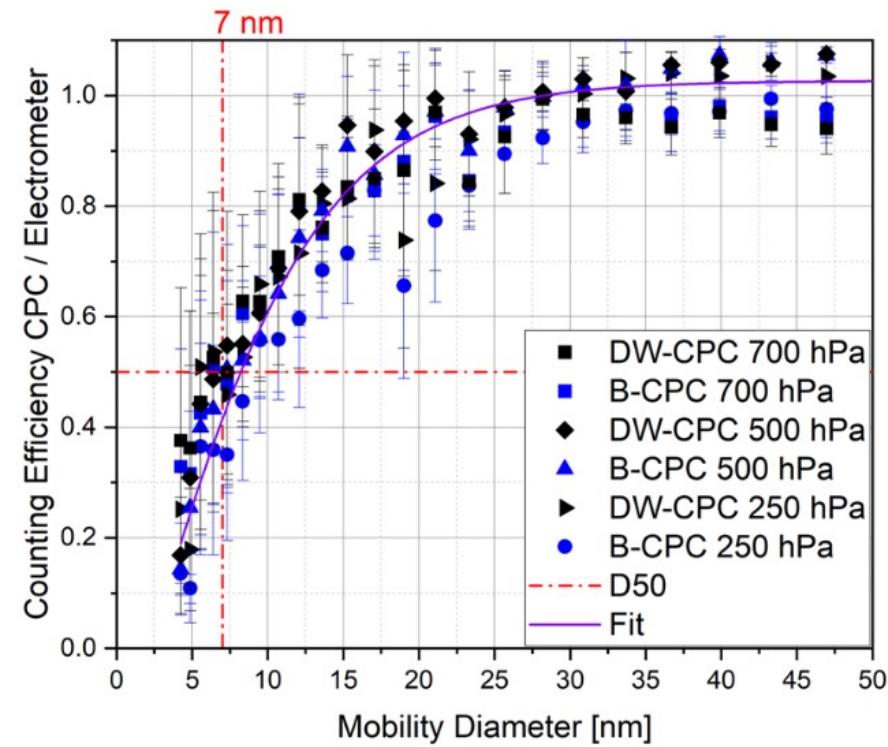


SKY – CPC 5411

Quality Check – Used Feature

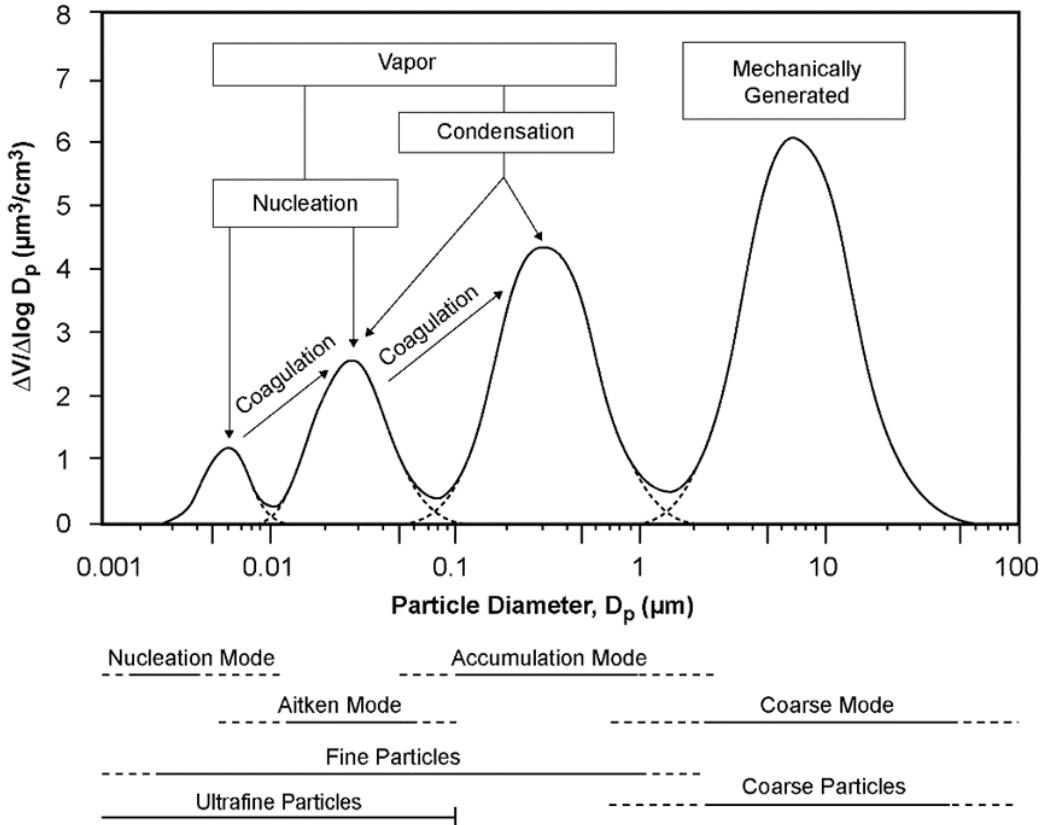


FRESH COMBUSTION SOOT

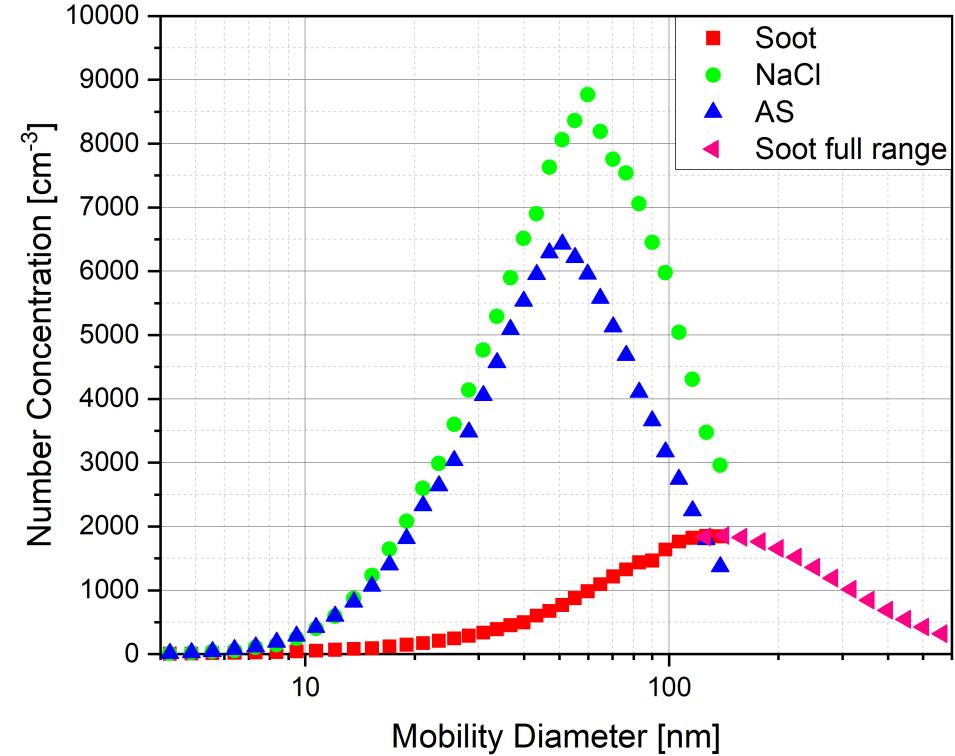


INTRODUCTION

Aerosol

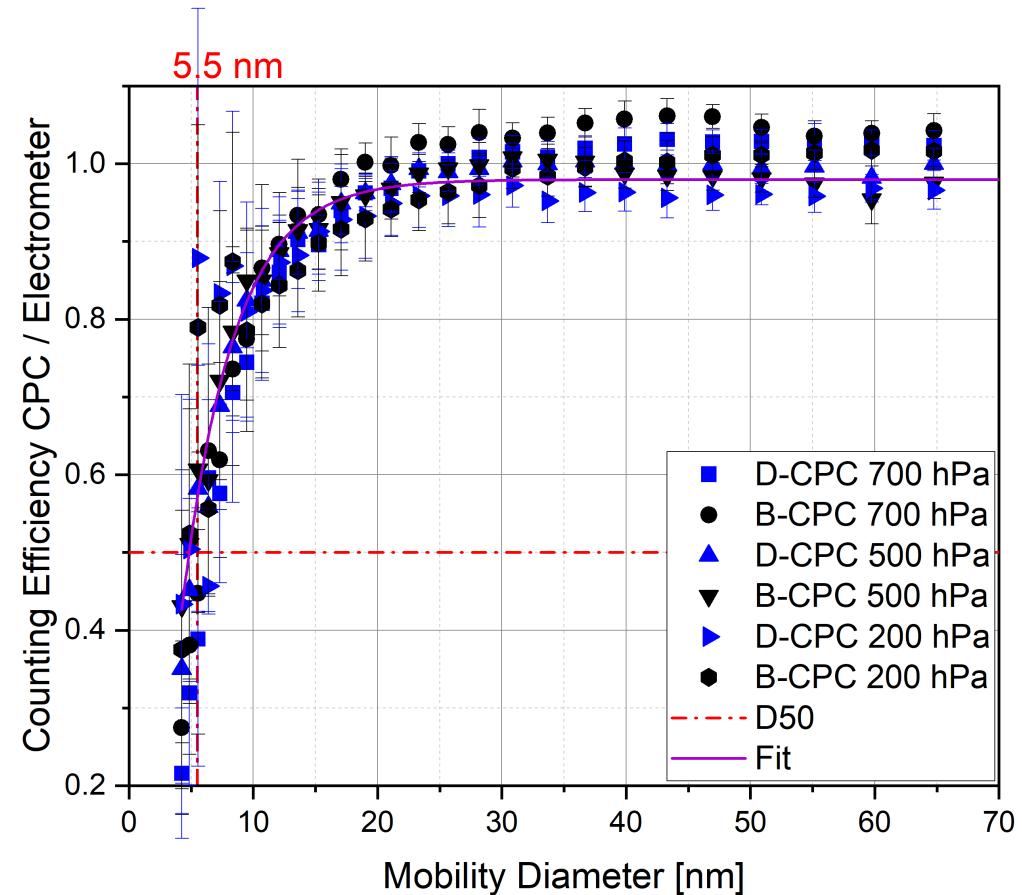


Wilson, W et al. USEPA U.S. Environmental Protection Agency, Washington, DC, EPA 600/P-99/002aF-bF 2004



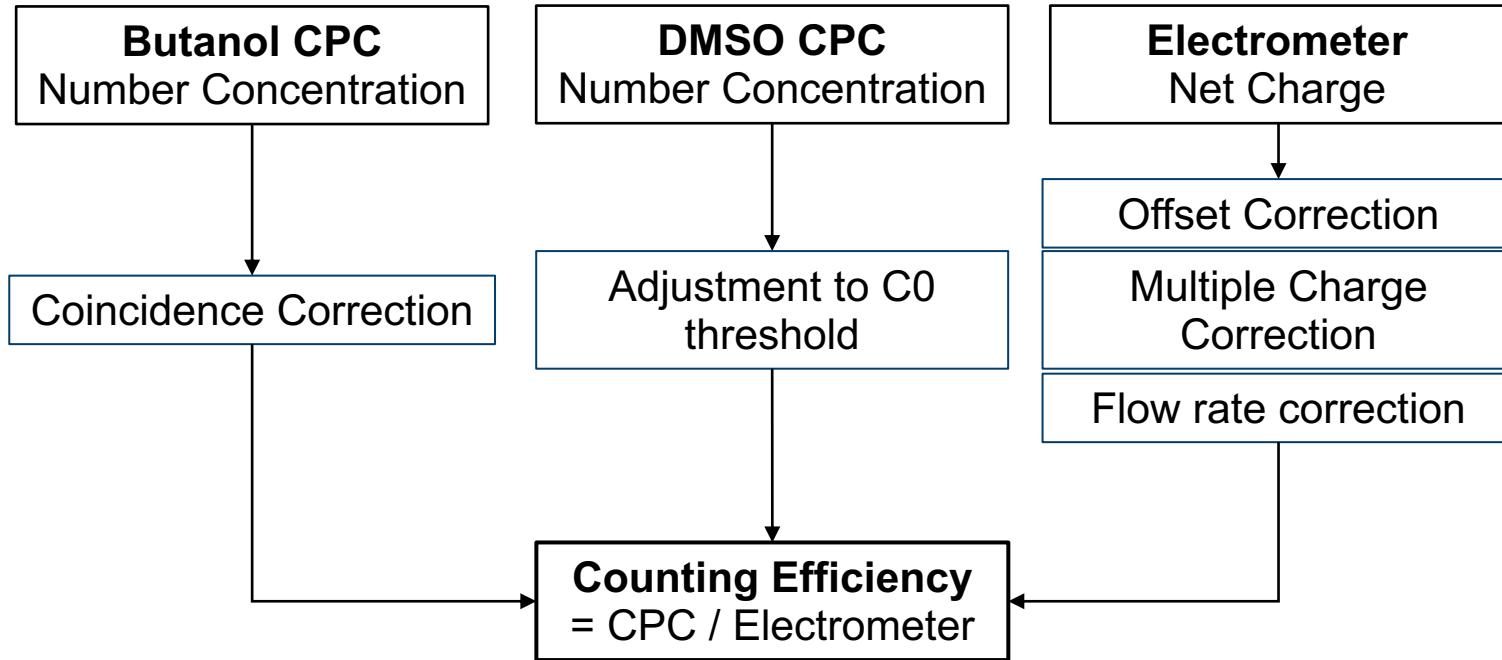
CPC COUNTING EFFICIENCY

Ammonium Sulphate Particles



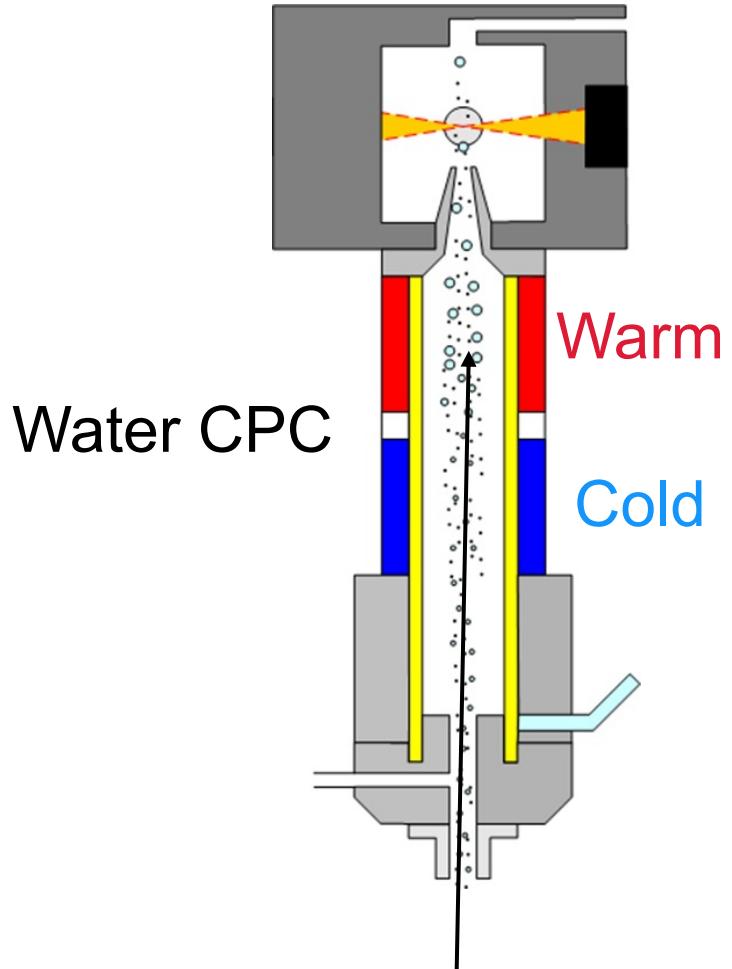
DATA ANALYSIS

Procedure



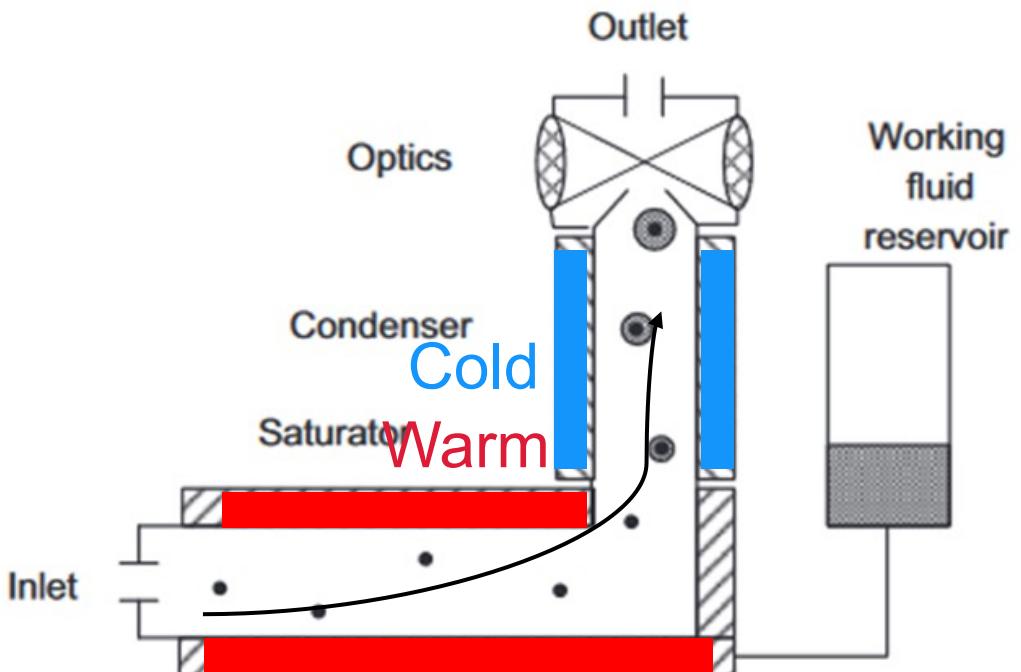
INTRODUCTION

Difference between Water and Butanol



Water CPC

Butanol CPC



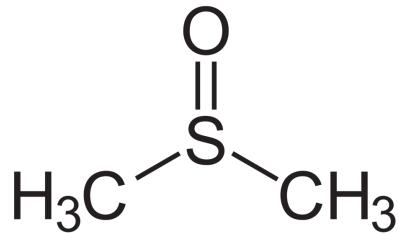
CHARACTERISATION

CPC

and

Working Fluid

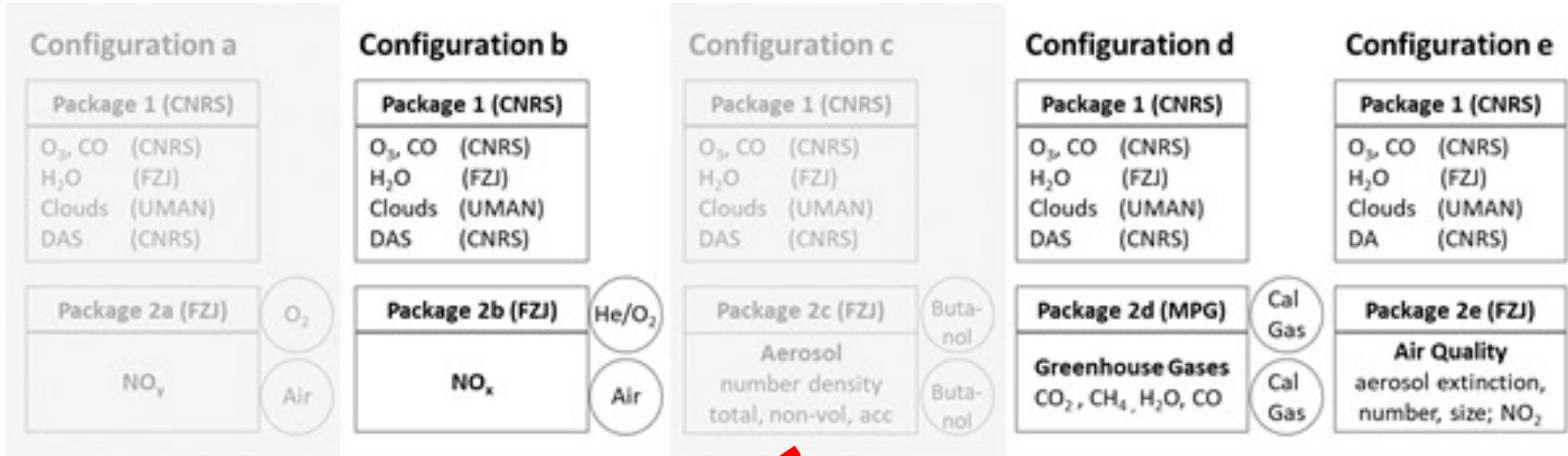
- Cut-off Efficiency
- Activation for different particle types
- Concentration Linearity



- Vapour Pressure
- Particle Activation
- Long-Term Stability

INTRODUCTION

Need of a new Working Fluid



Working Fluid: ~~Butanol~~; ~~Fluorinert~~; Water 😊

flammable



works only at low pressures