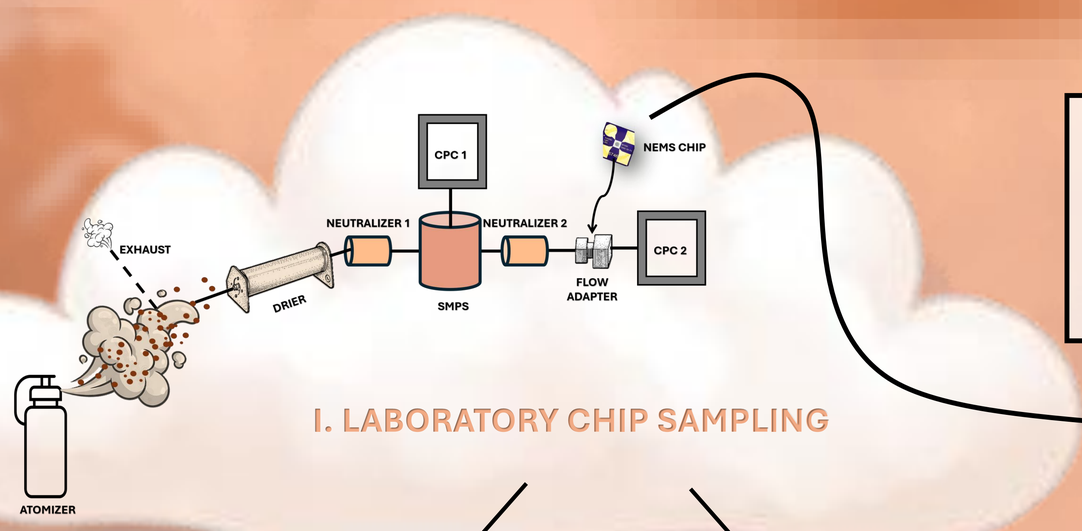
Quantifying functional group abundances of (ultrafine) aerosol particles with a NEMS-FTIR system for source attribution studies

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[2]Invisible Light Labs GmbH
[3]Institute of Chemical Technologies and Analytics, TU Wien
[4] Centre for Atmospheric Sciences, Indian Institute of Technology Delhi

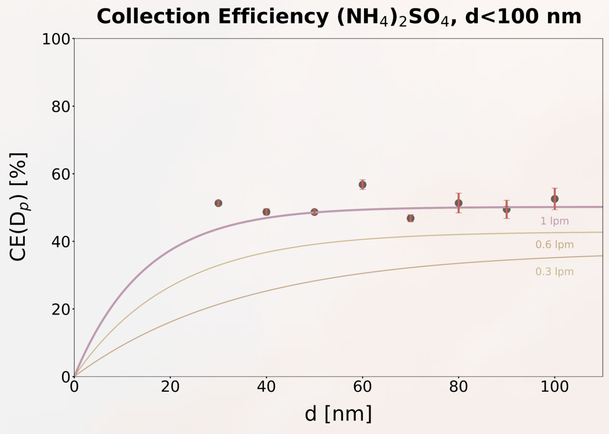


I. LABORATORY CHIP SAMPLING

BACKGROUND

The chemical composition of ultrafine particles is decisive for their specific **health effects** and **climate impact** but also carries information on the dominant sources of these particles. To overcome the so far limitations in available chemical composition analysis techniques of sub-100 nm we use **NEMS-FTIR** (Nanoelectromechanical sensors coupled to a Fourier transform infrared spectrometer).

Collection Efficiency $(NH_4)_2SO_4$, d<100 nm

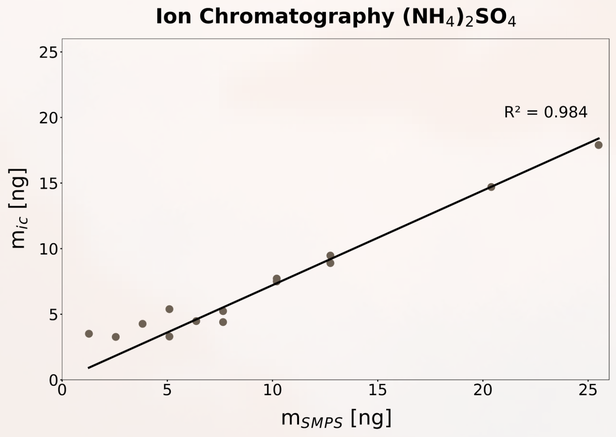


Particle number concentration measurements in a transmission experiment (setup I) are used to show the size-dependent particle collection efficiency of the NEMS-chips, which is in the order of around 50% in the sub-100 nm range. The collection efficiency can be expressed as:

$$CE(D_p) = \frac{1}{\eta} \cdot \frac{C_{\#CPC2_{NEMS}}}{C_{\#CPC1_{NEMS}}} \text{ and } \eta = \frac{C_{\#CPC2}}{C_{\#CPC1}}$$

$C_{\#CPC1_{NEMS}}$ & $C_{\#CPC2_{NEMS}}$ ... *particle number concentration of CPC 1 & 2 with NEMS chip*
$C_{\#CPC2}$ & $C_{\#CPC1}$ ... *particle number concentration of CPC 1 & 2 without NEMS chip*

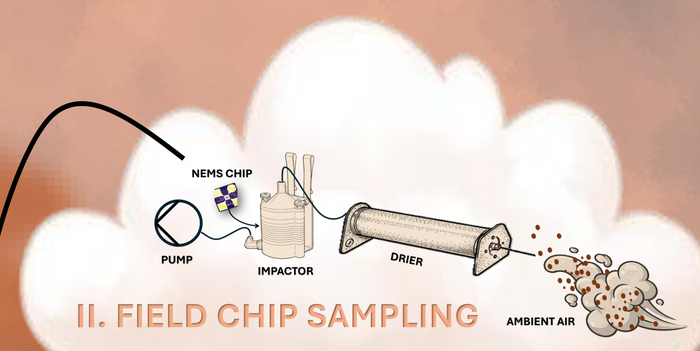
Ion Chromatography $(NH_4)_2SO_4$



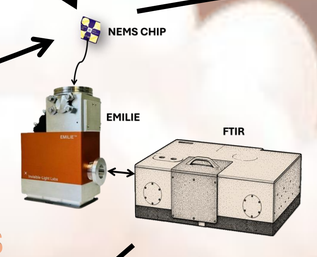
The collected ultrafine mass on the filters is verified through ion chromatography and shows linear behavior regarding the theoretical predicted mass, which is based on collection efficiency measurements (setup I). The sampled mass can be expressed as:

$$m_{SMPS} = CE(D_p) \cdot t \cdot C_{\#} \cdot V_{sph} \cdot \rho_s \cdot Q$$

$CE(D_p)$ ... *collection efficiency accounting for losses*
t ... *sampling time*
$C_{\#}$ ... *particle number concentration*
V_{sph} ... *Volume of particle assuming spherical aerosols*
ρ_s ... *density of substance*
Q ... *flow rate*



II. FIELD CHIP SAMPLING



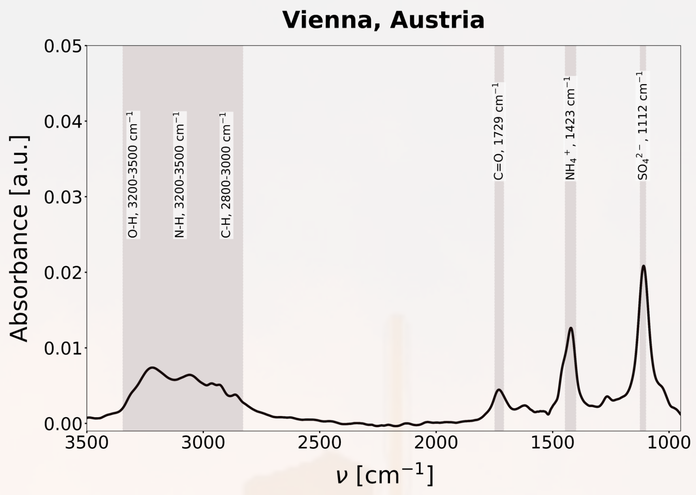
III. NEMS-FTIR CHIP ANALYSIS

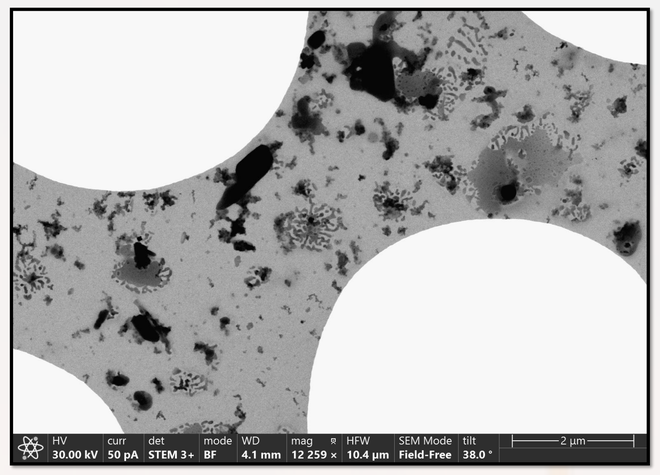
IV. STEM CHIP ANALYSIS

RESULTS

- **We show that the size-dependent particle collection efficiency $CE(D_p)$ of the NEMS-chips is in the order of around 50% in the sub-100 nm range, confirming already existing experimental predictions [1] for the flow of 1 liter per minute.**
- The collected ultrafine mass on the filters is verified through ion chromatography, revealing a discrepancy between predicted and actual mass.
- Scanning Transmission Electron Microscopy (STEM) analysis reveals turbulences in the aerosol flow leading to higher particle losses to the surroundings of the chip than accounted for from the collection efficiency measurements.

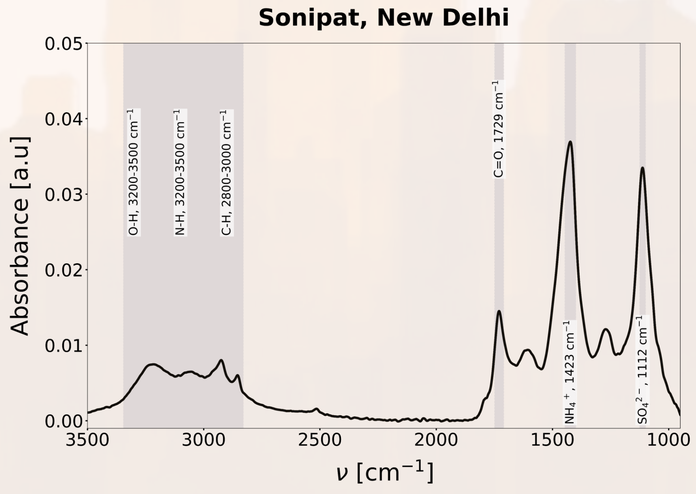
Vienna, Austria

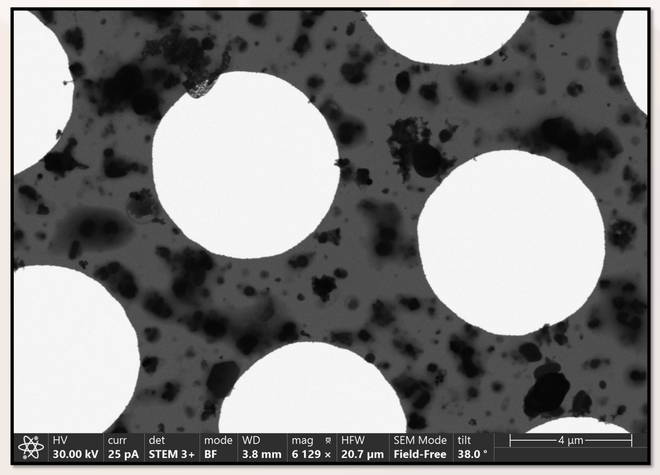




Left: Ambient air spectrum from Austria sampled (setup II.) using a flow rate of 1 liter per minute and a sampling time of 60 minutes. Sampled on March 18, 2026 in the afternoon.
Right: STEM image of the sampled ambient air chip from Vienna, recorded using the FEGSEM Quanta from USTEM.

Sonipat, New Delhi





Left: Ambient air spectrum from India sampled (setup II.) using a flow rate of 1 liter per minute and a sampling time of 5 minutes. Sampled on November 24, 2025 in the afternoon.
Right: STEM image of the sampled ambient air chip from India, recorded using the FEGSEM Quanta from USTEM.

OUTLOOK

- The overall project goal targets the usage of EMILIE [2] as tool for **source apportionment of PM0.1**, showcasing the difference in air pollution composition of contrasting environments (slightly and highly polluted).
- Future aspects include the improvement of spatial and temporal data collection through **multiple measurement campaigns** in India, Europe and the Americas.
- **Functional Group Analysis** of EMILIE spectra with established procedures like AIRSpec [3].
- Performance of Positive Matrix Factorization (**PMF**) [4]

[1] Surdu, M., et al, (2026), Quantifying submicrometer atmospheric aerosol chemical composition using nanoelectromechanical Fourier transform infrared spectroscopy, https://doi.org/10.1126/sciadv.aeb2254
[2] Luhmann, N., et al, (2023), Nanoelectromechanical Infrared Spectroscopy with In Situ Separation by Thermal Desorption: NEMS-IR-TD, https://doi.org/10.1021/acssensors.2c02435
[3] Reggente, M., et al, (2019), An open platform for Aerosol InfraRed Spectroscopy analysis – AIRSpec, https://doi.org/10.5194/amt-12-2313-2019
[4] Comero, S., et al, (2009), Positive matrix factorisation (PMF): An introduction to the chemometric evaluation of environmental monitoring data using PMF, https://doi.org/10.2788/2497

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