Testing respiratory effects and immunotoxic impacts across the environmental or workplace safety and the pharmaceutic efficacy domains employing the NAVETTA in vitro aerosol exposure system

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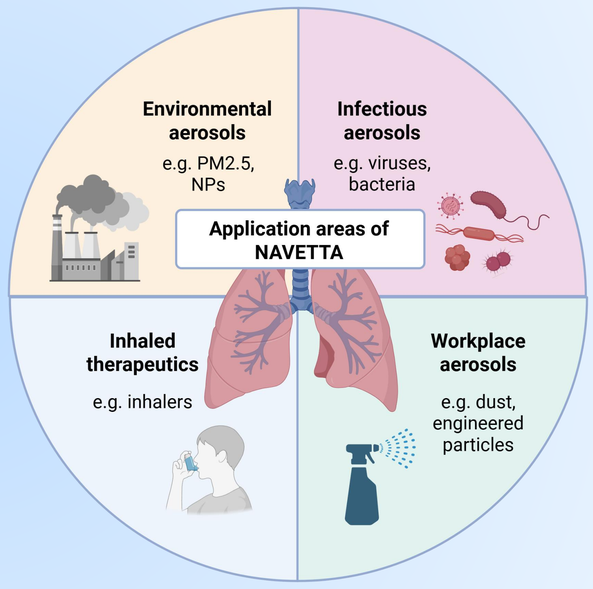
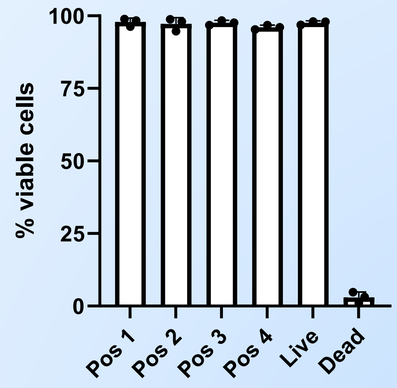
Background and Aim

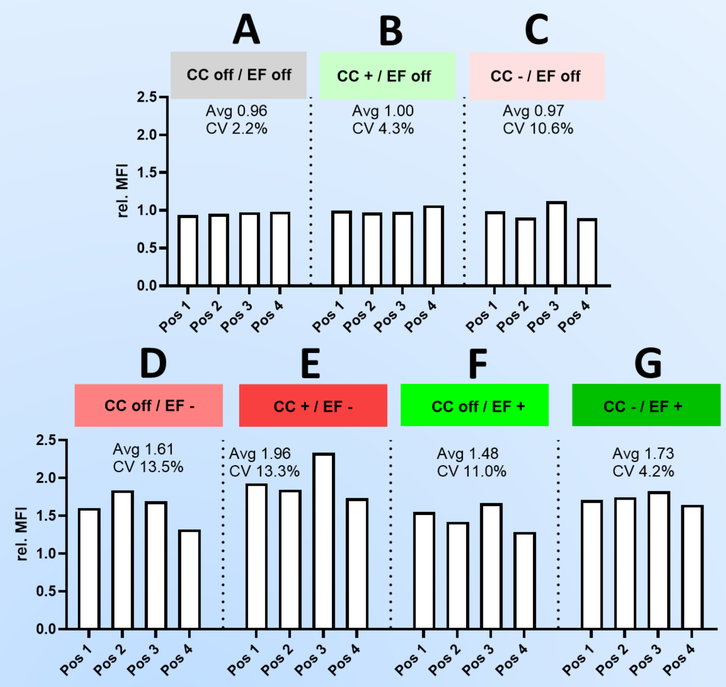
Airborne particles such as pollutants, infectious agents, and therapeutic aerosols affect respiratory health through lung deposition.
Conventional in vitro models lack realistic exposure conditions, while *in vivo* approaches are limited. **Air-liquid interface (ALI)** cultures with controlled aerosol delivery provide a physiologically relevant and ethically aligned alternative supporting the 3R principles (Reduce, Replace and Refine).
This study presents the **NAVETTA** system for controlled aerosol deposition onto lung epithelial cultures to assess immunotoxicity, barrier integrity, and pharmacological effects.



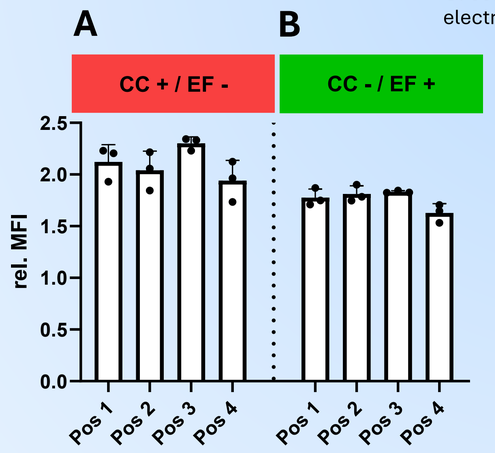
Results



Long-term (24 h) exposure of ALI cultured A549 cells. Viability was tested by CellTiter-Blue assay (CTB), live: incubator control, dead: 0.1% Triton X-100.



Influence of particle charge and electric field on deposition.
Relative Mean Fluorescence Intensity (rel. MFI) across four positions (mean and coefficient of variation (CV) %) is shown for conditions without electric field (A–C: uncharged, positively charged, negatively charged particles) and with electric field (D–G: combinations of field polarity and particle charge). The results highlight the impact of electrostatic conditions on deposition efficiency and uniformity.

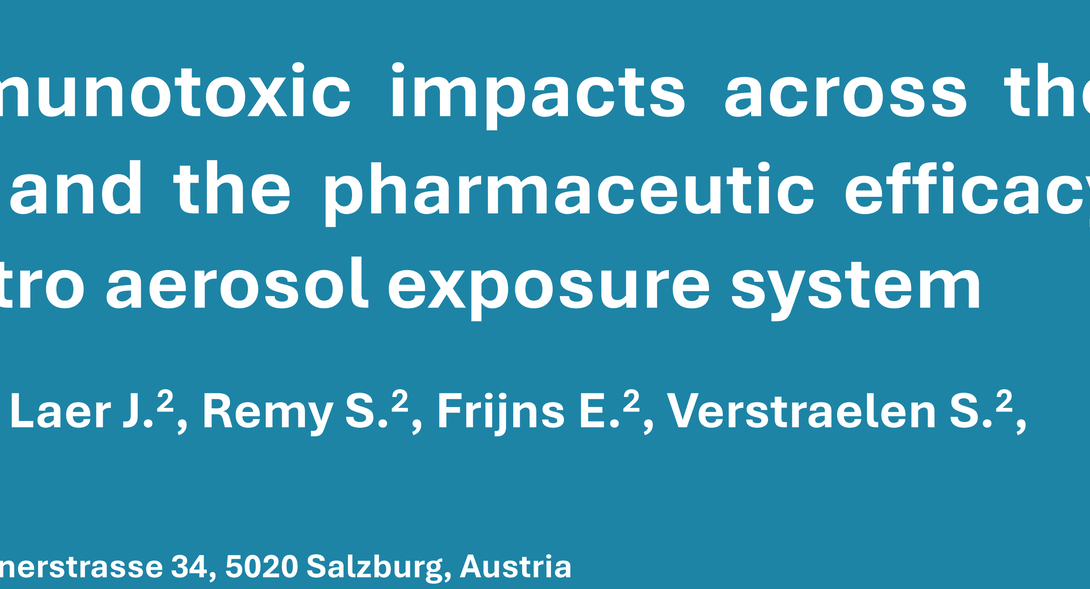


Run	Condition	Avg [rel MFI]	CV [%]
1	CC + / EF -	2.23	4.0
2	CC + / EF -	2.11	6.0
3	CC + / EF -	1.96	13.3
Total (run-to-run)		**2.10**	**9.3**
1	CC - / EF +	1.73	4.3
2	CC - / EF +	1.83	4.7
3	CC - / EF +	1.72	7.6
Total (run-to-run)		**1.76**	**5.9**

Table 1

Run-to-run and position-to-position variability for pristine FITC-labeled silica NP.
The NAVETTA system shows reproducible run-to-run deposition as well as a low position-to-position variability.
A. Deposition, measured as MFI, of additionally positively charged aerosol (using a corona charger (CC), CC+) in a negative electric field (EF-).
B. Deposition, measured as MFI, of additionally negatively charged (CC-) aerosol in a positive EF (EF+).
Table 1 lists average relative MFI values (relative to untreated controls) and the CV% representing the position-to-position variability within one run and over three runs.

The Navetta Workplace



NAVETTA aerosol exposure system and experimental setup.
Schematic overview of the NAVETTA platform (A) illustrating controlled aerosol generation, conditioning, and deposition onto air-liquid interface cell cultures using low-flow conditions and an electric field. Panel B illustrates the preparation of Transwell inserts prior to aerosol exposure experiments. The photograph (C) shows the corresponding laboratory setup used for reproducible aerosol exposure experiments.

Outlook

Future studies will involve inducing inflammation in lung epithelial cells using Tumor Necrosis Factor α (TNFα) and subsequently exposing them to aerosolized liposomes loaded with a pharmaceutical. This approach will allow evaluation of anti-inflammatory efficacy under physiologically relevant air liquid interface conditions using the NAVETTA platform.

To better reflect the complexity of the human lung, advanced air liquid interface co culture models incorporating various and different cell types will be established and exposed using the NAVETTA system.

Conclusion

The NAVETTA allows the determination of cellular uptake and responses upon alveolar deposition of aerosols, making it a powerful tool for in vitro efficacy and safety monitoring of bio-based nano-pharmaceutics.

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vito

BOHS British Occupational Hygiene Society

The Himly Lab