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Portable air-liquid interface exposure chamber for field emissions toxicity assays

Michal Vojtisek-Lom[1,2], Luboš Dittrich[1], Tereza Cervena[2], Martin Pechout[1,3], Jakub Ondracek[4], Anezka Vimrova[2], Jan Topinka[2], Pavel Rössner Jr.[2]

[1] **Technical University of Liberec;** Institute of Mechatronics and Computer Engineering, Studentska 2, 461 17 Liberec, CZ
[2] **Institute of Experimental Medicine of the CAS;** Department of Toxicology and Molecular Epidemiology, Vídeňská 1083, 142 20 Prague 4, CZ
[3] **Czech University of Life Sciences Prague;** Department of Vehicles and Ground Transport, Kamýcká 129, 165 00 Prague 6, CZ
[4] **Institute of Chemical Process Fundamentals of the Czech Academy of Sciences;** Rozvojová 135, 165 00, Prague 6, CZ

Contact: michal.vojtisek@tul.cz, +420 774 262 854

Background:

- Air pollution is the greatest environmental human health risk.
- Reality differs from the theory and from the lab.
- Increasing complexity of mixtures -> in-vitro toxicity assessment. State of the art: exposure of cell cultures and models at air-liquid interface (ALI) analogous to i.e, human lung surface.
- 1996 – first PEMS - portable emissions monitoring system – to measure real-world (real driving) emissions – now expanding the range of uses and pollutants.
- In this work, trying to overcome the distance between the source and the toxicological laboratory.

Goal: "PETS" – portable emissions toxicity system ("biological detector", "bio-PEMS", …)

- Portable ALI exposure chamber for use in the field / in a moving vehicle &
- Mobile toxicological incubator & auxiliaries to serve as field-deployable toxicological lab that can be brought to the testing campaign.



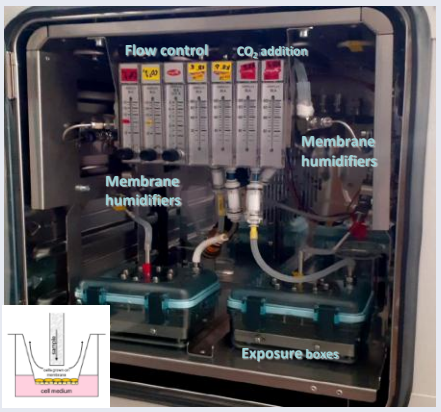


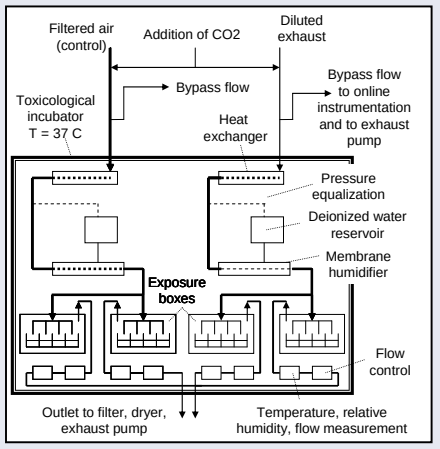
Experimental: Mobile laboratory (base) for field use

- Auxiliary equipment kept at the field base: storage incubator for additional cultures, laminar flow box, freezer, supplies
- The field laboratory was deployed in a van, 2x3 m garden shed, 3x4 m party tent, …
- Longest transport: Prague, CZ - Tampere, FI

Validation:

Outdoor air sampled during 5-day campaigns at -5 to +32 C ambient.
Diluted engine exhaust sampled during on-road tests while mounted on a heavy-duty truck and during laboratory tests.





Experimental: Incubator

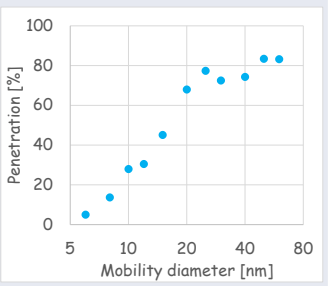
- Cell cultures placed in commercial 6 mm inserts
- 8 inserts in standard 24-well plate sealed in an exposure box
- Two "sample" and two "control" boxes placed in an incubator
- Sample (polluted indoor or outdoor air, diluted exhaust/effluent, …) and control (pure air) heated to 37 C, humidified by Nafion membrane humidifiers (deionized water applied directly to the membrane) to > 85% RH, CO_2 increased to 5%, symmetrically distributed in each exposure box to 8 inserts at 25 cm^3/min/insert.
- Particles and gases deposit by diffusion.
- Incubator is treated like a sampler, sealed exposure boxes are brought in and out for exposures 1-4 hr/day. 1-5 days

Validation:

- Sampling system <u>particle losses / penetration rate</u> characterized by simultaneous measurements at the incubator inlet and the exposure box inlet.

Penetration 50% at ~15 nm, ~80% at >20 nm with silver particles.

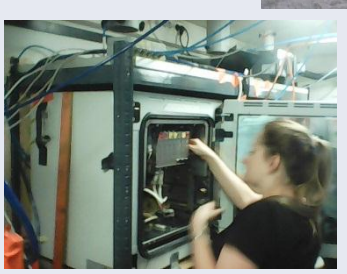
- <u>Particle deposition rate</u> characterized by sampling silver nanoparticles on transmission electron microscope (TEM) grids placed in lieu of cell cultures & TEM imaging & counting.



Deposition efficiency approx. 4-5% for polydisperse silver particles with 10-12 nm and 30 nm geometric mean diameter.

On-road truck exhaust study

Exhaust from two Euro 6 trucks with different age and mileage, diluted by porous tube diluter, was sampled during operation on diesel fuel and renewable diesel in the winter in Finland during trips of several hours of duration.



The incubator was along with a range of online and offline instruments in a container mounted on the trailer.

PAREMPI
Particle emission prevention and impact: from real-world emissions of traffic to secondary PM of urban air

Implications:

- Mobile toxicological lab setup can be brought in a van to the testing site.
- Sealed exposure boxes are prepared and handled in the mobile laboratory and placed into the portable incubator for exposure.
- The portable incubator can be used in a vehicle (car, truck, ship, aircraft) or in a laboratory in a manner similar to a gas or particle analyzer.
- This setup expands the possibilities for toxicity studies by exposure of cell cultures at air-liquid interface by making ALI exposure feasible in field conditions, away from the standard laboratory.
- The toxicological work has not been made simpler or easier, it remains complex, time-consuming and expensive; this is the next challenge.

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