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Towards continuous measurement of the oxidative potential of air

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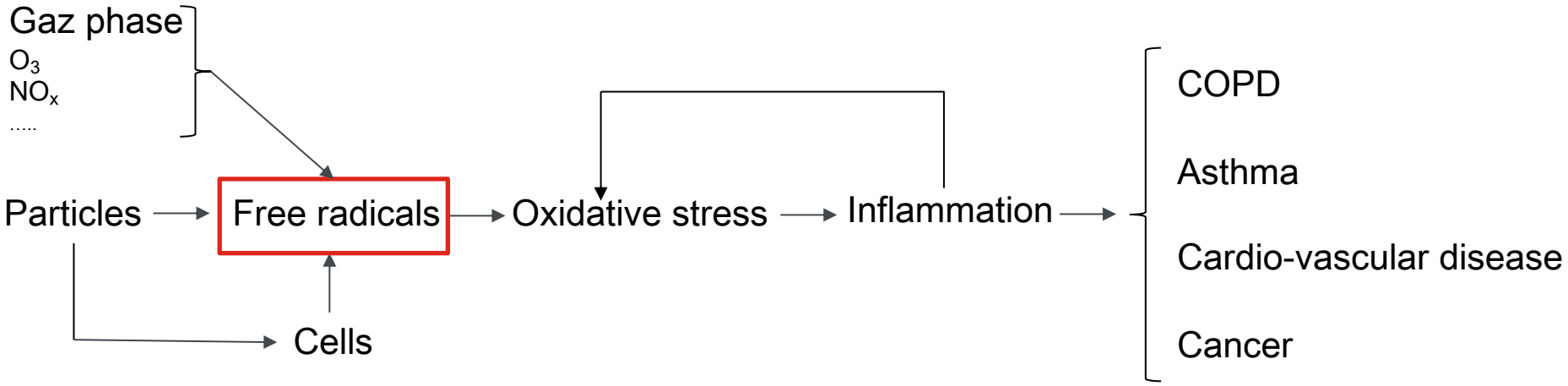
Promotion of Environmental Technologies
Federal Office for the Environnement



Adapted from Ayres et al., Inhal Toxicol. 2008
https://doi.org/10.1080/08958370701665517

Biological effective dose: Amount of radicals able to oxidise biological components

Use acellular assays with chemicals in the reduced state

Dithiothreitol (DTT),
Glutathion (GSH),
Ascorbic acid (AA)
Fe^{2+} (FOX),…

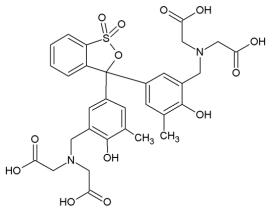


Extraction

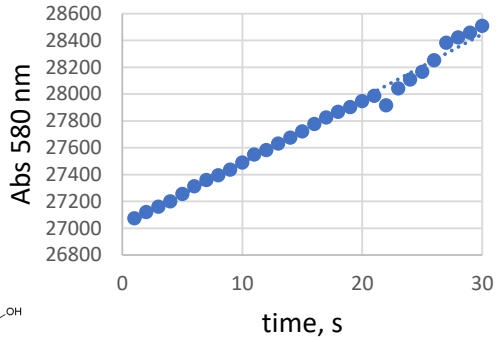
OP assay

Fe(II) → Fe(III)-OX

H_2O_2 (ROS)



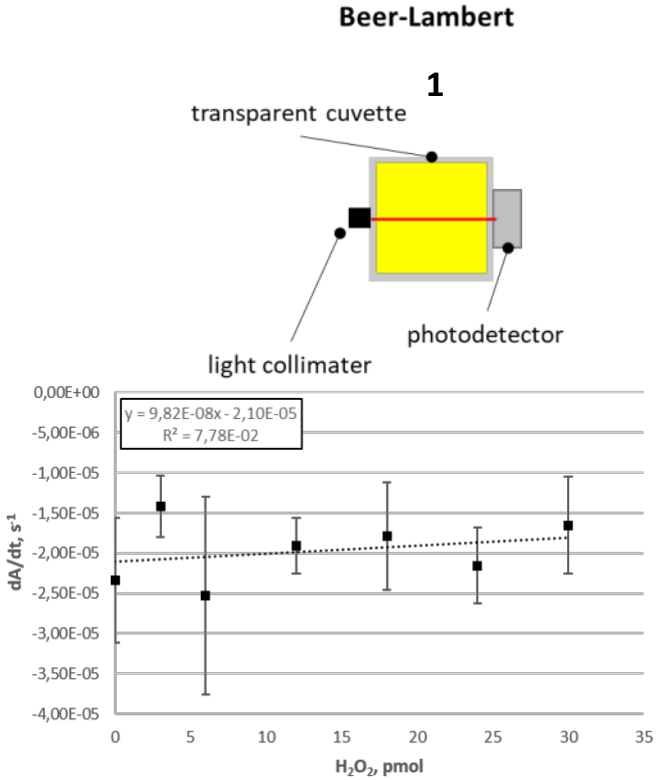
Orange Xylenol (OX)

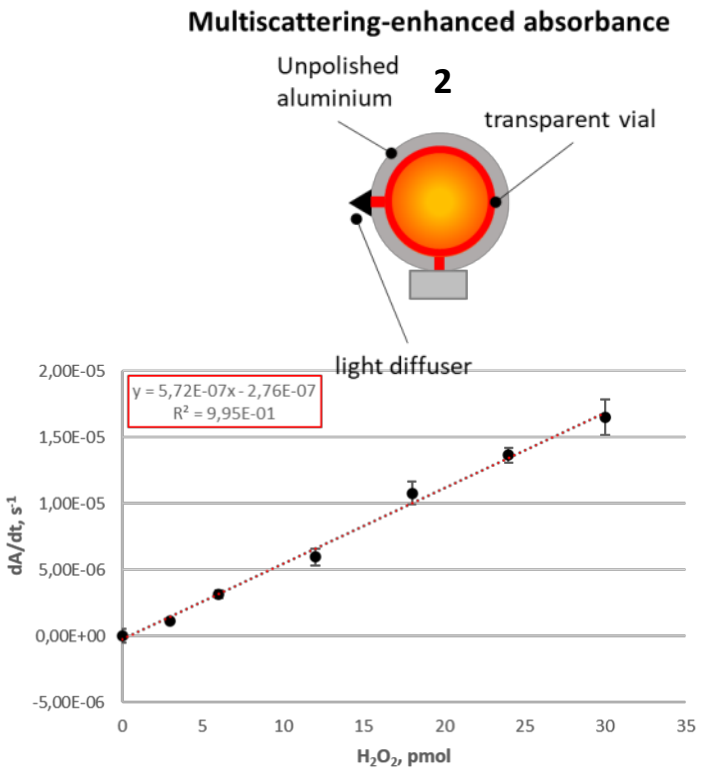


- Gaz fraction ignored
- Storage effect
- No OP dynamics

- Which solvent?
- Only solvent-soluble compounds

- Rapid response: Minutes
- Robust: Integrated and simple assay
- Extended measurement: Weeks
- Sensitive: Multiscattering-enhanced absorbance strategy

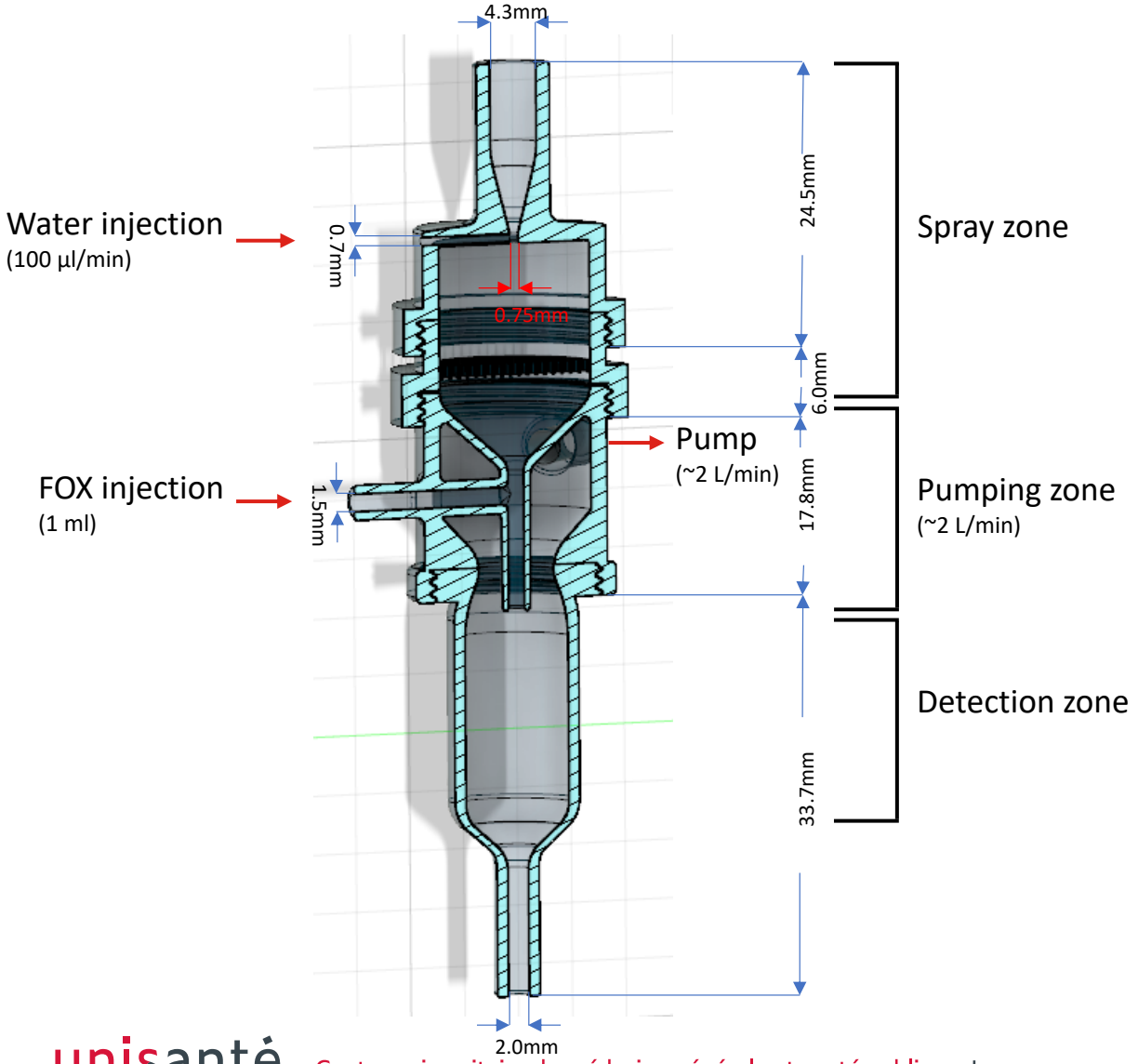




Goekce et al. Medicine in Novel technology and devices, 2022
DOI: 10.1016/j.medntd.2022.100120

On-line device

Design (3-D printing)



Cyclic sequence: 9 min

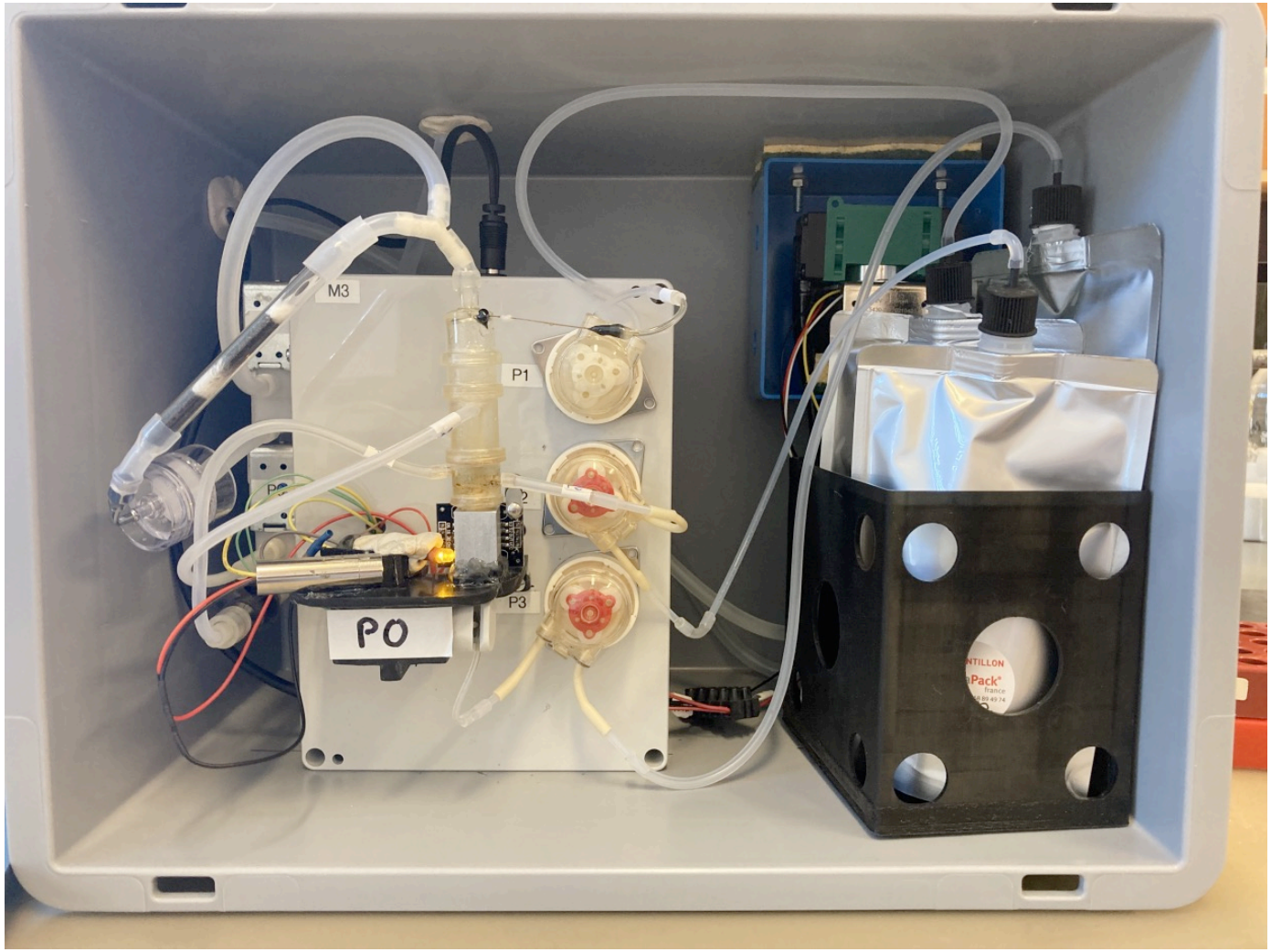
Air sampling: 2.5 min @ 2L/min

Sample loading in detection zone

FOX loading: ~1 min

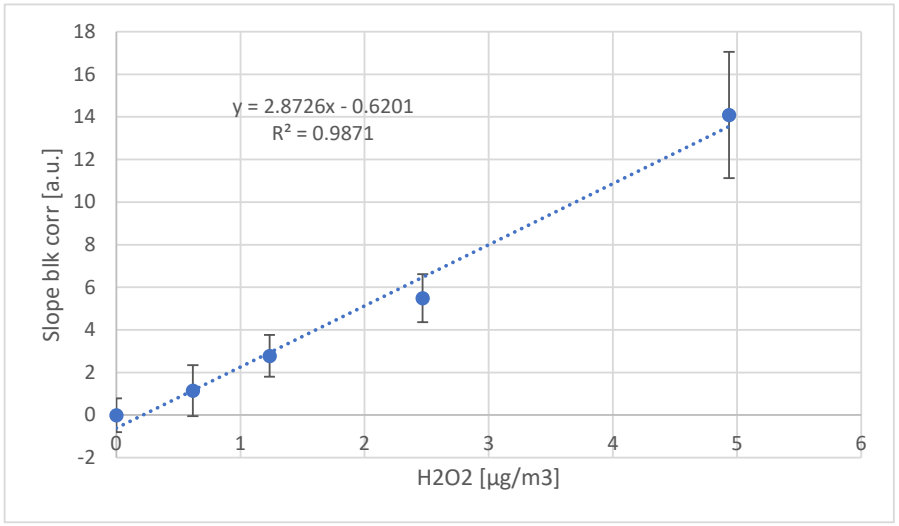
Sample analysis: 2 min

Washing steps: 2 x 2 min

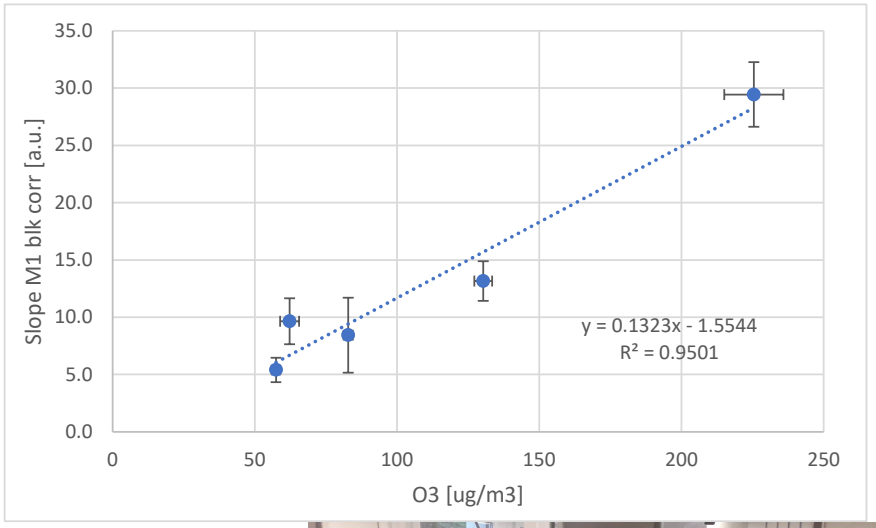

M3
P1
P3
PO

Calibration:

H_2O_2



Ozone

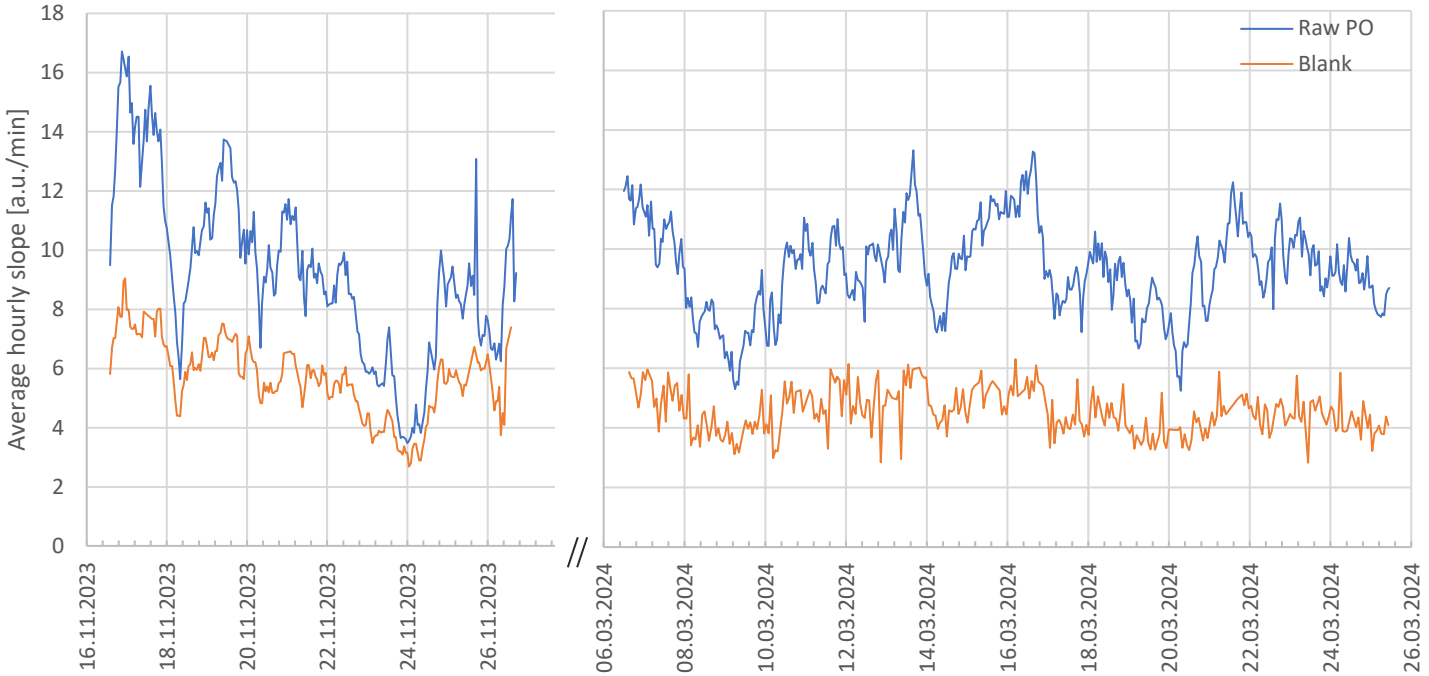


	H_2O_2	O_3
Limit of detection [µg/m^3]	0.35	51
Limit of quantification [µg/m^3]	1.0	150
Repetability CV [%]	< 12	< 20

On-line device

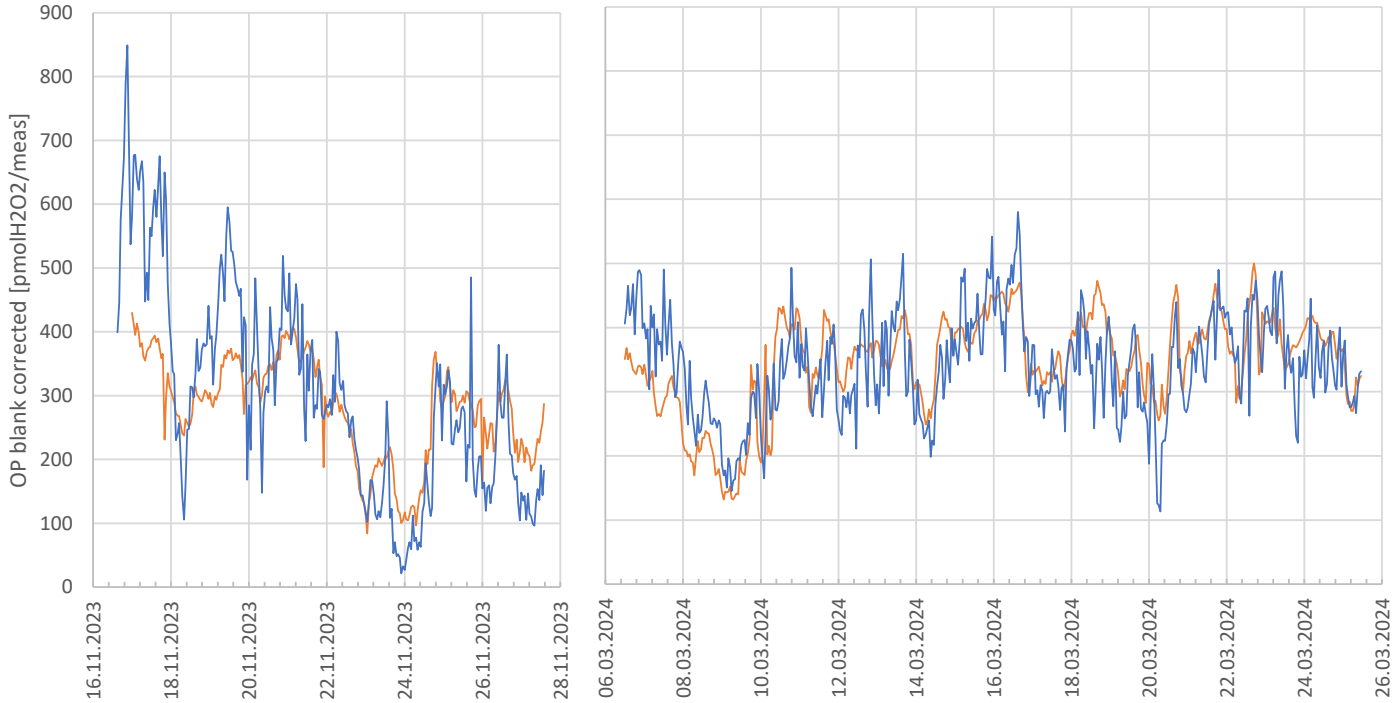
Air quality station «Plaines-du-Loup» Lausanne, Switzerland

Characteristics: urban site, at 100 m from a high trafic road

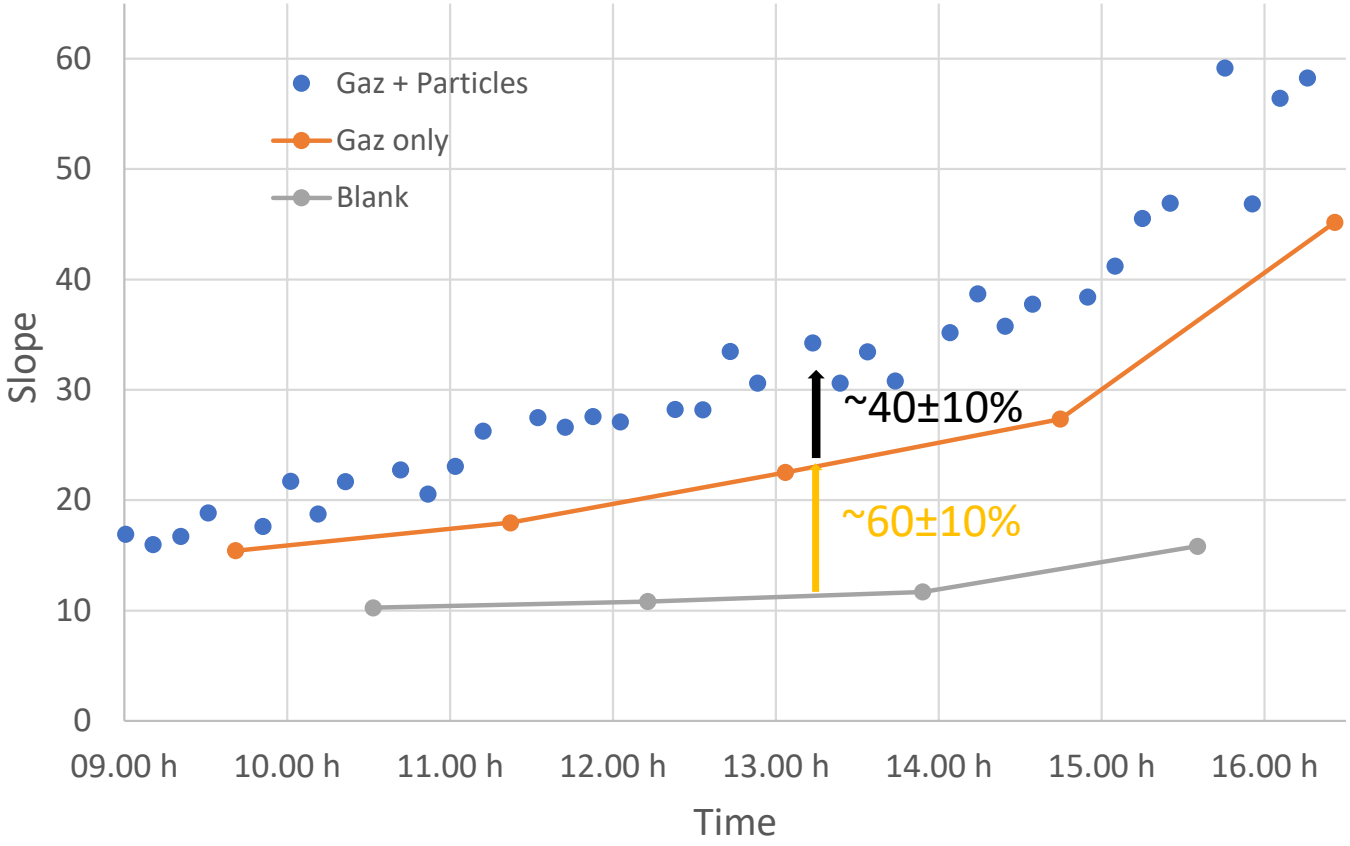


- Identify associations between OP and air pollution déterminants:
  O_3; NO_2; $PM_{2.5}$; UFP (nbr, size); RH; T_{air}; Light

All data: $OP^{FOX} = 2.33*O_3 - 3.99 *PM_{25} - 1.81*size + 1.75\ RH + 10.3*T + 107.9$ r^2: 0.52



- Contribution PM vs Gaz phase to OP (on-line)



- Possibility to measure the ambient OP during an extended period of time
- The device is validated and sensitive enough for OP measurement in ambient air
- Further work to better understand the influencing environmental variables for OP
    - Continue the sampling campaigns during summer and autumn 2024
    - Comparison with other on-line instruments using other OP assays

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Thanks

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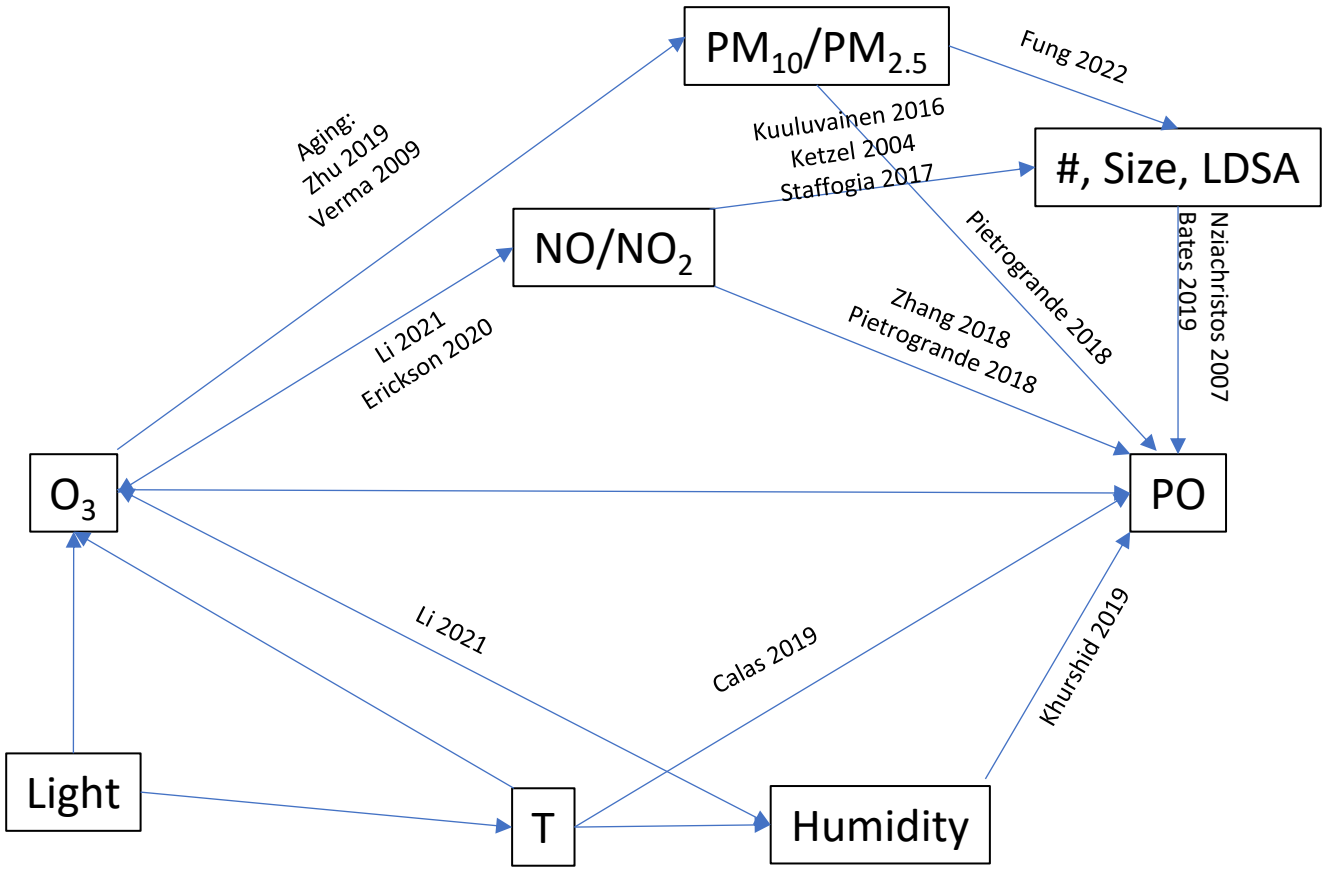
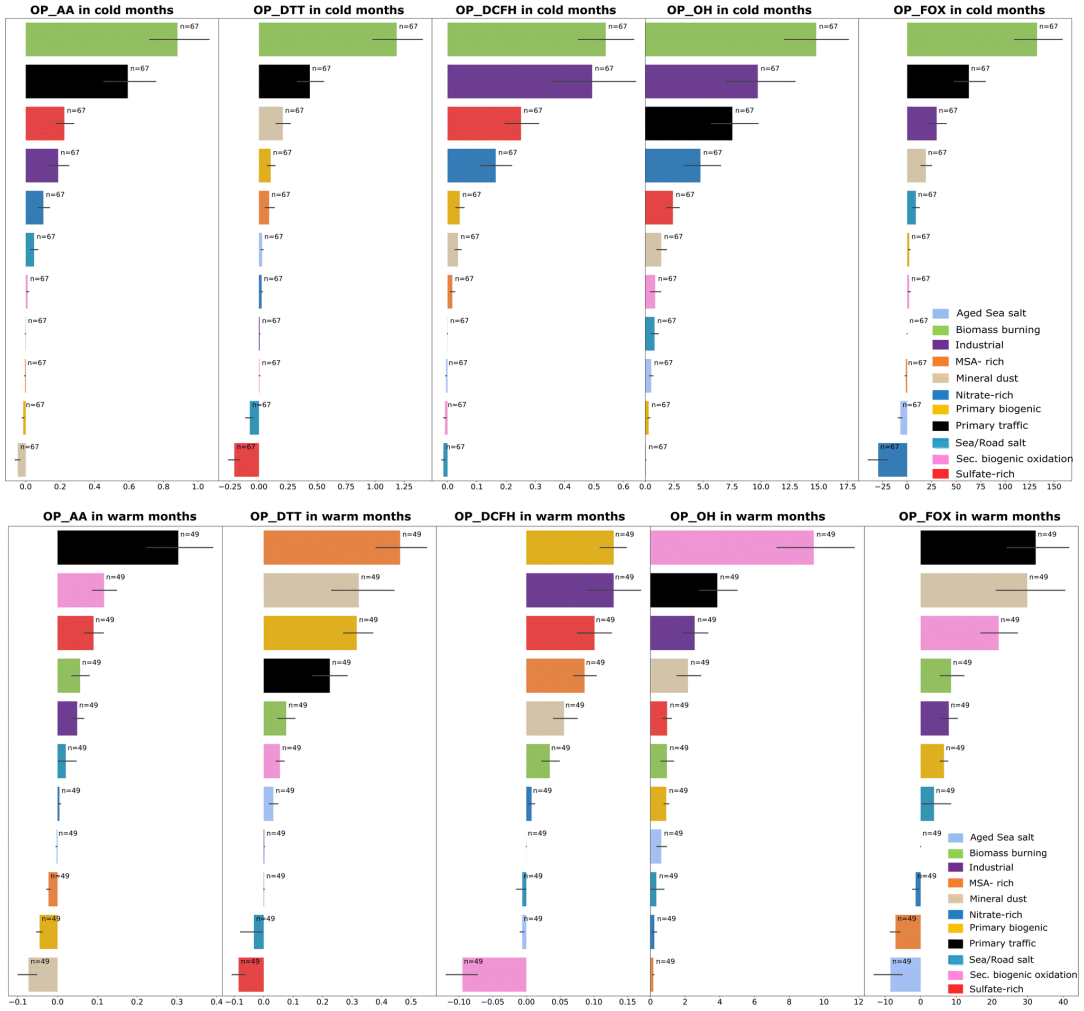
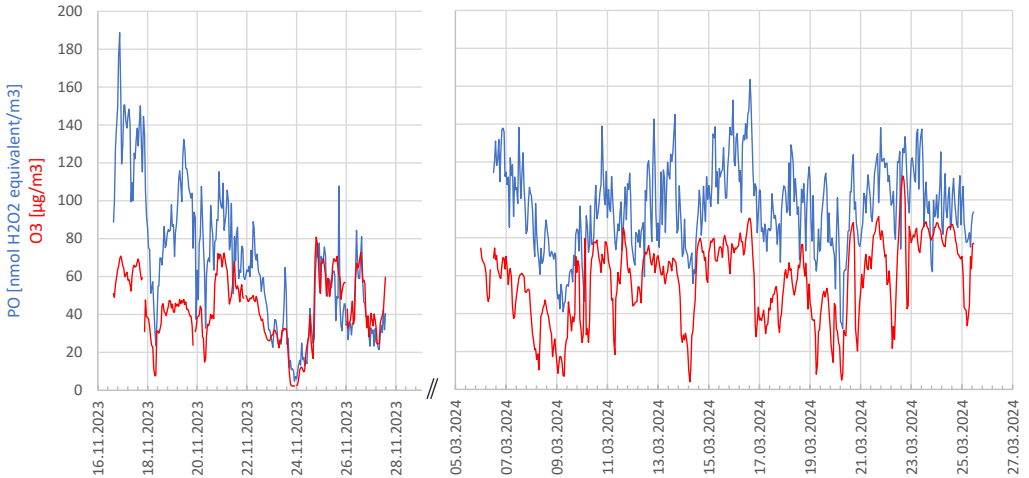

$PM_{10}/PM_{2.5}$
Fung 2022
#, Size, LDSA
Aging:
Zhu 2019
Verma 2009
Kuuluvainen 2016
Ketzel 2004
Staffogia 2017
NO/NO_2
Pietrogrande 2018
Nziachristos 2007
Bates 2019
Li 2021
Erickson 2020
Zhang 2018
Pietrogrande 2018
O_3
PO
Li 2021
Calas 2019
Khurshid 2019
Light
T
Humidity



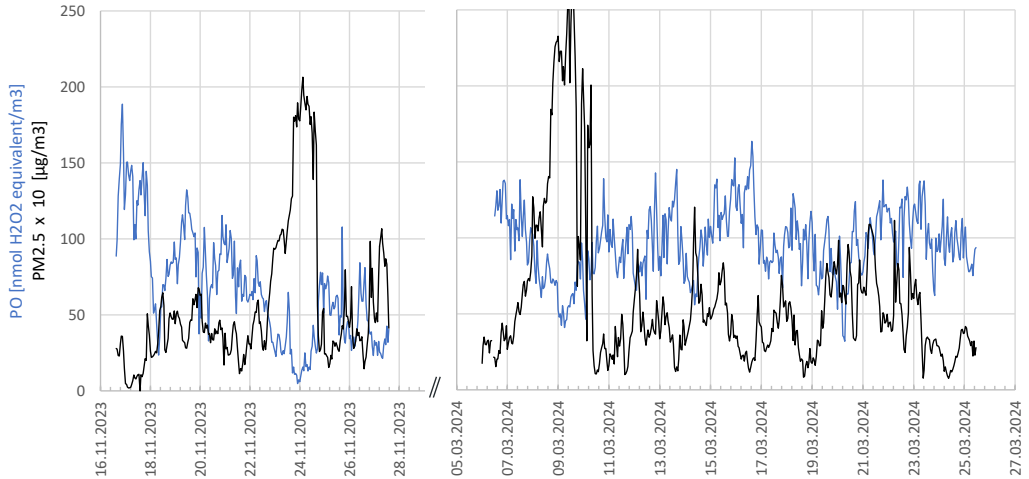
Dominutti et al., Environ Sci: Atmosphere. 2023
http://dx.doi.org/10.1039/D3EA00007A

- Identify associations between OP and air pollution déterminants:
  O_3; NO_2; $PM_{2.5}$; UFP (nbr, size); RH; T_{air}; Light

O_3



$PM_{2.5}$



November 2023: $PO = 2.02*O_3 - 9.57*PM_{25} - 1.14*size + 26.7*T + 182.1$ r^2: 0.70

March 2024: $PO = 2.68*O_3 + 1.49*NO_2 - 3.01*PM_{25} + 1.06*RH + 2.56*T + 75.9$ r^2: 0.46