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Developing a High Time-Resolution Online Instrument to Quantify Aerosol Oxidative Potential via Ascorbic Acid Oxidation

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Many large-scale epidemiological studies have shown a close correlation between adverse human health effects and ambient $PM_{2.5}$ exposure. A report by the World Health Organisation estimates that 1 out of 8 deaths globally are linked to air pollution. Even though various epidemiological studies underline this argument, the chemical components and physical properties of particulate matter that leads to the observed health effects remains highly uncertain.

Aerosol oxidative potential defined as the capability of particles to produce reactive oxygen species (ROS) with subsequent depletion of anti-oxidants, naturally present in the human lung, has been widely suggested as measure of their potential toxicity. Due to the fact that ROS (i.e. inorganic and organic peroxides and radicals) are highly reactive, they are therefore short-lived. Subsequently, classical offline analysis, where aerosol particles are typically collected on a filter for 24h, may lead to an underestimation of the oxidative potential.

Therefore, we developed an online instrument that can continuously measure particle oxidative potential with a high time resolution (10 minutes). We further developed an online instrument described in Wragg et al. (2016) and implemented a physiologically relevant assay to assess aerosol oxidative potential, based on the chemistry of ascorbic acid (Campbell et al. (2019)). Ascorbic acid (AA) is a prevalent naturally occurring anti-oxidant present in the lung and can therefore be used as a proxy to measure the oxidative potential of aerosol.

In this work, we further developed the AA online assay based on Campbell et al. (2019), implementing more physiologically relevant chemical conditions such as pH7 and we improved components of the instrument to increase its detection limit. With the current instrument AA oxidation can be quantified via two different spectroscopic methods: one based on fluorescence as described in Campbell et al. (2019) and a newly developed UV-absorption detection system using a liquid waveguide capillary cell (LWCC) which is a very sensitive long pathway (100cm) absorption cell.

For the fluorescence approach, a limit of detection (LOD) of 0.22 $\mu g/m^3$ was determined for copper (Campbell et al. (2019)). In comparison, the current detection limit for the UV-absorption based setup is an order of magnitude lower (0.02 $\mu g\ Cu/m^3$). This LOD is close to observations of copper concentrations at urban European locations, which are in the range of 0.001-0.009 $\mu g/m^3$. Using both detection methods, we gain an improved understanding of the oxidation process,

because the absorbance method measures AA depletion whereas in the fluorescence method the formation of the AA oxidation product dehydroascorbic is quantified. The online ascorbic acid assay as described will be applied in lab experiments (i.e. flow tubes or smog chamber) as well as for field measurements.

With the improvements of having a more physiological relevant assay and an improved detection method, this instrument is capable of providing a real-time and more realistic estimation of the oxidizing aerosol properties and their potential effect on human health compared to traditional offline methods.

Wragg, F. P. H. et al. (2016), Atmospheric Measurement Techniques, 9(10), pp. 4891–4900.

Campbell, S. J. et al. (2019), Analytical Chemistry, 91, 20, 13088-13095.