Correlations between the toxicity and optical properties of atmospheric aerosol measured by self-developed photoacoustic and supplementary instrumentation

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Light absorbing carbon (LAC) is in the focus of scientific interest both regarding its climatic and human health effects. Despite of its importance it is griddled with huge uncertainty. On one hand, based on radiative forcing, LAC is thought to be the second most important anthropogenic atmospheric pollutant following carbon dioxide, however according to other studies the climatic impact of LAC might be overestimated in most climate models (Liu et al., 2015). There are several reasons for that. LAC particulates have very complex characteristics with significant regional fluctuations. They go through considerable physical and chemical aging even during their relatively short residence time in the ambience. On top of it there is still no standardized and reliable instrumentation capable of determining the complex optical properties of LAC in the whole climate relevant wavelength range.

LAC is the most dominant constituent in the ultrafine particle size range that is assigned with the most severe health concerns. Particles with a characteristic size under 1 μm are to deposit in the lower respiratory system causing severe respiratory and pulmonary diseases. Nowadays, human health aspects of particulate matter are determined by various toxicity tests carried out on filter samples. These methods can be time consuming and expensive. What is more, they are usually carried out with relatively low time resolution so they supply data on particulate toxicity with a great time lag. Also they do not carry information about the daily variation of ambient toxicity that could be indicator of contribution emitting sources.

Recently many studies have verified that there is a strong relationship between the wavelength dependency of aerosol optical absorption (Aerosol Angström Exponent, AAE) and the chemical composition of particulate matter. As particulate toxicity also strongly depends on chemical composition, real-time measurement of the AAE could open up novel possibilities in real time air quality monitoring. Although one of the best candidates for the measurement of the wavelength dependency of aerosol optical absorption is photoacoustic spectroscopy (PAS), multi-wavelength instrumentation is still not widespread.

In this study we are presenting results of a field measurement campaign focusing on determining correlations between the real-time measured optical properties and the offline measured eco-, geno- and cytotoxicity of atmospheric aerosol based on filter sampling in uquely high time resolution. Optical absorption was measured by our recently developed 4λ-Photoacoustic Spectrometer. Toxicity test were carried out on filter samples that were collected with a 6-hour time resolution throughout the measurement campaign. Ecotoxicity was determined by a method based on *Vibrio fischeri* bioluminescence inhibition bioassay. Cytotoxicity was determined by the *Pseudomonas putida* growth inhibition test (ISO 10712:1995). Finally, mutagenity was investigated by the Ames test, using *Salmonella typhimurium TA98 and TA1535* histidine auxotrophic mutant strains. Additionally, other characteristics were monitored parallel during the campaign like size distribution (SMPS), organic to elemental carbon ratio (OC/EC Analyzer) and organic compounds like polycyclic aromatic hydrocarbons (PAH) and BTEX. The filters were also analyzed for levoglucosan, total carbon and ions.

We found correlation between the different toxicity parameters, absorption response and OC/EC measured during the campaign. These results are to propose the possibility of the real time characterization of aerosol toxicity by the measurement of AAE.

	AAE@1064-355nm	**OC/EC**
AAE@1064-355nm	-	0,443
Mutagenity (TA98)	0,735	0,740
Mutagenity (TA1535)	0,741	0,842
Ecotoxicity (1/EC50)	0,246	0,443
OC/EC	0,443	-

Correlation coefficients (R) between the measured AAE, organic to elemental carbon ratio and toxicity values measured by different methods.

References:

Liu, S. et al. (2015) *Enhanced light absorption by mixed source black and brown carbon particles in UK winter*. Nat. Commun. 6:8435 doi: 10.1038/ncomms9435