A thermodenuder assisted dual-wavelength dual cell photoacoustic aerosol analyser with enhanced source apportionment capability

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Light absorbing particulate matter has been in bright spotlight of late years. Atmospheric light absorbing carbon (LAC) and mineral dust (MD) have well-known climatic impact. The biggest uncertainties of climatic model calculations are associated with these constituents. LAC is considered to have become the second most important anthropogenic air pollutant following CO_2 considering radiative forcing. In the atmosphere LAC is present in externally or internally mixed structures with miscellaneous organic compounds. However, most climatic models only account for the external mixing state. If accounted for, internal mixture is generally assumed as a structure of a spherical carbonaceous core and a non-absorbing organic shell (Mie theory core-shell model). Both theoretical models and laboratory investigations have verified that non-absorbing coating can enhance light absorption of the soot core by up to a factor of 2. The phenomenon is called the lens effect (Liu et al, 2015). Absorption enhancement also depends on morphology and coating thickness. Moreover, it has been demonstrated that the presence of non-absorbing coating enhances Aerosol Angstrom Exponent (AAE – the wavelength dependency of the absorption spectrum) of Black Carbon (BC) particles up to 1.6 from the generally assumed 1.0. It makes the differentiation between Black Carbon (BC) and Brown Carbon (BrC) more complicated. It has been shown in many recent studies that although LAC is negligible considering its contribution in aerosol mass it is utterly dominant in respect of human health effects. As a result of their huge specific area and submicron size, such particles are able to penetrate and transport various toxic substances into the lower respiratory system. Subsequently, they are precursors of severe respiratory and pulmonary diseases.

One generally accepted tool for the classification of aerosol constituents with different thermal stability is the thermodenuder. A thermodenuder consists of two parts. First is the heating section where the aerosol compounds with given thermal stability can be evaporated. The second section is an absorber, where the previously evaporated species can be separated from the gas stream. This way the effect of coating on aerosol absorption enhancement can be studied among both laboratory and field conditions.

The photoacoustic method has been proved to be an outstanding candidate for the determination of absorption enhancement attributed to both absorbing and non-absorbing aerosol coating (Liu et al, 2015). The PA method enables the investigation of the optical absorption spectrum in-situ and in aerosol phase. It is also devoid of the measurements artifacts associated with filter-based techniques. The recent availability of multi-wavelength mobile photoacoustic instrumentation opens new field in the determination of real time investigation of absorption enhancement factors of different types of coatings and its wavelength dependency as well. This could provide essential input data in climate fording models.

In this study we are presenting a novel self-developed mobile dual-wavelength photoacoustic aerosol analyser (2λ-PAS). Two operational wavelengths of the instrument (405 and 1064 nm) make the investigation of the absorption spectrum possible in a wide and climate relevant spectral range from the near-IR to the UV. The instrument is equipped with dual measurement channels, one simple, and one equipped with a thermodenuder, which be operated in a wide temperature range (25-300°C). This way the differential absorption response of thermally fragmented aerosol can be investigated. The instrument and the thermodenuder has been optimized concerning aerodynamic and themophoretic particle losses. We are presenting the gaseous and particle calibration protocol of the instrument. The particle phase calibration has been carried out with reference instrument using standard aerosol generation methods. This instrument is a simple and useful tool that could open new perspectives in the investigation of internally mixed aerosol.

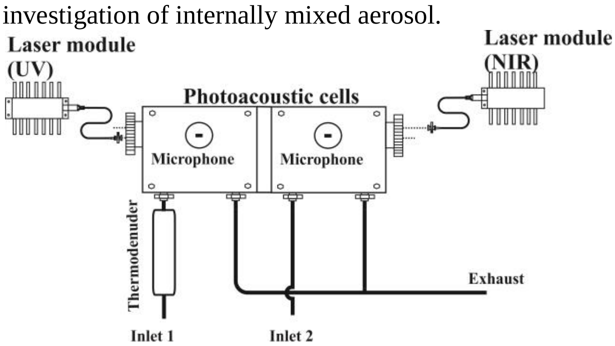

Figure 1.: Schematic setup of the mobile dual-wavelength photoacoustic aerosol analyser (2λ-PAS)

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