Activity report

Campaign name: WOODIESEL2009; Host Chamber:PSI-SCAC; Period: 2009.08.13-2009.09.30

The Multi-Wavelength Photoacoustic Spectrometer (MuWaPaS), developed at the University of Szeged, Hungary, was operated at the smog chamber of Paul Sheerer Institute, Switzerland, Villigen in the period of 2009.08.13 – 2009.09.28. In this measurement campaign the MuWaPas was applied to measure light absorption and its wavelength dependency on artificially generated biomass and diesel aerosols under various conditions. The main scientific goals, using this instrument in the woodiesel2009 measurement campaign were:

- The instrument characterisation and the demonstration of its feasibility to light absorption and its wavelength dependency measurement of artificially generated ambient aerosols.
- Instrument inter-comparison using filter based such as 7-λ Aethalometer and MAAP (Multi Angle Absorption Photometer) and filter free such as (Photoacoustic) methods.
- The possible determination of EC/OC fraction of the generated biomass and diesel aerosols using the obtained angstrom exponent of the multi-wavelength PAS.

The characteristic performances of the Multi-wavelength PAS.

Using the calibration mode of the instrument each cell was illuminated with 532nm laser irradiation subsequently. The actually illuminated cell was purged through with known concentration of NO_2 gas using a cylinder of 10 ppm NO_2 mixed into synthetic air. During the calibration procedure the PA response and the light power were recorded parallel. By taking into account that the optical absorption of NO_2 at 532nm wavelength is well known, the cell response to the unit optical absorption and laser power can be determined. The measured and calculated characteristic performances of the instrument are listed in table 1.

Wavelength (nm)	Slope (nV/ppb)	Cell constant (nV/(Mm-1/mW))	Power (mW)	Noise (nV)	MDOA (Mm-1)
1064	**30,1**	**1,05**	**220**	**503,2**	**0,54**
532	**39,1**	**1,46**	**76**	**256**	**0,59**
355	**52,6**	**1,84**	**17,6**	**122,4**	**0,94**
266	**33,3**	**1,3**	**6,8**	**245**	**6,9**

Table 1. *The characteristic performances of the Multi-Wavelength Photoacoustic System. MDOA - Minimum detectable optical absorption coefficient.*

The measurement results using the MuWaPas system with various types of artificially generated aerosols

Using the measurement mode the instrument was used to measure light absorption by the aerosol sample. The temporal variation of the measured PA signal at 355nm shown in Fig.1.

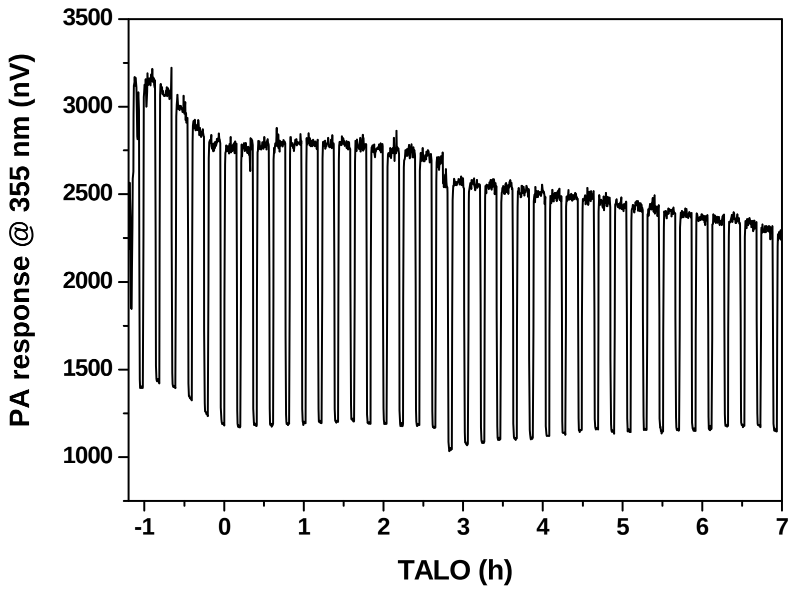


Figure 1: *Temporal variation of the measured PA signal at 355nm.*

This figure demonstrates the necessity of the background correction by means of the frequently switched magnetic valve between the aerosol and aerosol free (filtered) sampling. The background corrected PA response using the determined cell constant and the measured light power at each wavelength can be converted to optical absorption in Mm^{-1} unit. The background corrected PA response of this sampling at different wavelengths can be shown in Fig.2.

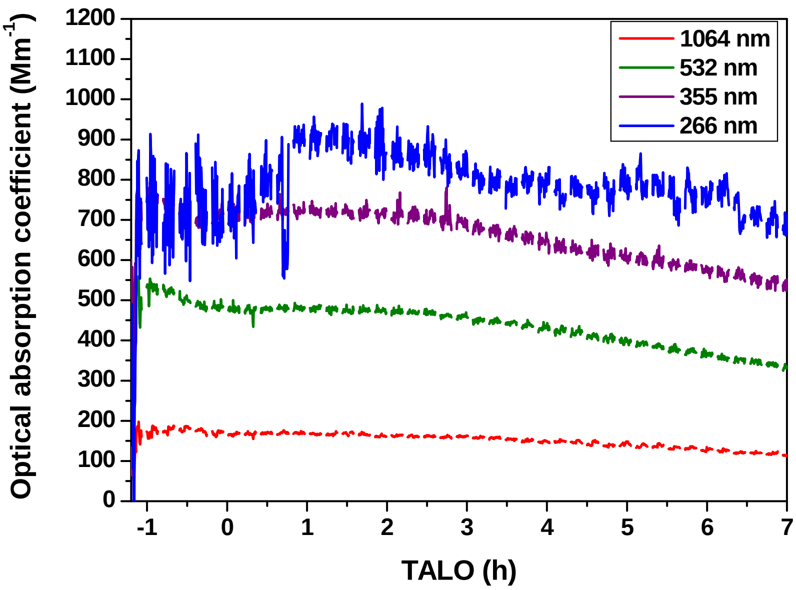


Figure 2: *Optical absorption coefficient at four different wavelengths measured by the MuWaPas system*

To quantitatively characterise the correlation between the filter based (Aethalometer) and the filter free (PAS) techniques the Aethalometer readout was intra/extrapolate to the PAS wavelengths using the measured angstrom exponent. The two instrument response at 355nm, depicted in Fig.3, shows a very good correlation.

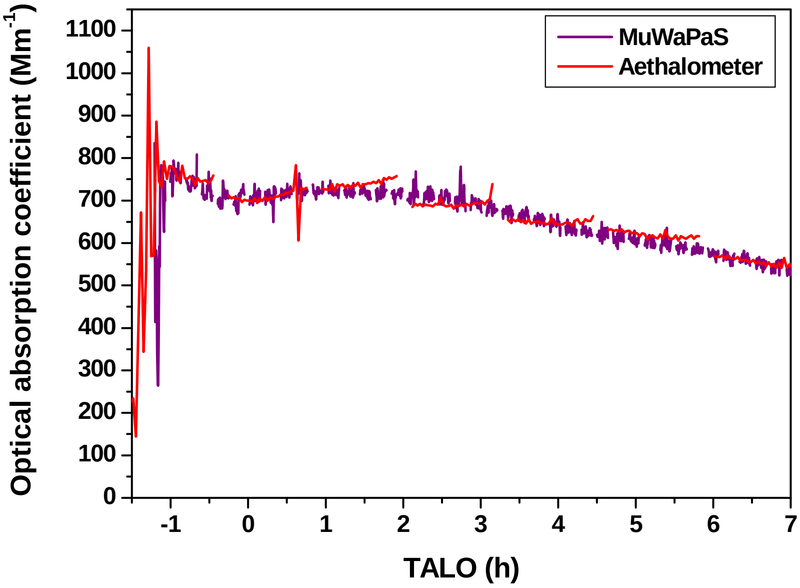


Figure 3. *Optical absorption coefficient of the investigated sample measured by MuWaPas and the Aethalometer at 355nm.*

During the whole measurement campaign the major problem was to eliminate the gas phase cross sensitivity (especially in ozone effect) in the deep UV wavelength region (266nm). We have made several efforts to eliminate the ozone effect after the measurement using the ozone concentration measurement and the calibration results of the proper PA cell to ozone molecules but most likely due to the chemical instability of O_3 we have not found any useful data evaluation method to minimizing this artefact.

Nevertheless, most of the experiments the determined optical absorption coefficient and its wavelength dependency, quantified by angstrom exponent term, shows an acceptable agreements between the different measurement technique as represented in Fig. 4 and 5.

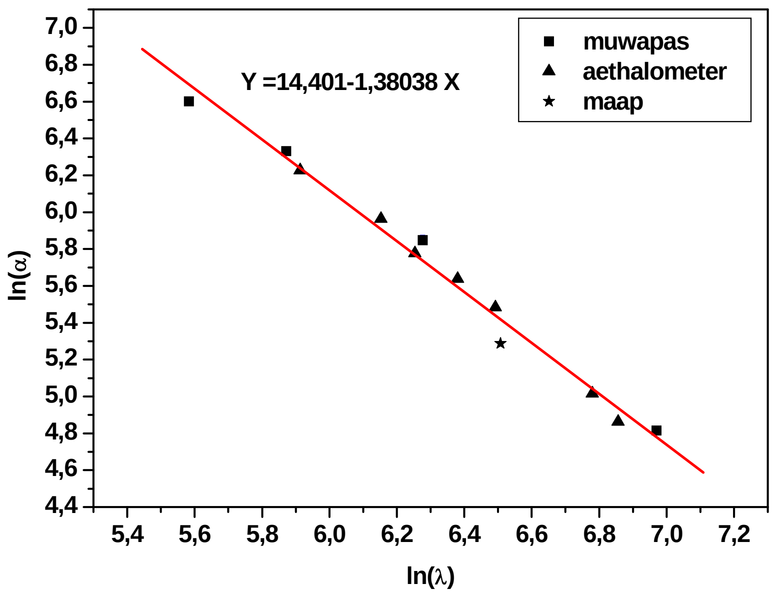


Figure 4. *Absorption of biomass aerosol sample as a function of wavelength measured by the PA system (squares), the MAAP (star) and by the Aethalometer (triangle).*

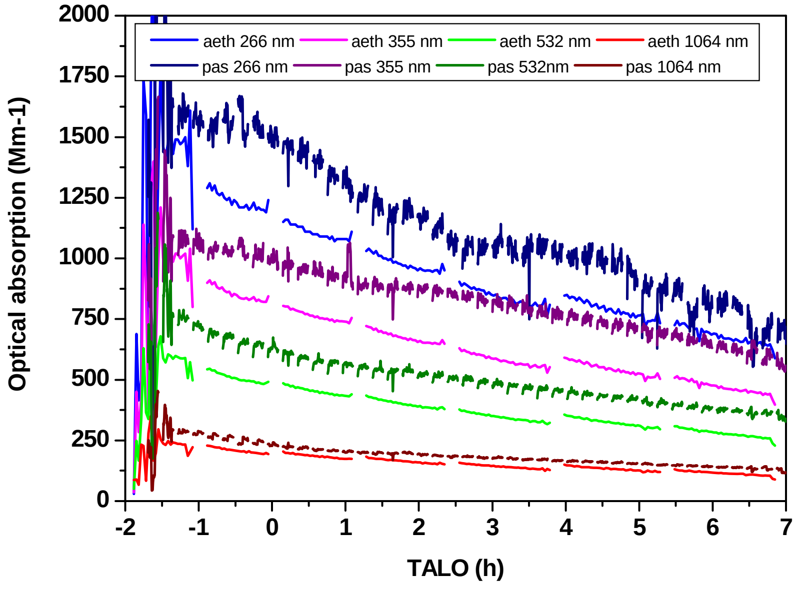
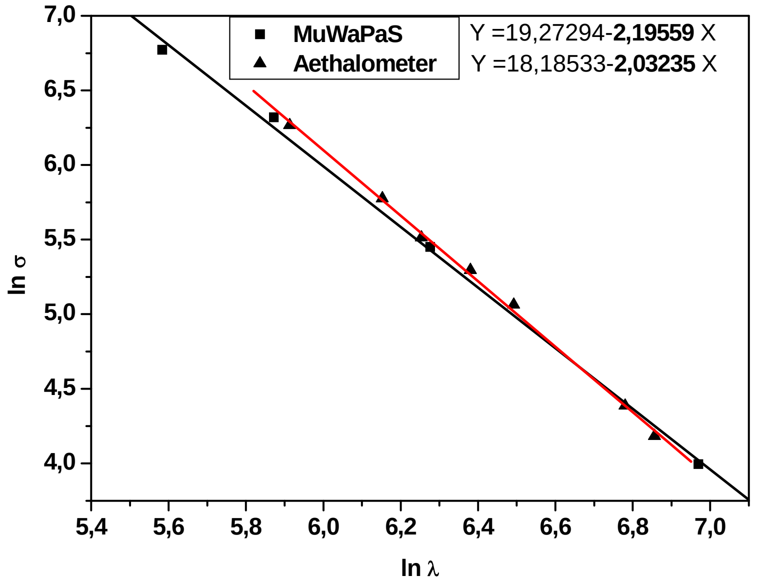


Figure 5. *The optical absorption coefficient of the investigated sample at the four wavelength of the PA instrument measured by MuWaPas, and by the Aethalometer.*

As one can generally said about these experiments that the wavelength dependency in all cases shows excellent agreement using different methods, and the absolute value of the measured optical absorption showing significant but acceptable differences (below 30%) take into account that the presently used instruments introduce a substantial bias into the applied techniques.

The characteristic differences in wavelength dependency of light absorption were found between the biomass and diesel aerosols. In contrast with the biomass aerosols in which cases the measured angstrom exponent was between 1.3 and 2, depend strongly from the sample generation, the diesel aerosol has around unit angstrom exponent independently from the sample generation conditions. An example is shown in Fig. 6a and 6b.



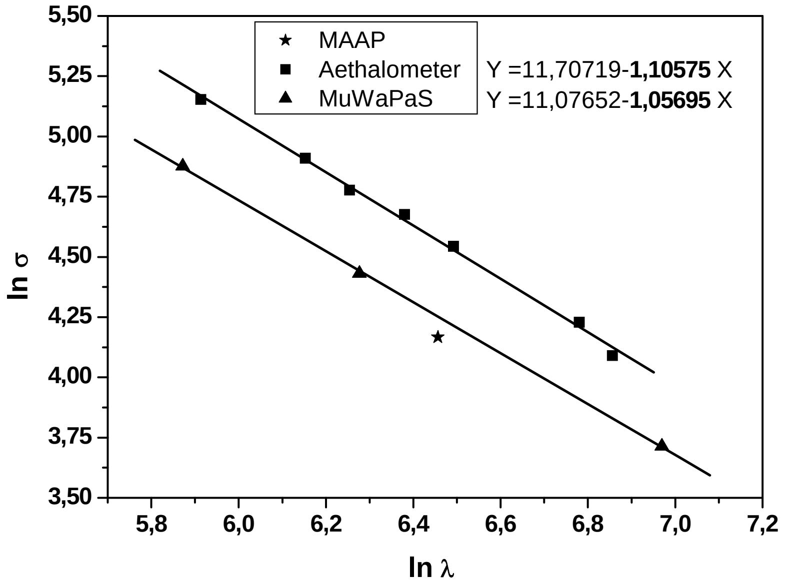


Fig. 6a and b. *Absorption of diesel (upper graph) and biomass (lower graph) aerosol as a function of wavelength measured by Aethalometer, MAAP and Aethalometer.*

Conclusion: we have installed and operated our novel Multi-Wavelength Photoacoustic System (MuWaPaS) successfully during the woodiesel2009 measurement campaign at PSI smog chamber. The characteristic performances of the instrument were thoroughly determined by NO_2 calibration. The instrument performances make this equipment capable of determining the light absorption of aerosols under the atmospherically relevant condition (below $20Mm^{-1}$). The available detection limits are between $0.54Mm^{-1}$ and $7Mm^{-1}$ in optical absorption. During this measurement campaign the feasibility of the instrument for optical characterisation was demonstrated under various conditions. During the whole campaign the MAAP and the Aethalometer measured parallel the optical absorption and its wavelength dependency of the generated samples. Expectedly, further smoothing of the data evaluation take into account a supplementary methodology measurement such as size distribution and further improving the correction factors, optimizing for the applied measurement condition, these differences will be minimizing. The further data evaluation is under process. The publication of the finally evaluated results is under consideration.