

## **Absorption at San Antonio with 3-Wavelength Photoacoustic Soot Spectrometer, Tricolor Absorption Photometer (ASAPT) Field Campaign Report**

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**Absorption at San Antonio with  
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Spectrometer, Tricolor Absorption  
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Field Campaign Report**

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## **Acronyms and Abbreviations**

ARM	Atmospheric Radiation Measurement
EC	elemental carbon
MAE	mass absorption efficiency
NIOSH	National Institute for Occupational Safety and Health
OC	organic carbon
PASS-3	3-wavelength photoacoustic soot spectrometer
PI	principal investigator
PM	particulate matter
QFF	quartz fiber filter
TAP	tricolor absorption photometer
TCEQ	Texas Commission on Environmental Quality
UTSA	University of Texas, San Antonio

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## 1.0 Summary

### 1.1 Sampling and Instrumentation

Fine particulate matter (PM<sub>2.5</sub>; particulate matter with an aerodynamic diameter of 2.5 $\mu$ m and smaller) samples were collected at the University of Texas, San Antonio (UTSA) campus (29.57901, -98.62889) from May 15-30. An additional measurement at the UTSA site included aerosol absorption coefficient of PM<sub>1</sub> (particulate matter with an aerodynamic diameter of 1.0 $\mu$ m and smaller) using a tricolor absorption photometer (TAP) (Brechtel Mfg. Inc., Hayward, California). The sampling site is approximately 15 miles northwest of downtown San Antonio and in close proximity to major highway 10 and is just south of a forested area. The setup of the sampler and TAP and collection of PM<sub>2.5</sub> samples were completed by Baylor University's graduate student, Subin Yoon.

Three three-wavelength photoacoustic soot spectrometers (PASS-3s) were shipped to San Antonio for testing and possible data collection. R. Subramanian went to San Antonio to lead this effort with assistance from Yoon. Each instrument had a critical flaw that inhibited its use for this campaign. Two instruments had low laser power for each wavelength; in addition, there were power and overheating issues with the one instrument that was installed on a test basis. The third instrument had computer issues that impeded any testing. In short, these three instruments would require a major overhaul in terms of lasers and computer systems to be brought back to field capability. As a result, the filter-based optical measurements were added to the campaign as an alternate measurement that would provide mass absorption efficiency at a single wavelength, but no scattering measurement. The TAP instrument was successfully installed and collected data for San Antonio, but full use of the data would have required a co-located scattering measurement.

This campaign was co-located with a Texas Commission on Environmental Quality (TCEQ) ozone field study. That TCEQ field study was a collaboration of the University of Houston (PI James Flynn), Rice University (Co-PI Robert Griffen), and Baylor University (Co-PIs Rebecca Sheesley and Sascha Usenko).

## 2.0 Results

### 2.1 PM<sub>2.5</sub> Filter-Based Sampling

PM<sub>2.5</sub> samples were collected on 90mm quartz fiber filter (QFF) (Pall Corporation, Ann Arbor, Michigan) using a URG 3000b medium-volume sampler (URG Corporation, Research Triangle Park, North Carolina). Prior to sampling, each QFF was baked at 550°C for 12hr, stored in petri dishes lined with baked aluminum, and individually packed in Ziploc<sup>®</sup> bags. All samples were stored in a freezer prior to and post sampling. Blanks were handled in the same manner as the sampled filters. During this sampling period, day and night samples were collected. Day samples (D) collected PM<sub>2.5</sub> from 06:30 to 19:50 while night samples (N) collected PM<sub>2.5</sub> from 20:00 until 06:20. Two of the 23 QFF samples are 24hr samples, one of which was collected from May 28 at 20:00 till May 29 at 19:50 and the other from May 29 at 20:00 until May 30 at 19:50. The exclusion of sampling for days May 19 to May 22 and the two 24-hr samples were due to precipitation events that would have likely collected lower aerosol concentrations due to wet deposition.

After the campaign, the samples were brought back to Baylor University where they were analyzed for ambient bulk carbon concentrations. Organic carbon (OC) and elemental carbon (EC) concentrations were analyzed using a thermal optical transmission method on a Sunset Laboratory's carbon analyzer using the NIOSH protocol [1]. Ambient concentrations were blank corrected using an average of three field blanks.

## 2.2 MAE Calculation from Filter-Based Samples

Mass absorption efficiency (MAE) of EC was calculated from the light attenuation, ATN, from the carbon analyzer. When using the NIOSH method [1], ATN is equivalent to the initial absorbance of the 678nm laser through the sampled filter. Calculation for the absorption coefficient,  $b_{\text{abs}}$ , is

$$b_{\text{abs}}(\text{Mm}^{-1}) = \text{ATN} \times A/V$$

where A represents the sampled filter area used in the carbon analyzer ( $\text{mm}^2$ ) and V is the volume of air sampled ( $\text{m}^3$ ). The absorption coefficient is then used to determine the MAE:

$$\text{MAE} (\text{m}^2\text{g}^{-1}) = b_{\text{abs}}/\text{EC}$$

where EC is the filter loading of the sample ( $\mu\text{g C cm}^{-2}$ ). Due to multiple scattering effects and shadowing effects associated with filter-based measurements of absorption, calculation is typically corrected with two empirical correction factors, C and R(ATN), where:

$$R(ATN) = (1/f - 1) \times \frac{[\ln(ATN) - \ln(10)]}{[\ln(50) - \ln(10)]} + 1$$

A value of 1.103 is used for the  $f$  to correct for MAE [2, 3]. A value of  $C=2.14$  has been applied due to contribution from both biomass and fossil fuel combustion sources [3]. Corrected MAE values were calculated using the following equation:

$$\text{MAE}_{\text{corrected}} (\text{m}^2\text{g}^{-1}) = \text{MAE} / [C \times R(ATN)]$$

## 2.3 Tricolor Absorption Photometer

The TAP is a real-time instrument that measures light absorption of aerosols at three wavelength light sources: 652nm (red), 528nm (green), and 467nm (blue). This instrument is a filter-based method, meaning the particles are deposited on a filter for real-time optical measurements. Continuous  $b_{\text{abs}}$  measurements of aerosols were made from May 19 to May 28 using the TAP.

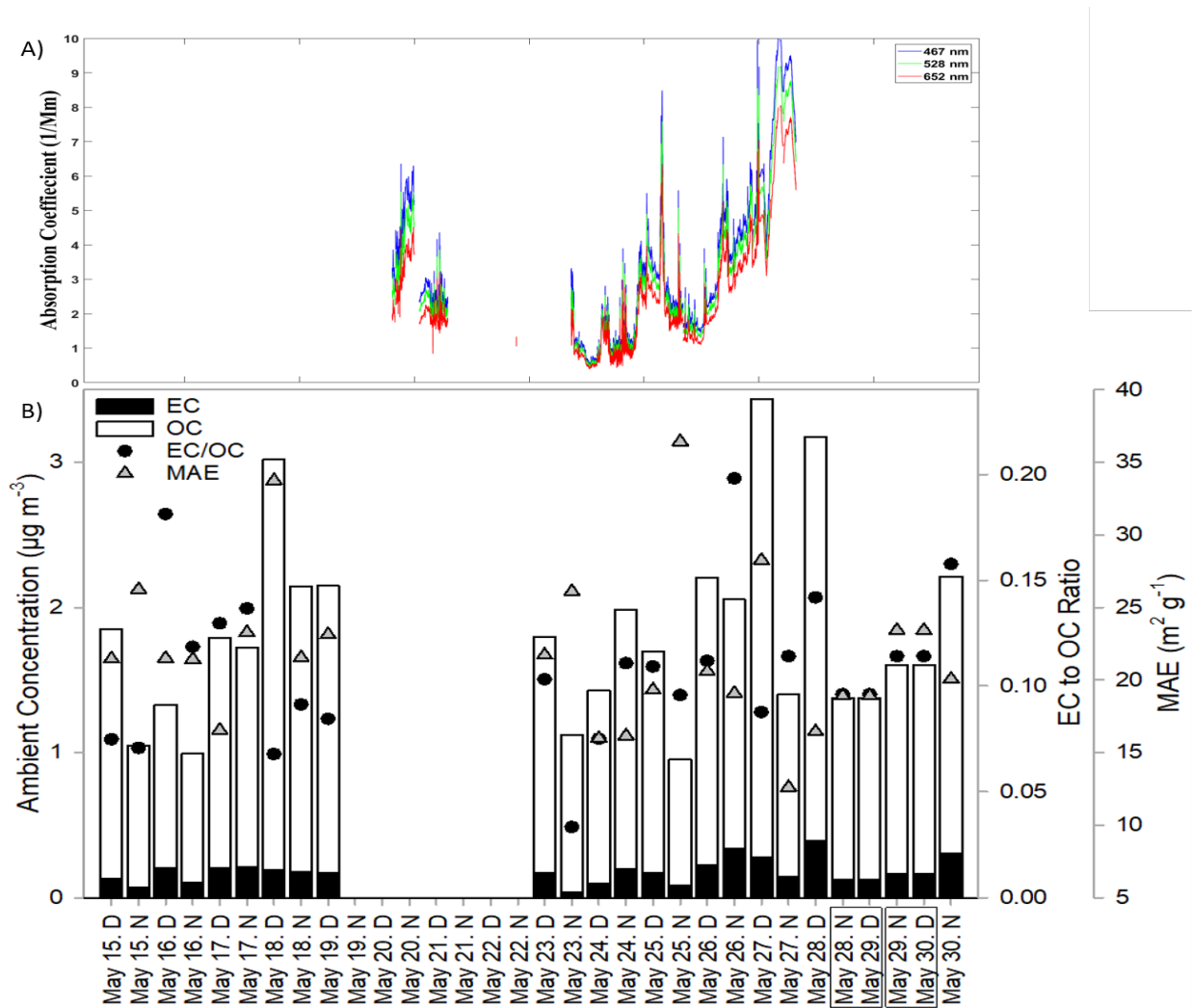
### Results

Average ambient OC concentrations for the day and night samples are  $1.97 \pm 0.67$  and  $1.40 \pm 0.43$ , respectively. Average ambient EC concentrations for the day and night samples are  $0.20 \pm 0.08$  and  $0.17 \pm 0.10$ , respectively. These day and night sample averages excludes OC and EC concentrations from the 24hr May 29 ( $1.26 \pm 0.13$  and  $0.12 \pm 0.08$ , respectively) and May 30 ( $1.44 \pm 0.14$  and  $0.16 \pm 0.08$ , respectively) samples. EC to OC ratios were also calculated and included in Figure 1B. Average EC to

OC ratio is  $0.11 \pm 0.04$ . No difference of average EC to OC ratio is observed between day and night samples.

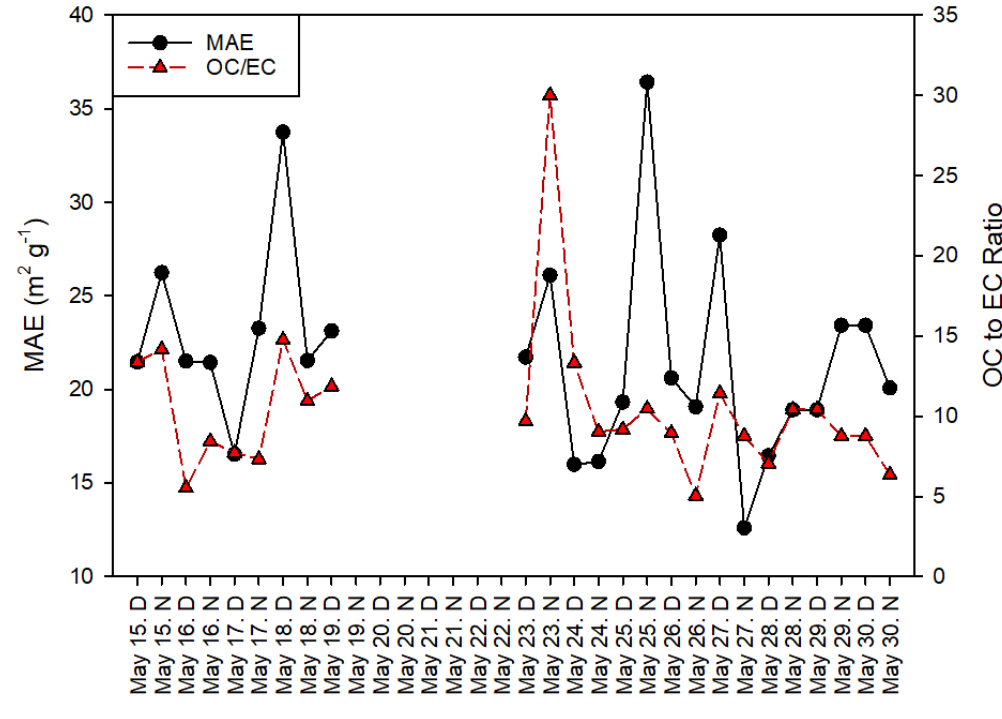
Average calculated MAE value for EC from the QFFs is  $21.9 \pm 5.6 \text{ m}^2\text{g}^{-1}$ . There was no significant difference between day and night samples. Compared to an uncoated (“naked”) soot particle which has a MAE value of  $7.5 \pm 1.2 \text{ m}^2\text{g}^{-1}$  [4], calculated MAE values are much larger. This is due to the soot particle acquiring non-absorbing coatings, mainly sulfate and OC, which lead to absorption enhancement. Diurnal patterns of MAE seem to coincide with OC and EC ratios (Figure 2).

From the TAP data, average  $b_{\text{abs}}$  for blue, green, and red light is  $3.4 \pm 2.4 \text{ Mm}^{-1}$ ,  $3.0 \pm 2.2 \text{ Mm}^{-1}$ , and  $2.5 \pm 1.8 \text{ Mm}^{-1}$ , respectively. All TAP and filter-based data has been uploaded to the ARM Data Archive.

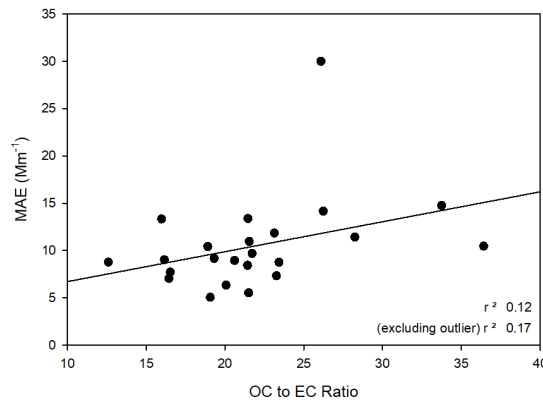


**Figure 1.** A) Real-time measurement of absorption coefficient (Mn-1) of PM1 aerosols using three wavelengths: 467nm, 528nm, and 652nm. Measurement was made by TAP instrument. B) Ambient concentration of OC and EC ( $\mu\text{g m}^{-3}$ ) with calculated EC to OC ratio (right Y-axis) and MAE ( $\text{Mm}^{-1}$ ) values (offset right Y-axis). Boxed samples represent the 24hr samples where a single sample spanned both D and N periods.





**Figure 2.** Diurnal pattern of MAE and OC-to-EC ratio of QFF samples.



**Figure 3.** Correlation of calculated MAE and OC-to-EC ratio of QFF samples.

### 3.0 References

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## 4.0 Publications

None at this time.

