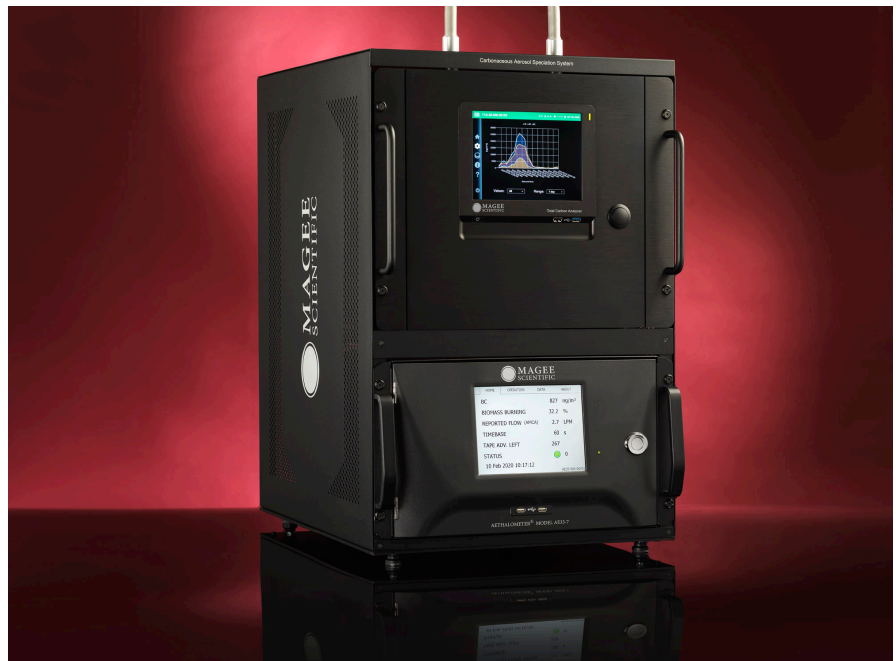




AEROSOL  
MAGEE SCIENTIFIC

## STUDIES OF AEROSOL CARBONACEOUS MATTER USING THE CARBONACEOUS AEROSOL SPECIATION SYSTEM (CASS) COMBINED WITH AN AEROSOL CHEMICAL SPECIATION MONITOR (ACSM)



### MOTIVATION

#### APPLICATION NOTE

This Application Note describes the combination of the Carbonaceous Aerosol Speciation System (CASS) and an Aerosol Chemical Speciation Monitor (ACSM). The ACSM is used for real-time monitoring of non-refractory aerosol particle mass and chemical composition. It reports particulate ammonium, nitrate, sulfate, chloride, and other organic species as "organic matter" (OM). The ACSM is one component of the standard equipment used at ACTRIS monitoring stations for determination of organic matter (OM) within the PM<sub>2.5</sub> and PM<sub>1</sub> fractions. (<https://www.actris.eu/>)

The Magee Scientific Carbonaceous Aerosol Speciation System, (CASS), is the combination of the TCA08 Total Carbon Analyzer and the AE33 Aethalometer. This creates a revolutionary instrument for determination of the Total Carbon (TC), the Elemental Carbon (EC), the Black Carbon (BC) and the Organic Carbon (OC) content of suspended aerosol particles in real-time. The equipment is suitable for both scientific laboratory studies as well as routine air-quality monitoring. The most important features that characterize and distinguish CASS from other OC/EC analyzers on the market are:

- NO GLASS, NO GAS, NO CATALYST: rugged, field-proven hardware
- Continuous real-time data

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**DISCUSSION**

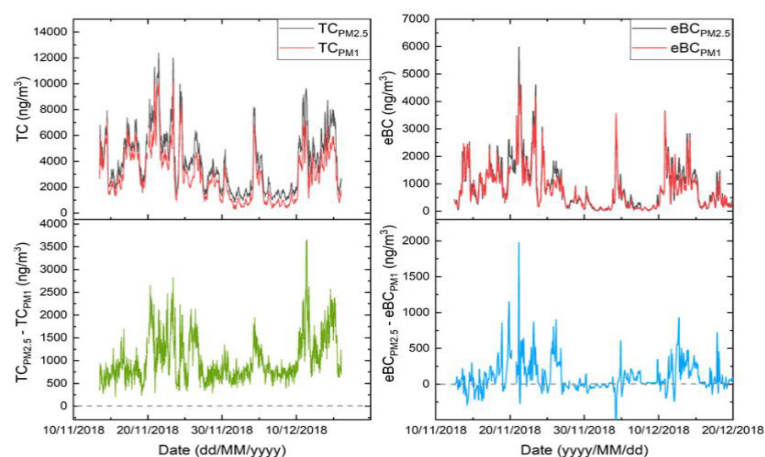
Carbonaceous aerosols include fractions of Black Carbon (BC) as well as Organic Matter (OM). "OM" represents many different molecular structures including carbon and other elements such as hydrogen, oxygen, nitrogen and sulphur (Brown et al., 2013; Crenn et al., 2015). The total amount of carbon (TC) is commonly divided into fractions of "organic carbon" (OC) and "elemental carbon" (EC), although these categorizations are strongly dependent on whichever thermal-analytical protocol is used.

During the third ACTRIS inter-comparison at a station located near Paris (LSCE-SIRTA) the CASS instrument together with an ACSM were successfully used to study the factors which determine the relationship between "OM" and "OC". The results show that this depends on external factors such as source type, monitoring location, season, and meteorology. Lower OM/OC ratios can be attributed to fresh aerosol emissions from traffic; while higher values indicate well-aged oxygenated organic ambient aerosols.

In parallel, the TC-BC measuring method using the CASS instrument combination was compared to the offline analysis of high-volume filter samples of both PM1 and PM2.5, collected in parallel and subsequently processed by a conventional OC/EC analyzer (Sunset Labs.) using the EUSAAR\_2 thermal protocol. The results showed excellent agreement (correlation  $R^2 = 0.94$ ) between the real-time CASS data and the offline OC/EC thermal analysis.

These results may be summarized as follows:

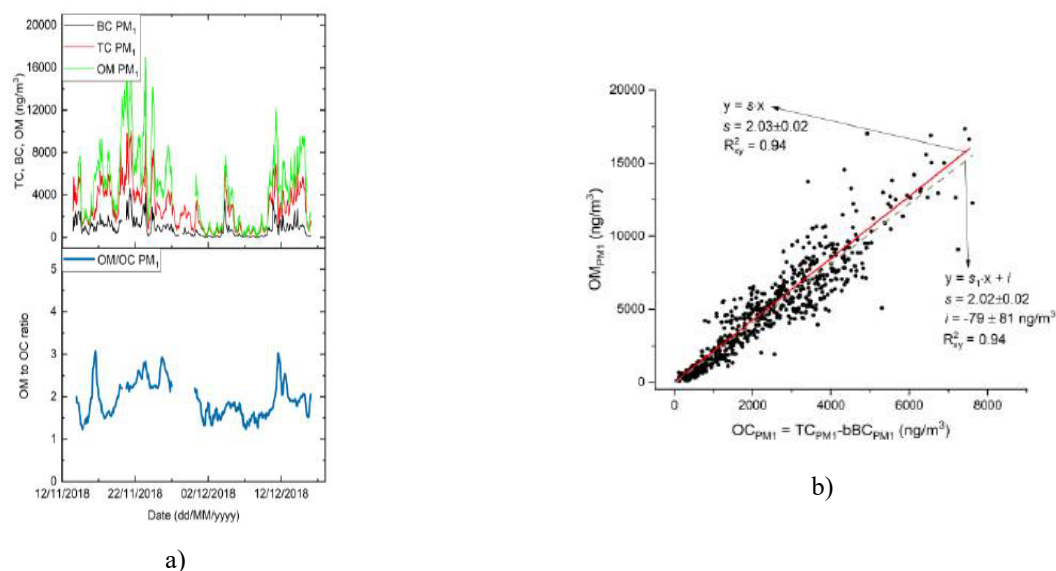
1. The combination of the CASS and ACSM instruments can immediately characterize OM/OC variations and discriminate between local and regional aerosols.
2. The highly time resolved OC data from the CASS instrument is an essential quality control method in aerosol mass spectrometry when using different aerodynamic lenses for PM speciation, comparing OM/OC ratios of different PM fractions (e.g., PM1 vs PM2.5).



**Figure 1:** Comparison of high-time-resolution measurements of TC and BC in PM1 and PM2.5. The temporal variations of pollutants in different size fractions can discriminate between local and regional sources of air pollution. The offset of around  $550 \text{ ng/m}^3$  in TC between PM1 and PM2.5 is attributed to the size difference in local pollution; while the difference in proportionality (slope  $\approx 1.16$ ) comes from regional transport events of aged aerosol.

**DISCUSSION**

3. Finally, standard ACSM operation has the common problem of the "CO<sub>2</sub>+ interference". This affects the calculated OA mass, mass spectra, molecular oxygen-to carbon ratio (O/C) and f<sub>44</sub> (e.g., Pieber et al., 2016). In order to eliminate this bias, it is essential to have high-time-resolution measurements of Organic Carbon: which are provided directly by the Magee Scientific CASS instrument.



**Figure 2:** Comparison between OM and OC. OM is obtained from ACSM, while OC is derived from the new TC-BC method. a) time-series of data; b) correlation between OM and OC levels for PM<sub>1</sub> fractions ( $R^2 = 0,94$ ).

**Related Articles**

- M. Rigler, et. al. (2020): High time resolution measurement of TC, BC, EC, OC and OM in PM<sub>1</sub> and PM<sub>2.5</sub>, 1st International Conference on Application of Air Quality in Science and Engineering Purposes, 10-12 February 2020, Kuwait
- N.L. Ng, et. al. (2017): An Aerosol Chemical Speciation Monitor (ACSM) for Routine Monitoring of the Composition and Mass Concentrations of Ambient Aerosol, *Aerosol Sci. and Technol.* 45: 7, 780-794, DOI: 10.1080/02786826.2011.560211
- V. Cren et. al. (2015): ACTRIS ACSM intercomparison – Part 1: Reproducibility of concentration and fragment results from 13 individual Quadrupole Aerosol Chemical Speciation Monitors (Q-ACSM) and consistency with co-located instruments, *Atmos. Meas. Tech.*, 8, 5063-5087, 2015
- R. Fröhlich et. al. (2015): ACTRIS ACSM intercomparison – Part 2: Intercomparison of ME-2 organic source apportionment results from 15 individual, co-located aerosol mass spectrometers, *Atmos. Meas. Tech.*, 8, 2555-2576, 2015
- M. Rigler et.al. (2020): The new TC-BC method and online instrument for the measurement of carbonaceous aerosols, *Atmos. Meas. Tech. Discuss.*, <https://doi.org/10.5194/amt-13-4333-2020>
- M. Pieber, et. al. (2016): Inorganic Salt Interference on CO<sub>2</sub>+ in Aerodyne AMS and ACSM Organic Aerosol Composition Studies, *Environ. Sci. Technol.* 2016, 50, 19, 10494-10503