Coupling optical and chemical properties of primary and secondary carbonaceous aerosols

F. Costabile[1], S. Gilardoni[2], F. Barnaba[1], M. Rinaldi[2], S. Ferrari[3], V. Poluzzi[3], G. P.Gobbi[1]

[1]ISAC-CNR, via Fosso del Cavaliere, Rome, Italy
[2]ISAC-CNR, via Gobetti 101, Bologna, Italy
[3]ARPA Emilia Romagna, via Rocchi 19 ,Bologna, Italy
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Presenting author email: f.costabile@isac.cnr.it

Carbonaceous aerosol particles are one of the most abundant aerosol components in the urban atmosphere. They are composed by black carbon (BC) and organic carbon (OC) plus additional quantities of trace elements; their particle size ranges over several orders of magnitude from the ultrafine (particle diameter, $D_p < 100$nm) to the fine region ($< 100\text{nm} < D_p < 1\mu\text{m}$). Relating their optical properties to chemical properties is necessary to assess their contribution on air pollution and on the radiative balance in the atmosphere .

On one hand, BC-rich aerosols show high absorption: their BC content cause those aerosols to strongly absorb light with a flat spectral variability. On the other hand, optical properties of BC-rich aerosols do vary with varying D_p: their D_p vary from the ultrafine (soot mode, 60-100 nm in D_p, i.e., motor vehicle emissions) to the small accumulation mode (100-300 nm, typical of lower temperature combustion processes such as biomass smoke). Clearly defining BC-rich aerosol properties requires to separate them with regard to homogeneous properties (i.e.,D_p, chemical composition, and spectral optical properties). Similar definitions are still missing.

Aerosols with large OC content also exhibit a variety of optical properties varying with varying the type of organic molecular species. Some organic molecular species cause the aerosol to mainly produce light scattering effects. Other aerosol organic molecular species show, on the contrary, absorption effects with a strong spectral variability. The absorption spectral variability depends on the OC content referred to as brown carbon (BrC) (Kirchstetter et al., 2004). A clear understanding of optical properties in BrC-rich organic aerosols is still far to be reached.

In this work we analyze optical, chemical and microphysical properties of carbonaceous aerosol particle in the urban area of Bologna during an intensive campaign of the "Supersito" project. The objective is to relate aerosol spectral optical properties to relevant chemical properties for selected types of organic aerosols varying with varying BC and BrC contents, and particle diameters.

Aerosol chemical composition, species size distribution, and organic aerosol chemical properties are measured by an High Resolution Time of Flight Aerosol Mass Spectrometer (HR-TOF-AMS). Aerosol spectral optical properties are measured by a 3-wavelenght PSAP and a 3-wavelenght integrating nephelometer operating in the visible region. Particle number size distributions are measured by SMPS+APS (TSI).

The bulk aerosol is separated in primary and secondary carbonaceous aerosol populations through the analysis of the aerosol spectral optical properties: Scattering Angstrom Exponent (SAE), Absorption Angstrom Exponent (AAE), Single Scattering Albedo (SSA) and its variability dSSA. Aerosol absorption is separated in the absorption due to BC, and the one due to BrC. The identified aerosol types are analysed in terms of chemically-resolved size distributions (fig.1).

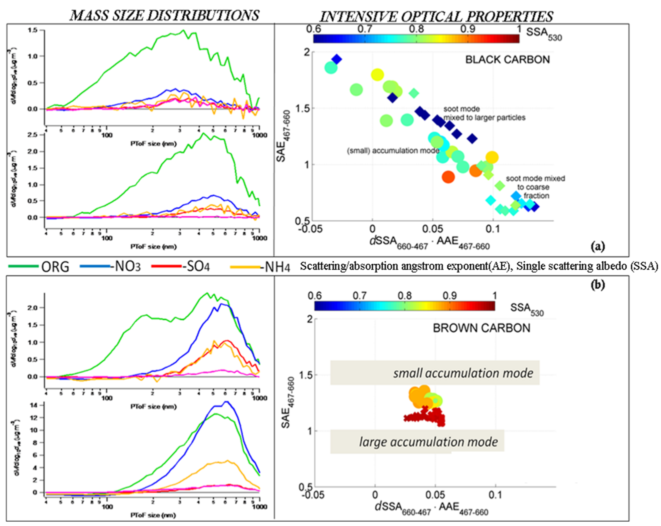

Figure 1: Optical properties and mass size distribution of major chemical constituents of: (a) mixed aerosols dominated by black carbon (soot-BC and not-soot-BC); (b) organic aerosols rich in Brown Carbon (small and large accumulation mode).

The results, still in progress, will be analyzed to obtain optical properties of carbonaceous aerosols concerning both freshly emitted particles (motor vehicles and biomass smoke), and aged secondary organic aerosols. Major conclusions will constrain spectral absorption properties of the selected aerosol types to estimate in particular refractive indices, Angstrom exponents, and mass absorption efficiencies. Conclusions will also target chemical properties of the organic molecular species contributing to the spectral absorption.

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