Black Carbon in Dust and Geological Material: Reconciling Thermal/Optical and Spectral Quantification Methods

L.-W.A. Chen[1], Y.M. Han[2], J.A. Robles[1], J.C. Chow[1], J.J. Cao[2] and J.G. Watson[1]

[1]Division of Atmospheric Sciences, Desert Research Institute, Reno, Nevada, 89512, USA
[2]Key Laboratory of Aerosol Science & Technology, SKLLQG, Institute of Earth Environment, Chinese Academy of Sciences, Xi'an, 710075, China
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Presenting author email: antony@dri.edu

Black carbon (BC) is produced from incomplete combustion of biomass and fossil fuel. Atmospheric BC aerosol affects the Earth's climate with a direct radiative forcing estimated second only to carbon dioxide (CO_2). Through sequestration of carbon and nutrients in the pedosphere, BC plays an important role in the global carbon cycle. Owing to its inert nature and long lifetime, BC in sedimentary rocks keeps long-term records of paleoenvironmental changes (e.g., Husain *et al*, 2008; Han *et al*, 2012).

There has not been a universally accepted method for BC measurement. Quantifying BC in samples dominated by geological material (GM), such as fugitive dust, surface soil, and sediment, is especially challenging, since GM interferes BC determination with commonly used thermal/optical methods, which separate BC from organic carbon (OC) on filters by different evolving temperatures and atmospheres and correct charring of OC by monitoring filter reflectance and/or transmittance (Chen *et al*, 2012). GM and salts are known to change OC charring behaviour and promote BC evolution at lower temperatures (Wang *et al*, 2010). Pure optical methods that quantify BC based on light absorption (e.g., Arnott *et al*, 2005) can be interfered by iron-rich GM showing substantial light absorption in the visible region.

In this study, improvements in BC quantification were made by introducing acid pre-treatment for thermal/optical methods and spectral detection for optical (light absorption) methods. Surface soil samples with relatively low BC contents and street dust samples with relatively high BC contents (from motor vehicle exhausts and coal combustion) were collected from the Baoji city (~155 km from Xi'an) in Central China. The samples were resuspended in a chamber and sampled onto Teflon and quartz-fiber filters after a 2.5 µm size-cut inlet. Particulate mass was first quantified by gravimetry while BC by conventional thermal/optical methods as well as an optical transmissometer (Magee Scientific, Berkeley, CA, USA).

Small portions of dust/soil samples (100±50 mg each) were then acid pre-treated following Han *et al* (2012) prior to resuspension and thermal/optical analysis. The pre-treatment remove carbonate, metal oxides, and at least 95% of silicates. This substantially reduces the GM interference and concentrates BC levels in the samples. Original and treated filter samples were both examined by an integrating-sphere based spectrometer (Lambda 35 PerkinElmer, Norwalk, CT, USA) for diffusive reflectance and transmittance, from which the spectral absorption was derived. Absorption by BC was decoupled from those by dust and brown carbon using an approach similar to Yang *et al* (2009) assuming BC is the only significant light absorber at 950 nm.

Figure 1 compares the conventional and pre-treated BC from thermal/optical reflectance (TOR) analysis (Chow *et al*, 2007). The pre-treatment preserves most BC, as evidenced by a good agreement for those with higher BC mass fractions. Measurement precision and detection limit have been greatly improved by the pre-treatment, which allows for detecting <0.1% of BC in the samples. The measured BC correlates well with light absorption at 950 nm. Further validations of the method with standards and reference materials are carried out and will be presented. The light absorption efficiency/absorption Ångström exponent of BC and GM from spectral measurements will also be discussed.

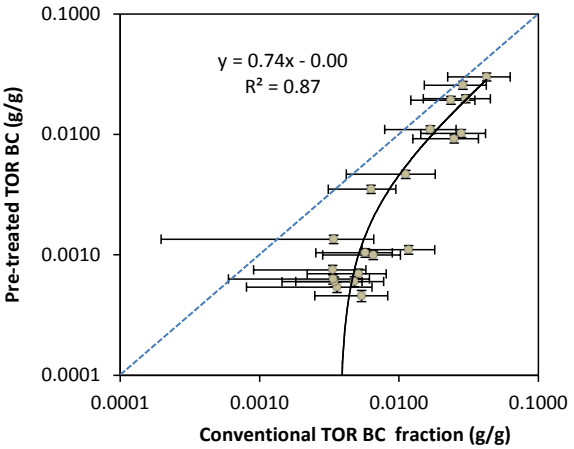

Fig. 1. Conventional versus pre-treated BC fractions in dust and soil samples by TOR analysis.

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