Optical Properties and Molecular Compositions of Atmospheric Brown Carbon in Nanjing, East China

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Brown Carbon (BrC) shows solar absorption behavior in ultraviolet and near-infrared region, and plays a significant role in atmospheric radiative forcing and regional/global climate. In present study, light absorption properties of water- and methanol-soluble BrC in ambient $PM_{2.5}$ in Nanjing in Western Yangtze River Delta in China during 2014-2015 were investigated. Besides, typical molecular compositions of BrC (nitrophenol compounds) with their light absorption contributions to BrC were also identified with ultra-performance liquid chromatography-triple quadrupole tandem mass spectrometry. The average concentration of water-soluble organic carbon (WSOC) was 6.1±3.0 $\mu g/m^3$, contributing to 61% of total organic carbon (OC). Larger WSOC concentrations in autumn and winter were related to the intense emissions from biomass burning. Light absorption coefficient (Abs), mass absorption efficiency (MAE) and absorption Angstrom exponent (AAE) of WSOC (methanol-soluble OC (MSOC)) were 5.8 Mm^{-1} (11.9 Mm^{-1}), 0.92 m^2g^{-1} (1.15 m^2g^{-1}) and 5.36 (4.97), respectively. Strong positive correlation (R^2=0.93) was found between light absorption of WSOC and MSOC. Both light absorption of WSOC and MSOC showed distinct seasonal variations, with larger Abs values in winter and autumn. The average concentration of the detected nitrophenol compounds was 9.1±7.9 ng m^{-3}. Among the detected nitrophenol compounds, nitrocatechols (NCs), which can be used as tracers of biomass burning, increased significantly in winter (8.6 ng m^{-3}) and autumn (5.6 ng m^{-3}). While nitrosalicylic acids (NSAs), which were mainly generated by secondary reactions, accounted for larger proportions in summer (52.4%) and spring (40.9%). Nitrophenols contributed 0.32±0.13% to total light absorption of MSOC. Light absorption contributions of nitrophenol varied in different seasons in the order of winter (0.43%) > autumn (0.32%) > spring (0.27%) > summer (0.21%). NCs are the most important light-absorbing components among all the nitrophenol compounds, with the light absorption contribution of 64.7%. These findings will help to better understand optical properties and climatic effects of light-absorbing organic aerosols.

Keywords: brown carbon, light absorption, water-soluble organic carbon, methanol-soluble organic carbon, nitrophenol

