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Contributions of nitrated aromatic compounds to the light absorption of water-soluble and particulate brown carbon in different atmospheric environments

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Recently the importance of light absorbing carbon, so-called brown carbon (BrC), on aerosol light absorption properties became more and more evident. The presence of BrC can enhance the light absorption of aerosols and therefore have an impact on the earth climate system. Despite the numerous studies published in the past few years little is known about the molecular composition and sources of BrC or the impact of single organic molecules on the BrC light absorption.

The present study aims to deepen the understanding of atmospheric particulate and water soluble BrC by determining the ambient concentrations of eight individual nitrated aromatic compounds (nitrophenols and nitrated salicylic acids), and connecting the obtained chemical information with the light absorption properties of aqueous particle extracts (indicating water soluble BrC) and the overall particulate BrC light absorption.

High-volume filter samples were collected during six campaigns, performed at five locations in two seasons: (I) two campaigns with strong influence of biomass burning (BB) aerosol – at the TROPOS institute (winter, 2014, urban background, Leipzig, Germany) and the Melpitz research site (winter, 2014, rural background); (II) two campaigns with strong influence from biogenic emissions – at Melpitz (summer, 2014) and the forest site Waldstein (summer, 2014, Fichtelgebirge, Germany), and (III) two CAREBeijing-NCP campaigns – at Xianghe (summer, 2013, anthropogenic polluted background) and Wangdu (summer, 2014, anthropogenic polluted background with a distinct BB-episode), both in the North China Plain.

The light absorption properties of the aqueous particle extracts were determined by UV/Vis spectrometry for the same set of filter samples. Particulate BrC light absorption properties were derived from a seven-wavelength Aethalometer for a subset of these samples. A clear seasonality was observed in the data from the German sites where higher
concentrations as well as higher light absorption coefficients (Abs370) and mass absorption efficiencies (MAE370) were found in winter than in summer.

The light absorption of the aqueous filter extracts was found to be pH dependent, with larger values at higher pH. In general, Abs370 ranged from 0.21 – 21.8 Mm-1 under acidic conditions and 0.63 – 27.2 Mm-1 under alkaline conditions, over all campaigns. The observed MAE370 was in a range of 0.10 – 1.79 m2 g-1 and 0.24 – 2.57 m2 g-1 for acidic and alkaline conditions, respectively.

The Aethalometer measurements support the findings from aqueous particle extracts of only weakly absorbing biogenic aerosol particles in comparison to the more polluted and BB influenced aerosol particles from an urban background site.

The obtained chemical and optical information was connected to determine the relative contribution of individual species to the light absorption of aqueous particle extract and particulate BrC. The mean contribution of nitrated aromatic compounds to the aqueous extract light absorption over all campaigns ranged from 0.10 % – 1.25 % under acidic conditions and 0.13 % – 3.71 % under alkaline conditions. The mass contribution of the target compounds to water-soluble organic carbon was five times lower than their contribution to Abs370,

which corroborates conclusions of other studies that even small amounts of light absorbing compounds can have a disproportionately high impact on the aerosol light absorption properties.