Online shape and density measurement of single black carbon aerosol particles

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Black carbon (BC) aerosols in the atmosphere play crucial roles in affecting global radiative budget and human health. Density and morphology are key properties that infer the chemical composition, mixing state and aging pathway of BC particles. Here, we developed a novel method to assess morphology and density of single black carbon aerosol particles by measuring their aerodynamic diameters (*Da*) , electrical mobility diameters (*Dm*) and mass of their black carbon contents (*mBC*). Three groups of ambient aerosols with different *Da* (200nm, 350nm, 500nm) selected by AAC were studied during two sampling periods (2018 winter and 2019 summer). The BC-dominated particles (almost pure BC) were observed at Mode (***Da*** *=200nm,****Dm1*** *=135nm*), which contributed the largest number fraction[XW1] of particles with a D_a of 200nm. The morphology of these BC-dominated particles was found to be near-spherical, as their shape factor was ~1.02, indicating the aging of freshly emitted-BC particle was fast and a small amount of secondary materials was sufficient to change particle shapes from fractal aggregate to near-spherical. Besides, traffic was found to be one of the main emission sources of the BC-dominated particles, which was consistent with the fact that the number fraction of BC-dominated particle in BC particles increased significantly during the morning and evening rush-hour. The majority of BC particles with D_a of 350nm and 500nm were coated by thick layers of secondary substances. The shape of these particles with thick coating was likely to be spherical. The particles in Mode(Da =350nm,Dm =259.5nm) and the particles in Mode(Da =500nm,Dm =358.7nm) accounted for a main fraction of particles with the D_a of 350nm and 500nm, respectively. It is found that the density of these BC particles in Mode(Da =350nm,Dm =259.5nm) and Mode(Da =500nm,Dm =358.7nm)was 1.62 and 1.77g/cm^3, repectively, suggesting that ammonium sulfate (bulk density: 1.73 g/cm^3) and ammonium nitrate (bulk density: 1.77 g/cm^3) internally mixed with organic materials (~1.2 g/cm^3) could be their main components, which was consistent with their average single particle mass spectra. The AAC-DMA-SP2 online system is a novel method to investigate both morphology and density of each single BC particle, which can help identify the formation and aging pathway of BC aerosols.

Keywords: Black carbon, Aerosol, Single particle

