Geophysical Research Abstracts
Vol. 17, EGU2015-2841, 2015
EGU General Assembly 2015

Physico-chemical and optical properties of combustion-generated particles from coal-fired power plant, automobile and ship engine and charcoal kiln.

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Similarities and differences in physico-chemical and optical properties of combustion generated particles from various sources were investigated. Coal-fired power plant, charcoal kiln, automobile and ship engine were major sources, representing combustions of coal, biomass and two different types of diesel, respectively. Scanning electron microscopy (SEM), high resolution transmission electron microscopy (HRTEM) and energy-dispersive X-ray spectroscopy (EDX) equipped with both SEM and HRTEM were used for physico-chemical analysis. Light absorbing properties were assessed using a spectrometer equipped with an integrating sphere.
Particles generated from different combustion sources and conditions demonstrate great variability in their morphology, structure and composition. From coal-fired power plant, both fly ash and flue gas were mostly composed of heterogeneously mixed mineral ash spheres, suggesting that the complete combustion was occurred releasing carbonaceous species out at high temperature (1200-1300 ºC). Both automobile and ship exhausts from diesel combustions show typical features of soot: concentric circles comprised of closely-packed graphene layers. However, heavy fuel oil (HFO) combusted particles from ship exhaust demonstrate more complex compositions containing different morphology of particles other than soot, e.g., spherical shape of char particles composed of minerals and carbon. Even for the soot aggregates, particles from HFO burning have different chemical compositions; carbon is dominated but Ca (29.8%), S (28.7%), Na(1%), and Mg(1%) are contained, respectively which were not found from particles of automobile emission. This indicates that chemical compositions and burning conditions are significant to determine the fate of particles. Finally, from biomass burning, amorphous and droplet-like carbonaceous particles with no crystallite structure are observed and they are generally formed by the condensation of low volatile species at low-temperature (∼300-800 ºC) combustion conditions. Depending on burning sources, significantly different optical properties were observed; diesel combustion particles from automobile and ship showed wavelength independent absorbing properties whereas the particles from coal and charcoal kiln combustion showed the enhanced absorption at shorter wavelength which is a brown carbon characteristic. Our findings suggest that source dependent properties and distributions across the globe should be considered when their impacts on climate change and air qualities are discussed.