Chemical modification of Asian dust during long-range transport

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Mineral dust is the largest component of global particulate matter by mass. It can be transported for weeks across transcontinental distances. During their atmospheric lifetime, mineral dust particles become 'aged' upon reaction with trace gases such as ozone, nitrogen and sulphur oxides, various acids and organic species, and by coagulating with different particle types [1]. These aging processes modify the physical and chemical properties of particles with strong implications for their role in atmospheric chemistry, the Earth's climate, and their toxicity and health effects. Single-particle analysis can provide direct insights into the heterogeneous chemistry of mineral dust aerosol during long-range transport. Recent studies have shown direct evidence for the uptake of reactive gases such as nitric, sulphuric, and hydrochloric acids onto Asian dust particles [2, 3, 4].

The present study aims at comparing the extent of chemical modification of Asian dust particles sampled in Incheon, Korea during several Asian dust storm events in 2002-2006. Mixing of Asian dust with air pollutants and sea-salts strongly depends on the characteristics of Asian dust storm events such as air-mass backward trajectories. For instance, no significant chemical modification of mineral dust corresponded to fast moving air-masses at high altitudes. Inversely, extensive chemical modification was correlated with longer residence times over the continent (interaction with anthropogenic emissions) and in marine atmosphere (coagulation with deliquesced sea-salts). Furthermore, our single-particle analyses give supporting evidences of atmospheric reactivity processes. Before dust storm events, most of the particulate nitrate was found in aged sea-salt particles [4]. During dust storms, however, the majority of nitrate was found in reacted mineral dust particles. Calcium-containing minerals such as calcite and dolomite were observed to react efficiently to form calcium nitrate deliquesced species.

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Heterogeneous aging of Asian dust storm particles transported from China to Korea

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Amospheric aerosols were collected in Beijing, China and Incheon, Korea during a dust-storm event in spring 2005. Backward trajectories were of purely continental origin for Beijing samples and of both continental and marine origins for Incheon sample. The morphology, elemental composition and mixing state of particles, as well as chemical reactions on mineral particle's surface were examined by SEM/EDX.

In Beijing, mineral dust accounted for more than 88% of particles, among which 68%, 12%, and 9% of particles were AlSi-, SiO_2-, and $CaCO_3$-containing, respectively. About 43% of mineral dust particles were found in Incheon, consistent with dilution of soil-derived aerosols during long-range transport from China to Korea. Direct observation of sulfate and nitrate formation on dust particles was evidenced by our single-particle analyses [1, 2, 3, 4]. Reacted $CaCO_3$ particles (identified as $CaNO_3$, $CaSO_4$, and $Ca(NO_3,SO_4)$ species) represented less than 2% in Beijing while amounting to 11% in Incheon, indicating dust particles experienced chemical modifications upon interaction with gaseous air pollutants during transport. While no sea-salt particle was encountered in Beijing, marine particles apportioned to 37% in Incheon. Marine particles were observed in different stages of conversion, from fresh to aged sea-salts (e.g. $NaNO_3$, (Na, Mg)NO_3, Na_2SO_4 and their mixtures). About 23% of dust particles were found internally mixed with sea-salts in Incheon, demonstrating that mineral dust efficiently mixed with sea-salts during tranport over the Yellow Sea.

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