Photo-transformation of single NaNO₃ particle and influence on their hygroscopic properties

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Marine aerosols represent more than half of global emission of particles into the troposphere (IPCC, 2014).

During their stay in the atmosphere, aerosols are subject to physicochemical transformations. These transformation processes have a direct impact on atmospheric chemistry and climate changes. One of the well-known atmospheric reactions is the sodium chloride conversion into sodium nitrate particles, when marine air masses are subjected to NO₃/NO₂ gaseous species (Finlayson-Pitts 2003; Liu, 2007). Otherwise, aerosol particles are exposed to solar radiation. The photoconversion of nitrate ions into nitrite and peroxy nitrite under solar radiation is well known in aqueous phase. Some similar process would be expected when aged sea salts containing nitrate particles are formed. While atmospheric photochemical processes in gas phase are well studied, only sparse works have been devoted to the photoactivity of particles in the atmosphere.

In this presentation, we will show the studies carried out on sodium nitrate single particles when exposed to UV radiation and the influence of the photochemical products on their hygroscopic properties. We have used an acoustic levitation system coupled to micro-Raman spectrometry (See photo in Figure 1) to investigate the physical and chemical modifications of particles without the influence of a contacting surface.

Aqueous NaNO₃ droplets were irradiated for several minutes with UV-light (λ = 260 ± 6 nm) and nitrite and peroxy nitrite ions were identified in the Raman spectrum for the fundamentals at 815, 1278 and 1330 cm⁻¹ for aqueous NO₃⁻ ion (Belyi, 1995) and 980 cm⁻¹ for ONOO⁻ ion (Tsai et al) and as shown in Figure 1.

By following the Raman spectrum and the size of the photodegraded particles as a function of the relative humidity, we demonstrated that the presence of irradiation products modifies the hygroscopic properties, especially for the deliquescence relative humidity (DRH) that was seen to decrease (Figure 2). In fact, we have evidenced both a MDRH (mutual deliquescence relative humidity) and a second DRH, as consequence of the final mixture in the drop, in agreement with the NaNO₃/NaNO₂ deliquescence diagram.

The phototransformation of single levitated particles, containing sodium nitrate, yield to the formation of NO₃⁻ and ONOO⁻ ions which altered the hygroscopic properties of the nitrate containing particles. These results evidenced a subsequent implication for hygroscopicity properties of nitrate containing particles in the atmosphere which are in great abundance in polluted area.

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