Photo-transformation of nitrate levitated particles and influence on their hygroscopic properties

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The effect of aerosol particles on climate change is still not very accurately estimated since many heterogeneous processes lead to changes in chemical composition but also in size and morphology of the particles. Studying the aging processes of aerosols at the single particle scale is an added value to better understand the physical-chemical mechanisms intervening in heterogeneous atmospheric processes since these processes are complex and still remain unresolved.

Nitrate is mainly formed in the atmosphere by reaction of NO_x with sea salt or ammonia. Several papers have been published on the thermodynamics, phase transition, and hygroscopicity of pure or mixed nitrates salts (Wang et al., 2011, Yeung & Chan, 2010). In addition, nitrate photochemistry is well known and is recognized to generate NO_2 and nitrite ions (Dubowski et al., 2002; Jacobi et al., 2006; Roca et al., 2008). Nonetheless, photochemical studies of nitrate salts in single levitated particles as well as the influence of the photoproducts on the hygroscopic properties have not been conducted.

Micro-Raman spectroscopy, coupled to an environmental levitation cell, is especially useful for studying, at micrometric scale, the in-situ modifications of aerosol when exposed to reactive environments or humidity without the influence of a contacting surface (Krieger et al., 2012). In this work, we have used micro-Raman spectroscopy coupled to an environmental acoustic levitation cell to study the physical and chemical processes occurring in pure or mixed sodium and ammonium nitrate single particles when exposed to UV-Vis light and their hygroscopic properties before and after irradiation.

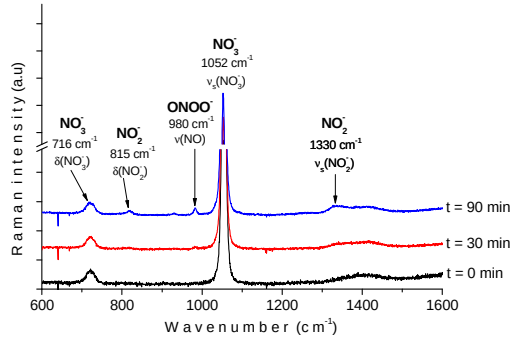

Figure 1. Raman spectra of $NaNO_3$ before and after 0, 30 and 90 minutes of irradiation

Aqueous nitrate levitated drops were irradiated with UV-Vis light and Raman spectra were recorded as a function of the irradiation time. After irradiation, NO_2^- and $ONOO^-$ ions were observed to arise in the droplets as shown in figure 1.

Relative humidity cycles were performed after and before irradiation and modifications of the humidity cycle were observed before irradiation as shown in figure 2. Thus, a lower DRH value was evidenced as consequence of photochemical products.

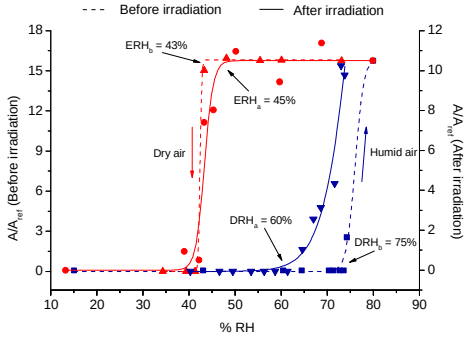

Figure 2. Relative humidity cycles of a levitated particle of $NaNO_3$ before and after irradiation.

In this work, the photo-transformation of pure or mixed sodium and ammonium nitrate single levitated particles were investigated by µ-Raman spectroscopy coupled to an environmental levitation cell. NO_2^- and $ONOO^-$ ions were evidenced as the main photo-products in the process. An alteration in the hygroscopic properties of the particles after irradiation was clearly evidenced.

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