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Environmental Transmission Electron Microscopy of Individual Atmospheric Particles from the North Atlantic

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Understanding the composition and physical properties of atmospheric particles is important to model their effects on climate radiative forcing. In addition to their direct interactions with sunlight through scattering and absorption, aerosol particles also act as nuclei forming clouds in the atmosphere. Overall, these aerosol-cloud interactions are inadequately understood. [1] The particle composition in the atmosphere varies by altitude and is different between the boundary layer and the free troposphere. Sources of aerosol particles in the eastern North Atlantic range from sea spray to new particle formation events from gas-particle conversion. Micron-size particles consist of primarily sea salt mixed with marine non-volatile organics, while the submicron size particles are dominated by organics from the ocean surface. [2]

The Azores archipelago in the eastern North Atlantic is an optimal place to study the composition and the effects of marine particles on clouds in a remote oceanic environment as well as being a cross-road for long-range transport of continental particles. For the study presented here, the particle samples were collected during the Aerosol and Cloud Experiment in the Eastern North Atlantic (ACE-ENA) field study, [3] onboard the ARM aerial facility platform (G-1 aircraft) and at the ground ENA supersite. Multi-modal chemical imaging of individual particles was performed using complementary capabilities of electron microscopy and scanning transmission x-ray microscopy. The distribution of particle types was characterized using computer controlled scanning electron microscopy with energy dispersive x-ray spectroscopy for the composition of thousands of particles. [4] High resolution mass spectrometry was used to characterize the chemical composition of the organic fraction of collected particles. Particles were further investigated using environmental transmission electron microscopy to determine thermal stability, ice nucleation activity, and water uptake on a single particle basis.

Figure 1 shows a characteristic image of micron-size particles containing NaCl at the particle cores. Other elements, such as Mg, are concentrated at the particle exterior. Additionally, the particles contain S and O with predominance in the needle type structures protruding throughout the particles. Water uptake experiments of these particles in the ETEM (Fig. 2) reveal that the NaCl core initiates to take up water above 50% RH and deliquesced by 70% RH. While the S containing needles uptake water only above 80% RH. These particles phase separate upon drying and are fully effloresced by 36% RH. This work illustrates differences in the activity of various marine particles during atmospheric processes such as water uptake that have important implications on cloud formation. [5]

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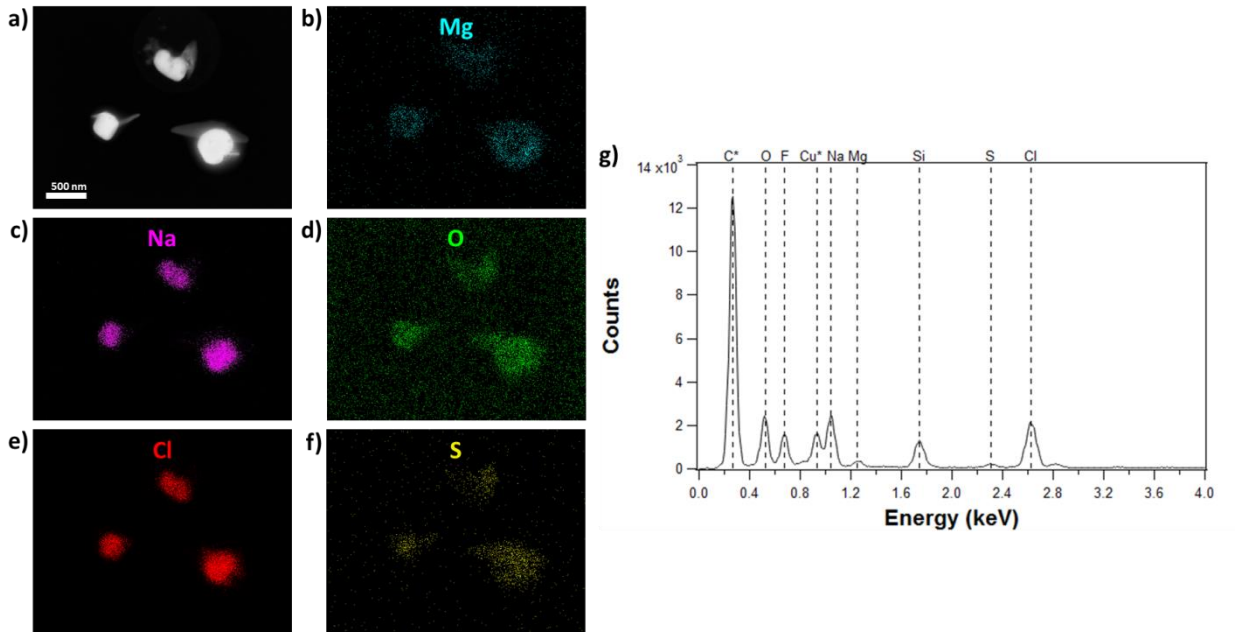

Figure 1. a-f) EDS maps of atmospheric particles collected at the ground site in the Azores archipelago, showing the distribution of elements within micron-size particles. g) EDS spectra of the particles (C and Cu are primarily from the substrate).

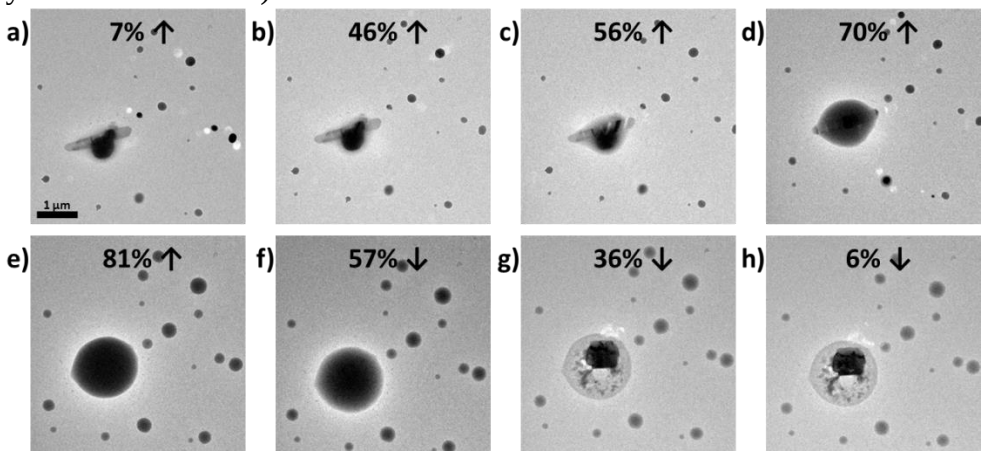

Figure 2. Hydration (a-e) and dehydration (f-h) experiment of individual marine particles performed using ETEM. Relative humidity at each point is displayed on the image.

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