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How do salts' surfaces behave in the presence of water vapor?

Content

Aerosolized salt particles emerge from several pathways and important continental sources include saline lakes and playas (1). Once in the atmosphere these particles play roles in atmospheric processes and are active multiphase materials due to their high hygroscopicity (2). Below deliquescence conditions, the interfacial nature of solvating material can lead to unique chemical environments and hence differ from the bulk (3). The structure and properties of the interface directly influence the heterogeneous processes that are important to the atmosphere. In our studies, the interfacial phase transition behavior of salts was investigated across a spectrum of relative humidity (RH) and temperature conditions. Both pure (MgSO_4 and MgCl_2) and natural salts (brine sample and desert sample) were studied. The brine sample was collected in Qaidam (China), a large region of saline lakes and playas, while the desert sample was collected in the Gobi Desert (East Asia). Ambient Pressure X-ray Photoelectron Spectroscopy (APXPS) and Near Edge X-rays Absorption Fine Structures (NEXAFS) were used to examine in detail the materials' topmost molecular layers.

Results reveal that water condenses below deliquescence conditions on pure and natural salts, even at low relative humidity. Natural salts are composed of a multitude of salt species and probing the materials' topmost molecular layers shows that different salt compositions exist at the interface as the relative humidity is varied. This is the case for the brine sample, for which chloride enrichment and sulfate depletion occurs as the RH transitions from 0% to 4.4%. A complementary molecular dynamics simulation demonstrates that this behavior is enabled by the different hydration numbers of the two species and the limited amount of condensed water. For the desert sample data, preliminary analyses show that the composition of the topmost molecular layers evolved towards pure NaCl as RH increased from 0% to 70%. Complementary molecular dynamics simulations are ongoing with the aim of illuminating underlying mechanisms.

These results underline that the interfacial composition of salts may change with changing relative humidity. APXPS offers a powerful means to study the interaction between water vapor and salts' topmost molecular layers, simulating natural conditions on Earth. Nonetheless, the scope of these experiments is not limited to Earth but may also yield insight into other systems, like Mars. The Qaidam basin is considered to be a terrestrial analogue to Mars (4), which has its own unique water vapor cycling and reservoirs (5).

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