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Single Particle Studies of Heterogeneous Atmospheric Chemistry on Aluminum Oxide Particles in a Quadrupole Trap

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Abstract: This report documents a research program consisting of laboratory and field measurements investigating the atmospheric chemistry and aerosol microphysics of the impacts of rocket motor exhausts on upper atmospheric chemical cycles and ozone. The experimental investigation employs a laboratory quadrupole trap electrodynamic levitation apparatus to study heterogeneous processes on single **aluminum oxide** particles representative of those exhausted into the atmosphere by solid rocket motors. We have investigated the activities of different types of **aluminum oxide** particles for uptake of gas-phase H2O and HCl. The particle types investigated were alpha-Al2O3, gamma-Al2O3, H2SO4- treated alpha-Al2O3, H2SO4-treated gamma-Al2O3, and metastable **aluminum oxide** formed by rapid cooling from molten Al2O3 in a shock tube, analogous to particle processing in a rocket exhaust nozzle. Particles were treated with H2SO4 by vapor deposition in an oven. The kinetic measurements consisted of independent, simultaneous observations of mass uptake and particle size increase upon exposure of single particles to fixed concentrations of H2O or HCl in slowly flowing gas mixtures at 1 atm and temperatures from 300 K to 190 K. alpha-Al2O3 and gamma-Al2O3 were essentially inert toward H2O and HCl uptake, however they readily adsorbed monolayer-equivalent levels of H2SO4 vapor, and H2SO4-coated and metastable particles were active toward H2O and HCl uptake. The measured uptake efficiencies imply fast reaction rates within rocket exhaust plumes, potentially leading to CCN behavior as well as heterogeneous chlorine activation by these particles. The field measurements consisted of in situ ozone mixing ratio measurements on the NASA WB57-F high altitude aircraft, as part of a suite of instrumentation designed to characterize the chemistry and dynamics of rocket exhaust plumes in the lower stratosphere.

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