Hygroscopicity of Early Earth Aerosol Analogs and Implications for Their Direct and Indirect Radiative Effects

CHRISTA A. HASENKOPF[1], MIRIAM A. FREEDMAN[2], O. BRIAN TOON[1], and MARGARET A. TOLBERT[2]

[1]*Department of Atmospheric and Oceanic Sciences, University of Colorado, Boulder, CO, United States 80309, Ph: (303) 492-1433, Email: Christa.Hasenkopf@colorado.edu*

[2]*Cooperative Institute for Research in the Environmental Sciences, University of Colorado, Boulder, CO, United States 80309*

We have explored the hygroscopicity and the ability to act as cloud condensation nuclei (CCN) of early Earth organic analog aerosol. The aerosol are generated via continuum ultraviolet (λ = 120 nm – 400 nm) photolysis of an early Earth analog gas mixture, which is designed to mimic possible atmospheric conditions during the Archean. Titan aerosol analog is tested for comparison. Water uptake is measured via extinction measurements of dry and humidified aerosols flowed through a tandem cavity ringdown aerosol extinction spectrometer.

Water uptake is observed on both aerosol analogs at a relative humidity (RH) of 80%. Also, the hygroscopicity of the early Earth aerosol analog is measured at relative humidities from 78% to 87%. We find the optical growth of the early Earth aerosol is similar to slightly soluble organic acids, such as phthalic acid. On average, the optical growth at RH = 80% of the early Earth analog is slightly larger than the Titan analog, which is consistent with previous chemical analyses [1]. In order to translate our measurements of hygroscopicity in the subsaturated regime into both optical effects of the aerosol at RH < 100% and the CCN ability at RH > 100%, we rely on the hygroscopicity parameter κ [2]. We retrieve $\kappa = 0.22 \pm 0.12$ (78% > RH > 87%). This hygroscopicity value indicates that the aerosol could have had significant cooling and even heating effects that deviate from the expected antigreenhouse effect of the dry aerosol. The magnitude and sign of the effect depends upon the diameter and shape of the aerosol. If early Earth organic aerosol were present during the Archean, they could activate into CCN at reasonable – and even low – water vapor supersaturations. In regions where the haze dominated, the aerosol, once activated, would create short-lived, optically thin clouds.

Keywords: Titan; early Earth; tholins; antigreenhouse effect; laboratory analogs.

References

[1] M. G. Trainer, et al., *PNAS*, **103**, 18035-18042 (2006)

[2] M. D. Petters and S. M. Kreidenweis, *Atm. Chem. & Phys.***7,** 1961-1971 (2007)