Additive water uptake of urban atmospheric HULIS and inorganic mixtures

*Ruichen Zhou¹, Afsana Sonia², Chenran Wei², Michihiro Mochida¹,²

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Graduate School of Environmental Studies, Nagoya University

Atmospheric aerosols’ ability to absorb water, known as hygroscopicity, is a crucial factor that impacts aerosol aging, cloud formation, and aerosol-related environmental impacts. The hygroscopicity of organic-inorganic mixed aerosols in the atmosphere is important for understanding the water uptake of aerosols; however, the hygroscopicity of the mixtures is not fully understood yet. Some studies found that the water uptake of mixtures can be described by the Zdanovskii–Stokes–Robinson (ZSR) relationship, which assumes that the water uptake of each component is additive, while others found that the water uptake is not additive for ambient mixtures of organic and inorganic components.

In this study, we evaluated the hygroscopic behavior of the mixtures of humic-like substances (HULIS) from urban atmospheric aerosols and ammonium sulfate (AS) with varying mixing ratios using a hygroscopicity tandem differential mobility analyzer and model-based analyses. The hygroscopicity parameter (κ) of mixtures of HULIS and AS generally follows the ZSR relationship with the mean deviation of 16% and the absolute mean deviation of 0.03. However, these deviations could be largely attributed to measurement uncertainties from the dry particle shape and residual inorganics in the HULIS solution, which reduces the deviations to 8% in an extreme condition. Uncertainties from the surface tension depression by surfactants and their bulk-surface partitioning were also predicted, which accounted for a small part of the deviation. Further, this study found that the non-ideality of the solution can potentially explain the deviations of the mixtures from the ZSR relationship, particularly in mixtures containing fatty acid.

In conclusion, this study supports the use of the ZSR relationship as an approximation in predicting the hygroscopicity of organic-inorganic mixtures in ambient aerosols. Future studies are encouraged for better predictions with the consideration of uncertainties associated with the measurements and physical/chemical properties.

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