Pyruvic acid photolysis: Characterization of the secondary organic aerosol formed

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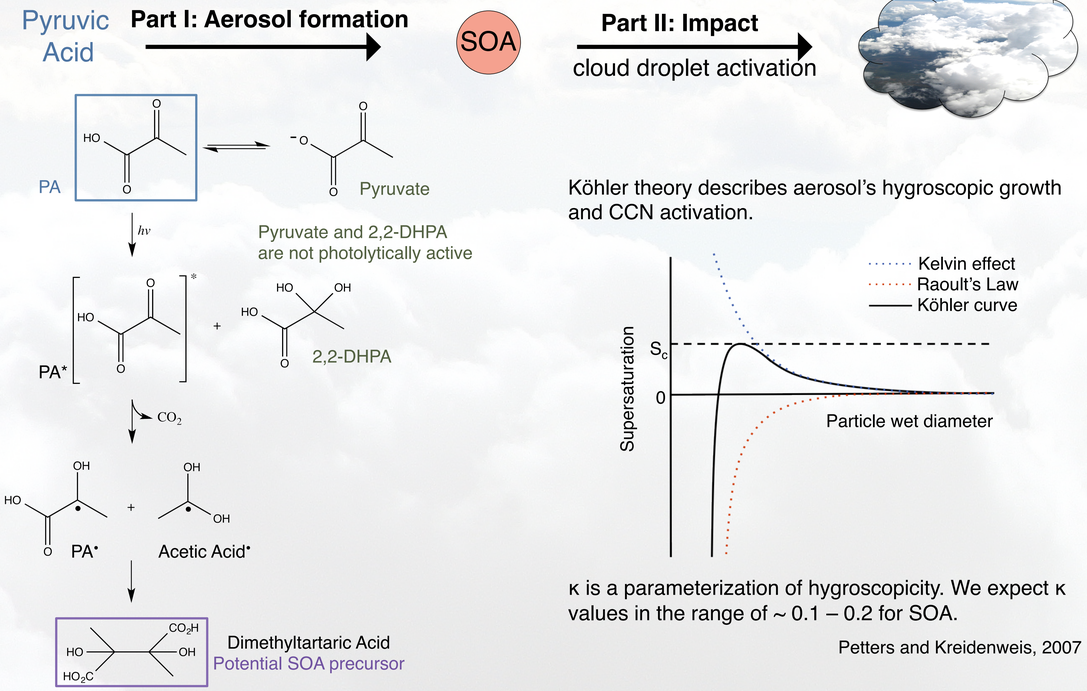
Research Question

What is the role of aqueous-phase chemistry in aerosol-cloud interactions?

Background

- Volatile organic compounds (VOCs) react in the atmosphere to produce secondary organic aerosol (SOA)
- A better understanding of aqueous-phase SOA formation and evolution is needed to improve climate models and our current understanding of the atmosphere
- Pyruvic acid is ubiquitous in the atmosphere and currently used in climate models as a proxy for similar molecules
- Aqueous-phase pyruvic acid was photolyzed and aerosolized to characterize the formed SOA (Part I: Aerosol formation)
- We examined the resulting change in aerosol mass and change in the formed aerosol's ability to act as cloud condensation nuclei (CCN) (Part II: Impact)



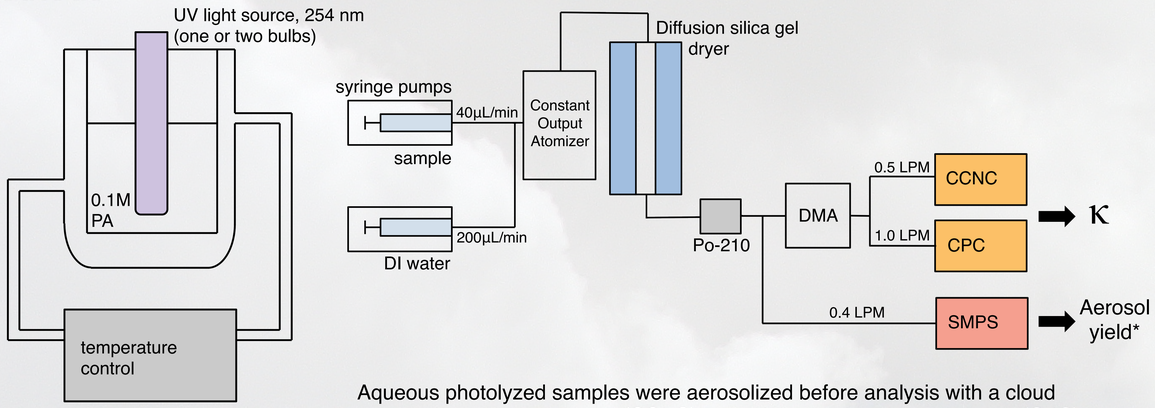
Adapted from Reed Harris et al., 2014

Köhler theory describes aerosol's hygroscopic growth and CCN activation.

κ is a parameterization of hygroscopicity. We expect κ values in the range of ~ 0.1 – 0.2 for SOA.

Petters and Kreidenweis, 2007

Methods

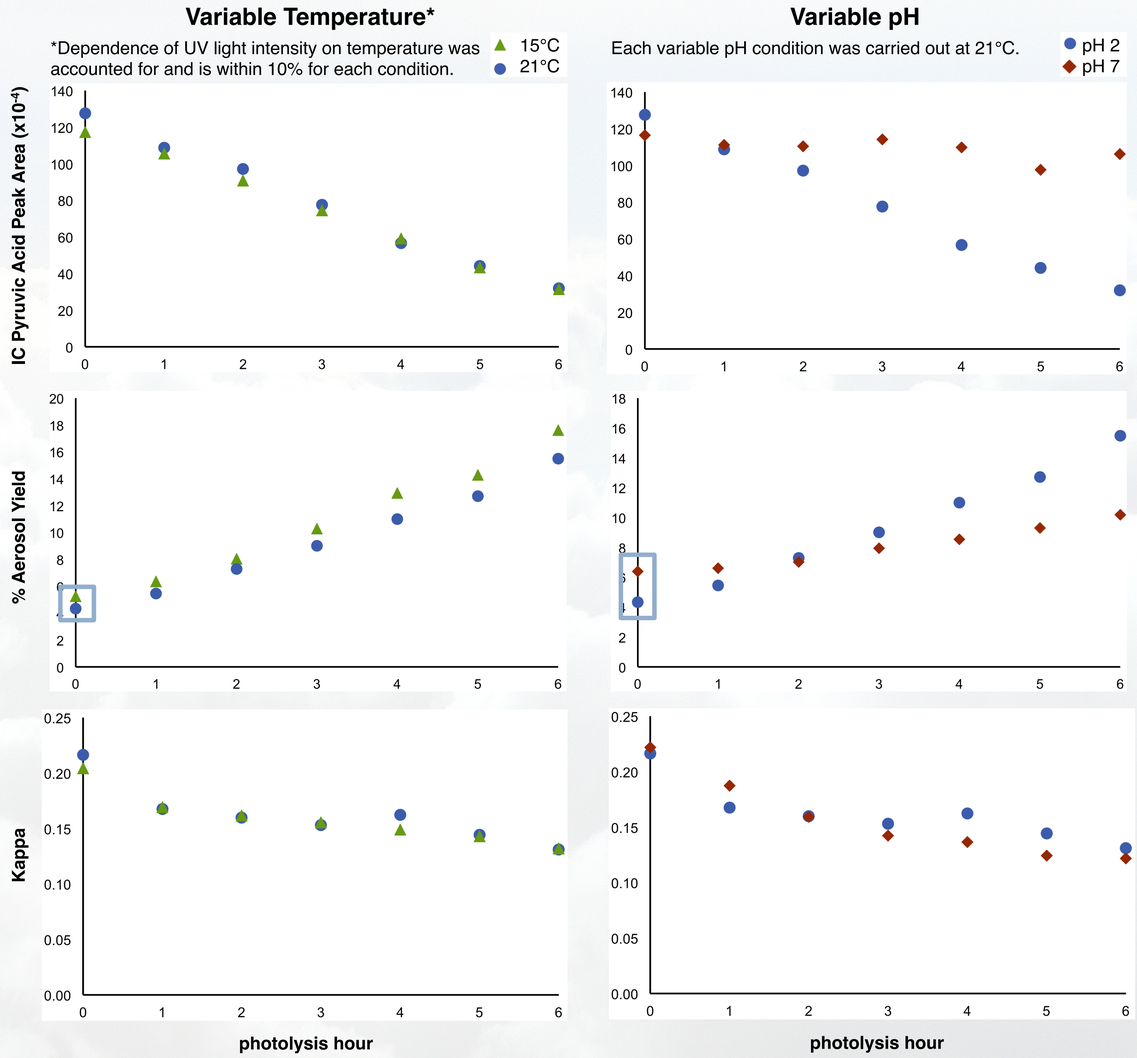


0.1M Pyruvic acid was photolyzed in a glass photoreactor for 6 hours.

Aqueous photolyzed samples were aerosolized before analysis with a cloud condensation nuclei counter (CCNC) and condensation particle counter (CPC) to determine κ, and scanning mobility particle sizer (SMPS) to determine aerosol yield.

$$\text{*Aerosol yield} = \frac{\text{volume of aerosol}}{\text{volume of initial PA}}$$

Results



Summary

- Unreacted room temperature pyruvic acid was atomized to yield ~ 4% aerosol and a κ value of 0.22
- Photolysis in the 15 and 21°C condition resulted in an increase in aerosol yield from ~ 4% to ~ 15%
- In the three conditions investigated, κ decreased from ~ 0.2 to ~ 0.1
- In the pH 7 condition, aerosol yield increased from ~ 6% to only 10%
- At pH > 2.18 (pyruvic acid's pK_a), the concentration of the less photolyzable pyruvate anion increases, and the rate of photolysis decreases

References and Acknowledgements

Petters, M. D., and S. M. Kreidenweis. "A single parameter representation of hygroscopic growth and cloud condensation nucleus activity." *Atmospheric Chemistry and Physics* 7.8 (2007): 1961-1971.

Reed Harris, Allison Early, et al. "Photochemical Kinetics of Pyruvic Acid in Aqueous Solution." *The Journal of Physical Chemistry A* (2014).

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