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Secondary organic aerosol formation through fog processing of VOCs

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Volatile Organic Compounds (VOCs) including benzene, toluene, ethylbenzene and xylenes (BTEX) have been determined in highly concentrated amounts (>1 ug/L) in intercepted clouds in northern Arizona (USA). These VOCs are found in concentrations much higher than predicted by partitioning alone.

The reactivity of BTEX in the fog/cloud aqueous phase was investigated through laboratory studies. BTEX species showed fast degradation in the aqueous phase in the presence of peroxides and light. Observed half-lives ranged from three and six hours, substantially shorter than the respective gas phase half-lives (several days). The observed reaction rates were on the order of 1 ppb/min but decreased substantially with increasing concentrations of organic matter (TOC).

The products of BTEX oxidation reactions were analyzed using HPLC-UV and LCMS. The first generation of products identified included phenol and cresols which correspond to the hydroxyl-addition reaction to benzene and toluene. Upon investigating of multi-generational products, smaller, less volatile species are predominant although a large variety of products is found. Most reaction products have substantially lower vapor pressure and will remain in the particle phase upon droplet evaporation.

The SOA generation potential of cloud and fog processing of BTEX was evaluated using simple calculations and showed that in ideal situations these reactions could add up to 9% of the ambient aerosol mass. In more conservative scenarios, the contribution of the processing of BTEX was around 1% of ambient aerosol concentrations.

Overall, cloud processing of VOC has the potential to contribute to the atmospheric aerosol mass. However, the contribution will depend upon many factors such as the irradiation, organic matter content in the droplets and droplet lifetime.