Size, Temperature and Composition of a Droplet as a Function of Time at Non-isothermal Multicomponent Growth or Evaporation

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Detailed description of time-dependent behavior of multicomponent droplets is a necessary step in understanding the aerosol processes in the Earth's atmosphere. New experimental techniques for tracking the changes in temperature and chemical composition of small droplets (Lemoine and Castanet, 2013) extend the requirements to the modern theory of droplet growth.

Multicomponent diffusion growth or evaporation of a droplet, for which the influence of surface curvature on the equilibrium vapor pressure can be neglected, proceeds with gradual approach to the stationary values of the concentrations of components and temperature in the droplet (Mattila *et. al.*, 1997). The theory for the early stage of condensation or evaporation of a droplet, when size, temperature and composition of a droplet change simultaneously and can affect each other, has not been elaborated yet.

We present here a rigorous derivation of a new set of equations for the size, composition and temperature of a small multicomponent droplet at its evaporation or condensation in a mixture of vapors and non-condensable carrier gas. The approach is based on our previous studies (Shchekin *et. al.*, 2011; Kuchma *et. al.*, 2013). The obtained heat and mass balance equations at the droplet boundary together with the transport equations allow one to take into account the non-stationary effects of diffusion, heat conduction, transient processes in the droplet, cross-effects of mutual and thermal diffusion, the Stefan flow and motion of the boundary of the droplet, the effects of non-ideality on the partial volumes, evaporation and specific heats, saturation pressure of components (Kuchma *et. al.*, 2014). Our analysis shows that a correct description of the thermal effects at droplet growth is only possible within the non-stationary approach to the heat and mass transfer. Under the condition that the concentrations of vapors are much smaller than the carrier gas concentration, we simplified the set of equations by neglecting effects of thermal diffusion, Stefan's flow and the movement of the droplet boundary and found a numerical solution (Fig.1). In the steady regime of growth or evaporation of a multicomponent droplet, the equations for the stationary values of temperature and component concentrations in the droplet were derived and analyzed.

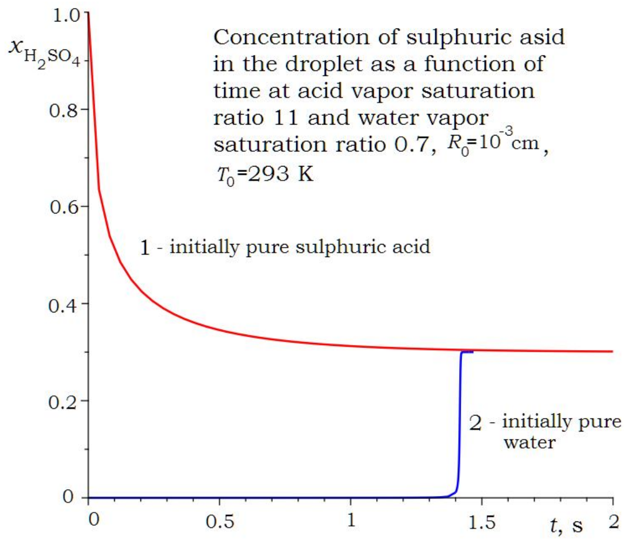

Figure 1. Composition of binary droplet of water and sulphuric acid under atmospheric conditions.

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References

Lemoine, F., Castanet, G. (2013). *Experiments in Fluids*, **54**, 1-17.

Mattila, T., Kulmala, M., Vesala T. (1997). *J. Aerosol Sci.,* **28**, 553-564.

Shchekin, A.K., Kuni, F.M., Lezova, A.A. (2011). *Colloid Journal*, **73**, 394-405.

Kuchma, A.E., Martyukova, D.S., Lezova, A.A., Shchekin, A.K. (2013). *Colloids and Surfaces A*, **432**, 147-156.

Kuchma, A.E., Shchekin, A.K., Lezova, A.A., Martyukova, D.S. (2014). *Colloid Journal,* in press.