

Critical size of charged aerosol particles in the presence of adsorbable foreign gas

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The processes of nucleation and condensation growth of particles (clusters) are of interest both for atmospheric phenomena and for different fields of new technology related to the production and use of nanoparticles. It is known that the charge of particles (clusters) can essentially affect the critical size of particles and the rate of homogeneous nucleation (Reist, 1993).

Let us consider the joint effect of the particle charge and the presence of adsorbable foreign gases on the critical size of particles. Further, we for simplicity do not examine the effect related to a change of the concentration of polar molecules of the vapor near the particle surface due to the particle charge (Nadykto *et al.*, 2003).

Taking into account the dependence of the surface tension on the pressure of the adsorbable foreign gas according to (Luijten *et al.*, 1997), we can obtain following equation for the critical diameter d_{cr} of the particle with the elementary charge q :

$$\ln S = \frac{V_m}{kT} \left[\frac{4\sigma_0}{d_{cr}} - \frac{2q^2}{\pi d_{cr}^4} \left(\frac{1}{\varepsilon_g} - \frac{1}{\varepsilon_p} \right) \right] + \frac{4V_m n_a}{d_{cr}} \ln \left(\frac{P_L}{P_a + P_L} \right) - \ln \left(\frac{\alpha_c}{\alpha_e} \right), \quad (1)$$

where S is the saturation ratio, k is the Boltzmann constant, T is the temperature, V_m is the volume per molecule in the particle, ε_p and ε_g are respectively the dielectric constants of the particle substance and the gas phase, α_c is the condensation coefficient, α_e is the evaporation coefficient, σ_0 is the surface tension of the pure substance (i.e. the substance without adsorbed molecules of the foreign gas), n_a is the number of adsorption sites per unit area, P_a is the foreign gas pressure; the value of P_L can be written as

$$P_L = \frac{n_a (2\pi m_a kT)^{1/2}}{\beta \tau}. \quad (2)$$

Here τ is the adsorption time of foreign gas molecules (it can depend in the general case on the

particle charge), m_a is the mass of the molecule of the foreign gas, β is the sticking coefficient of the foreign gas molecules for the part of the surface not occupied by adsorbed molecules.

It is seen from Eq. (1) that in the case, when $\alpha_c / \alpha_e < 1$, the effect of the adsorbable foreign gas can compensate to some extent the effect related to a difference in the condensation and evaporation coefficients (e.g. in the case of the size-dependent condensation coefficient).

Figure 1 shows the dependence of $\ln S$ on the critical diameter of the charged water drop.

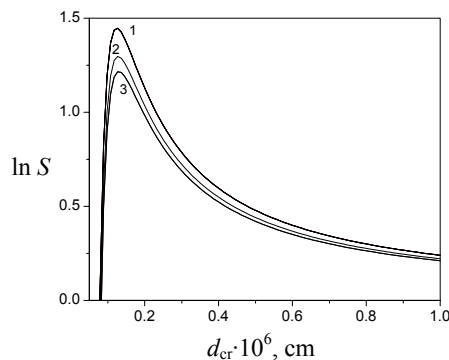


Figure 1. Dependence of $\ln S$ on the critical diameter of the water drop with the elementary charge at $T = 273$ K and $\alpha_c = \alpha_e$; 1: $P_a = 0$, 2: $P_a / P_L = 0.3$, 3: $P_a / P_L = 0.5$.

It is seen from Fig. 1 that with the increase of P_a / P_L the value of S corresponding to the definite value of d_{cr} decreases.

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Reist, P. C. (1993). *Aerosol Science and Technology*. New York: McGraw-Hill.

Nadykto, A. B., Makela, J. M., Yu, F., Kulmala, M., & Laaksonen, A. (2003). *Chem. Phys. Lett.*, 382, 6-11.

Luijten, C. C. M., Bosschaart, K. J., & van Dongen, M. E. H. (1997). *J. Chem. Phys.*, 106, 8116-8123.