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Absorption of Soluble Gases by Ultrafine Atmospheric Aerosol Particles

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In the continental boundary layer, there are frequent observations of the formation of ultrafine particles accompanied by the subsequent growth. Gas absorption of soluble trace atmospheric gases by atmospheric aerosol particles including ultrafine particles plays an important role in climate and atmospheric chemistry. In this study we developed a model for absorption of soluble trace gases by ultrafine liquid aerosol particles taking into account dissociation reaction of the first order in a liquid phase. In the case when radius of the particle is comparable with the mean free path transport of reactant molecules cannot be described by Fickian diffusion. However, application of the flux-matching theory allowed using transient diffusion equation with the kinetic boundary conditions for the description of gas absorption by nanoaerosols. We derived linear integral equation for the transient mass flux to a liquid droplet. Integral equation was solved numerically by the method based on the approximation of the integral using the quadrature formula with unequally space mesh. Using the suggested model we studied theoretically of sulfur dioxide (SO_2), dinitrogen trioxide ($N2O_3$) and chlorine (Cl2) absorption by water nanoaerosol. It is showed that enhanced depletion of the dissolved $N2O_3$ gas in a water droplet due to chemical reaction leads to the decrease of $N2O_3$ concentration in the bulk of a water droplet and to the increase of the concentration gradient at the gas-liquid interface. Consequently, the mass flux of dinitrogen trioxide into a droplet is higher than the fluxes of sulfur dioxide and chlorine at later stage of gas absorption. It was showed also that neglecting kinetic effects leads to significant overestimation of the soluble gas flux into a droplet during all the period of gas absorption.