

## FEATURES OF THE DIFFUSIOPHORESIS OF AEROSOL DROPLETS WITH ALLOWANCE FOR THE INFLUENCE OF THE EVAPORATION (STICKING) COEFFICIENT AND INTERNAL FLOWS

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*A new theory of diffusiophoresis of large volatile spherical aerosol droplets, which is a further development of the previous investigations, has been formed. Account has been taken of the influence of the evaporation coefficient  $\alpha$  of the droplet liquid, the surface-tension coefficient variable along the droplet surface, and internal flows in the droplet on the diffusiophoresis velocity. The formulas obtained enable one to directly find the velocity of motion of single large aerosol droplets in a binary gas mixture inhomogeneous in concentration.*

Droplets on whose surface we have the evaporation or condensation of their constituent substance are commonly referred to as volatile droplets [1–3]. The diffusiophoresis of large volatile particles, i.e., particles with  $Kn \ll 1$ , has been considered in [2–4], where the influence of the evaporation coefficient  $\alpha$  of the droplet liquid on the diffusiophoresis velocity has not been taken into account directly, which is a substantial drawback of these works. Furthermore, it has been shown in [2, 5] that, if the viscosity of the internal region of a droplet is comparable to the viscosity of the medium around the droplet in value, the contribution of the internal flows to the diffusiophoresis velocity becomes very substantial. Therefore, it became necessary to consider the theory of diffusiophoresis of large spherical volatile aerosol particles with direct account taken of the evaporation coefficient  $\alpha$  of the droplet liquid with internal flows and interphase surface tension variable along the droplet surface. By the evaporation (sticking) coefficient we mean the quantity whose value is determined as the ratio of the total radial flux of vapor molecules experiencing phase transition under given conditions (different from saturation) to the same flux in complete saturation of the gas medium with vapor under the same conditions. We are dealing with the molecular flux supplied to the droplet surface (condensation) or the molecular flux removed from the droplet surface (evaporation).

Let us consider a spherical droplet of radius  $R$ , consisting of a one-component liquid with a thermal conductivity  $\chi_l$  and a mass of an individual molecule  $m_l$ . The droplet is placed in a binary gas mixture, which is inhomogeneous in concentration and whose one component is the vapor of the droplet liquid. The gas mixture has a thermal conductivity  $\chi_e$ , a viscosity  $\eta_{0e}$ , and the coefficient of mutual diffusion of the components  $D_{12}^{(e)}$ . At a large distance from the droplet, we maintain constant gradients of concentrations of the components of the gas mixture  $(\nabla C_{1e})_\infty$  and  $(\nabla C_{2e})_\infty$ , where

$$C_{1e} = \frac{n_{1e}}{n_e}, \quad C_{2e} = \frac{n_{2e}}{n_e}, \quad (1)$$

here  $n_e = n_{1e} + n_{2e}$ .

It is clear that  $C_{1e} + C_{2e} = 1$  and

$$\nabla C_{1e} = -\nabla C_{2e} \quad (2)$$

at each point of the gas mixture.

The droplet radius is assumed to be so large as compared to the mean free paths of the molecules of the components of the gas mixture  $\lambda_1$  and  $\lambda_2$  that the problem can be solved in the hydrodynamic regime [1–7]. It is as-

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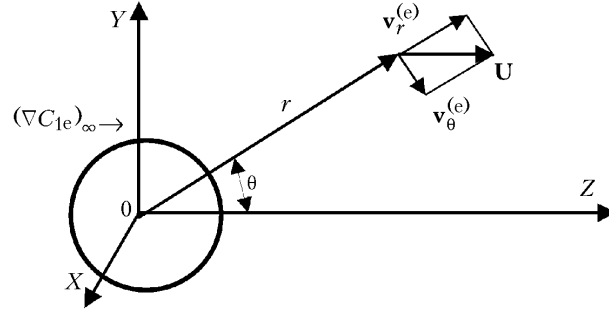


Fig. 1. Motion of a droplet in the external medium.

sumed that the droplet retains its spherical shape in motion. This holds true if (as has been shown in [3]) the external-pressure forces are small as compared to the pressure from surface tension, which can be expressed in the form of the relation

$$\sigma/R \gg \eta_{0e} \frac{|\mathbf{U}|}{R}. \quad (3)$$

Thus, it is assumed that the droplet retains its spherical shape in the process of motion; therefore, the problem is conveniently solved in the spherical coordinate system  $r, \theta, \varphi$  with the origin at the center of the droplet.

The polar axis  $Z = r \cos \theta$  will be selected along the gradient  $(\nabla C_{1e})_\infty$ . We will consider the droplet to be quiescent and the center of gravity of the external mixture to be moving relative to the center of the droplet with velocity  $\mathbf{U}$  when  $r \rightarrow \infty$  (see Fig. 1 and [8] and [3]).

The distributions of velocities, pressures, temperatures, and concentrations inside the droplet and outside is satisfy the following system of differential linearized equations written in vector form [3]:

$$\eta_{0e} \nabla^2 \mathbf{v}^{(e)} = \nabla p^{(e)}, \quad (4)$$

$$\operatorname{div} \mathbf{v}^{(e)} = 0, \quad (5)$$

$$\eta_{0i} \nabla^2 \mathbf{v}^{(i)} = \nabla p^{(i)}, \quad (6)$$

$$\operatorname{div} \mathbf{v}^{(i)} = 0, \quad (7)$$

$$\nabla^2 C_{1e} = 0, \quad (8)$$

$$\nabla^2 T_i = 0, \quad (9)$$

$$\nabla^2 T_e = 0. \quad (10)$$

The boundary conditions [3, 8]

$$v_r^{(e)} = |\mathbf{U}| \cos \theta, \quad (11)$$

$$v_{\theta}^{(e)} = - |\mathbf{U}| \sin \theta, \quad (12)$$

$$p^{(e)} = p_0^{(e)}, \quad (13)$$

$$C_{1e} = C_{01e} + |(\nabla C_{1e})_{\infty}| r \cos \theta, \quad (14)$$

$$T_e = T_{0e} \quad (15)$$

hold true at a large distance from the droplet when  $r \rightarrow \infty$  (also, see Fig. 1).

On the droplet surface, we have the following boundary relations:

$$\left( n_{02e} v_r^{(e)} - D_{12}^{(e)} n_{0e} \frac{m_1}{\rho_{0e}} \frac{\partial C_{2e}}{\partial r} \right) \Big|_{r=R} = 0, \quad (16)$$

$$\left( n_{01e} v_r^{(e)} - D_{12}^{(e)} n_{0e} \frac{m_2}{\rho_{0e}} \frac{\partial C_{1e}}{\partial r} \right) \Big|_{r=R} = n_{0e} \alpha v (C_{1e}^{(\text{sat})} - C_{1e}) \Big|_{r=R}, \quad (17)$$

$$v_{\theta}^{(e)} - v_{\theta}^{(i)} \Big|_{r=R} = \frac{K_{t,sl}^{(e)}}{T_{0e} R} \frac{\partial T_e}{\partial \theta} \Big|_{r=R} + \frac{K_{d,sl}^{(e)} D_{12}^{(e)}}{R} \frac{\partial C_{1e}}{\partial \theta} \Big|_{r=R}, \quad (18)$$

$$T_e \Big|_{r=R} = T_i \Big|_{r=R}, \quad (19)$$

$$\left( -\chi_e \frac{\partial T_e}{\partial r} + \chi_i \frac{\partial T_i}{\partial r} \right) \Big|_{r=R} = -n_{0e} \alpha v L m_1 (C_{1e}^{(i)} - C_{1e}) \Big|_{r=R}. \quad (20)$$

The temperature  $T_i$  inside the droplet and the concentration  $C_{1e}$  must take finite values.

Boundary condition (16) reflects the fact of impermeability of the droplet surface to the second component of the binary gas mixture not experiencing phase transition. In this condition, the first term is equal to the radial convective flux of the second component, whereas the second term is equal to the radial diffusion flux of the same component. Condition (17) expresses the continuity of the radial flux of the first (volatile) component through the droplet surface. The left-hand side of relation (17) is equal to the radial flux of the first component outside the droplet; this radial flux represents the sum of convective and diffusion fluxes. The right-hand side of relation (17) characterizes the radial flux of the first component, which is removed from the droplet surface through the Knudsen layer and is in proportion to the evaporation coefficient  $\alpha$  of the droplet liquid. The latter flux has not been taken into account earlier in the theory of diffusiophoresis of large volatile aerosol droplets (see [1–3]). Derivation of the expression for this flux is based on the fact that the radial molecular flux of the droplet-liquid vapor is determined from simple statistical considerations (see [9]) and is equal to the quantity  $n_{0e} \alpha v (C_{1e}^{(\text{sat})} - C_{1e}) \Big|_{r=R}$ ,  $v = \sqrt{kT_{0e}/(2\pi m_1)}$ .

Relation (18) expresses the existing phenomena of thermal and diffusion slips of the binary gas mixture along the droplet surface which are in proportion to the coefficients of thermal  $K_{t,sl}^{(e)}$  and diffusion  $K_{d,sl}^{(e)}$  slip respectively (see [3, 8, and 10–16]).

The temperature at the droplet–gas phase boundary is continuous. Therefore, we have relation (19) for it at the boundary. The continuity of the heat flux through the droplet surface is given by condition (20) on whose right-hand side account is taken of the heat going into phase transition and proportional to  $L$ .

To the boundary conditions noted above we must add the equality to zero of the radial component of the convective liquid flux through the droplet surface

$$v_r^{(i)} = 0 \quad \text{when } r = R \quad (21)$$

and the known conditions of nonflow of the radial and tangential components of the viscous-stress tensor on the droplet surface [7]

$$\left( -p^{(e)} + 2\eta_{0e} \frac{\partial v_r^{(e)}}{\partial r} \right) \Big|_{r=R} - \frac{2\sigma_0}{R} - 2 \frac{\partial \sigma}{r \partial T_i} \Big|_{T_i=T_{0i}} (T_i - T_{0i}) \Big|_{r=R} = \left( -p^{(i)} + 2\eta_{0i} \frac{\partial v_r^{(i)}}{\partial r} \right) \Big|_{r=R}, \quad (22)$$

$$\eta_{0e} \left( \frac{1}{r} \frac{\partial v_r^{(e)}}{\partial \theta} + \frac{\partial v_\theta^{(e)}}{\partial r} - \frac{\partial v_\theta^{(e)}}{\partial r} \right) \Big|_{r=R} + \frac{1}{r} \frac{\partial \sigma}{\partial T_i} \Big|_{T_i=T_{0i}} \frac{\partial T_i}{\partial \theta} \Big|_{r=R} = \eta_{0e} \left( \frac{1}{r} \frac{\partial v_r^{(i)}}{\partial \theta} + \frac{\partial v_\theta^{(i)}}{\partial r} - \frac{\partial v_\theta^{(i)}}{\partial r} \right) \Big|_{r=R}. \quad (23)$$

The surface tension  $\sigma$  appearing in (22) and (23) is represented in the linear approximation of the series-expansion parameter  $|R\nabla C_{1e}|_\infty$  and can be written as follows:

$$\sigma = \sigma_0 + \frac{\partial \sigma}{\partial T_i} \Big|_{T_i=T_{0i}} (T_i - T_{0i}). \quad (24)$$

We note that the surface tension decreases with increase in the temperature, i.e.,  $\partial \sigma / \partial T < 0$ . It will suffice to refer to the experimental data [17] and the simplest theory in this field [18, 19].

We emphasize that all the boundary conditions (16)–(23) have been written in linearized form in the series-expansion parameter noted and the average values of  $n_e$ ,  $n_{1e}$ ,  $n_{2e}$ ,  $\eta_e$ ,  $\eta_i$ , and  $T_e$  have been substituted instead of these quantities on the droplet surface (see [3]).

We also note that the saturating concentration  $C_{1e}^{(\text{sat})}$  is a function of the temperature  $T_i$  and it can be expanded in the series-expansion parameter  $|R\nabla C_{1e}|$  with the retention of terms linear in this parameter:

$$C_{1e}^{(\text{sat})} (T_i) \Big|_{r=R} = C_{01e}^{(\text{sat})} (T_{0i}) \Big|_{r=R} + \frac{\partial C_{1e}^{(\text{sat})}}{\partial T_i} \Big|_{T_i=T_{0i}} (T_i - T_{0i}) \Big|_{r=R}. \quad (25)$$

The problem of gas-mixture flow about the droplet and internal flows have azimuth symmetry because of the selection of the direction of the polar axis along the gradient  $(\nabla C_{1e})_\infty$ . Therefore, the variable quantities  $\mathbf{v}^{(e)}$ ,  $\mathbf{v}^{(i)}$ ,  $p^{(e)}$ ,  $p^{(i)}$ ,  $C_{1e}$ ,  $T_e$ , and  $T_i$  are independent of the azimuth angle  $\varphi$  and  $v_\varphi^{(e)}$  and  $v_\varphi^{(i)}$  are equal to zero (see [1–3, 5, and 7]).

Solutions of the system of differential equations (4)–(10) in spherical coordinates [3] with account for boundary conditions (11)–(15) can be represented in the form (see [3])

$$\mathbf{v}_r^{(e)} = \left( \frac{A_e}{r^3} + \frac{B_e}{r} + |\mathbf{U}| \right) \cos \theta + \frac{\gamma_e}{r}, \quad (26)$$

$$\mathbf{v}_\theta^{(e)} = \left( \frac{A_e}{2r^3} - \frac{B_e}{2r} - |\mathbf{U}| \right) \sin \theta, \quad (27)$$

$$p^{(e)} = p_0^{(e)} + \eta_{0e} \frac{B_e}{r^2} \cos \theta, \quad (28)$$

$$C_{1e} = C_{01e} + |(\nabla C_{1e})|_{\infty} r \cos \theta + \frac{\mu_e^{(C)}}{r^2} \cos \theta + \frac{\varphi^{(C)}}{r}, \quad (29)$$

$$T_e = T_{0e} + \frac{\mu_e^{(T)}}{r^2} \cos \theta + \frac{\varphi^{(T)}}{r}, \quad (30)$$

$$\mathbf{v}_r^{(e)} = (Q_i + D_i r^2) \cos \theta + \mathbf{v}_{r0}^{(i)}, \quad (31)$$

$$\mathbf{v}_{\theta}^{(i)} = -(Q_i + 2D_i r^2) \sin \theta, \quad (32)$$

$$p^{(i)} = p_0^{(i)} + 10\eta_i D_i r^2 \sin \theta, \quad (33)$$

$$T_i = T_{0i} + \mu_i^{(T)} r \cos \theta. \quad (34)$$

Next, having substituted the solutions (26)–(34) into boundary conditions (16)–(23), we obtain the system of algebraic equations for determination of the unknown constants  $A_e$ ,  $B_e$ ,  $|\mathbf{U}|$ ,  $\mu_e^{(C)}$ ,  $\mu_e^{(T)}$ ,  $\mu_i^{(T)}$ ,  $Q_i$ ,  $D_i$ ,  $\varphi^{(C)}$ , and  $\varphi^{(T)}$  and of the quantities  $v_{r0}^{(i)}$  and  $C_{01e}$ .

If  $\mathbf{U}$  is the velocity of incidence of the gas-mixture flow onto the droplet, the vector of the velocity of diffusiophoresis of the droplet relative to the center of gravity of the gas mixture [3] will be equal to

$$\mathbf{U}_D = -\mathbf{U}. \quad (35)$$

Having obtained the analytical expression for  $|\mathbf{U}|$  (after conversion to the vector notation), we will have

$$\begin{aligned} \mathbf{U}_D = & -\frac{6\eta_{0i}}{(3\eta_{0i} + 2\eta_{0e}) \Delta} \left[ K_{d.sl}^{(e)} D_{12}^{(e)^2} (2\chi_e + \chi_i + n_{0e} \alpha \nu L m_1 R \delta) + \right. \\ & \left. + \left( \frac{K_{t.sl}^{(e)}}{T_{0e}} + \frac{R}{3\eta_{0i}} \delta_{\sigma} \right) D_{12}^{(e)} n_{0e} \alpha \nu L m_1 R \right] (\nabla C_{1e})_{\infty} + \frac{3(\eta_{0i} + 2\eta_{0e}) D_{12}^{(e)} m_1}{(3\eta_{0i} + 2\eta_{0e}) \Delta \rho_{0e}} \left[ (2\chi_e + \chi_i) n_{0e} \alpha \nu R \right] (\nabla C_{1e})_{\infty}, \end{aligned} \quad (36)$$

where

$$\Delta = [2\chi_e + \chi_i] \left( 2D_{12}^{(e)} + \frac{n_{02e}}{n_{0e}} \alpha \nu R \right) + 2D_{12}^{(e)} n_{0e} \alpha \nu L m_1 R \delta, \quad (37)$$

$$\delta = \frac{\partial C_{1e}^{(sat)}}{\partial T_i} \Big|_{T_i=T_{0i}}, \quad \delta_{\sigma} = \frac{\partial \sigma}{\partial T_i} \Big|_{T_i=T_{0i}}. \quad (38)$$

Let us consider some limiting cases of formula (36). If  $\alpha \rightarrow 0$ , we have

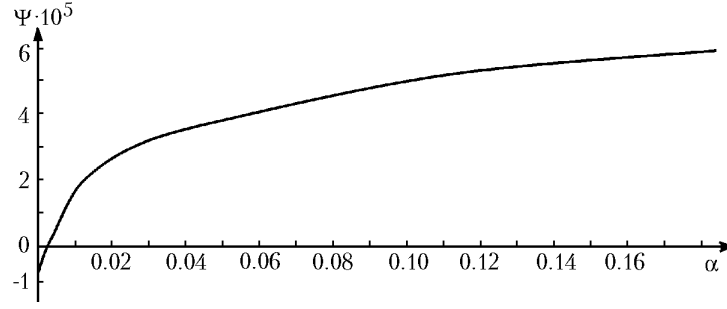


Fig. 2. Coefficient  $\Psi$  vs.  $\alpha$  under normal conditions.

TABLE 1. Coefficient  $\Psi$  as a Function of  $\alpha$  of a Water Droplet (at the top, at  $T_{0e} = 310$  K, at the bottom, at  $T_{0e} = 360$  K)

$\alpha$	0	0.0029	0.1	0.2	0.5	0.7	-1
$\Psi \cdot 10^5$	-0.74	0	5.16	5.85	6.346	6.45	6.52
$\alpha$	0	0.0027	0.1	0.2	0.5	0.7	1
$\Psi \cdot 10^5$	-0.74	0	5.26	5.93	6.41	6.5	6.585

$$\lim_{\alpha \rightarrow 0} \mathbf{U}_D = -\frac{3\eta_{0i}}{3\eta_{0i} + \eta_{0e}} K_{d,sl}^{(e)} D_{12}^{(e)} (\nabla C_{1e})_{\infty}. \quad (39)$$

Formula (39) gives the velocity of diffusiophoresis of a large nonvolatile droplet with allowance for internal flows. If  $\eta_{0i} \gg \eta_{0e}$ , which is quite realizable, for  $\eta_{0e}/\eta_{0i} \rightarrow 0$  from (39) we obtain

$$\lim_{\substack{\alpha \rightarrow 0 \\ \eta_{0e}/\eta_{0i} \rightarrow 0}} \mathbf{U}_D = -K_{d,sl}^{(e)} D_{12}^{(e)} (\nabla C_{1e})_{\infty}. \quad (40)$$

i.e., the classical formula for the velocity of diffusiophoresis of a large nonvolatile droplet particle.

If the thermal conductivity of the droplet is  $\chi_i \gg \chi_e$ , i.e., in the limit  $\chi_e/\chi_i \rightarrow 0$ , from (36) we obtain

$$\lim_{\chi_e/\chi_i \rightarrow 0} \mathbf{U}_D = -\frac{6\eta_{0i}}{(3\eta_{0i} + 2\eta_{0e}) \Delta_1} \left\{ K_{d,sl}^{(e)} D_{12}^{(e)2} \left[ 1 + \frac{n_{0e} \alpha \nu L m_1 R \delta}{\chi_i} \right] + \left[ \frac{K_{t,sl}^{(e)}}{T_{0e}} + \frac{R}{3\eta_{0i}} \delta_{\sigma} \right] \frac{D_{12}^{(e)} n_{0e} \alpha \nu L m_1 R}{\chi_i} \right\} (\nabla C_{1e})_{\infty} + \left\{ \left( \frac{3(\eta_{0i} + 2\eta_{0e})}{3\eta_{0i} + 2\eta_{0e}} \right) \frac{D_{12}^{(e)} m_1}{\rho_{0e} \Delta_1} n_{0e} \alpha \nu R \right\} (\nabla C_{1e})_{\infty}, \quad (41)$$

where

$$\Delta_1 = \left( 2D_{12}^{(e)} + \frac{n_{02e}}{n_{0e}} \alpha \nu R \right) + \frac{2D_{12}^{(e)} n_{0e} \alpha \nu L m_1 R \delta}{\chi_i}.$$

Evaluations with the use of the formulas obtained have shown that the diffusiophoresis velocity  $\mathbf{U}_D$  changes in both absolute value and direction with increase in the coefficient of evaporation  $\alpha$  of the droplet liquid. This is shown fairly well by the shape of the plot (Fig. 2) of the factor of proportionality  $\Psi$  between  $\mathbf{U}_D$  and  $(\nabla C_{1e})_{\infty}$  ( $\mathbf{U}_D = \Psi (\nabla C_{1e})_{\infty}$ ) as a function of the evaporation coefficient of a water droplet of radius  $R = 10 \mu\text{m}$ , suspended in air under normal conditions. In the case of very small  $\alpha$  ( $0 < \alpha \leq 0.003$ ), the velocity  $\mathbf{U}_D$  drops without changing its initial direction ( $\mathbf{U}_D < 0$ ). The reason is that the role of the effects of thermal and diffusion slips (caused by the nonuniform phase transition in motion along the droplet surface) here is dominant and the droplet moves down in the

concentration  $C_{1e}$  for  $K_{d,sl} > 0$ . When  $\alpha \geq 0.03$  the role of a purely reactive effect of evaporation and variable surface tension ( $\partial\sigma/\partial T < 0$ ) grows and the droplet moves up in the concentration  $C_{1e}$ .

Table 1 gives the coefficient  $\Psi$  as a function of  $\alpha$  of the water droplet of radius  $R = 10 \mu\text{m}$ , which is suspended in air at  $T_{0e}$  equal to 330 and 360 K respectively and a pressure of  $10^5$  Pa.

## NOTATION

$A_e$ , constant coefficient dependent on the parameters of the mixture and the droplet,  $\text{m}^4/\text{sec}$ ;  $B_e$ , the same,  $\text{m}^2/\text{sec}$ ;  $C_{1e}$  and  $C_{2e}$ , dimensionless relative concentrations of the first and second components of the gas mixture respectively;  $C_{01e}$ , dimensionless average value of the relative concentration of the first component of the gas mixture;  $D_{12}^{(e)}$ , coefficient of mutual diffusion of the first and second components of the gas mixture,  $\text{m}^2/\text{sec}$ ;  $D_i$ , constant coefficient dependent on the parameters of the mixture and the droplet,  $1/\text{msec}$ ;  $\text{div } \mathbf{v}^{(e)}$  and  $\text{div } \mathbf{v}^{(i)}$ , dimensionless divergences of the velocity of the center of inertia of the gas mixture outside the droplet and inside it;  $k = 1.38 \cdot 10^{23}$ , Boltzmann constant, J/K; Kn, Knudsen number;  $L$ , specific heat of phase transition, J/K;  $m_1$  and  $m_2$ , masses of the molecules of the first and second components of the gas mixture, kg;  $n_{1e}$  and  $n_{2e}$ , concentrations of the molecules of the first and second components of the external gas mixture,  $\text{m}^{-3}$ ;  $n_{01e}$  and  $n_{02e}$ , the same, average value,  $\text{m}^{-3}$ ;  $n_e$ , total concentration of the external gas mixture,  $\text{m}^{-3}$ ;  $n_{0e}$ , the same, average value,  $\text{m}^{-3}$ ;  $p^{(e)}$  and  $p^{(i)}$ , pressures outside the droplet and inside it, Pa;  $p_0^{(e)}$ , average value of the pressure outside the droplet, Pa;  $Q_i$ , constant coefficient dependent on the parameters of the mixture and the droplet,  $\text{m}/\text{sec}$ ;  $r$ , distance from the center of the droplet to a point of the medium, m;  $R$ , radius of an aerosol particle, m;  $T_e$  and  $T_i$ , temperature outside the droplet and inside it respectively, K;  $T_{0e}$  and  $T_{0i}$ , the same, average values, K;  $\mathbf{U}_D$ , diffusiophoresis velocity,  $\text{m}/\text{sec}$ ;  $\mathbf{U}$ , velocity of incidence of the gas-mixture flow onto the droplet,  $\text{m}/\text{sec}$ ;  $\mathbf{v}^{(e)}$  and  $\mathbf{v}^{(i)}$ , velocities of the center of inertia of the gas mixture outside the droplet and inside it,  $\text{m}/\text{sec}$ ;  $\mathbf{v}_r^{(e)}$  and  $\mathbf{v}_\theta^{(e)}$ , radial and tangential components of the mass velocity,  $\text{m}/\text{sec}$ ;  $\mathbf{v}_{r0}^{(i)}$ , average value of the radial component of the mass velocity,  $\text{m}/\text{sec}$ ;  $(X, Y, Z)$ , Cartesian coordinate system, m;  $\alpha$ , dimensionless coefficient of evaporation of the droplet liquid;  $\gamma_e$ , constant coefficient dependent on the parameters of the mixture and the droplet,  $\text{m}^2/\text{sec}$ ;  $\eta_{0e}$  and  $\eta_{0i}$ , average viscosities of the gas mixture and the droplet,  $\text{N}\cdot\text{sec}/\text{m}^2$ ;  $(r, \theta, \varphi)$ , spherical coordinate system, m, rad, and rad;  $\mu_e^{(C)}$ ,  $\mu_e^{(T)}$ , and  $\mu_i^{(T)}$ , constant coefficient dependent on the parameters of the mixture and the droplet,  $\text{m}^2$ ,  $\text{K}\cdot\text{m}^2$ , and  $\text{K}/\text{m}^2$ ;  $v$ , one-fourth of the average absolute thermal velocity of vapor molecules,  $\text{m}/\text{sec}$ ;  $\Psi$ , proportionality factor;  $\rho_{0e}$ , average density of the gas mixture,  $\text{kg}/\text{m}^3$ ;  $\sigma$ , surface-tension coefficient at the droplet–binary gas mixture boundary,  $\text{N}/\text{m}$ ;  $\sigma_0$ , the same, average value,  $\text{N}/\text{m}$ ;  $\chi_e$  and  $\chi_i$ , thermal conductivities of the external medium and the droplet,  $\text{W}/(\text{K}\cdot\text{m})$ ;  $\nabla C_{1e}$  and  $\nabla C_{2e}$ , concentration gradients of the first and second components of the gas mixture respectively,  $\text{m}^{-1}$ ;  $(\nabla C_{1e})_\infty$  and  $(\nabla C_{2e})_\infty$ , constant gradients of concentrations of the first and second components of the gas mixture respectively,  $\text{m}^{-1}$ ;  $\nabla p^{(e)}$ , pressure gradient outside the droplet,  $\text{Pa}/\text{m}$ ;  $\nabla T_e$  and  $\nabla T_i$ , dimensionless gradients of the temperature outside the droplet and inside it respectively. Subscripts and superscripts:  $C$ , relative concentration;  $e$ , external;  $i$ , internal;  $T$ , temperature;  $\text{sat}$ , saturation;  $\text{t.sl}$ , thermal slip;  $\text{d.sl}$ , diffusion slip.

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