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Notation

A_i	area for component *i*, m^2
a'	interfacial area per unit volume of vapour bubbles, m^2/m^3
a_b	vapour-liquid interfacial area per unit volume of dispersion, m^2/m^3
a_d	liquid-liquid interfacial area per unit volume of dispersion, m^2/m^3
B_{ij}	NRTL parameters; see Table 3.3, K
c_i	molar concentration of species *i*, mol/m^3
c_t	mixture molar density, mol/m^3
c_t^L	mixture molar density of the liquid phase, mol/m^3
c_t^V	mixture molar density of the vapour phase, mol/m^3
d_b	bubble diameter, m
d_d	droplet diameter, m
D_{12}	Fick diffusivity in binary mixture, m^2/s
$Đ_{ij}$	Maxwell-Stefan diffusivity for pair i-j, m^2/s
$Đ_{x,ij}$	Maxwell-Stefan diffusivity for pair i-j for the liquid phase, m^2/s
$Đ_{y,ij}$	Maxwell-Stefan diffusivity for pair i-j for the vapour phase, m^2/s
E_i	component Murphree stage efficiency, dimensionless
E_i^{MV}	component Murphree point efficiency, dimensionless
Fo	Fourier number, dimensionless
G_{ij}	NRTL parameters; see Table 3.3, dimensionless
g	acceleration due to gravity, m/s^2
h	distance along froth height, m
h_f	height of dispersion, m
i	component index
$[I]$	identity matrix, dimensionless
j	component index
$\boldsymbol{J}_i$	molar diffusion flux of species *i* relative to the molar average reference velocity $\boldsymbol{u}$, $mol/m^2\ s$
k_{ij}	element for matrix of multicomponent mass transfer coefficient, m/s
$[k]$	matrix of multicomponent mass transfer coefficients, m/s
$[k_x]$	matrix of multicomponent liquid mass transfer coefficients, m/s
$[k_y]$	matrix of multicomponent vapour mass transfer coefficients, m/s
K_i	concentration factor for component *i*, kg^{-1}
$[K_{eq}]$	diagonal matrix of K-values, dimensionless
$[K_{Oy}]$	matrix of multicomponent overall mass transfer coefficients, m/s
$[K^{OV}]$	matrix of multicomponent overall mass transfer coefficients, m/s
m	mass (of molecule), kg
$\boldsymbol{N}_i$	molar flux of species i, $mol/m^2\ s$
$\boldsymbol{N}_t$	mixture molar flux, $mol/m^2\ s$
$[NTU^{OV}]$	matrix of overall number of vapour phase transfer units, dimensionless
$[NTU_{Ox}]$	matrix of overall number of liquid phase transfer units, dimensionless
$[NTU_{Oy}]$	matrix of overall number of vapour phase transfer units, dimensionless
n	number of diffusing species, dimensionless
n	number of species in the mixture, dimensionless
$[Q]$	$\equiv \exp[-[NTU_{Oy}]]$, dimensionless
r_i	response factor of the GC for component *i*, m^2/kg

$[R_y]$	matrix of inverse mass transfer coefficients, m^{-1} s
S	parameter defined in Eq. (4.13), m/s
Sh	Sherwood number, dimensionless
t_b	liquid-bubble contact time, s
t_c	liquid-bubble contact time, s
T	temperature, K
$\boldsymbol{u}_i$	velocity of the diffusing species i, m/s
$\boldsymbol{u}$	molar average mixture velocity, m/s
V	volume, m^3
V_b	single bubble rise velocity, m/s
$V_{injection}$	injection volume taken by the GC automatically, m^3
x_i	liquid composition for component i, dimensionless
y_i	vapour composition for component i, dimensionless
z_i	mole fraction of component i of the appropriate phase, dimensionless

Greek letters

α_{ij}	non-randomness parameter in NRTL equation; see Table 3.3, dimensionless
ε_G	hold-up of vapour, dimensionless
ε_d	hold-up of drops, dimensionless
κ_{ij}	binary Maxwell-Stefan mass transfer coefficients, m/s
$\kappa_{x,ij}$	binary Maxwell-Stefan liquid mass transfer coefficients, m/s
$\kappa_{y,ij}$	binary Maxwell-Stefan vapour mass transfer coefficients, m/s
ρ_L	density of the liquid, kg/m^3
μ_L	liquid viscosity, Pa s
μ_i	molar chemical potential, J/mol
σ	surface tension, N/m
τ^V	vapour phase residence time, s
τ_V	vapour phase residence time, s
τ_{ij}	NRTL parameters; see Table 3.3, dimensionless
ξ	dimensionless distance along dispersion or column height, dimensionless

Subscript

b	referring to a bubble
cal	referring to calibration solution
cs	referring to calibration sample (for GC)
E	referring to conditions entering a specified stage
eq	referring to equilibrium
f	referring to the froth
i	component index
j	component index, stage index
k	component index
L	referring to conditions leaving a specified stage
Lc	referring to the continuous liquid phase

Ld	referring to the dispersed liquid phase
mix	referring to withdrawn column samples
n	component index
OV	overall parameter referred to the vapour phase
Oy	overall parameter referred to the vapour phase
ref	referring to reference solution/component
s	referring to sample solution (for GC)
solvent	referring to solvent to dissolve in
t	referring to total mixture
V	referring to the vapour phase
x	referring to the liquid phase / component index
y	referring to the vapour phase

Superscript

L	referring to the liquid phase
Lc	referring to the continuous liquid phase
Lc,b	referring to the continuous liquid phase next to bubble
Lc,d	referring to the continuous liquid phase next to drop
Ld	referring to dispersed liquid droplet phase
M	referring to Murphree
V	referring to the vapour phase
*	referring to equilibrium state

Dimensionless criteria

Sh Sherwood number $\left[\frac{\kappa\, d_b}{Đ} = \frac{2}{3}\pi^2 \left(\frac{\sum_{m=1}^{\infty} \exp\{-m^2\pi^2 Fo\}}{\sum_{m=1}^{\infty} \frac{1}{m^2} \exp\{-m^2\pi^2 Fo\}} \right)\right]$

Sh_{ij} Sherwood number $\left[\frac{\kappa_{y,ij}\, d_b}{Đ_{y,ij}} = \frac{2}{3}\pi^2 \left(\frac{\sum_{m=1}^{\infty} \exp\{-m^2\pi^2 Fo_{ij}\}}{\sum_{m=1}^{\infty} \frac{1}{m^2} \exp\{-m^2\pi^2 Fo_{ij}\}} \right)\right]$

Fo Fourier number $\left[\frac{4Đ\, t}{d_b^2}\right]$

Fo_{ij} Fourier number $\left[\frac{4Đ_{y,ij}\, \tau^V}{d_b^2}\right]$