NOMENCLATURE

A	constant appearing in the analytical solution (dim.)
A^*	constant appearing in the analytical solution (dim.)
A_{ij}	interphase area for i-j phases (m^2)
a_v	microscale effective area ($m^2\ m^{-3}$)
a_{vM}	macroscale effective area ($m^2\ m^{-3}$)
c_{ji}	i-ion concentration in j-phase ($mol\ m^{-3}$)
$\tilde{c}_{ji}$	deviation of j-ion concentration in i-phase ($mol\ m^{-3}$)
$\langle c_{ji}\rangle^{i}$	intrinsic phase average i-ion concentration in j-phase ($mol\ m^{-3}$)
$\langle c_i\rangle^{*}$	one-equation model phase average i-ion concentration ($mol\ m^{-3}$)
d_p	pore diameter (m)
D_i	bulk solution diffusion coefficient ($m^2\ s^{-1}$)
$\underline{\underline{D}}_i^*$	one-equation model total effective diffusivity tensor ($m^2\ s^{-1}$)
$\underline{\underline{D}}_{i,diff}$	global effective diffusivity tensor ($m^2\ s^{-1}$)
$\underline{\underline{D}}_{i,disp}$	dispersion effective diffusivity tensor ($m^2\ s^{-1}$)
$\underline{\underline{D}}_{i,eff}$	microscale effective diffusivity tensor ($m^2\ s^{-1}$)
$\underline{\underline{D}}_{ii}$	diagonal effective diffusivity tensor, i=κ, γ ($m^2\ s^{-1}$)
$\underline{\underline{D}}_{ij}$	cross-term effective diffusivity tensor, i, j =κ, γ and i≠j ($m^2\ s^{-1}$)
$\underline{\underline{D}}_{i,eff}$	i-ion microscale effective diffusivity tensor ($m^2\ s^{-1}$)
$\underline{\underline{D}}_{ij}$	effective diffusivity tensor for the two-equation model ($m^2\ s^{-1}$)
$\underline{f}$	microscale closure vector fields (m)
$\underline{f}_{ji}$	macroscale closure vector fields, j =κ, γ (m)
F	Faraday constant ($C\ mol^{-1}$)
$\underline{g}$	microscale closure vector fields (m)
$\underline{g}_i$	macroscale closure vector fields s, i=κ, γ (m)
$\underline{g}_{ji}$	macroscale closure vector fields, j=κ, γ (m)
$\underline{h}_i$	macroscale closure vector fields (m)
$\underline{h}_{ji}$	macroscale closure vector fields, j=κ, γ (m)

$\underline{\underline{I}}$	unit tensor (dim.)
$\underline{j}_i$	closure vector fields, i=κ, γ (m)
k	interfacial transfer coefficient for potential(m s^{-1})
k_i	interfacial transfer coefficient for i-ion concentration (m s^{-1})
l_i	characteristic length in i-phase (m)
l_κ	mixed length scale combining interfacial and mass transport (m)
L_e	electrode length scale (m)
$\underline{n}_{ij}$	unit normal vector from the i into the j-phase (dim.)
N_i	ion flux (mol m^{-2} s^{-1})
Pe	Peclet number (dim.)
r	radial cylindrical coordinate (m)
r_1	Chang's unit cell particle dimension (m)
r_2	Chang's unit cell dimension (m)
R	gas constant (J K^{-1} mol^{-1})
R_m	radius of the microscale representative elementary volume (m)
R_M	radius of the macroscale representative elementary volume (m)
$\underline{h}_i$	macroscale closure vector fields (m)
Sh	microscale interfacial dimensionless mass transport coefficient (dim.)
Sh_M	macroscale interfacial dimensionless mass transport coefficient (dim.)
s_i	macroscale closure scalar fields (dim.)
t	time (s)
$\underline{t}_{ji}$	macroscale closure vector fields, j=κ, γ (dim.;)
$\underline{\underline{U}}_{i,eff}$	microscale effective mobility tensor (m^2 V^{-1} s^{-1})
$\underline{\underline{U}}_i^*$	macroscale total effective mobility tensor (m^2 V^{-1} s^{-1})
$\underline{\underline{U}}_{ij}$	two-equation model effective mobility tensors, i, j =κ, γ (m^2 V^{-1} s^{-1})
$\underline{v}_{ji}$	macroscale closure vector fields, j=κ, γ (m)
V_i	i-phase volume in REV (m^3)
V_m	microscale REV (m^3)
V_M	macroscale REV (m^3)
$\underline{v}_s$	convective velocity (m s^{-1})

$\underline{\tilde{v}}_s$	convective velocity deviation (m s^{-1})
$\langle \underline{v}_s \rangle^{\gamma}$	intrinsic phase average velocity (m s^{-1})
V_T	thermal voltage (V)
$\underline{w}_{ji}$	macroscale closure vector fields, j=κ, γ (m)
z_i	ionic charge number (dim.)

Greek letters

δ	Mass diffusivity ratio, ($\varepsilon_a D_{\kappa,eff}/D_{\gamma}$, dim.)
ε_i	i-phase volume fraction (dim.)
$\langle \varepsilon \rangle$	factor defined in eq. (25) (dim.)
ϕ	electrostatic potential (V)
ψ_i	dimensionless electrostatic potential in i-phase (dim.)
$\tilde{\psi}_i$	potential deviation in i-phase (V)
$\langle \psi_i \rangle^i$	intrinsic phase average potential in i-phase (dim.)
$\langle \psi \rangle^*$	one-equation model phase average potential (dim.)
η	phase permittivity (F m^{-1})
$\underline{\underline{\eta}}^*$	one-equation model effective permittivity tensor (F m^{-1})
$\underline{\underline{\eta}}_{eff}$	microscale effective permittivity tensor (F m^{-1})
$\underline{\underline{\eta}}_{ij}$	two-equation model effective permittivity tensors; i, j =κ, γ (F m^{-1})
λ_D	Debye length (m)
θ	azimuthal cylindrical coordinate (m)
$\underline{\nabla}$	nabla operator (m^{-1})
σ	charge density (C m^{-2})
$\langle \sigma \rangle_{ij}$	charge density area average; i, j =κ, γ; i≠j (C m^{-2})
ξ_{ji}	closure variables in eqns. (54) and (55), j =κ, γ (mol m^{-3})
ζ_{ji}	closure variables in eqns. (46) and (47), j =κ, γ (mol m^{-3})

Subscripts

α	α-phase
β	β-phase
γ	γ-phase
κ	κ-phase