Supporting Information 1:Paraments

The simulation of interface characteristics and charge transfer dynamics for layered electrodes using cascade capacitance in supercapacitors by COMSOL software

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1.Parameters of activated carbon as negative electrode

Property	Variable	Value	Unit	Property group
Electrical conductivity	sigma_iso ; sigmaii = sigma_iso, sigmaij = 0	32.4[S/m]	S/m	Basic
Electrolyte conductivity	sigmal_iso ; sigmalii = sigmal_iso, sigmalij = 0	80[S/m]	S/m	Electrolyte conductivity
Diffusion coefficient	D_iso ; Dii = D_iso, Dij = 0	3.9e-14[m^2/s]	m^2/s	Basic
Density	rho	2260[kg/m^3]	kg/m^3	Basic
Equilibrium potential	Eeq	Eeq_int1(soc)	V	Equilibrium potential
Temperature derivative of equilibrium potential	dEeqdT	0[V/K]	V/K	Equilibrium potential
Reference concentration	cEeqref	def.csmax	mol/m^3	Equilibrium potential
Maximum electrode state of charge	socmax	elpot.Eeq_inv(E_min)	1	Operational electrode state of charge
Minimum electrode state of charge	socmin	elpot.Eeq_inv(E_max)	1	Operational electrode state of charge
Maximum operational potential	E_max	4.2[V]	V	Operational electrode state of charge
Minimum operational potential	E_min	0[V]	V	Operational electrode state of charge
Equilibrium concentration	csEq	def.csmax*elpot.Eeq_inv(V)	mol/m^3	Equilibrium concentration

2.Parameters of KOH solution as electrolyte

Property	Variable	Value	Unit	Property group
Electrolyte conductivity	sigmal_iso ; sigmalii = sigmal_iso, sigmalij = 0	(A*M+B*M^2+C*M*T_K+D*M/T_K+E*M^3+F*M^2*T_K^2)*1[S/cm]	S/m	Electrolyte conductivity
Diffusion coefficient	D_iso ; Dii = D_iso, Dij = 0	3.75e-9[m^2/s]	m^2/s	Basic
Density	rho	(A_rho(T_degC)*M_reg^2+B_rho(T_degC)*M_reg+C_rho(T_degC))*1[kg/m^3]	kg/m^3	Basic
Transport number	transpNum	0.22	1	Species properties
Activity dependence	fcl	2	1	Species properties

3.Parameters of graphene oxide as positive electrode

Property	Variable	Value	Unit	Property group
Electrical conductivity	sigma_iso ; sigmaii = sigma_iso, sigmaij = 0	1000[S/m]	S/m	Basic
Electrolyte conductivity	sigmal_iso ; sigmalii = sigmal_iso, sigmalij = 0	100[S/m]	S/m	Electrolyte conductivity
Young's modulus	E	E_int(c/csmax)	Pa	Basic
Poisson's ratio	nu	nu_int(c/csmax)	1	Basic
Diffusion coefficient	D_iso ; Dii = D_iso, Dij = 0	1.4523e-13*exp(68025.7/8.314*(1/(T_ref/1[K])-1/(T2/1[K])))[m^2/s]	m^2/s	Basic
Thermal conductivity	k_iso ; kii = k_iso, kij = 0	1[W/(m*K)]	W/(m·K)	Basic
Heat capacity at constant pressure	Cp	750[J/(kg*K)]	J/(kg·K)	Basic
Density	rho	2300[kg/m^3]	kg/m^3	Basic
Equilibrium potential	Eeq	Eeq_int1(soc)+dEeqdT_int1(soc)*(T-298[K])	V	Equilibrium potential
Temperature derivative of equilibrium potential	dEeqdT	dEeqdT_int1(soc)	V/K	Equilibrium potential
Reference concentration	cEeqref	def.csmax	mol/m^3	Equilibrium potential
Maximum electrode state of charge	socmax	elpot.Eeq_inv(E_min)	1	Operational electrode state of charge
Minimum electrode state of charge	socmin	elpot.Eeq_inv(E_max)	1	Operational electrode state of charge
Maximum operational potential	E_max	4.2[V]	V	Operational electrode state of charge
Minimum operational potential	E_min	0[V]	V	Operational electrode state of charge
Volumetric strain	dvol	dVOLdSOL(c/def.csmax)	1	Intercalation strain
Equilibrium concentration	csEq	def.csmax*elpot.Eeq_inv(V)	mol/m^3	Equilibrium concentration

4.Parameters of $ZnMn_2O_4$ as positive electrode

Property	Variable	Value	Unit	Property group
Electrical conductivity	sigma_iso ; sigmaii = sigma_iso, sigmaij = 0	1000[S/m]	S/m	Basic
Electrolyte conductivity	sigmal_iso ; sigmalii = sigmal_iso, sigmalij = 0	100[S/m]	S/m	Electrolyte conductivity
Young's modulus	E	E_int(c/csmax)	Pa	Basic
Poisson's ratio	nu	nu_int(c/csmax)	1	Basic
Diffusion coefficient	D_iso ; Dii = D_iso, Dij = 0	1.4523e-13*exp(68025.7/8.314*(1/(T_ref/1[K])-1/(T2/1[K])))[m^2/s]	m^2/s	Basic
Thermal conductivity	k_iso ; kii = k_iso, kij = 0	1[W/(m*K)]	W/(m·K)	Basic
Heat capacity at constant pressure	Cp	750[J/(kg*K)]	J/(kg·K)	Basic
Density	rho	2300[kg/m^3]	kg/m^3	Basic
Equilibrium potential	Eeq	Eeq_int1(soc)+dEeqdT_int1(soc)*(T-298[K])	V	Equilibrium potential
Temperature derivative of equilibrium potential	dEeqdT	dEeqdT_int1(soc)	V/K	Equilibrium potential
Reference concentration	cEeqref	def.csmax	mol/m^3	Equilibrium potential
Maximum electrode state of charge	socmax	elpot.Eeq_inv(E_min)	1	Operational electrode state of charge
Minimum electrode state of charge	socmin	elpot.Eeq_inv(E_max)	1	Operational electrode state of charge
Maximum operational potential	E_max	4.2[V]	V	Operational electrode state of charge
Minimum operational potential	E_min	0[V]	V	Operational electrode state of charge
Volumetric strain	dvol	dVOLdSOL(c/def.csmax)	1	Intercalation strain
Equilibrium concentration	csEq	def.csmax*elpot.Eeq_inv(V)	mol/m^3	Equilibrium concentration

5.Parameters of cyclic voltammetry test

Name	Expression	Value	Description
V_min	0[V]	0 V	
V_max	1.6[V]	1.6 V	
v	0.05[V/s]	0.05 V/s	Scanning rate
tH	(V_max-V_min)/v	32 s	half-period

6.Electrolyte parameters preset by COMSOL software

Name	Expression	Unit	Description	Selection	Details
cd.sigmalrr	ionc.sigmal11	S/m	Electrolyte conductivity, rr-component	Domain 2	Meta
cd.sigmalphir	ionc.sigmal21	S/m	Electrolyte conductivity, phir-component	Domain 2	Meta
cd.sigmalzr	ionc.sigmal31	S/m	Electrolyte conductivity, zr-component	Domain 2	Meta
cd.sigmalrphi	ionc.sigmal12	S/m	Electrolyte conductivity, rphi-component	Domain 2	Meta
cd.sigmalphiphi	ionc.sigmal22	S/m	Electrolyte conductivity, phiphi-compon...	Domain 2	Meta
cd.sigmalzphi	ionc.sigmal32	S/m	Electrolyte conductivity, zphi-component	Domain 2	Meta
cd.sigmalrz	ionc.sigmal13	S/m	Electrolyte conductivity, rz-component	Domain 2	Meta
cd.sigmalphiz	ionc.sigmal23	S/m	Electrolyte conductivity, phiz-component	Domain 2	Meta
cd.sigmalzz	ionc.sigmal33	S/m	Electrolyte conductivity, zz-component	Domain 2	Meta
cd.Qh	-cd.Ilr*philr-cd.Ilz*philz	W/m^3	Total power dissipation density	Domain 2	+ operation
cd.IlMag	sqrt(realdot(cd.Ilr,cd.Ilr)+realdot(cd.Ilphi,cd.Ilphi)+realdot(cd.Ilz,cd.Ilz))	A/m^2	Electrolyte current density magnitude	Domain 2	
cd.Qli	0	A/m^3	Current source	Domain 2	+ operation
cd.tEr	-philTr	V/m	Tangential electric field, r-component	Boundaries 4–7	
cd.tEphi	0	V/m	Tangential electric field, phi-component	Boundaries 4–7	
cd.tEz	-philTz	V/m	Tangential electric field, z-component	Boundaries 4–7	
cd.Er	-philr	V/m	Electric field, r-component	Domain 2	
cd.Ephi	0	V/m	Electric field, phi-component	Domain 2	
cd.Ez	-philz	V/m	Electric field, z-component	Domain 2	
cd.ilr	-cd.sigmalrr*philr-cd.sigmalrz*philz	A/m^2	Electrolyte current density, r-component	Domain 2	+ operation
cd.ilphi	-cd.sigmalphir*philr-cd.sigmalphiz*philz	A/m^2	Electrolyte current density, phi-compone...	Domain 2	+ operation
cd.ilz	-cd.sigmalzr*philr-cd.sigmalzz*philz	A/m^2	Electrolyte current density, z-component	Domain 2	+ operation
cd.Ilr	cd.ilr	A/m^2	Electrolyte current density vector, r-com...	Domain 2	
cd.Ilphi	cd.ilphi	A/m^2	Electrolyte current density vector, phi-co...	Domain 2	
cd.Ilz	cd.ilz	A/m^2	Electrolyte current density vector, z-com...	Domain 2	
cd.phil	phil	V	Electrolyte potential	Domain 2	
cd.sigmaleffrr	cd.sigmalrr	S/m	Electrolyte conductivity, rr-component	Domain 2	
cd.sigmaleffphir	cd.sigmalphir	S/m	Electrolyte conductivity, phir-component	Domain 2	
cd.sigmaleffzr	cd.sigmalzr	S/m	Electrolyte conductivity, zr-component	Domain 2	

7.Electrode parameters preset by COMSOL software

Name	Expression	Unit	Description
cd.ivtot	cd.ivdl	A/m^3	Electrode reaction source
cd.av_dl_pce1_pdl1	1000000[1/m]	1/m	Double-layer area
cd.idl	0	A/m^2	Double-layer current density
cd.ivdl	cd.idl*cd.av_dl_pce1_pdl1	A/m^3	Double-layer current source
cd.itot	cd.idl	A/m^2	Total interface current density

8.Second current distribution parameters preset by COMSOL software

Name	Expression	Unit	Description
domflux.philr	2*cd.Ilr*pi*r*cd.d	A/m	Domain flux, r-component
domflux.philz	2*cd.Ilz*pi*r*cd.d	A/m	Domain flux, z-component
domflux.phisr	2*cd.Isr*pi*r*cd.d	A/m	Domain flux, r-component
domflux.phisz	2*cd.Isz*pi*r*cd.d	A/m	Domain flux, z-component
cd.d	1	1	Out-of-plane geometry extension
cd.bndflux_phil	if(r>0.001/sqrt(sqrt(mean(emetric2))),-0.5*dflux_spatial(phil)/(pi*r),NaN)	A/m^2	Boundary flux
cd.bndflux_phil	if(r>0.001/sqrt(sqrt(mean(emetric2))),0.25*(uflux_spatial(phil)-dflux_spatial(phil))/(pi*r),NaN)	A/m^2	Boundary flux
cd.nIl	cd.bndflux_phil/cd.d	A/m^2	Normal electrolyte current density
cd.nR	nR	1	Normal vector, R-component
cd.nPHI	0	1	Normal vector, PHI-component
cd.nZ	nZ	1	Normal vector, Z-component
cd.nR	dnR	1	Normal vector, R-component
cd.nPHI	0	1	Normal vector, PHI-component
cd.nZ	dnZ	1	Normal vector, Z-component
cd.bndflux_phis	if(r>0.001/sqrt(sqrt(mean(emetric2))),-0.5*dflux_spatial(phis)/(pi*r),NaN)	A/m^2	Boundary flux
cd.bndflux_phis	if(r>0.001/sqrt(sqrt(mean(emetric2))),-0.5*uflux_spatial(phis)/(pi*r),NaN)	A/m^2	Boundary flux
cd.bndflux_phis	if(r>0.001/sqrt(sqrt(mean(emetric2))),0.25*(uflux_spatial(phis)-dflux_spatial(phis))/(pi*r),NaN)	A/m^2	Boundary flux
cd.nIs	cd.bndflux_phis/cd.d	A/m^2	Normal electrode current density
cd.nil	0	A/m^2	Inward electrolyte current density
cd.nis	0	A/m^2	Inward electrode current density
cd.Qsi	0	A/m^3	Current source
cd.mulstopcond	1	1	Multiplicative stop condition
cd.stopcond	cd.mulstopcond	1	Solver stop condition
cd.Ect	NaN	V	Electrode potential
cd.nr	dnr		Normal vector, r-component
cd.nphi	0		Normal vector, phi-component
cd.nz	dnz		Normal vector, z-component
cd.nr	dnr		Normal vector, r-component
cd.nphi	0		Normal vector, phi-component
cd.nz	dnz		Normal vector, z-component
cd.nr	dnr		Normal vector, r-component