

Supplementary Materials

Ex-situ Fabrication of Polypyrrole-coated Core-Shell Nanoparticles for High-Performance Coin Cell Supercapacitor

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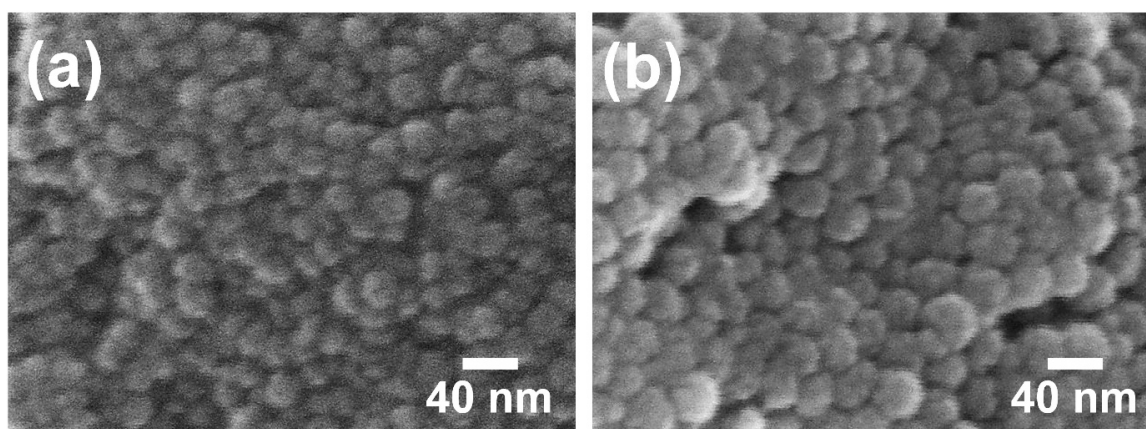


Figure S1. FE-SEM images of SiO₂-PPy core-shell NPs with (a) 12 nm and (b) 22 nm SiO₂ NPs prepared by ex-situ method.

Table S1. Elemental composition of pristine SiO₂ and SiO₂-PPy core-shell NP with 12 nm SiO₂ core prepared by ex-situ method.

Sample	Atomic ratio (%) [†]						C/N Value
	C	N	O	Si	Fe	Cl	
pristine SiO ₂	5.79	-	53.66	40.55	-	-	-
SiO ₂ -PPy core-shell	24.02	7.37	42.70	10.76	12.98	2.16	3.26

[†]These values were obtained in the SEM-EDAX mode for 50 sec, at a beam current of 0.1 A. and an accelerating voltage of 10 kV.

The elemental compositions of the pristine SiO₂ NP and core-shell NP were obtained by using the energy-dispersive X-ray (EDAX) analysis data obtained from the FE-SEM instrument (**Table S1**). The %C value of core-shell was increased compared to the pristine SiO₂ NP, while the %O and %Si values decreased due to the presence of PPy shells on the SiO₂ surface. The detection of N is attributed to the amine group of PPy, thereby the existence of PPy shell on the surface of SiO₂ NP can be confirmed [18,19]. The discovery of Fe and Cl atoms in the core-shell also indicates that PPy shell is doped by

FeCl₃·6H₂O. Observation of C atom in the pristine SiO₂ sample can be attributed to the carbon tape used to hold the sample on the EDAX specimen mount [19].

Table S2. Elemental composition of SiO₂-PPy core-shell NPs obtained using XPS analyses.

Sample	Atomic ratio (%) ¹						C/N Value
	C	N	O	Si	Fe	Cl	
ex-situ 12nm	23.09	7.65	43.52	6.53	11.75	7.46	3.02
ex-situ 22nm	22.81	7.33	45.33	7.08	10.26	7.19	3.11
ex-situ 12nm	20.35	6.21	48.69	8.31	9.82	6.62	3.28
ex-situ 22nm	19.68	5.76	49.86	9.13	9.58	5.99	3.42

Table S3. Peak analyses of XPS core spectra in the N(1s) region of SiO₂-PPy core-shell NPs.

Samples	XPS Atomic Ratio			
	-NH-	-NH•+	=NH+	N ⁺ /N ratio ¹
ex-situ 12nm	0.43	0.35	0.22	0.57
ex-situ 22nm	0.56	0.28	0.16	0.44
ex-situ 12nm	0.77	0.18	0.06	0.23
ex-situ 22nm	0.86	0.10	0.05	0.14

¹Values were calculated using the N(1s) core spectra of the samples.

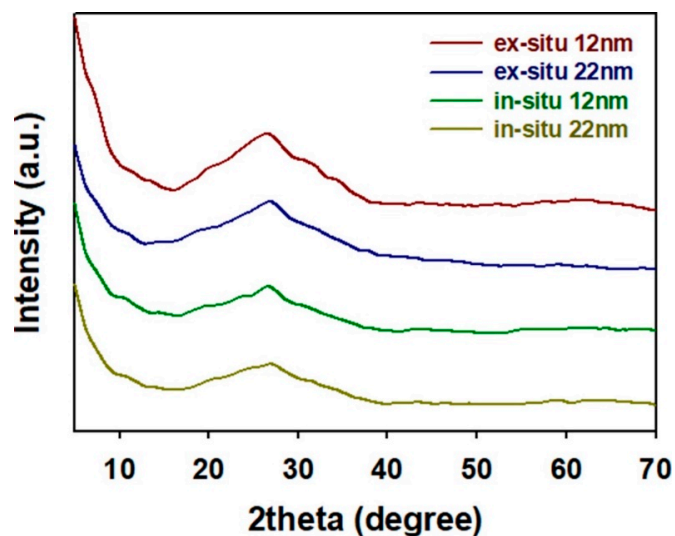


Figure S2. XRD patterns of ex-situ 12nm (red), ex-situ 22nm (blue), in-situ 12nm (green), and in-situ 22nm (olive green).

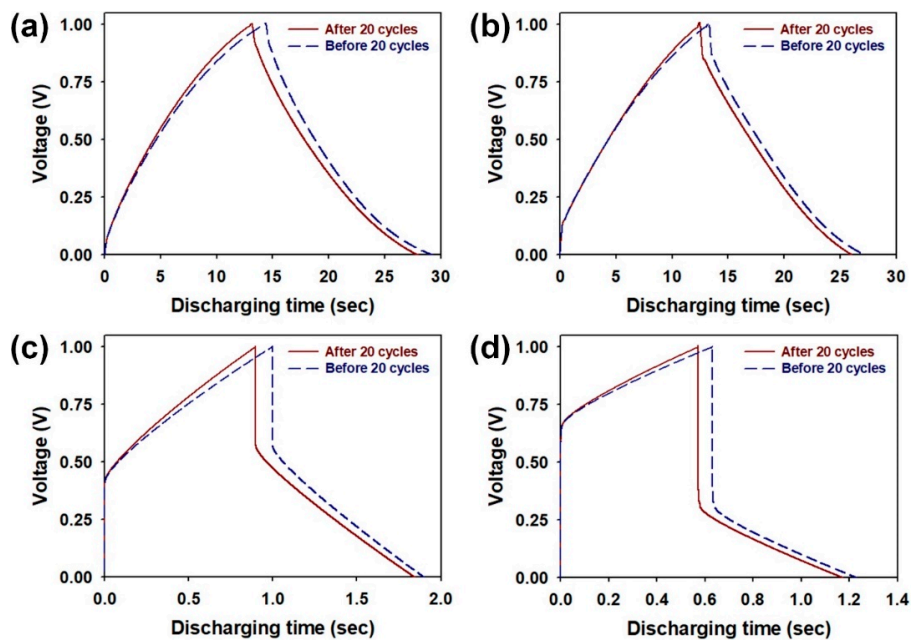


Figure S3. GCD curves of coin cells containing core-shell NPs before and after performing 20 CV cycles at a current of 1 mA/cm²: (a) ex-situ 12nm; (b) ex-situ 22nm; (c) in-situ 12nm, and (d) in-situ 22nm.