Aqueous Polypyrrole:Carboxymethyl Cellulose Conducting Binder for Graphite Electrodes in Lithium-Ion Batteries

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Supporting Information

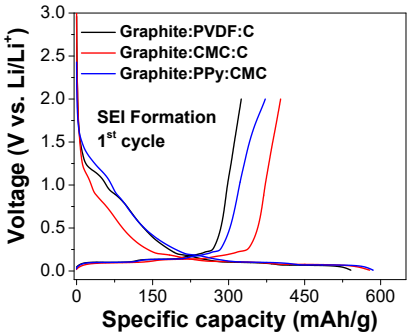


Figure S1: 1st charge/discharge curves to form SEI of Graphite:PVDF:C, Graphite:CMC:C, and Graphite:PPy:CMC electrodes at 0.1C.

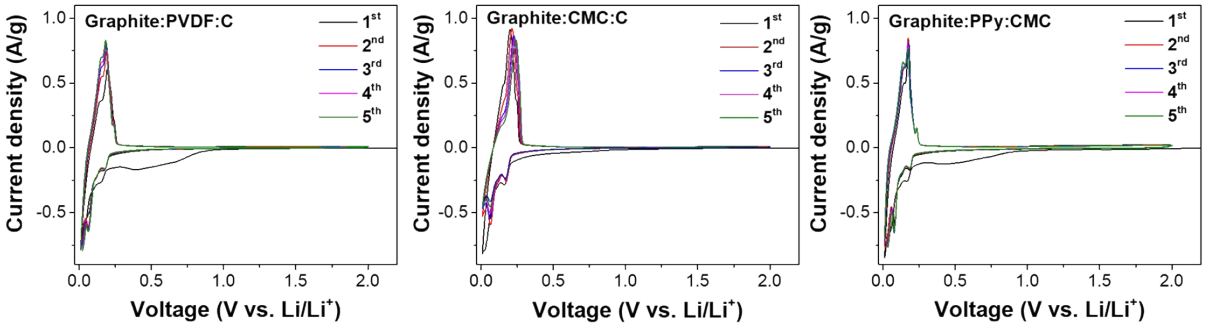


Figure S2: Cyclic voltammogram from the 1st to 5th cycles at 0.1 mV/s of **a)** Graphite:PVDF:C, **b)** Graphite:CMC:C, and **c)** Graphite:PPy:CMC cells.

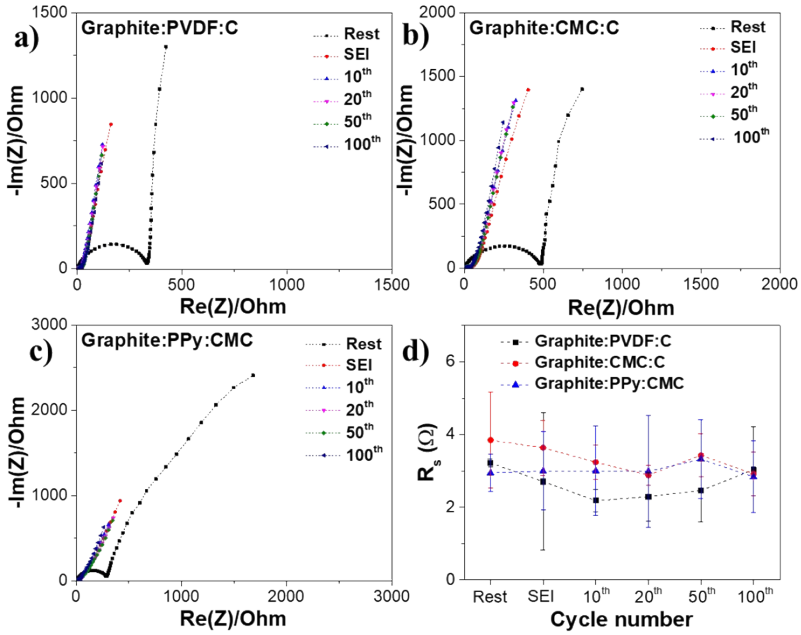
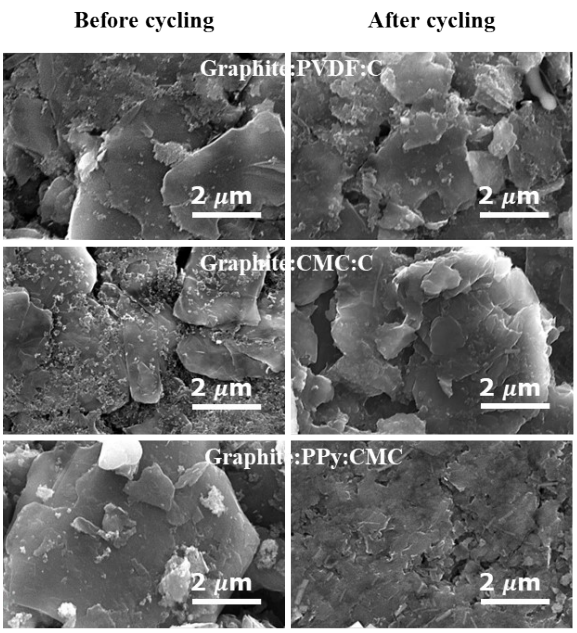


Figure S3: Representative Nyquist plots at larger scales of **a)** Graphite:PVDF:C, **b)** Graphite:CMC:C, and **c)** Graphite:PPy:CMC cells; **d)** R_s values, calculated from EIS results.



Element	Gra:PVDF:C	Gra:CMC:C	Gra:PPy:CMC
	Atomic %		
Before cycling			
C K	97.1 ± 2.1	96.4 ± 2.9	91.0 ± 2.1
N K	NA	NA	4.8 ± 0.6
O K	1.0 ± 0.1	3.1 ± 0.8	4.2 ± 0.4
F K	1.9 ± 0.2	NA	NA
After cycling			
C K	79.6 ± 3.0	67.4 ± 4.0	66.3 ± 3.0
N K	NA	NA	1.3 ± 0.9
O K	18.6 ± 1.8	31.4 ± 8.1	31.9 ± 2.9
F K	1.7 ± 0.2	0.7 ± 0.1	0.4 ± 0.3
P K	0.1 ± 0.06	0.4 ± 0.02	0.1 ± 0.01

Figure S4: SEM images (using ETD detector) and EDX results of Graphite:PVDF:C, Graphite:CMC:C, and Graphite:PPy:C electrodes before and after 100 cycles.

Table S1: XPS peak binding energies (eV) and their corresponding compound assignments for Graphite:PVDF:C and Graphite:PPy:C electrodes[1-8].

Sample	Peak	Graphite:PVDF:C		Graphite:CMC:C		Graphite:PPy:CMC	
		Binding energy (eV)	Assignment	Binding energy (eV)	Assignment	Binding energy (eV)	Assignment
Pristine	C 1s	284.8	C-C	284.8	C-C	284.8	C-C/C-H
		285.0	C-H	285.0	C-H	285.0	C-N
		286.0	C-O/C=O	286.8	C-O	286.4	C-O
		288.3	C-F	290.2	C=O	291.0	C=O
		291.0	$C-F_2$	NA	NA	NA	NA
Cycled	C 1s	283.1	C-Li	NA	NA	282.5	C-Li
		284.8	C-C/C-H	284.8	C-C/C-H	284.8	C-C/C-H
		286.8	C-O	285.7	C-O	286.8	C-O
		289.1	ROLi/ $ROCO_2Li$	285.8	C=O	288.4	C=O
		290.4	C-F/Li_2CO_3	290.3	C-O=C/ Li_2CO_3/ $ROCO_2Li$	289.8	Li_2CO_3/ $ROCO_2Li$
Pristine	O 1s	531.8	C=O	533.2	C=O	532.0	C=O
		533.3	C-O	533.8	C-O/C-OH	533.5	C-O/C-OH
		NA	NA	536.2	C-O-C	533.8	C-O-C
Cycled	O 1s	531.4	ROLi	529.3	ROLi	531.3	ROLi
		532.1	C=O/ Li_2CO_3	533.1	C=O/ Li_2CO_3	532.0	C=O/ Li_2CO_3
		533.8	C-O/ $Li_xPO_yF_z$	533.0	C-O/ $Li_xPO_yF_z$	533.8	C-O/ $Li_xPO_yF_z$
Pristine	F 1s	687.9	CF	NA	NA	NA	NA
		688.8	CF_2				
Cycled	F 1s	684.8	LiF	686.1	LiF	684.7	LiF
		686.0	CF	NA	NA	NA	NA
		687.4	$Li_xPO_yF_z$/ Li_xPF_y	688.6	$Li_xPO_yF_z$/ Li_xPF_y	686.6	$Li_xPO_yF_z$/ Li_xPF_y
Cycled	P 2p	134.1	$Li_xPO_yF_z$	133.3	$Li_xPO_yF_z$/ Li_xPF_y	134.0	$Li_xPO_yF_z$
		136.9	Li_xPF_y			136.8	Li_xPF_y
Cycled	Li 1s	54.6	Li_2O	54.5	Li_2O	54.5	Li_2O
		55.4	Li_2CO_3/ $ROCO_2Li$/ $Li_xPO_yF_z$	55.3	Li_2CO_3/ $ROCO_2Li$/ $Li_xPO_yF_z$	55.5	Li_2CO_3/ $ROCO_2Li$/ $Li_xPO_yF_z$
		56.3	LiF	56.2	LiF	56.4	LiF
Pristine	N 1s	NA	NA	NA	NA	399.8	C-N
Cycled	N 1s	NA	NA	NA	NA	399.6	C-N

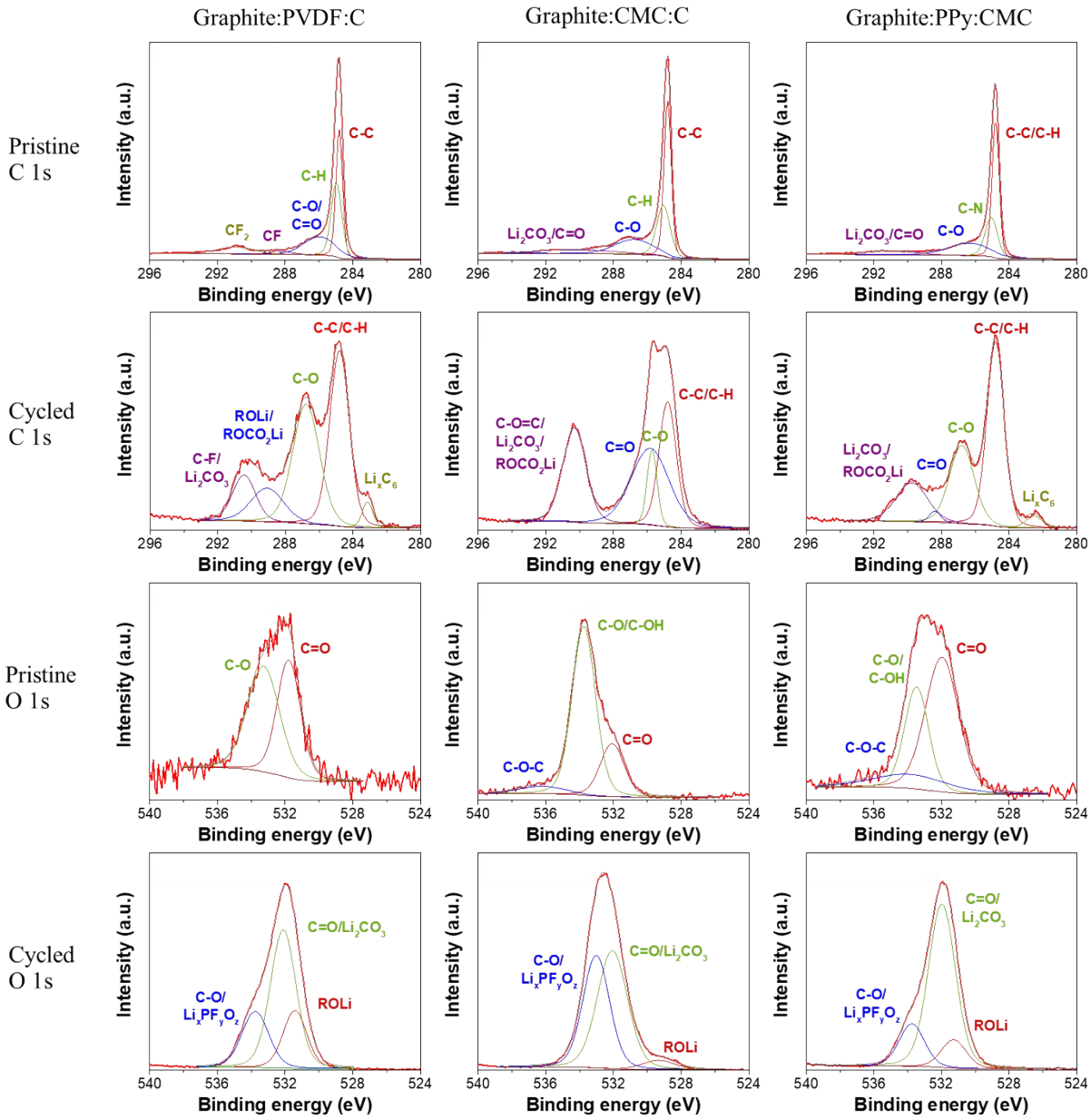


Figure S5: C 1s and O 1s XPS spectra of Graphite:PVDF:C, Graphite:CMC:C, and Graphite:PPy:CMC electrodes before and after 100 cycles at 0.5C.

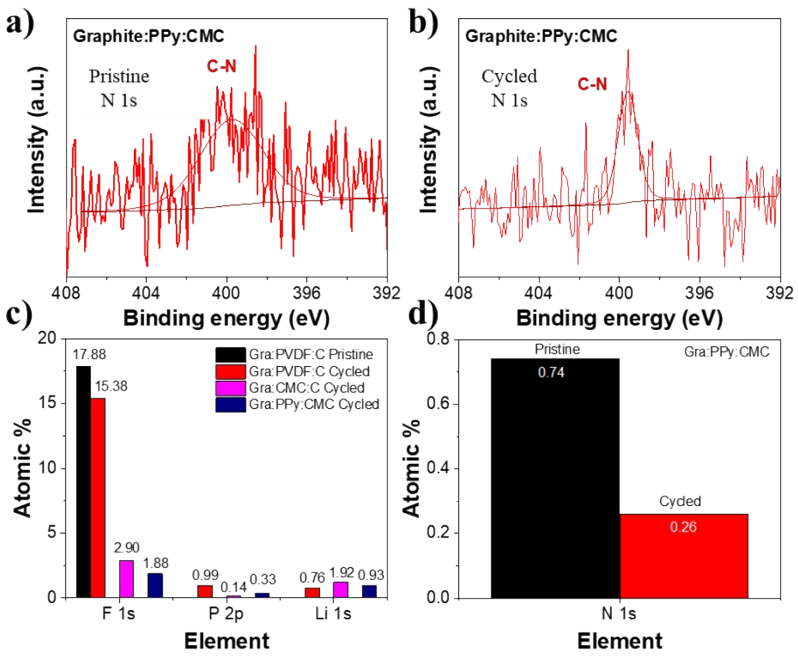


Figure S6: XPS spectra of N 1s of a Graphite:PPy:CMC electrode **a)** before cycling and **b)** after 100 cycles at 0.5C; **c)** atomic percentage of F, P, and Li, calculated based on the area of F 1s, P 2p, and Li 1s peaks in the survey spectra of Graphite:PVDF:C: Gaphite:CMC:C, and Graphite:PPy:CMC; **d)** atomic percentage of N calculated based on the area of N 1s peak in the survey spectra of Graphite:PPy:CMC.

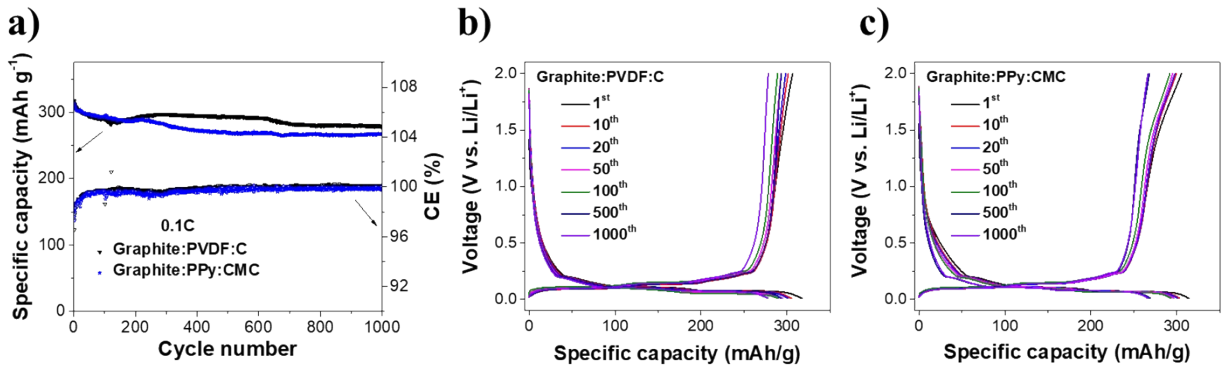


Figure S7: Cycling profile of Graphite:PVDF:C and Graphite:PPy:CMC for 1000 cycles at 0.1C.

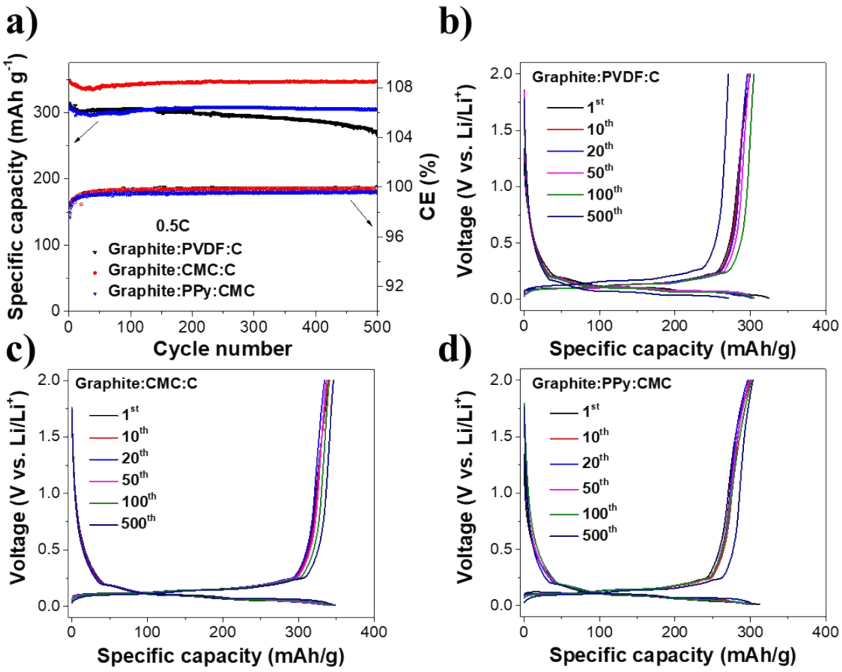


Figure S8: Cycling profile of Graphite:PVDF:C, Graphite:CMC:C, and Graphite:PPy:CMC for 500 cycles at 0.5C.

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