Supporting information

Multifunctional fluoroethylene carbonate for improving high-temperature performance of $LiNi_{0.8}Mn_{0.1}Co_{0.1}O_2$||$SiO_x$@Graphite lithium ion batteries

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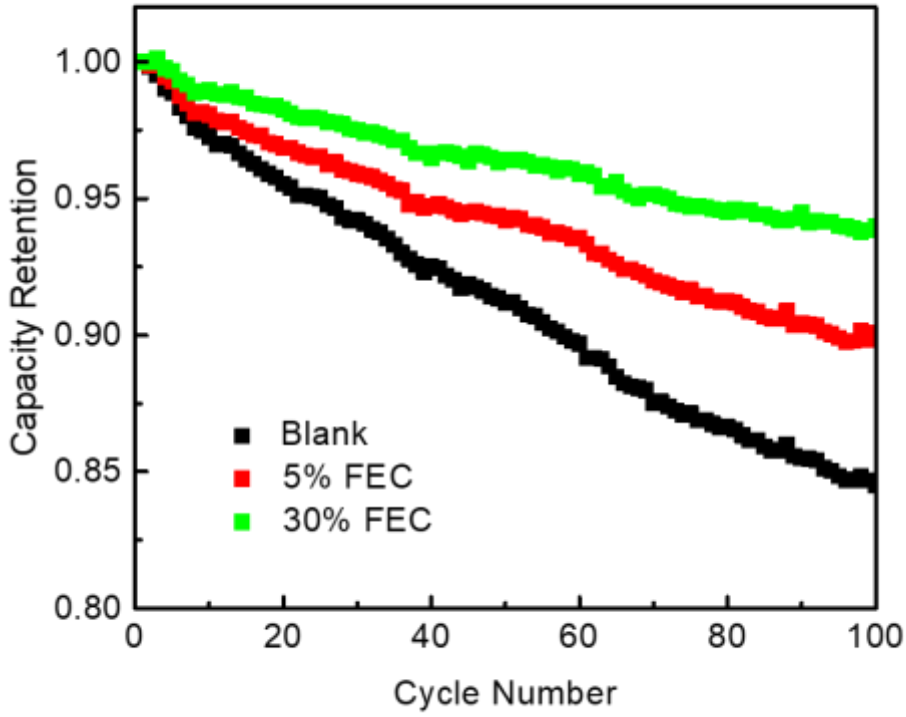


Figure S1. Cycling performance of the NMC811||SiO_x@Gr pouch cells with different electrolyte systems at 0.3 C and room temperature for 100 cycles.

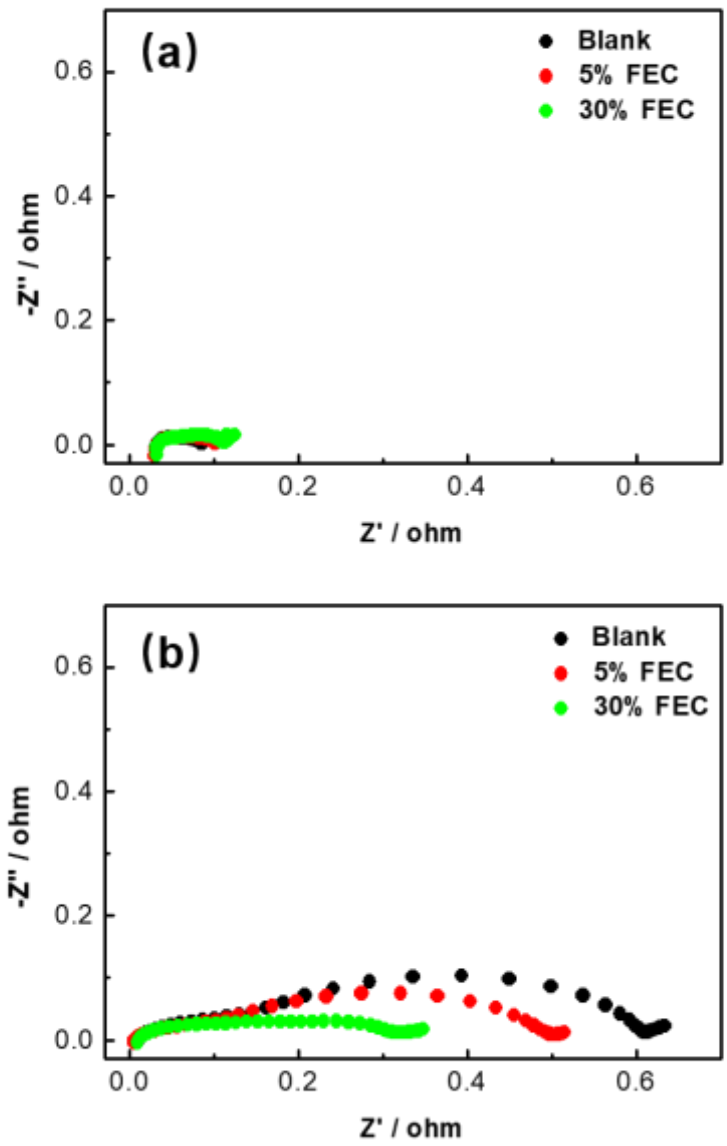


Figure S2. EIS of the NMC811||SiO_x@Gr pouch cells after (a) formation and (b) 100 cycles at 0.3 C and 45°C.

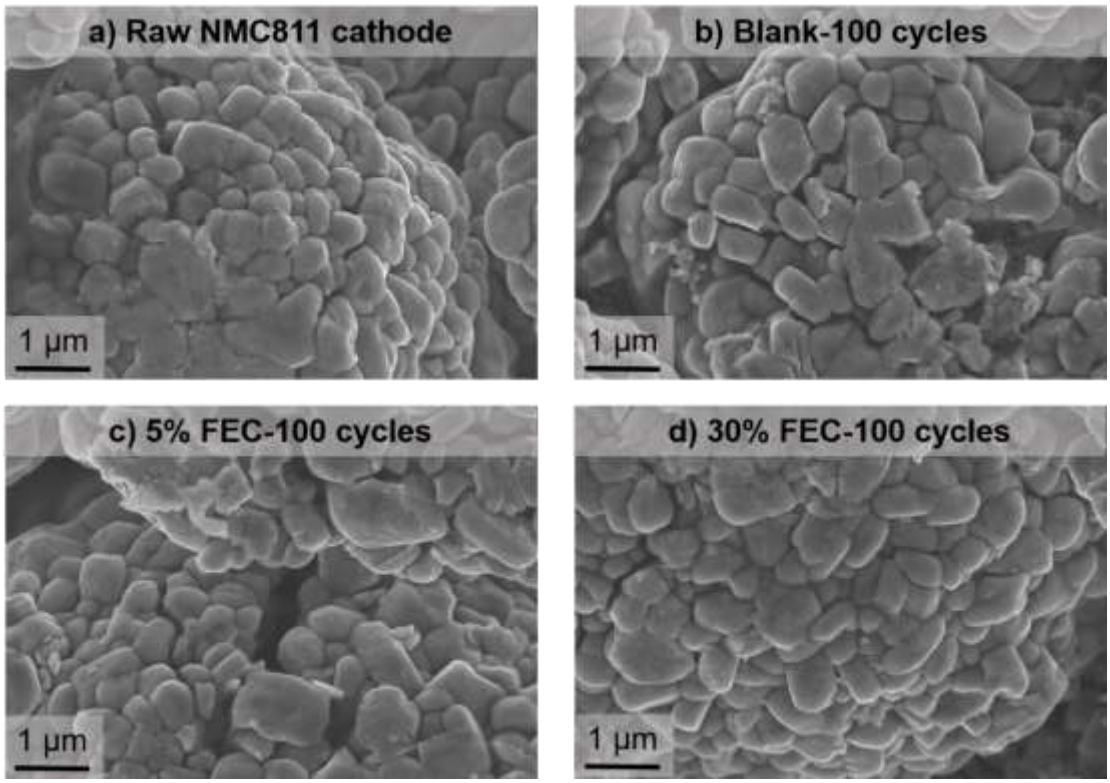


Figure S3. SEM images of the NMC811 cathodes (a) at raw state, and after 100 cycles with the (b) blank, (c) 5% FEC system and (d) 30% FEC systems.

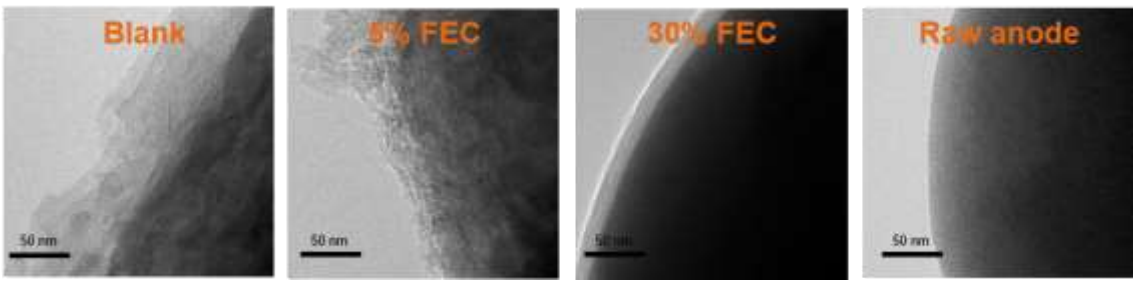


Figure S4. TEM results of the SiO_x@Gr anodes after 100 cycles for the three systems and at raw state.

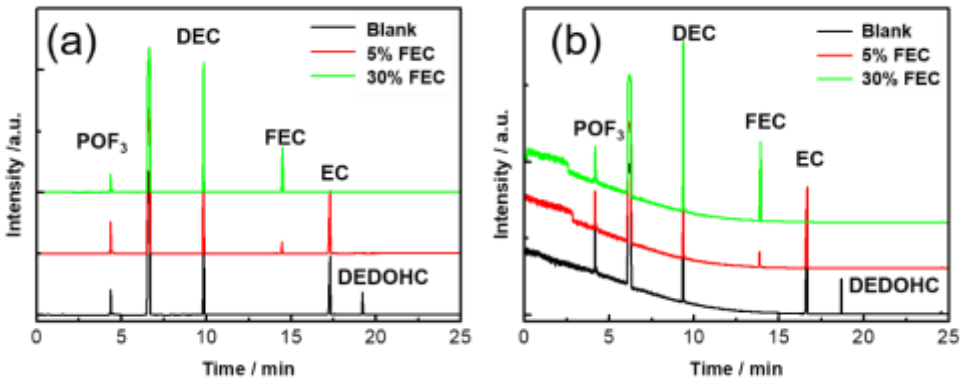


Figure S5. GC-MS chromatograms of the three electrolytes after (a) formation and (b) 100 cycles at 45℃.

Table S1. The charge/discharge capacities and *Coulombic* efficiency in the first formation cycle of the NMC811||SiO_x@Gr pouch cells using the three electrolyte systems.

	Charge capacity / mAh	Discharge capacity / mAh	*Coulombic* efficiency / %
Blank	1385.6	1181.5	85.3
5% FEC	1373.5	1169.2	85.1
30% FEC	1372.9	1173.9	85.5

Table S2. The charge/discharge specific capacities of the NMC811 electrodes using different electrolyte systems in the voltage range of 3.0-4.2 V at 0.3 C and 45°C. Note that the NMC811 electrodes were disassembled from the NMC811||SiO_x@Gr pouch cells after 100 cycles at 0.3 C and 45°C.

	Charge specific capacity / mAh/g	Discharge specific capacity / mAh/g
Blank	158.8	155.9
5% FEC	163.1	162.2
30% FEC	178.8	175.0

Table S3. The charge/discharge specific capacities of the SiO_x@Gr anodes using different electrolyte systems in the voltage range of 0.005-4.2 V at 0.3 C and 45°C. Note that the SiO_x@Gr electrodes were disassembled from the NMC811||SiO_x@Gr pouch cells after 100 cycles at 0.3 C and 45°C.

	Charge specific capacity / mAh/g	Discharge specific capacity / mAh/g
Blank	199.5	213.3
5% FEC	241.7	249.9
30% FEC	275.1	284.3

Table S4. The main electrolyte components detected from GC-MS for the three electrolyte systems after formation and 100 cycles.

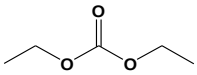
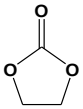
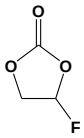
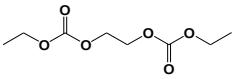
Peak Area / %	DEC	EC	FEC	DEDOHC
Structure				
Molecular Formula	$C_5H_{10}O_3$	$C_3H_4O_3$	$C_3H_4O_3F$	$C_8H_{14}O_6$
Blank-Formation	53.15	31.22	--	7.44
5% FEC-Formation	62.52	31.53	4.09	--
30% FEC-Formation	62.60	--	31.46	--
Blank-100 cycles	42.50	39.03	--	5.83
5% FEC-100 cycles	44.56	38.65	4.09	--
30% FEC-100 cycles	53.98	38.65	33.59	--

Table S5. LC-QTof-MS results collected from the electrolytes after 100 cycles.

		Blank-100 cycles	5% FEC-100 cycles	30% FEC-100 cycles
T / min	M / Z	Compound	Compound	Compound
1.73	183.0839	--	$C_7H_{12}O_5$ + Li	--
1.83	159.0398	$C_4H_9O_4P$ + Li	$C_4H_9O_4P$ + Li	--
2.03	209.0638	--	$C_8H_{10}O_6$ + Li	--
2.15	161.0352	--	$C_4H_8O_3PF$ + Li	$C_4H_8O_3PF$ + Li
2.32	241.0513	--	$C_8H_{10}O_8$ +Li	$C_8H_{10}O_8$ +Li
2.62	247.0555	$C_7H_{13}O_7P$ + Li	$C_7H_{13}O_7P$ + Li	--
2.82	311.0578	--	$C_{11}H_{12}O_{10}$+Li	--
2.93	187.0713	$C_6H_{13}O_4P$ +Li	--	--
2.98	151.0941	$C_7H_{12}O_3$ +Li	--	--
3.82	243.0482	$C_8H_{12}O_7$ + Na	$C_8H_{12}O_7$ + Na	--
3.90	205.0606	$C_6H_{15}O_4P$ + Na	--	--
5.44	267.0409	$C_7H_{14}O_6FP$ + Na	$C_7H_{14}O_6FP$ + Na	--
5.76	293.0781	$C_9H_{19}O_7P$ + Na	--	--
6.35	445.0997	$C_{13}H_{28}O_{11}P_2$ + Na	--	--
6.57	229.0692	$C_8H_{14}O_6$ + Na	$C_8H_{14}O_6$ + Na	--
6.73	273.0966	$C_{10}H_{18}O_7$ + Na	--	--
6.94	381.0942	$C_{12}H_{23}O_{10}P$ + Na	--	--
7.63	317.0849	$C_{11}H_{18}O_9$ + Na	$C_{11}H_{18}O_9$ + Na	--
8.43	405.1014	$C_{14}H_{22}O_{12}$ + Na	--	--
8.6,9.64	257.0993	$C_{10}H_{18}O_6$ + Na	--	--
10.48	345.1157	$C_{13}H_{22}O_9$+Na	--	--

10.96	285.131	$C_{12}H_{22}O_6$+Na	--	--
11.07	373.1464	$C_{15}H_{26}O_9$+Na	--	--

Table S6. LC-QTof-MS results collected from the NMC811 cathodes after 100 cycles.

		Blank-100 cycles	5% FEC-100 cycles	30% FEC-100 cycles
T / min	M / Z	Compound	Compound	Compound
1.26-2.49	305.1578	PEG	PEG	PEG
1.30		--	$C_4H_9O_5P$	--
2.42	257.0276	--	$C_8H_{10}O_8$ + Na	--
2.43-2.61	315.0328	--	--	$C_{10}H_{12}O_{10}$
2.66	263.0327	$C_7H_{13}O_7P$	--	--
3.93	243.0469	--	$C_8H_{12}O_7$ + Na	--
5.77	293.0769	$C_9H_{19}O_7P$	--	--
6.60	229.0697	$C_8H_{14}O_6$	--	--
7.64	317.0852	$C_{11}H_{18}O_9$	--	--

Table S7. LC-QTof-MS results collected from the SiO_x@Gr anodes after 100 cycles.

		Blank-100 cycles	5% FEC-100 cycles	30% FEC-100 cycles
T / min	M / Z	Compound	Compound	Compound
1.26-2.49	305.1578	PEG	PEG	PEG
1.19	253.0476	$C_6H_{15}O_7P$	--	--
1.26	191.0108	$C_6H_7O_5P$	--	--
1.30	235.0358	$C_6H_{13}O_6P$	--	--
1.62	341.0172	$C_8H_{16}O_9P_2$ + Na	--	--
1.80	385.0325	$C_{10}H_{16}O_{11}FP$ + Na	--	--
2.57	257.0280	--	$C_8H_{10}O_8$ + Na	--
3.83	205.0616	$C_6H_{15}O_4P$ + Na	--	--
3.95	243.0484	--	$C_8H_{12}O_7$ + Na	--
4.90	357.0858	$C_{10}H_{24}O_8P_2$+Na	--	--
5.67	509.1074	$C_9H_{19}O_7P$ + Na	--	--
6.24	445.1014	$C_{13}H_{28}O_{11}P_2$ + Na	--	--
6.60	229.0697	--	$C_8H_{14}O_6$ + Na	--