

Supporting Information

Ether and Siloxane Functionalized Ionic Liquid Mixtures as Electrolyte for Lithium-ion Batteries

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Table S1. Electrochemical stability window of various electrolytes at different temperatures.

Electrolytes	Electrochemical stability window (V)														
	10 °C			25 °C			40 °C			50 °C			60 °C		
	CL	AL	ESW	CL	AL	ESW	CL	AL	ESW	CL	AL	ESW	CL	AL	ESW
Ether-ether IL	-2.89	1.87	4.76	-3.08	1.98	5.06	-3.09	1.99	5.08	-2.91	2.07	4.98	-2.84	1.92	4.76
Ether-ether IL + PC	-2.96	1.86	4.82	-2.97	1.83	4.80	-2.95	1.67	4.62	-2.94	1.74	4.68	-2.95	1.80	4.75
Ether-ether IL + PC + LiTFSI	-3.61	2.03	5.64	-3.47	2.48	5.95	-3.32	2.37	5.69	-3.33	2.30	5.63	-3.19	2.27	5.46
Ether-siloxane IL	-3.15	2.40	5.55	-3.07	2.48	5.55	-3.10	2.45	5.55	-3.01	2.37	5.38	-2.99	2.24	5.23
Ether-siloxane + PC	-3.30	2.61	5.91	-3.16	2.59	5.75	-3.09	2.55	5.64	-3.29	2.51	5.80	-3.19	2.47	5.66
Ether-siloxane + PC + LiTFSI	-2.00	2.06	4.06	-2.01	2.20	4.21	-2.00	2.17	4.17	-1.91	2.13	4.04	-1.91	2.09	4.00

AL : Anodic Limit

CL : Cathodic Limit

ESW : Electrochemical Stability Window

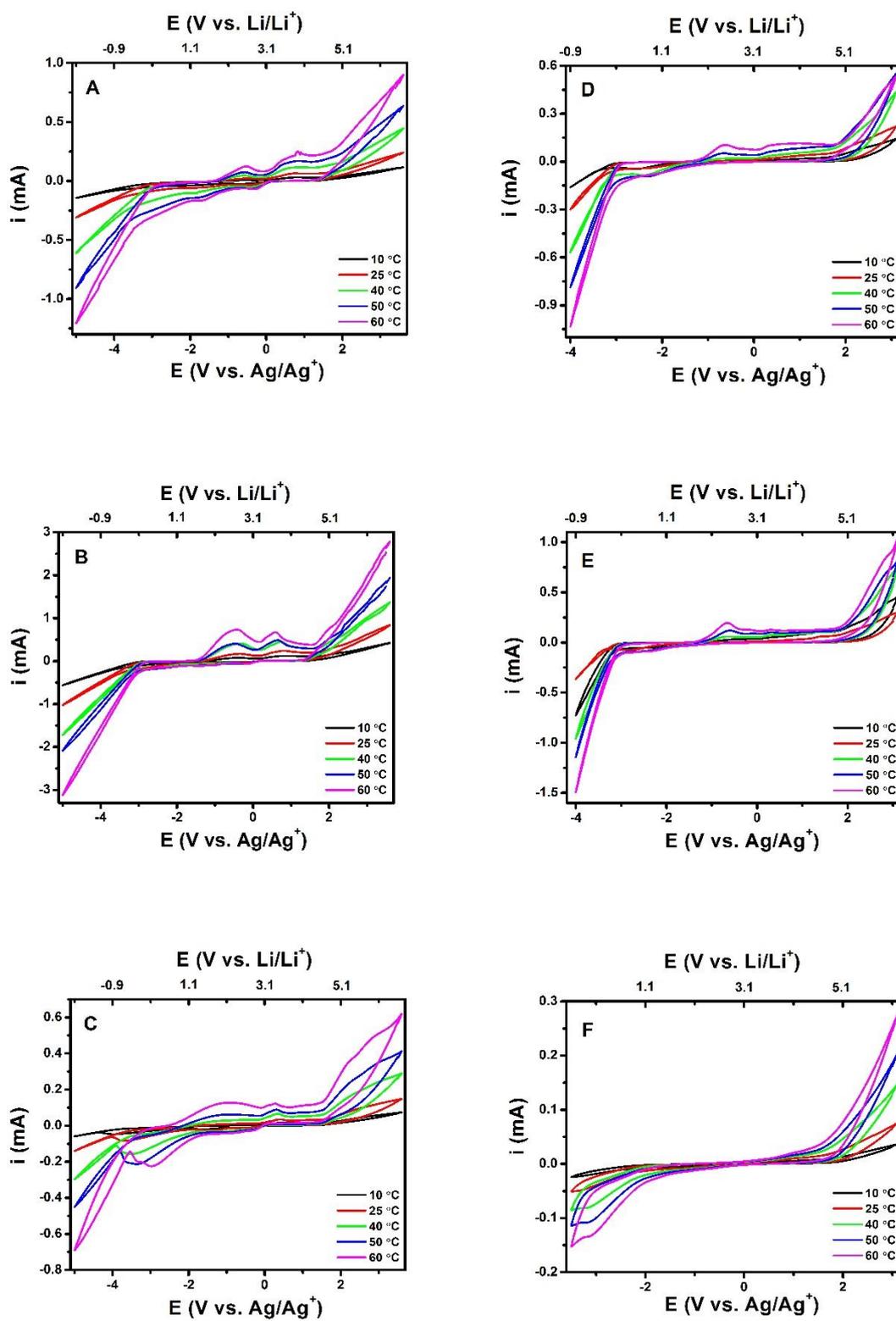


Figure S1. Cyclic voltammograms with varying temperatures for (A) ether-ether IL, (IL + PC) and (IL + PC + LiTFSI); (B) ether-siloxane IL, (IL + PC) and (IL + PC + LiTFSI) at a sweep rate of 50 mV/s, WE: glassy carbon (GC), CE: graphite rod, RE: Ag/Ag⁺/PC.

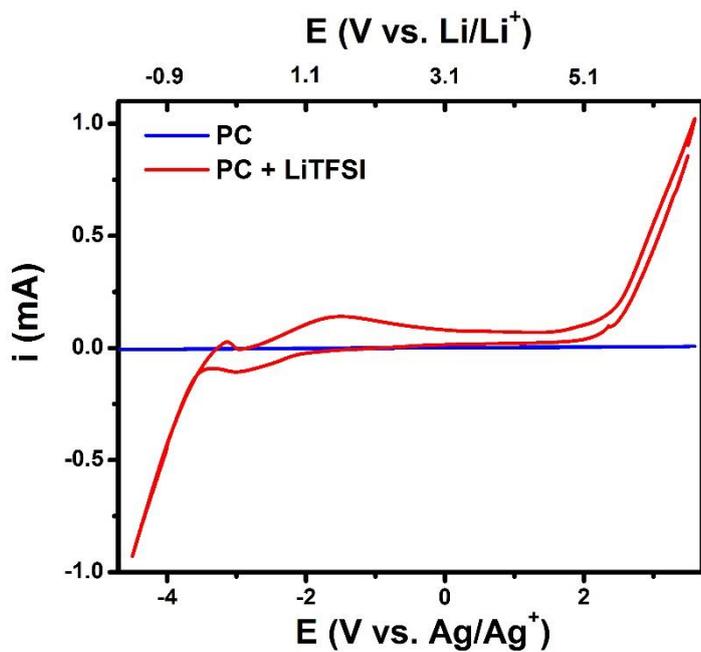


Figure S2. Cyclic voltammogram for propylene carbonate (PC) and PC with LiTFSI salt at a sweep rate of 50 mV/s, WE: glassy carbon (GC), CE: graphite rod, RE: Ag/Ag⁺/PC.

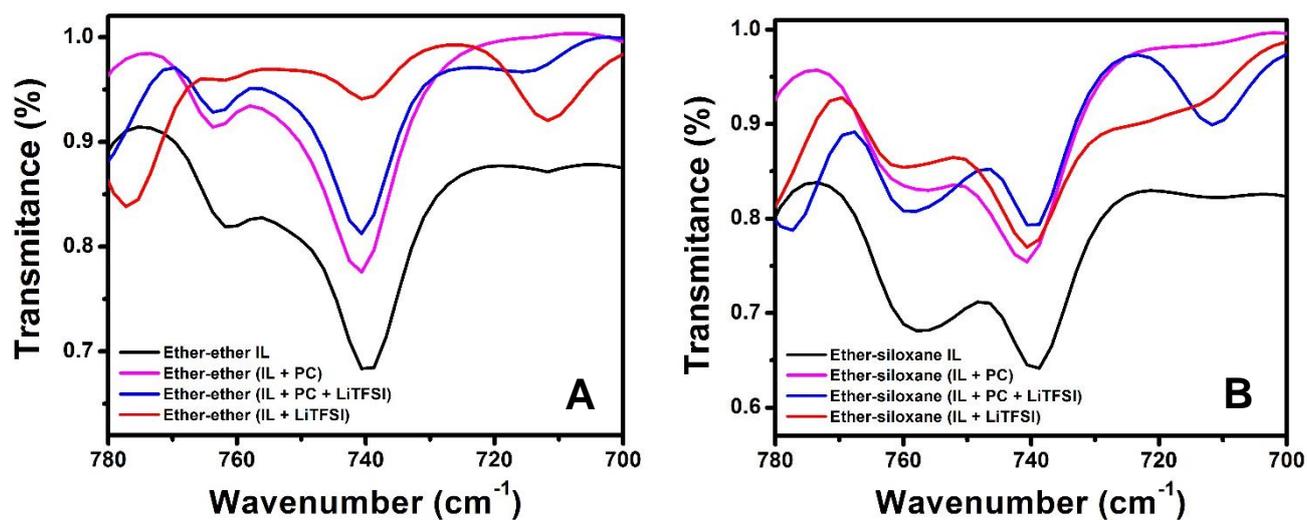


Figure S3. IR spectra of (A) ether-ether IL and (B) ether-siloxane IL and their respective composites.

Table S2. SNS stretching from TFSI Stretching frequencies in IR of electrolyte sample					
Vibrational modes	Electrolytes	IL	IL+PC	IL+LiTFSI	IL+PC+LiTFSI
ν_{S-N-S}	Ether-Ether	788.5	777.0	791.5	787.8
	Ether-Siloxane	789.0	777.0	794.0	787.0
$\nu_{C=O}^{[a]}$	Ether-Ether		1788.0		1786.0
	Ether-Siloxane		1791.8		1786.0

[a] $\nu_{C=O}$ for PC appears at 1786 cm^{-1}

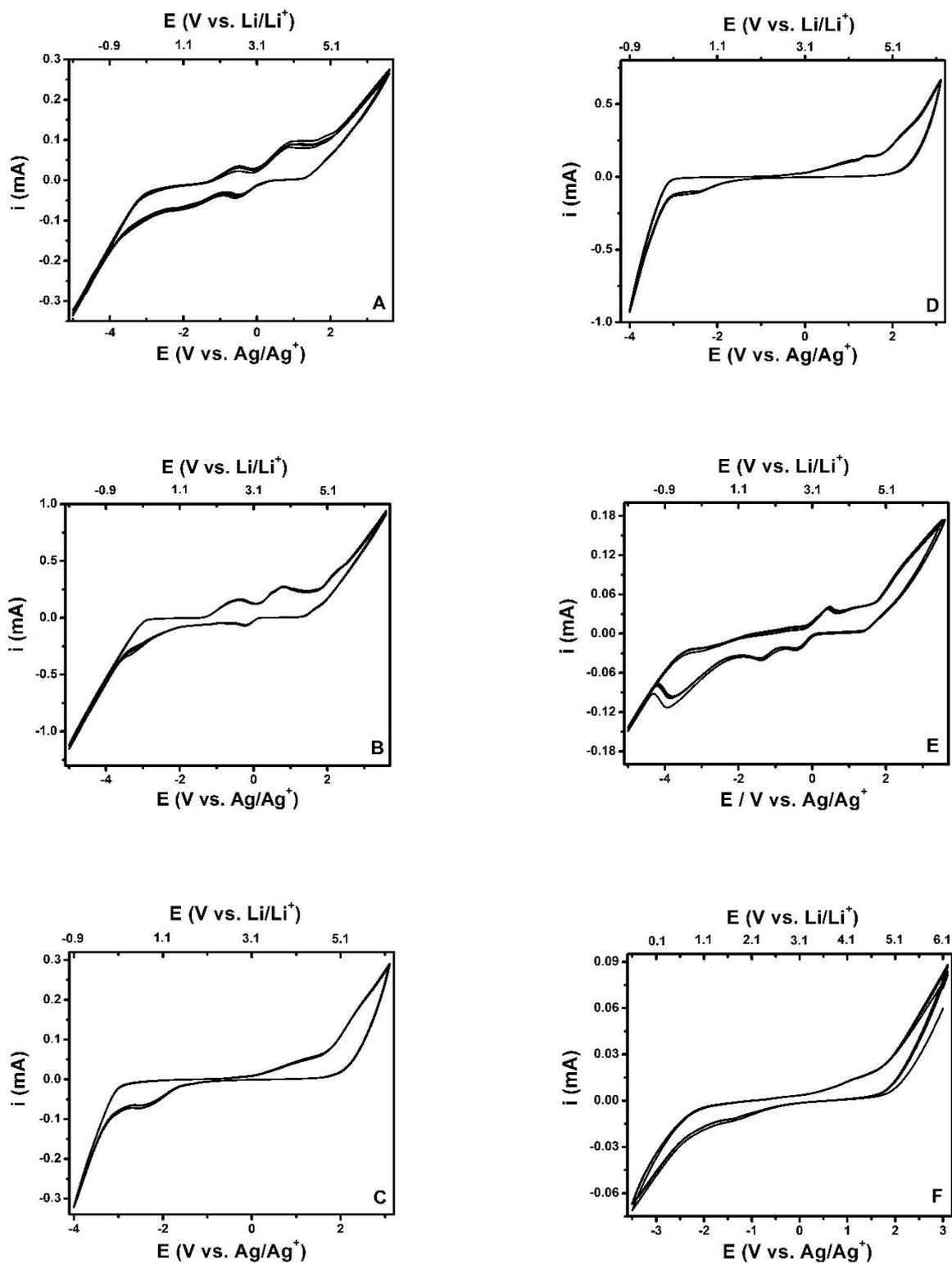


Figure S4. Cyclic voltammograms depicting nature of ILs after 10 cycles with varying temperatures for (A) ether-ether IL, (B) ether-ether (IL+ PC), (C) ether-siloxane IL, (D) ether-siloxane (IL + PC), (E) ether-ether (IL+ PC + LiTFSI) and (F) ether-siloxane (IL + PC + LiTFSI) at a sweep rate of 100 mV/s; WE: glassy carbon (GC), CE: graphite rod, RE: $\text{Ag}/\text{Ag}^+/\text{PC}$.

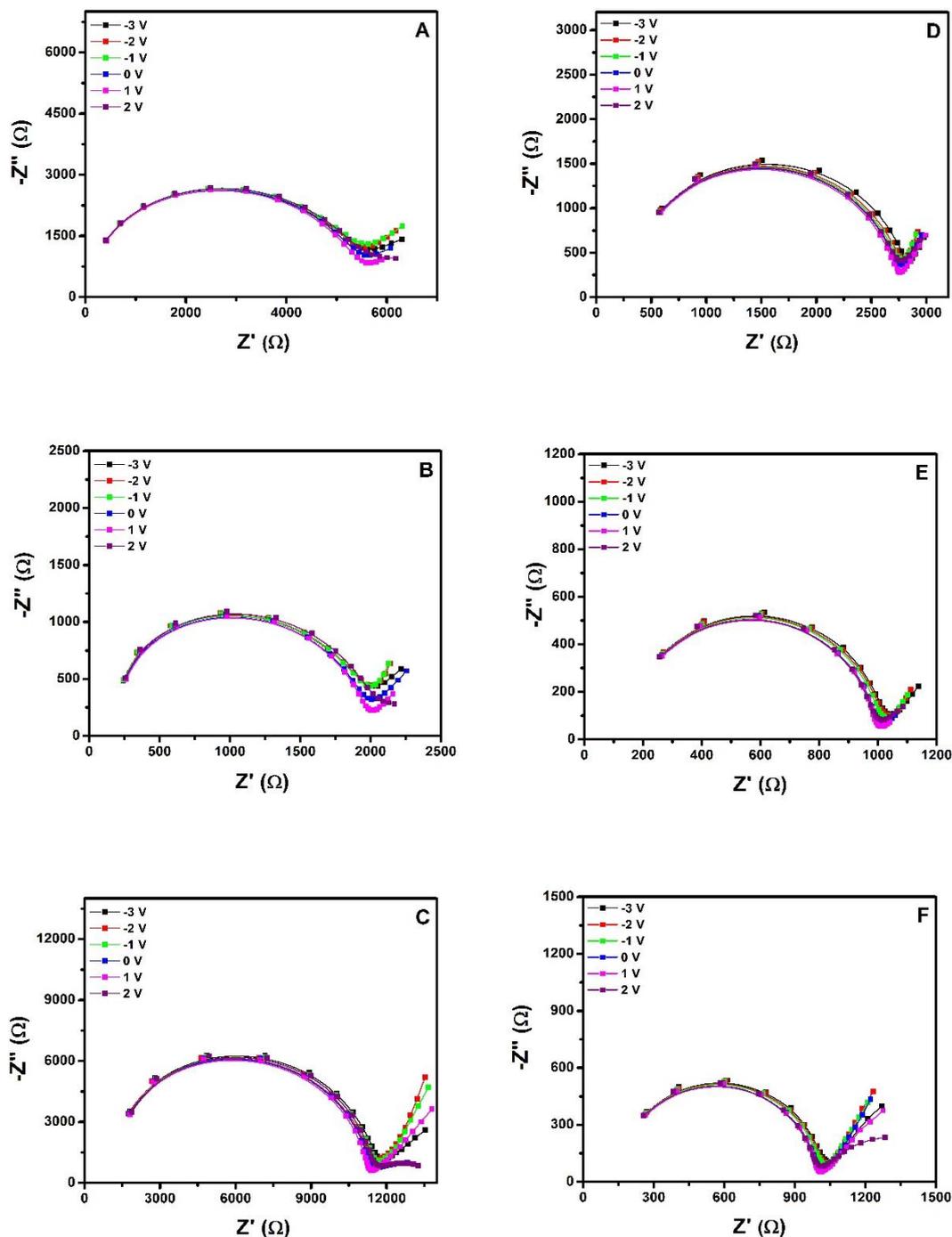


Figure S5. Impedance response with varying applied potential for (A) ether-ether IL; (B) ether-ether (IL + PC); (C) ether-ether (IL + PC + LiTFSI), performed in 50 mL jacketed glass cell (25.1 cm^{-1} cell constant); and (D) ether-siloxane neat IL; (E) ether-siloxane (IL + PC); (F) ether-siloxane (IL + PC + LiTFSI), performed in 20 mL jacketed glass cell (7.07 cm^{-1} cell constant) at $25 \text{ }^\circ\text{C}$, WE: glassy carbon (GC), CE: graphite rod, RE: Ag/Ag⁺/PC.

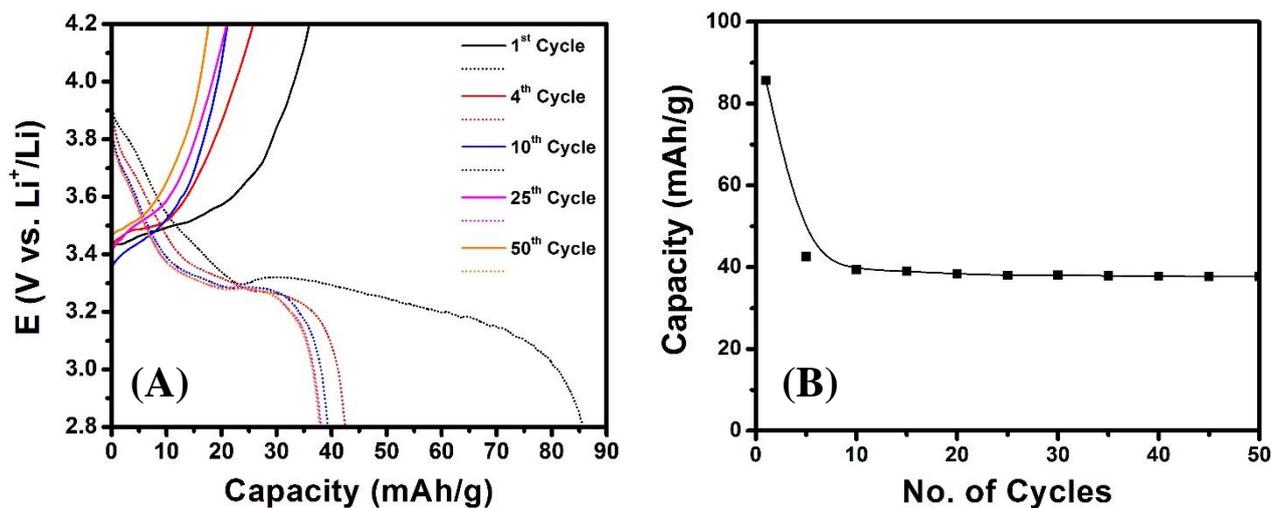


Figure S6. (A) Charge-discharge profile, and (B) Cycling discharge capacity for ether-ether IL solvent containing 1 mol of LiTFSI per kg electrolyte at 1C rate w.r.t the cathode for Li-ion cell.

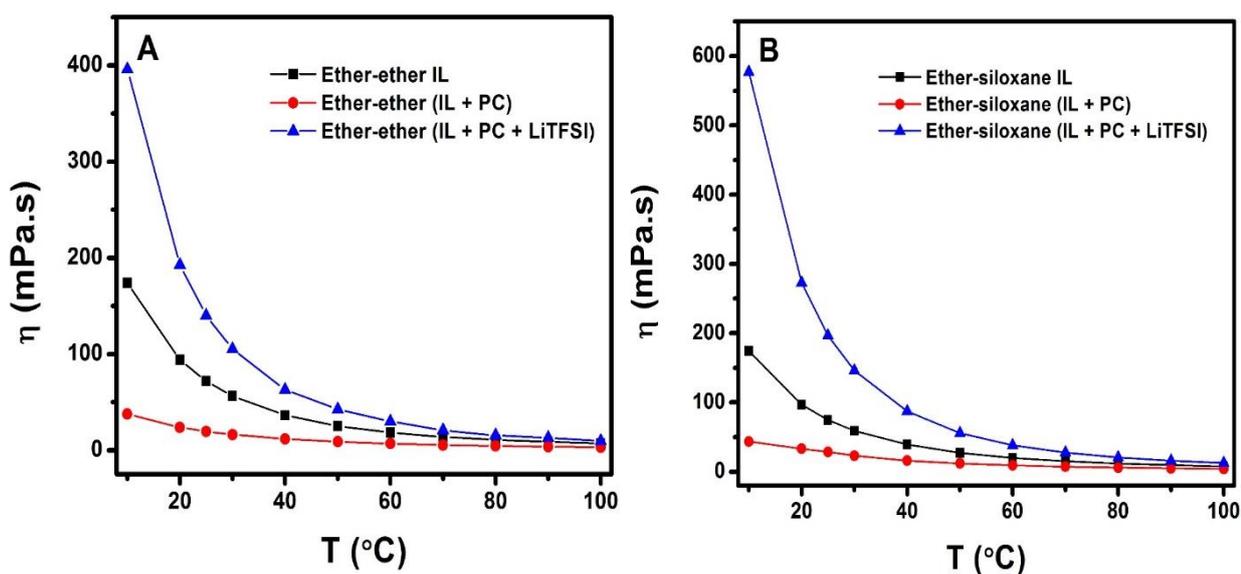


Figure S7. Temperature dependence of viscosity for various electrolytes (A) ether-ether IL, (IL + PC) and (IL + PC + LiTFSI); (B) ether-siloxane IL, (IL + PC) and (IL + PC + LiTFSI).

Table S3. Dynamic viscosity (η /mPa·s) at varying temperatures for ether-ether and ether-siloxane ILs.

Temp. (°C)	Neat IL		IL+PC		IL+PC+LiTFSI	
	ether-ether	ether-siloxane	ether-ether	ether-siloxane	ether-ether	ether-siloxane
10	174.10	174.28	37.48	43.58	396.04	577.33
20	94.02	96.97	23.81	33.23	192.73	272.93
25	71.98	74.71	19.51	28.66	140.03	196.77
30	56.36	59.22	16.27	23.18	105.08	146.06
40	36.49	39.23	11.77	16.07	62.94	87.18
50	25.19	27.35	8.91	11.97	42.59	55.89
60	18.34	20.01	6.88	9.25	30.03	38.43
70	13.88	15.21	5.38	7.33	20.65	27.82
80	10.85	11.92	4.37	5.95	15.46	20.89
90	8.70	9.58	3.65	4.93	12.86	15.79
100	7.14	7.67	3.11	4.17	9.66	12.51

Table S4. Thermal properties of ether-ether and ether-siloxane ILs derived from DSC measurements.

Electrolytes	T_g	First step				Second step			
		T_{start} (°C)	T_{onset} (°C)	T_{peak} (°C)	T_{endset} (°C)	T_{start} (°C)	T_{onset} (°C)	T_{peak} (°C)	T_{endset} (°C)
ether-ether IL	-74.5	-	-	-	-	309.7	426.8	480.5	494.7
ether-ether IL + PC	-84.1	110.5	141.5	176.3	245.9	363.5	426.7	469.2	507.5
ether-ether IL + PC + LiTFSI	-81.2	150.6	153.1	204.6	255.5	369.3	436.1	467.1	512.1
ether-ether + LiTFSI	-73.0	-	-	-	-	355.9	436.2	468.6	515.9
ether-siloxane IL	-72.3	-	-	-	-	307.4	430.4	483.0	498.1
ether-siloxane IL + PC	-85.6	103.7	137.0	177.2	243.8	352.3	428.2	472.5	505.9
ether-siloxane IL + PC + LiTFSI	-77.2	130.8	151.3	202.5	273.6	355.4	428.5	473.1	521.5
ether-siloxane IL + LiTFSI	-70.0	-	-	-	-	329.0	429.8	472.2	510.6

Table S5. VTF parameters for the conductivity and viscosity of the ILs and their electrolyte mixtures (estimated maximum error $\leq \pm 5\%$)

conductivity					viscosity			
ILs and electrolyte mixtures	σ_0 (mS/cm)	B (K)	T_0 (K)	R^2	η_0 (mPa.s)	B (K)	T_0 (K)	R^2
Ether-ether IL	2334.69	-850.66	-162.04	0.999	0.216	659	184.4	1
Ether-ether IL+PC	156.77	-182.05	-225.03	0.994	0.129	657.2	166.9	0.999
Ether-ether IL+PC+LiTFSI	5.26E6	-4535.94	10.72	0.999	0.213	706.1	189.1	0.999
Ether-siloxane IL	103.78	-378.47	-195.60	0.998	0.232	679.7	180.2	0.999
Ether-Siloxane IL+PC	85.46	-240.82	-198.92	0.993	3.357E-7	10561.2	281.7	0.995
Ether-Siloxane IL+PC+LiTFSI	23.57	-274.07	-226.27	0.999	0.234	733.7	189.0	1

VTF equation for conductivity $\sigma = \sigma_0 \exp\left(\frac{-B}{T-T_0}\right)$

VTF equation for the Viscosity $\eta = \eta_0 \exp\left(\frac{B}{T-T_0}\right)$