Supplementary Information

Exploring Vinyl Polymers as Soft Carbon Precursors for M-ion (M = Na, Li) Batteries and Hybrid Capacitors

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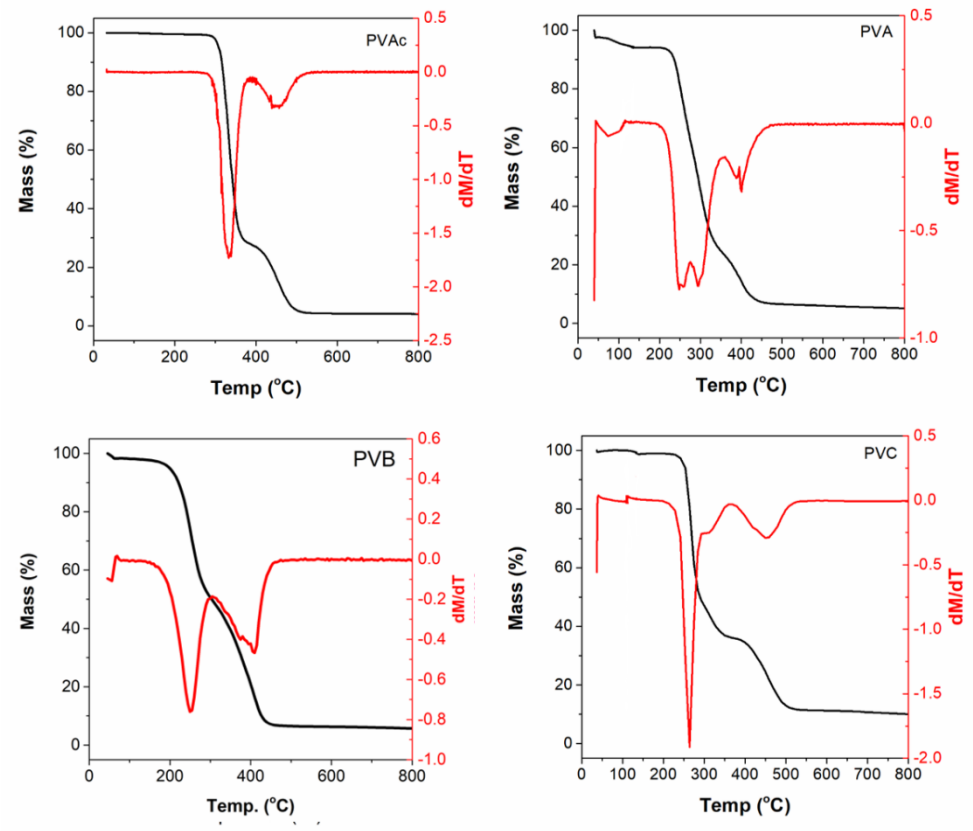


Figure S1. Thermo-gravimetrical analysis of the vinyl polymers under Ar atmosphere.

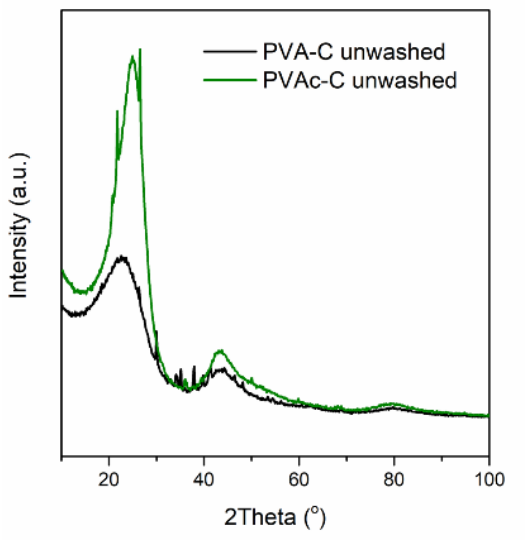


Figure S2. PXRD patterns of PVA- and PVAc-C samples before rinsing with water and ethanol.

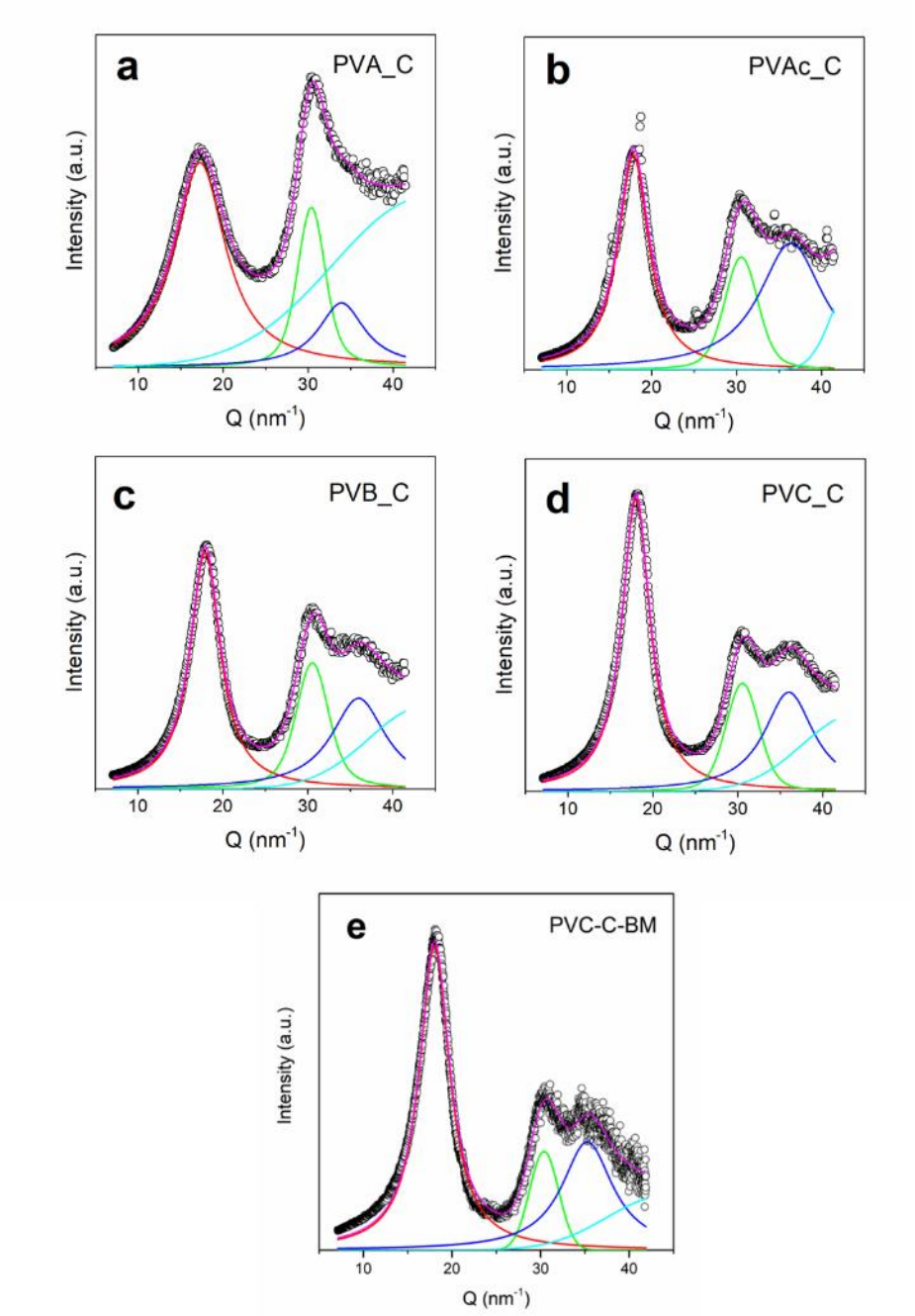


Figure S3. Corrected PXRD patterns of the pyrolyzed polymers as well as the ball-milled PVC-derived SC (PVC-C-BM) for polarization, Lorentz, and illuminated sample volume factors along with the fitting results with Voigt peaks.

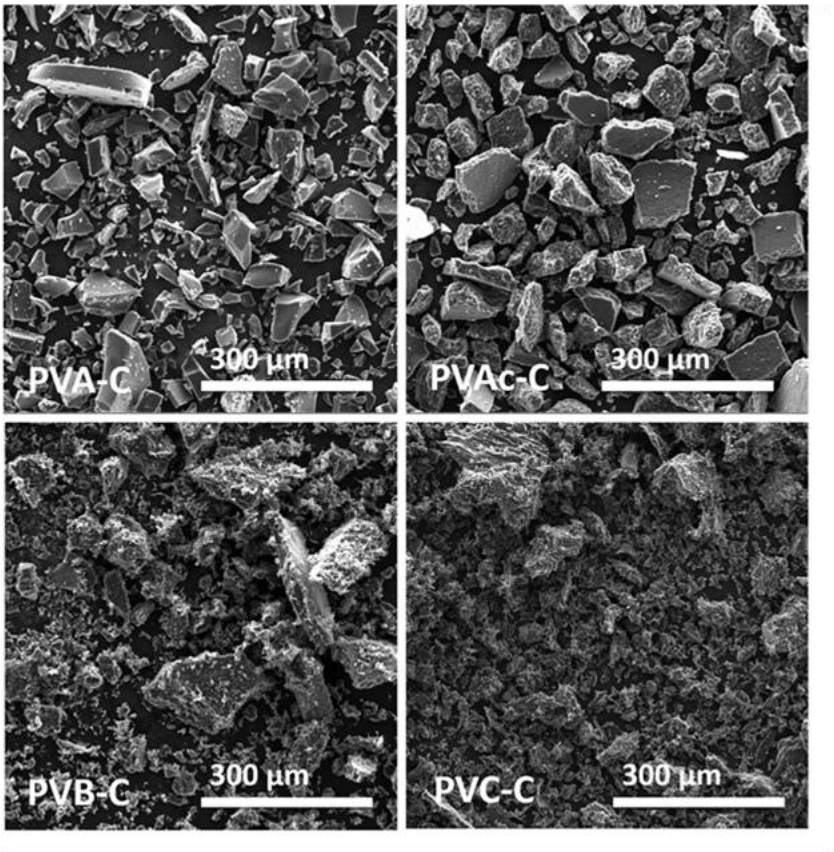


Figure S4. Scanning electron micrographs of the vinyl polymer-derived carbons at a pyrolysis temperature of 800 °C under Ar atmosphere, in a magnification of 300x.

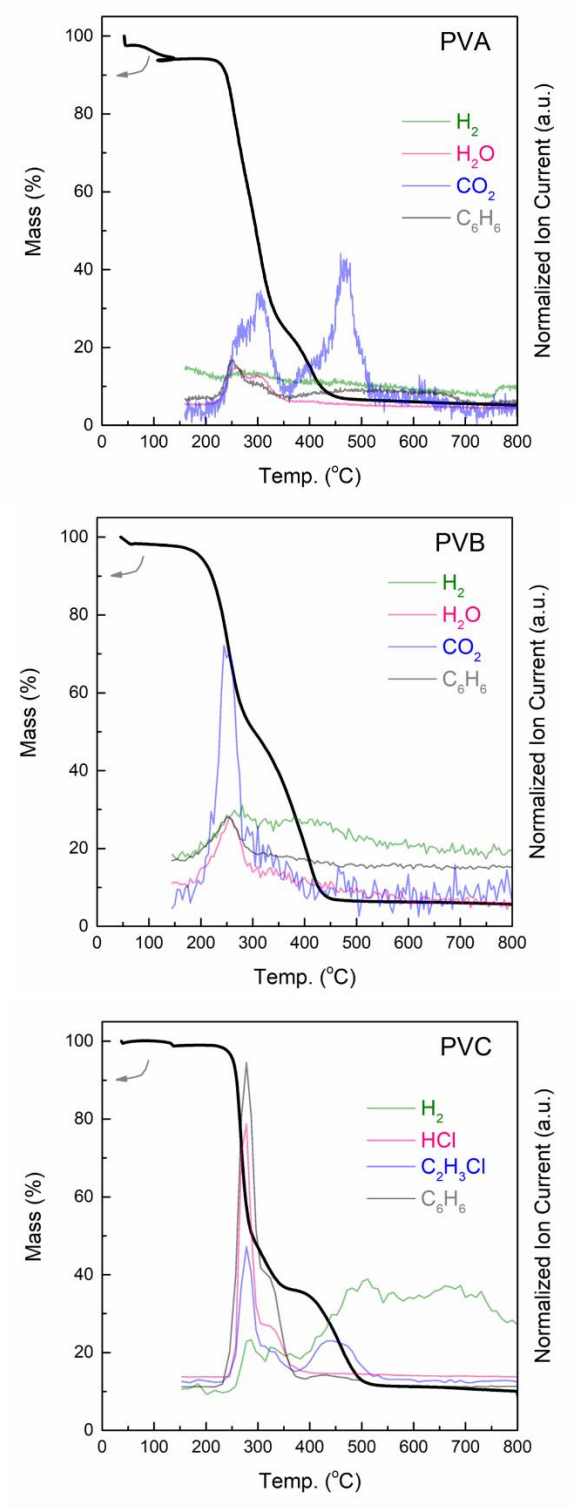


Figure S5. TG profiles of the samples along with their residual gas analysis.

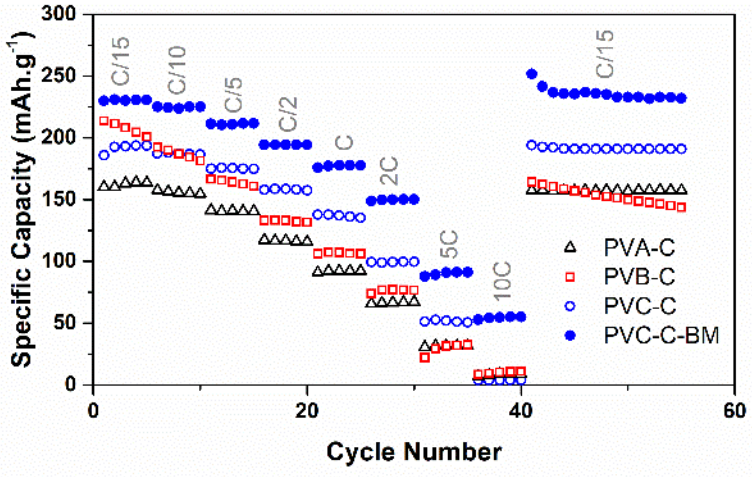


Figure S6. Rate capability (based on Q_{rev}) of the polyvinyl-derived soft carbons at various current loads ranging from C/15 to 10C.

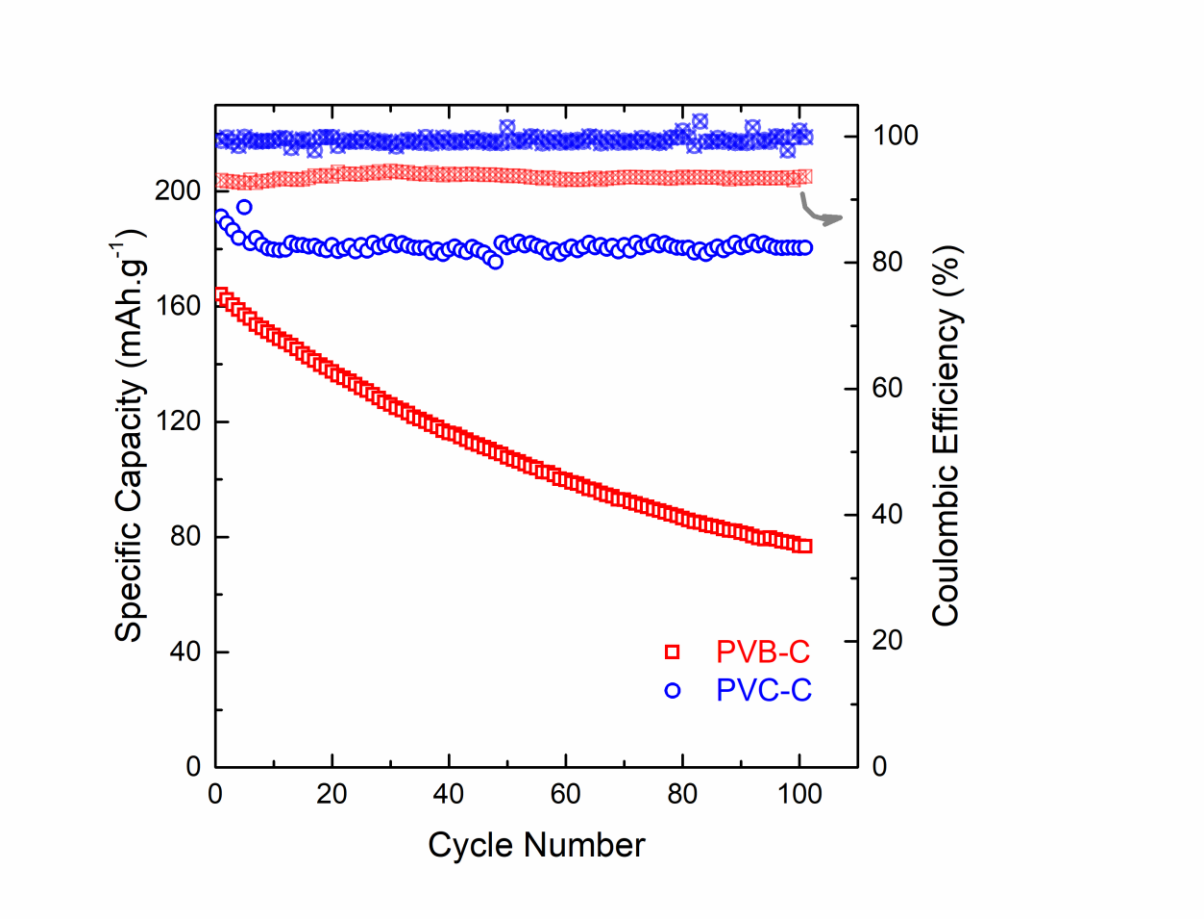


Figure S7. Cycling performance of the PVB-C and PVC-C samples in half cell vs Na at a current load of C/15 along with their coulombic efficiency.

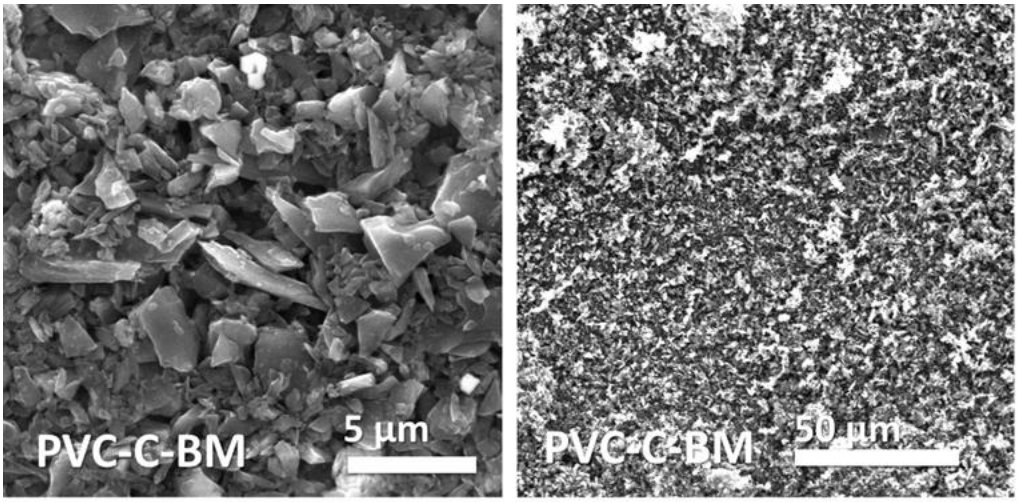


Figure S8. SEM images of the ball-milled PVC-derived carbon (PVC-C-BM).

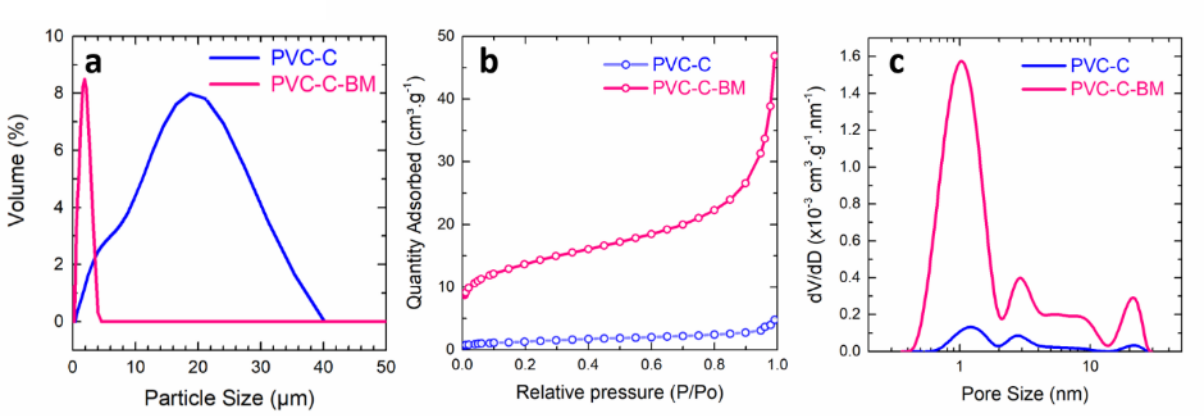
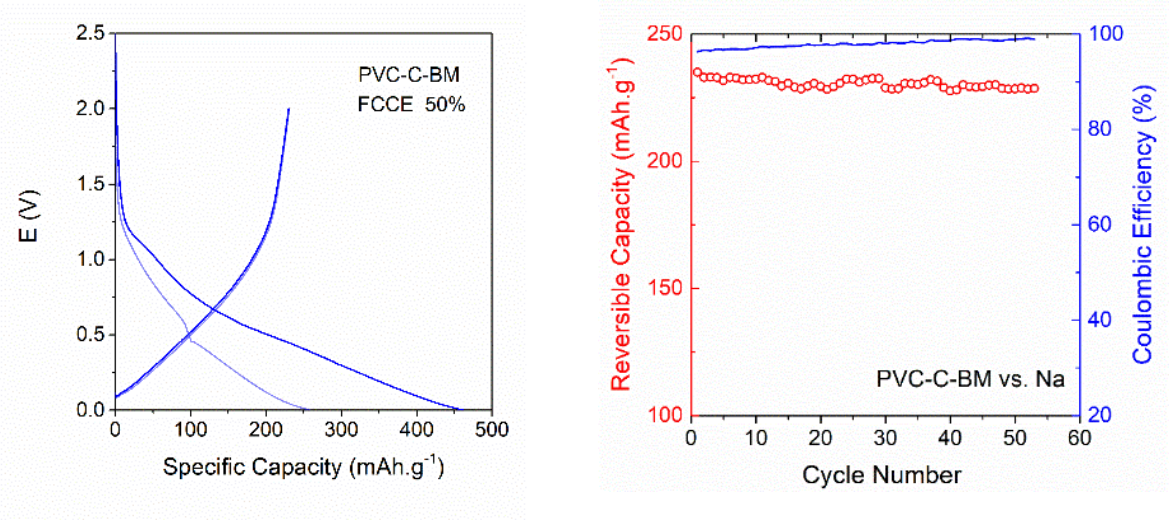


Figure S9. Particle size distribution (a), N_2 adsorption isotherms (b); and pore size distribution based on NLDFT (Non-Local Density Functional Theory) of the PVC-derived soft carbons (pristine: PVC-C and ball-milled: PVC-C-BM).



(**a**) (**b**)

Figure S10. Sodium storage properties of the PVC-C-BM sample: (a) Two first discharge-charge cycles and (b) cycling performance of the PVC-C-BM sample in 1 M $NaClO_4$ in EC:PC at C/15 rate.

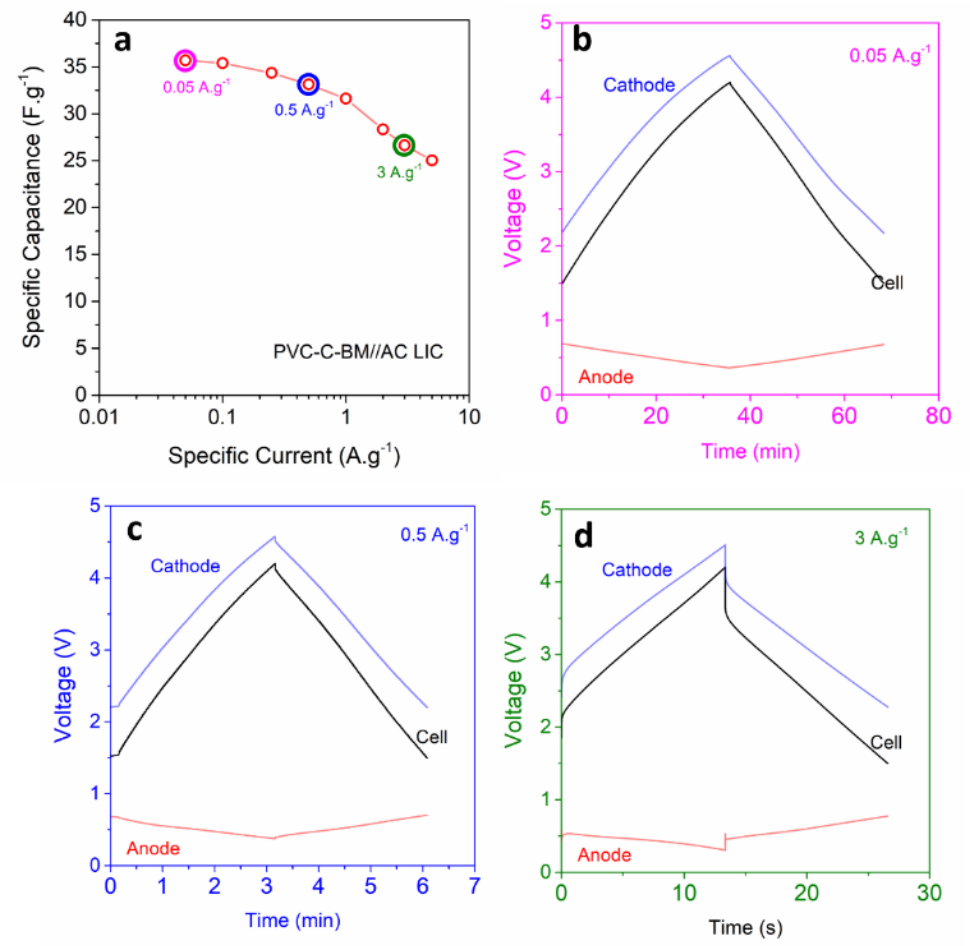


Figure S11. Electrochemical performance of the PVC-C-BM sample as the negative electrode in integration with YP80F Activated Carbon in hybrid lithium capacitors in mass ratio of SC:AC of 2:1: (a) rate capability of the PVC-C-BM//AC LIC device in 1 M $LiPF_6$ in EC:DMC; and the real time profiles of the hybrid cell in (b) 0.05 $A{\cdot}g^{-1}$, (c) 0.5 $A{\cdot}g^{-1}$, and (d) 3 $A{\cdot}g^{-1}$.

Table S1. The obtained properties of the SCs derived from pyrolysis of vinyl polymers.

Sample	Pyrolysis Yield (%)	$Yield_{TG}$ (%)
PVA-C	5.70(4.63)[1]	5.15
PVAc-C	4.98(3.8)	4.10
PVB-C	7.6	5.67
PVC-C	11.0	10.0

1 The yield in parenthesis was obtained after rinsing with water and ethanol.

Table S2. Comparison of the electrochemical performance of the previously reported soft carbons at low rate (at ≤ 40 mA·g^{-1}, except (*) at 100 mA·g^{-1}). When not mentioned in the original report, the average oxidation potential, <E_{ox}>, the reversible specific capacity (C_{re}) and/or the first cycle Coulombic efficiency (FCCE), were estimated by digitalization of the reported voltage–composition curves. Equation S1 was employed to estimate the full cell specific energy, considering the *Faradion* layered oxide as cathode material (165 mAh·g^{-1} at 3.2 V).

Precursor	Pyrolysis Temp. (°C)	<E_{ox}> (V)	C_{re} (mAh·g^{-1})	FCCE (%)	Energy (Wh·kg^{-1})	Ref.
PVA-C	800	0.498	160	65	219	This Study
PVB-C	800	0.529	212	56	248	This Study
PVC-C	800	0.547	195	70	237	This Study
PVC-C-BM	800	0.656	249	54	252	This Study
Petroleum Coke (PeC)	NA	-	70	-	--	1993 [1]
Carbon Black (Sawinigan)	NA	-	132	-	--	1993 [1]
Carbon Black (YPF)	NA	0.827	89	21	137	2001 [2]
Carbon Black (YPF)	NA	0.677	121	29	176	2001 [2]
Acetylene Black	NA	0.476	77	20	143	2001 [2]
Carbon Black (Super P)	NA	0.550	152	40.4	209	2014 [3]
Mesophase Pitch	NA	0.670	120	20	176	2011 [4]
PTCDA[1]	700	0.565	230	62	253	2015 [5]
PTCDA	900	0.479	200	66	246	2015 [5]
PTCDA	1100	0.430	125	65	197	2015 [5]
PTCDA	1600	0.468	90	47	159	2015 [5]
PTCDA	900	0.602	184	80	226	2017 [6]
PTCDA	900	0.501	200	67	244	2017 [7]
Mesitylene	700	0.490	130	60	197	2014 [8]
NTCDA[2]	500	1.210	125	46	141	2015 [9]
PVC[3]	600	0.494	199	65.4	244	2000 [10]
PVC	700	0.481	211	65.5	252	2000 [10]
PVC	800	0.445	212	65.8	256	2000 [10]
PVC	900	0.448	167	69.1	229	2000 [10]
PVC	1000	0.406	148	68.9	218	2000 [10]
PVC	1100	0.349	126	59.3	204	2000 [10]
PVC	1200	0.346	116	61.6	194	2000 [10]
PVC	1300	0.346	92	57.1	168	2000 [10]
PVC	1400	0.324	91	47.1	168	2000 [10]
PVC	1700	0.329	71	54.1	143	2000 [10]
PVC	600	0.508	200	66.3	243	2001 [11]
PVC (fiber)	700	0.573	271	70	269	2015 [12]
Polystyreme/D-glucose	1000	0.850	220	70	221	2012 [13]
PEO/PPO tri-block copolymer	500	0.950	234	71	218	2016 [14]
Pitch	600	0.442	164	56.4	227	2000 [10]
Pitch	800	0.547	174	64.7	225	2000 [10]
Pitch	1000	0.417	146	59.4	215	2000 [10]
Pitch	1200	0.396	114	55.2	189	2000 [10]
Pitch	1000	0.391	150	69.2	220	2001 [11]
Mesophase pitch /MCMB[4]	750	0.568	166	44.2	217	2000 [15]
Mesophase pitch /MCMB	700	0.610	240	66	253	2015 [16]
Mesophase pitch - templated	800	0.656	244	71	250	2016 [17]
Mesophase pitch - templated	800	1.130	331	45	228	2016 [17]
Petroleum Coke (PeC)	800	0.535	120	37	185	2002 [18]
Cellulose nano-crystals (CNC)	1000	1.430	450	25	214	2017 [19]
Polymerized acetone	800	1.310	359	34	214	2015 [20]

1) PTCDA: Perylenetetracarboxylic dianhydride; 2) NTCDA: Naphtalenetetracarboxylic dianhydride; 3) Polyvinyl chloride; 4) MCMB: Mesocarbon microbeads.

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