Electronic Supplementary Material (ESI) for Inorganic Chemistry Frontiers.

A fluorine/oxygen co-doping scheme for biomass carbon provides excellent rapid reaction kinetics for sodium/potassium-ion batteries

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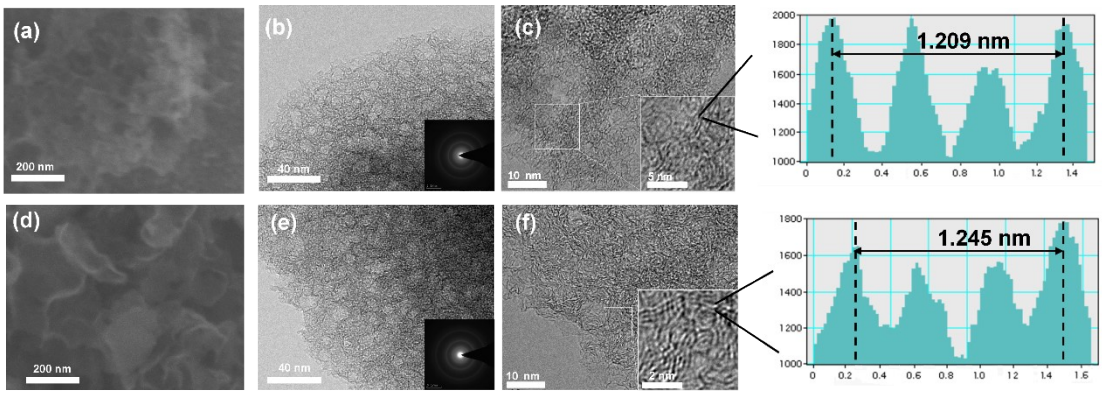

Fig. S1 The SEM and TEM images and lattice fringes (insets) of (a-c) FO-HC1100 and (d-f) FO-HC1300.

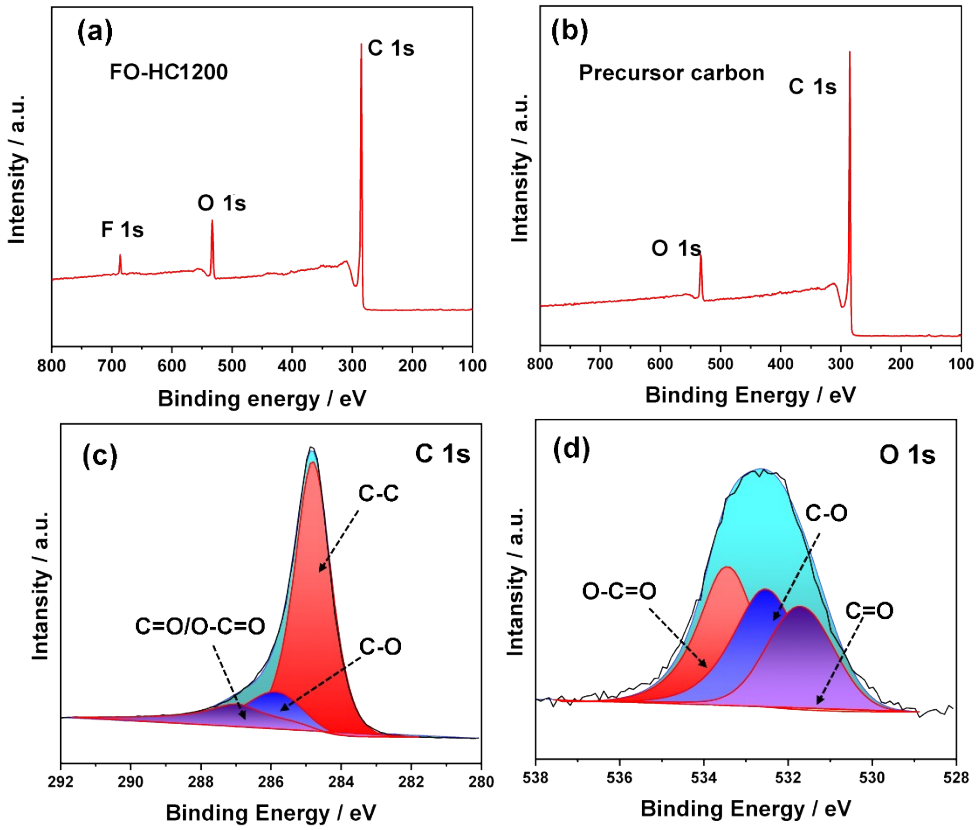

Fig. S2 (a) XPS survey spectrums of the FO-HC1200, (b) XPS survey spectrum, (c) C 1s and (d) O 1s of precursor carbon without hydrothermal reaction.

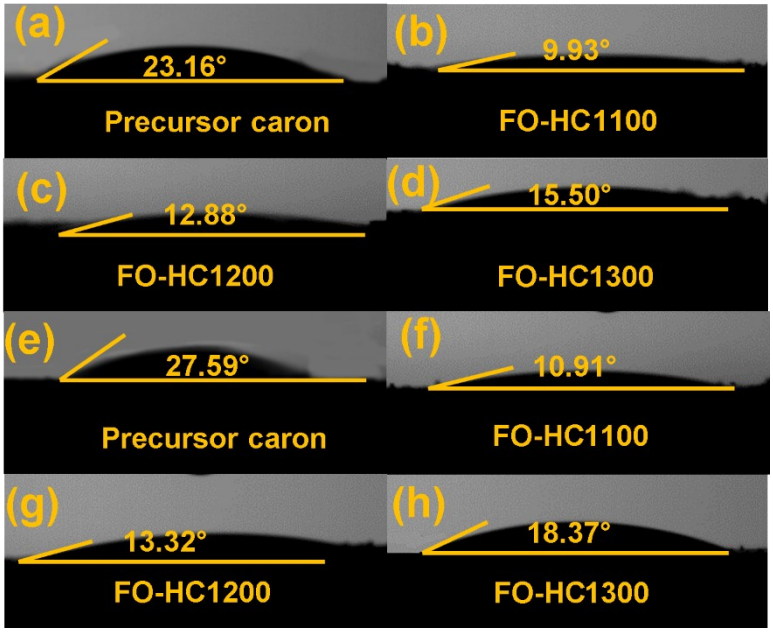

Fig. S3 Wetting angle test of FO-HCs on (a-d) sodium battery electrolyte and (e-h) potassium battery electrolyte.

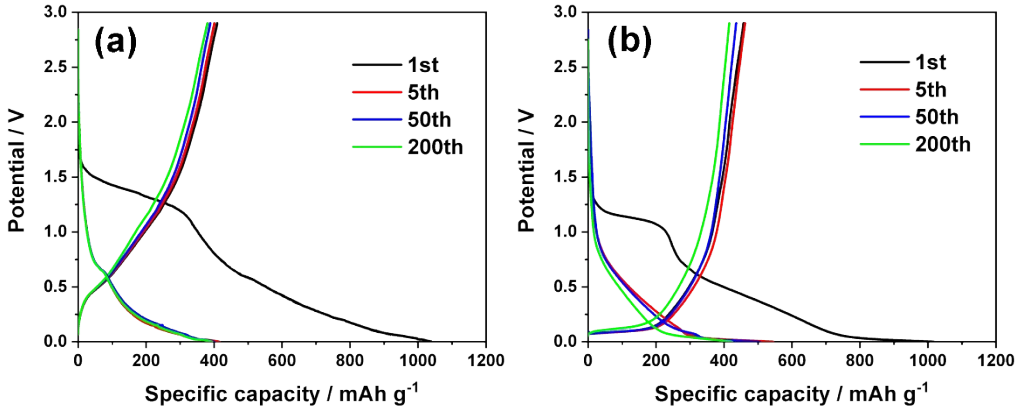

Fig. S4 The GCD profiles from 1st to 200th cycle of FO-HC1200 assembly at 100 mA g^{-1} in (a) PIB, (b) SIB.

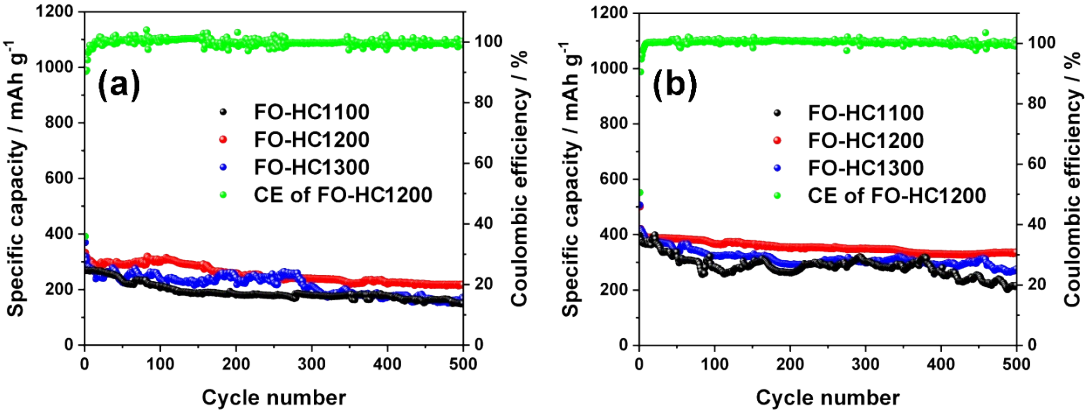

Fig. S5 The Long cycle performance from 1st to 500th cycle of materials at different temperatures under 1 A g^{-1} in (a) PIB, (b) SIB.

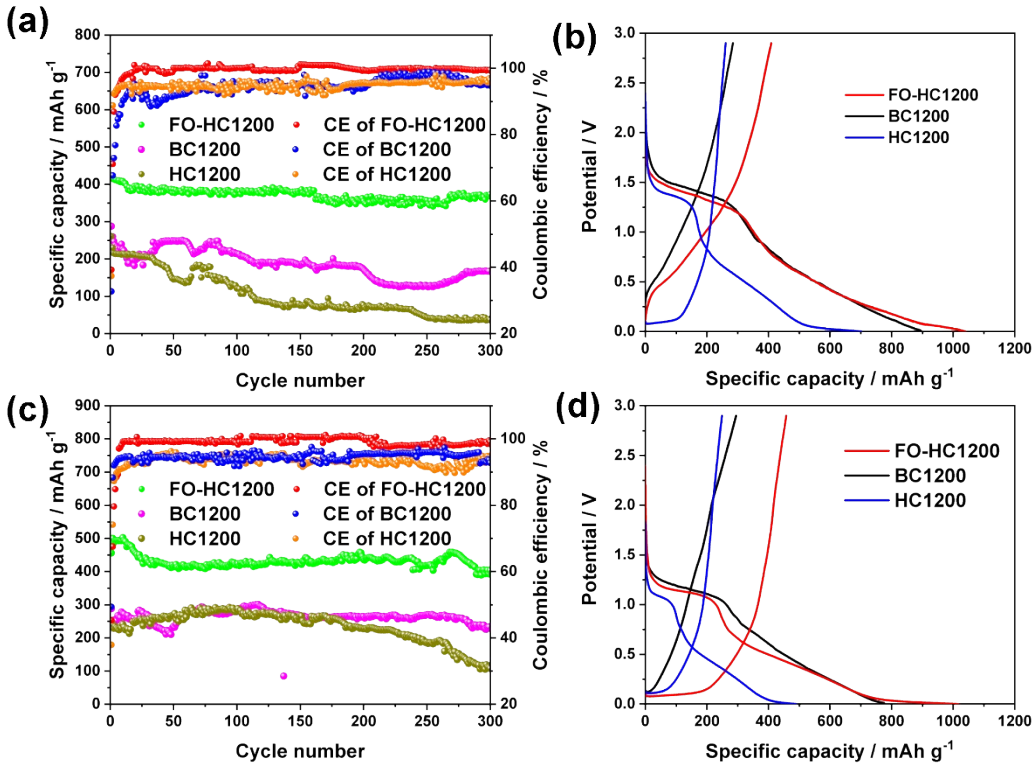

Fig. S6 FO-HC1200, BC1200 and HC1200 as anode materials for PIBs (a, b) and SIBs (c, d) respectively, display the initial and cycling performance under the condition of 100 mA g^{-1} current density. The carbon material obtained by using NAOH in the hydrothermal reaction process, with other preparation conditions unchanged, is called Blank Carbon (BC); the carbon material obtained without hydrothermal reaction and after secondary calcination is called Hard Carbon (HC).

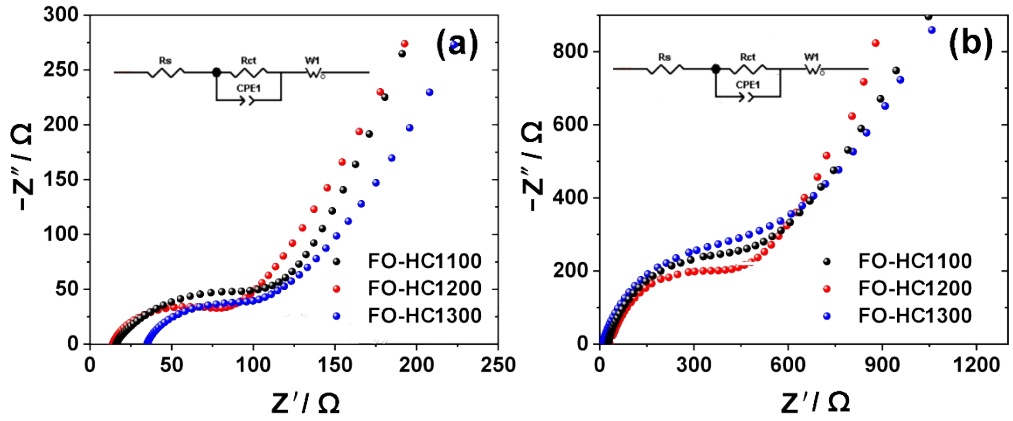

Fig. S7 The Nyquist plots of the first cycle of materials at different temperatures in (a) SIB, (b) PIB.

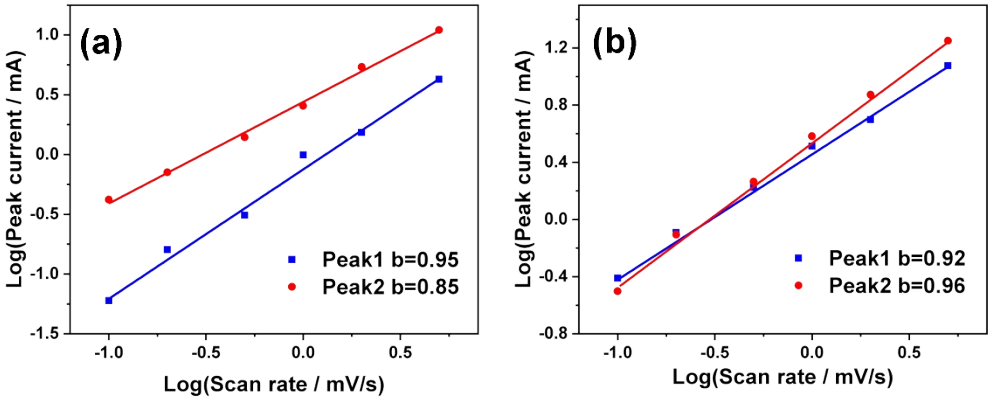

Fig. S8 The calculation of the b-value (a) PIB, (b) SIB.

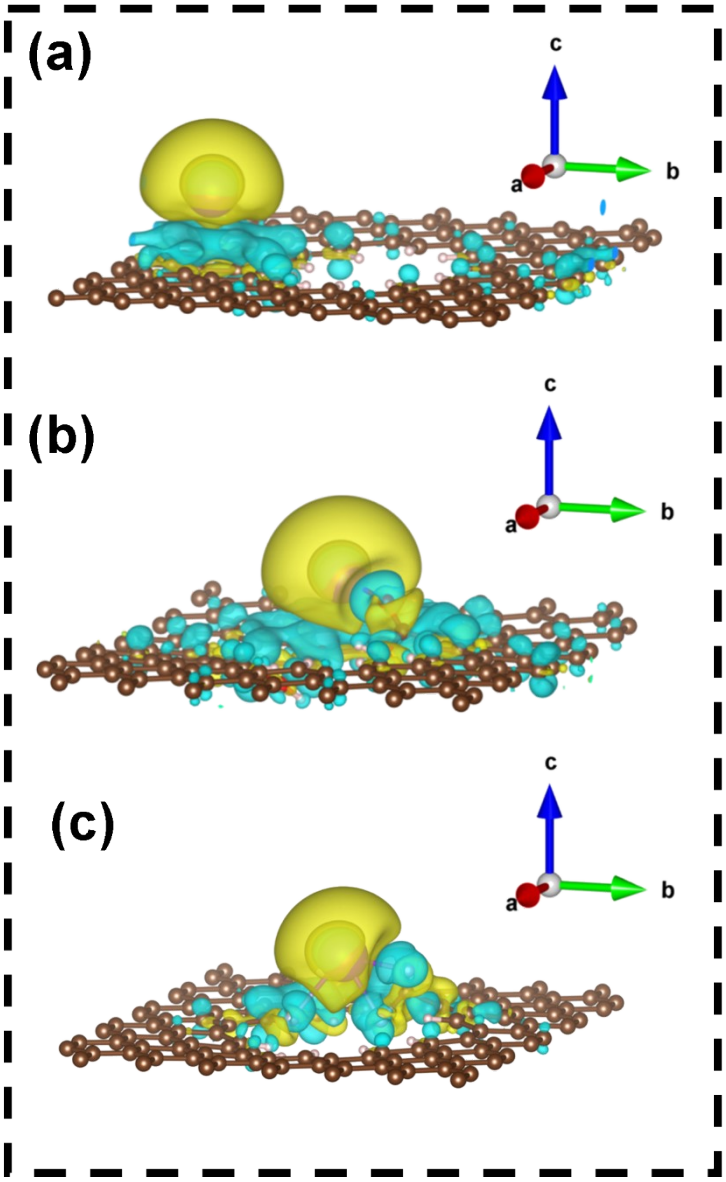

Fig. S9 Differential charge side vie: (a) graphene layer, (b) O-doped hard carbon, (c) F-doped hard carbon.

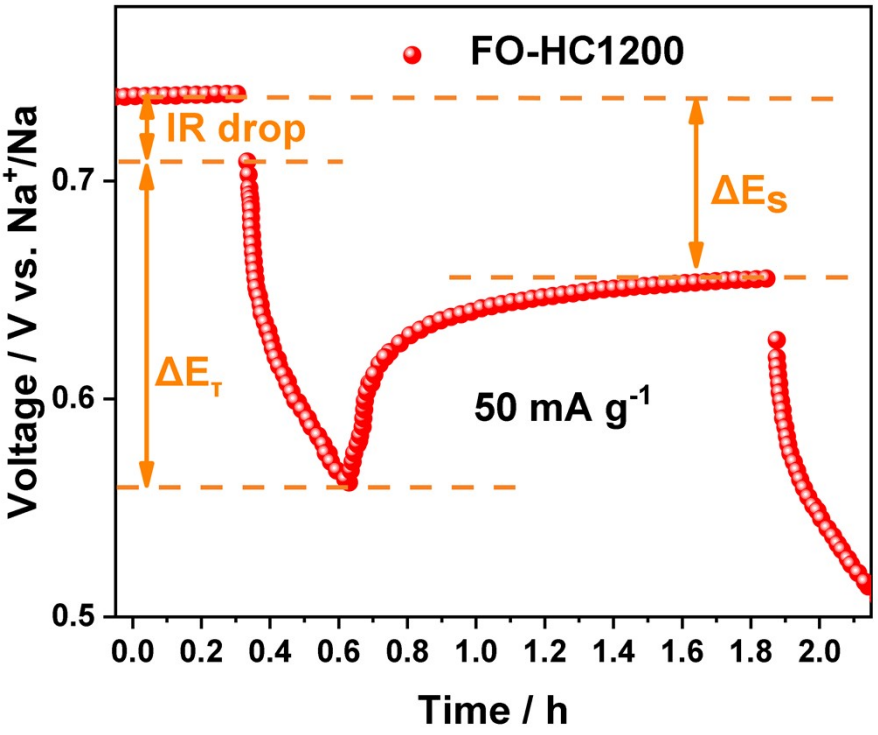

Fig. S10 Schematic of the calculation of diffusion coefficient using the GITT technique.

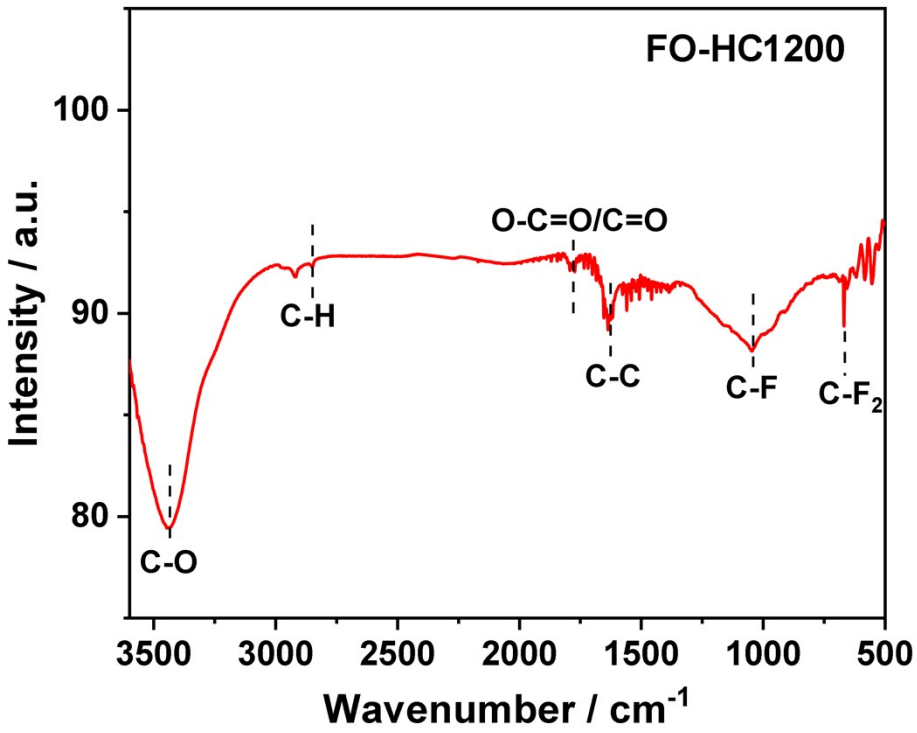

Fig. S11 The FITR test curve of FO-HC 1200.

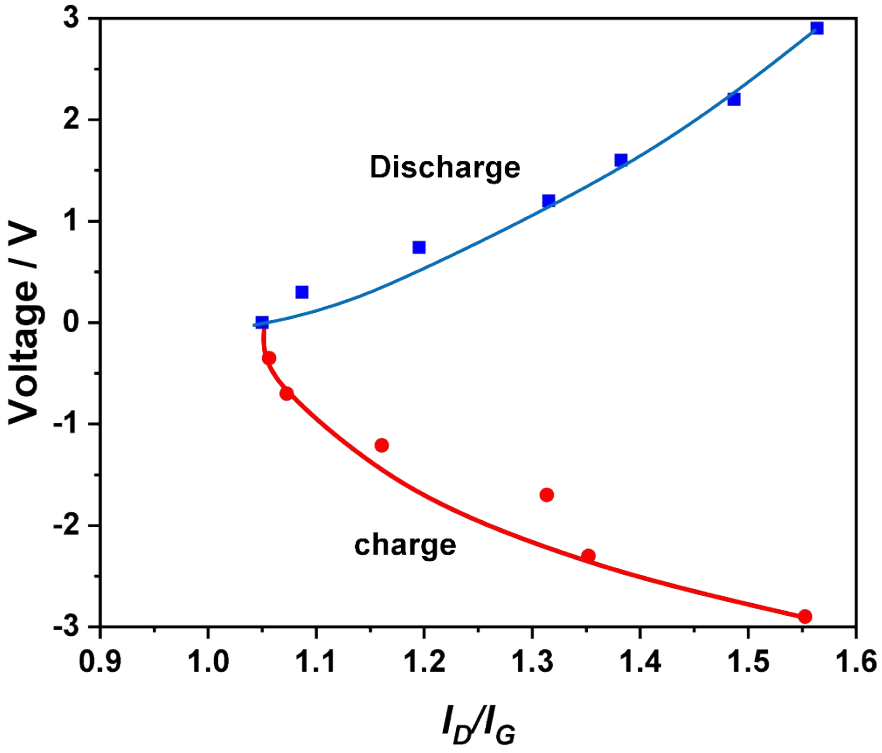

Fig. S12 In-situ Raman spectra are used for the FO-HC1200 anode, including the change of I_D/I_G value at certain voltages.

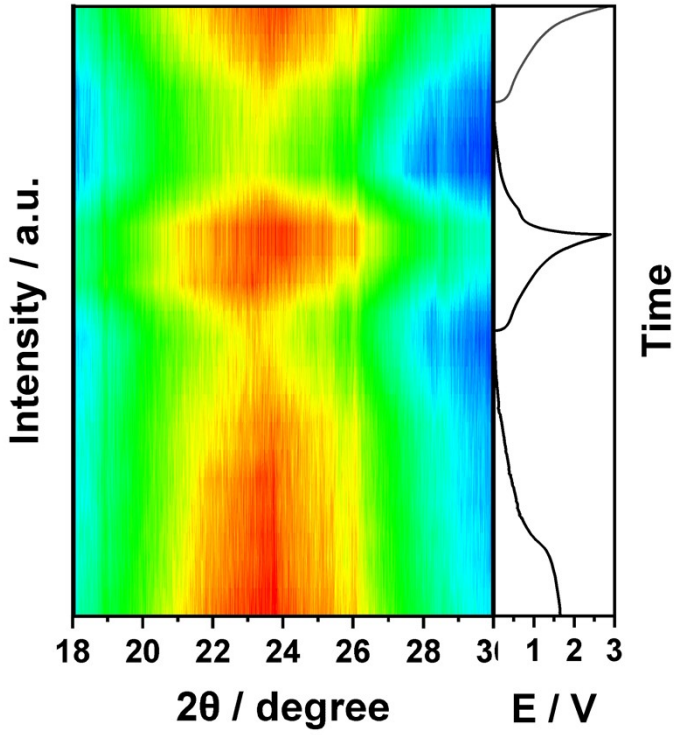

Fig. S13 In-situ XRD Contour plot of FO-HC1200.

Table S1 Textural properties of the samples of FO-HC1100, FO-HC1200 and FO-HC1300

Samples	$d_{(002)}$/nm	I_D/I_G	S_{BET} (m^2g^{-1})	V_P (cm^3g^{-1})
FO-HC1100	0.395	1.02	379.1	0.72
FO-HC1200	0.401	1.07	356.2	0.67
FO-HC1300	0.407	1.09	323.6	0.59

Table S2 Equivalent circuit parameters of theFO-HC1200 for PIBs/SIB after cycling.

Type	Cycle mumber	Rs/Ohm	Rct/Ohm
PIBs	Pristine	188.3	969.3
	5^{th}	163.5	871.3
	50^{th}	149.3	536.4
	300^{th}	142.8	496.1
SIBs	Pristine	31.7	203.5
	5^{th}	22.4	96.4
	50^{th}	15.2	53.7
	300^{th}	13.6	49.2

Table S3 Peak assignment of C 1s, O 1s and F 1s for FO-HC1200

Peak	BE/eV	Assignment	Fraction of species/%
C 1s	284.8	C-C	73.5
	285.8	C-O	13.9
	287	C=O/O-C=O	5.1
	288.7	C-F	5.2
	290.5	$C-F_2$	2.3
O 1s	533.5	O-C=O	29.4
	532.5	C-O	46.7
	531.8	C=O	23.9
F 1s	689.1	C-F	72.4
	690.2	$C-F_2$	27.6

Table S4 Peak assignment of C 1s and O 1s for Precursor carbon

Peak	BE/eV	Assignment	Fraction of species/%
C 1s	284.8	C-C	73.5
	285.6	C-O	13.9
	287.2	C=O/O-C=O	12.6
	533.4	O-C=O	29.4
O 1s	532.5	C-O	46.7
	531.7	C=O	23.9

Table S5 Electrochemical performance comparison of carbon anodes as PIBs in recent literatures with FO-HC1200.

Material	Capacity ($mAh\ g^{-1}$)	Current density ($mA\ g^{-1}$)	Cycles	Ref.
CS-HC	259.8	50	100	[1]
Bam-1300	287.7	300	150	[2]
NPS-FCM	162.1	1000	1000	[3]
NSHCM2	294	200	1000	[4]
P-HC	151.9	1000	2000	[5]
THC	203	30	1000	[6]
NOPC-750	309.8	100	2500	[7]
NO-YS-CS	215	500	2500	[8]
N-CNC	132.9	1000	200	[9]
PI-T-Pab	146.1	100	100	[10]
FO-HC1200	**347.2 / 216.3**	**100 / 1000**	**1000 / 500**	**This work**

Table S6 Electrochemical performance comparison of carbon anodes as SIBs in recent literatures with FO-HC1200.

Material	Capacity ($mAh\ g^{-1}$)	Current density ($mA\ g^{-1}$)	Cycles	Ref.
PC-1400	250	50	50	[11]
HC-1300	247.4	200	800	[12]
PB	146.9	2000	600	[13]
SAL	141.6	200	1000	[14]
SNS-1	353	25	1000	[15]
S-Cmph-700	145.6	2000	500	[16]
LCS-73	325	50	100	[17]
CSHP2	215	100	100	[18]
HC-GLC	320.7	150	100	[19]
HNC-550	352.2	100	300	[20]
FO-HC1200	**386.5 / 336.4**	**100 / 1000**	**1000 / 500**	**This work**

Table S7 Peak positions of C 1s and K 2p in XPS

Peak	Assignment		BE/eV	0nm	BE/eV	15nm	BE/eV	30nm
C 1s	KC_x		283.78	32.1%	283.91	47.3%	283.86	53.9%
	C-C		284.80	36.7%	284.56	20.4%	284.47	24.3%
	C-O		285.57	8.3%	285.41	11.6%	285.43	6.3%
	C=O		286.45	8.1%	285.91	8.7%	286.07	5.1%
	CO_3^{2-}		288.53	7.9%	288.15	4.5%	288.17	4.5%
	$C-F_2$		289.65	6.9%	289.23	7.5%	289.05	5.9%
K 2p	K-C	K2p1/2	296.23	20.5%	296.37	32.2%	296.44	K 2p
		K2p3/2	293.43	42.8%	293.70	26.9%	293.70	52.9%
	K-F	K2p1/2	295.64	14.1%	295.59	28.2%	295.70	5.8%
		K2p3/2	292.80	22.6%	292.92	12.1%	292.95	13.2%
O 1s	CO_3^{2-}		532.30	74.6%	532.18	70.4%	531.95	63.3%
	C=O		533.83	15.7%	533.61	19.7%	533.54	19.6%
	C-O		535.26	9.7%	535.03	9.9%	535.76	17.1%
F 1s	K-F		684.65	84.0%	684.43	76.3%	684.21	72.9%
	KPF_6		686.37	10.2%	686.75	9.9%	686.29	12.4%
	$C-F_2$		688.94	5.8%	688.35	13.8%	689.13	14.7%

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