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Supplementary Information

Improved electrochemical performance of boron-doped carbon-coated lithium titanate as an anode material for sodium-ion batteries

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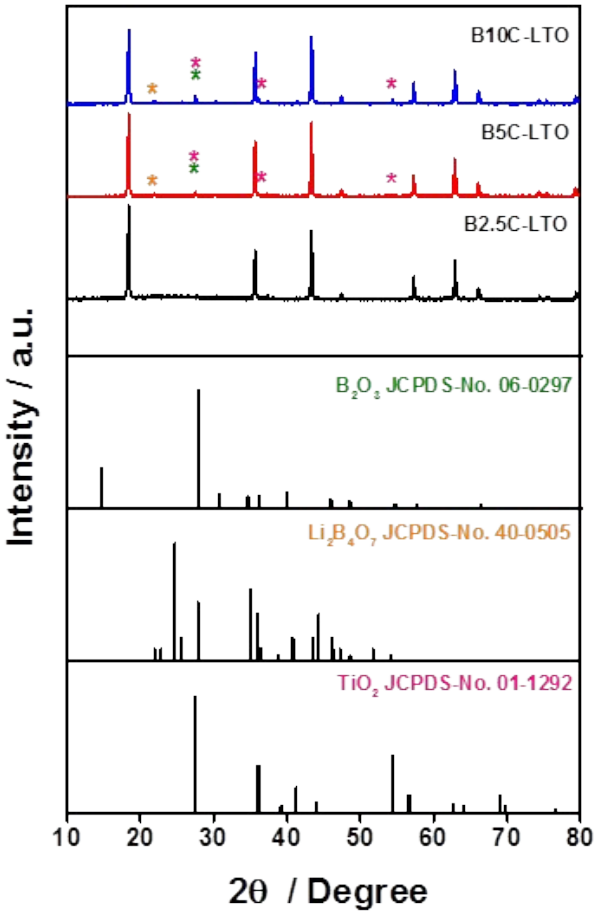

Fig. S1 XRD patterns of boron-doped carbon-coated LTO synthesized with varying amounts of H_3BO_3: B2.5C-LTO (BC-LTO, 2.5 wt%), B5C-LTO (5 wt%), and B10C-LTO (10 wt%).

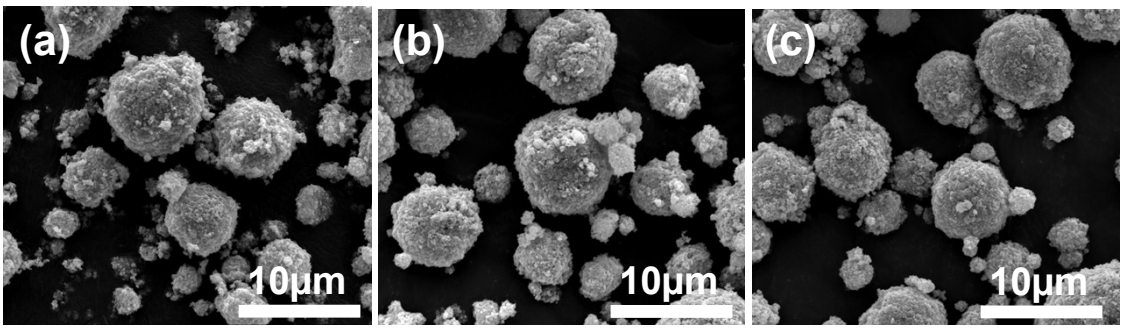

Fig. S2 SEM images at low magnifications of (a) P-LTO, (b) C-LTO, and (c) BC-LTO samples.

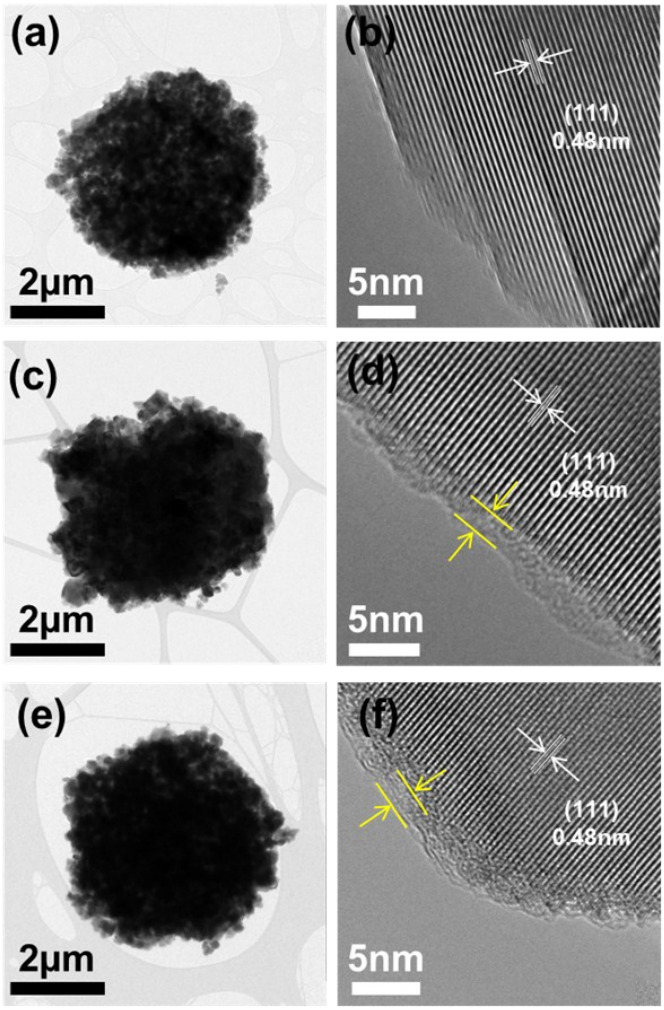

Fig. S3 TEM images of (a-b) P-LTO, (c-d) C-LTO and (e-f) BC-LTO.

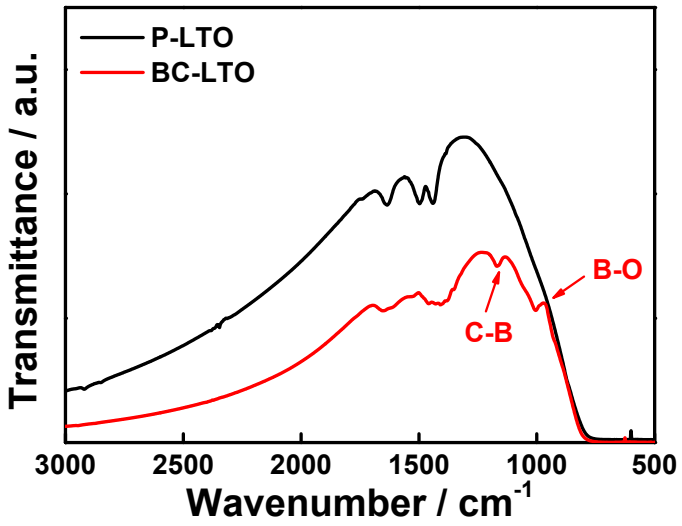

Fig. S4 FT-IR spectra of P-LTO and BC-LTO samples.

The FT-IR spectrum of BC-LTO shows two notable bands that are not observed in the spectrum of pristine LTO. These bands at ~1038 and ~1150 cm^{-1} correspond to B–O and C–B stretches, respectively. Commonly, C–B bands appear in the range of 1050–1200 cm^{-1}.[1,2] The B–O and C–B stretches clearly indicate the formation of BC_2O and BCO_2.

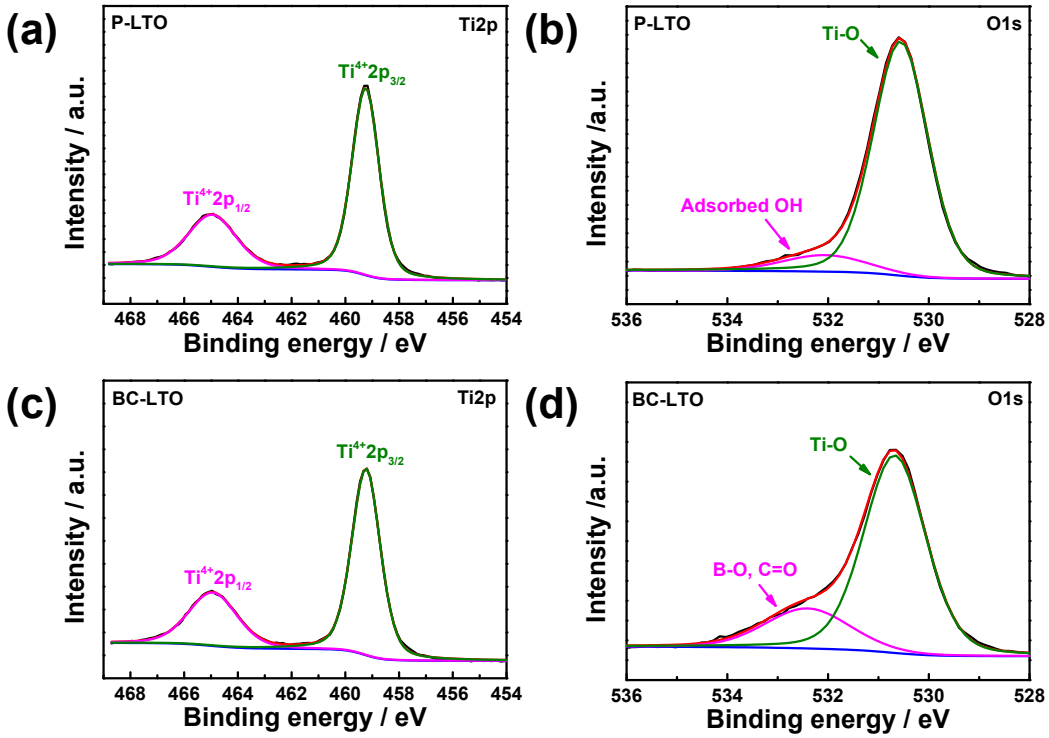

Fig. S5 (a) Ti2p and (b) O1s XPS spectra for P-LTO, and (c) Ti2p and (d) O1s XPS spectra for BC-LTO.

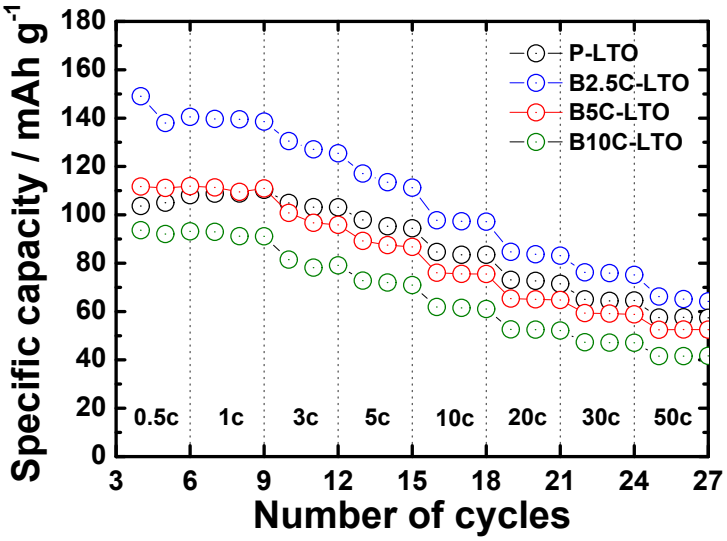

Fig. S6 Rate capabilities for the sodium extraction process in pristine LTO, B2.5C-LTO, B5C-LTO, and B10C-LTO samples from 0.5 to 50 C, with a constant 0.5 C rate applied for the sodium insertion process.

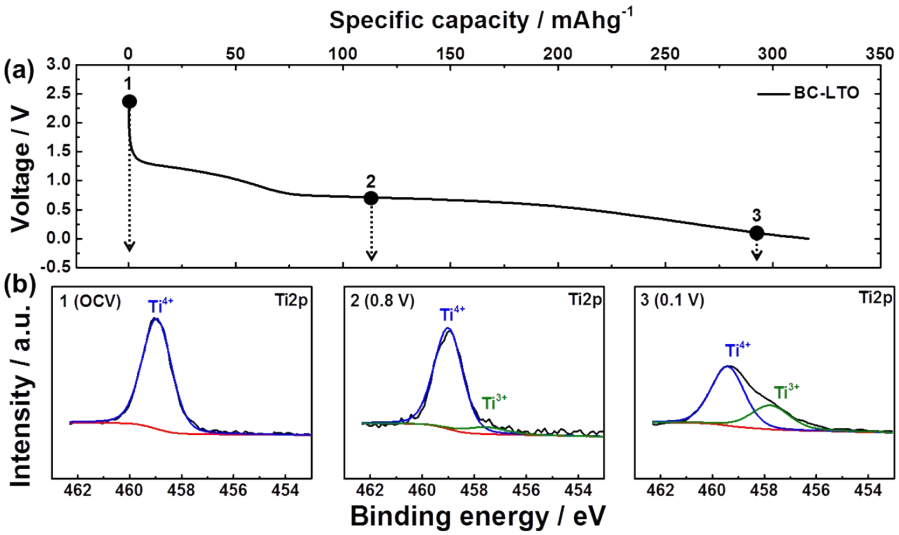

Fig. S7 High-resolution XPS spectra of BC-LTO electrode at OCP, 0.8V and 0.1V.

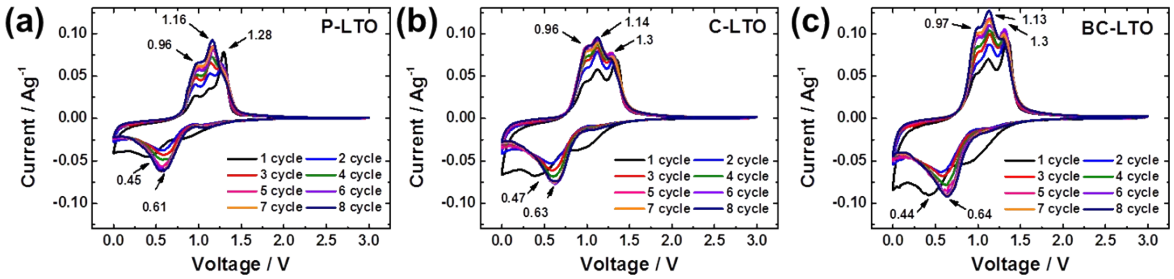

Fig. S8 Cyclic voltammetry curves at a scan rate of 0.1 mV s-1 of (a) P-LTO, (b) C-LTO and (c) BC-LTO.

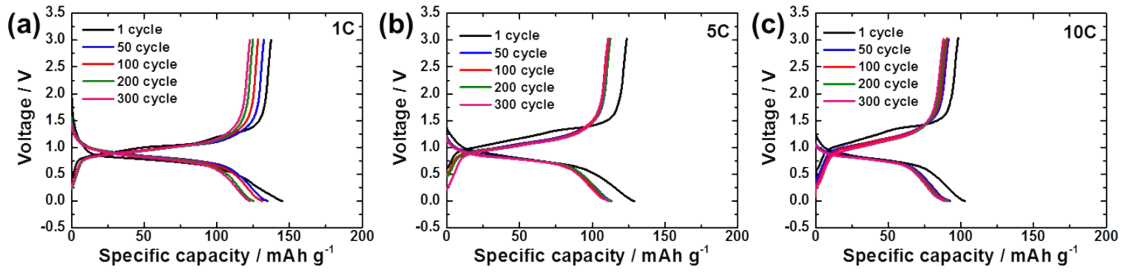

Fig. S9 Charge-discharge curves of BC-LTO electrode with different cycles at (a) 1, (b) 5, (c) 10 C- rate.

Table S1. Comparison of electrochemical properties of LTO materials for sodium-ion batteries.

Material name	Specific capacity (mA h g^{-1})						Cycle retention	Loading amount (mg cm^{-2})	Reference
	0.1C	0.5C	1C	3C	5C	10C			
BC-LTO	168.4	149	139.2	127.7	113.9	97.4	90% after 300th cycle (1C, 5C, 10C)	1.6	This
Porous $Li_4Ti_5O_{12}$	158	-	104	82 (2C)	-	-	93% after 100th cycle (1C)	0.8-1	3
C-coated $Li_4Ti_5O_{12}$ nanowire	168 (0.2C)	-	-	-	-	117	97% after 50th cycle (0.2C)	-	4
$Li_4Ti_5O_{12}$ nanorod	158	-	104	82 (2C)	-	-	~75%* after 100th cycle (0.1C) ~85%* at 200th cycle (2C)	2.14	5
$Li_4Ti_5O_{12}$ nanosheet	-	-	-	-	-	115	93% after 150th cycle (0.5C)	1.3	6
Na-doped $Li_4Ti_5O_{12}$	175	154	139	120 (2C)	84 (4C)	56 (8C)	80% after 800th cycle (2C)	1.4	7
MoS_2-quantum-dot -interspersed $Li_4Ti_5O_{12}$ nanosheet	-	-	-	118 (2C)	91	-	~85%* after t 200th cycle (2C)	1-2	8
Graphene-wrapped porous $Li_4Ti_5O_{12}$	200 (0.2C)	180 (0.6C)	145 (1.2C)	115	80 (6C)	58 (12C)	~95%* after 115th cycle (0.2C) ~95%* after 12000th cycle (3C)	1.5-2	9

* The cycle retention was calculated from the presented graph for cycle performance.

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