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A new general approach to synthesizing filled and yolk-shell structured metal oxide microspheres by applying a carbonaceous template

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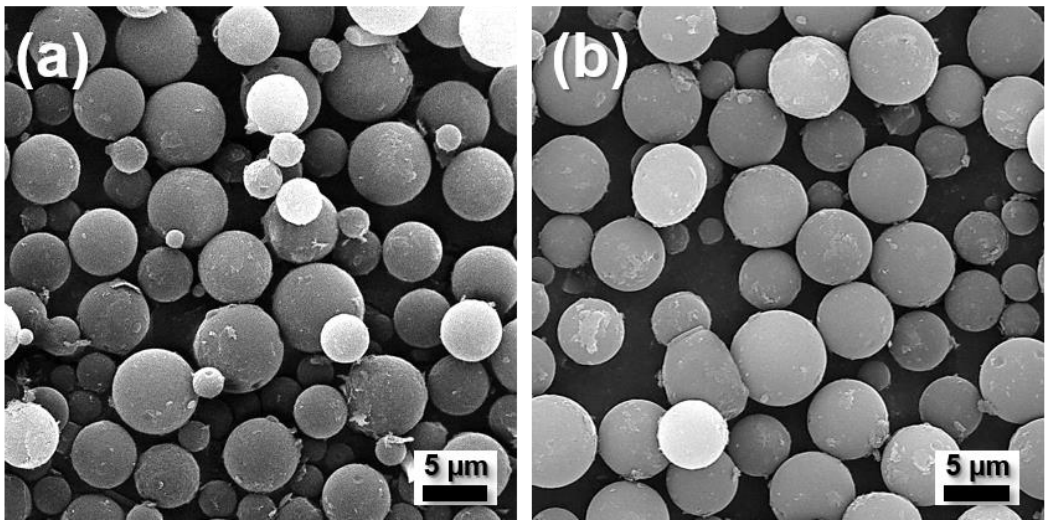

Fig. S1 SEM images of the carbonaceous template microspheres (a) before and (b) after impregnation of $Sn(Oct)_2$ at the loading rate of 0.3 mL.

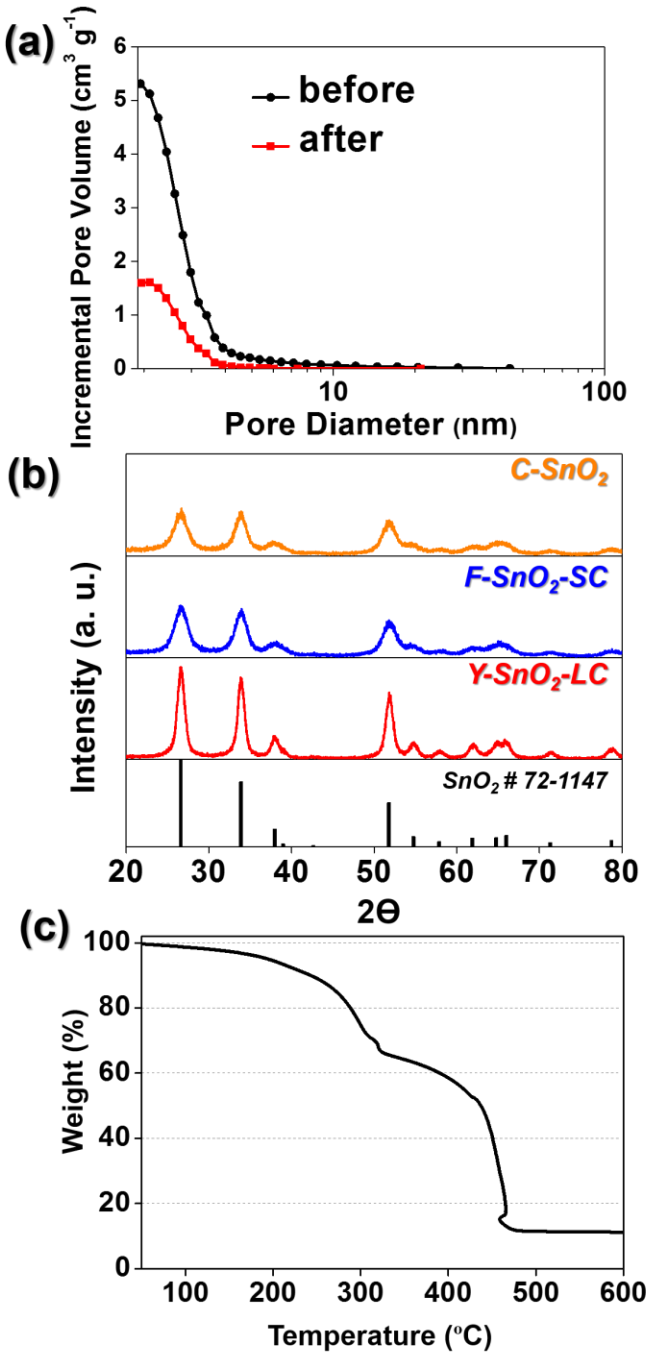

Fig. S2 (a) BJH pore size distributions of the carbon template microspheres before and after $Sn(Oct)_2$ impregnation, (b) XRD patterns of the C-SnO_2 and filled and yolk-shell structured SnO_2 microspheres, and (c) TG curve of the C-$Sn(Oct)_2$ composite microspheres measured under air atmospheres.

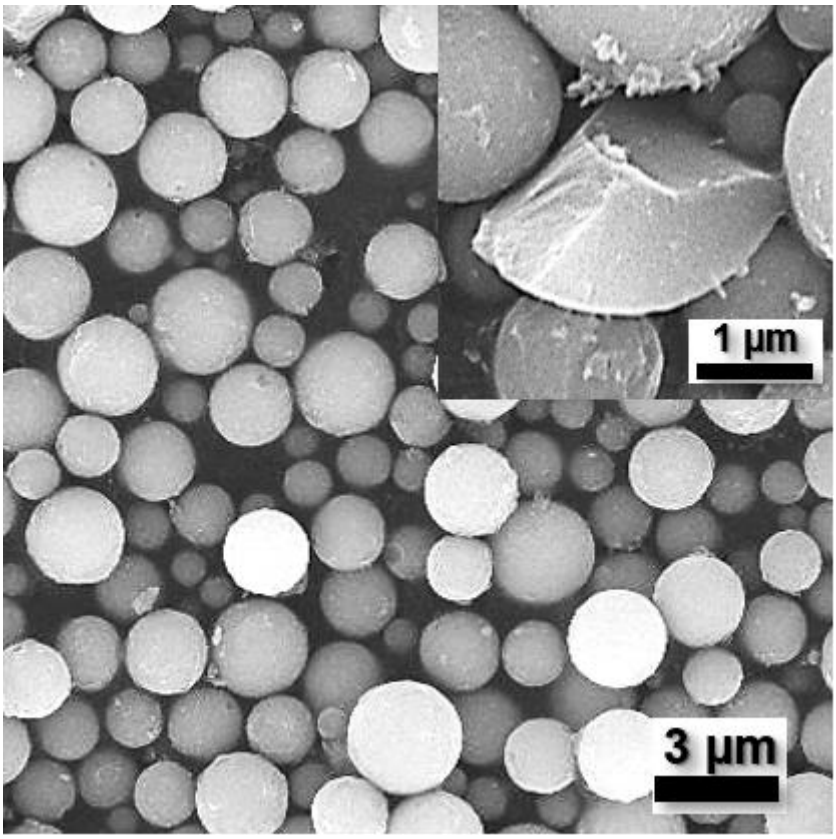

Fig. S3 Morphologies of the SnO_2 microspheres obtained by post-treatment of the C-SnO_2 microsphere (shown in Fig. 1) in an atmosphere with high oxygen concentration and ramping rate of 10 °C min^{-1} s.

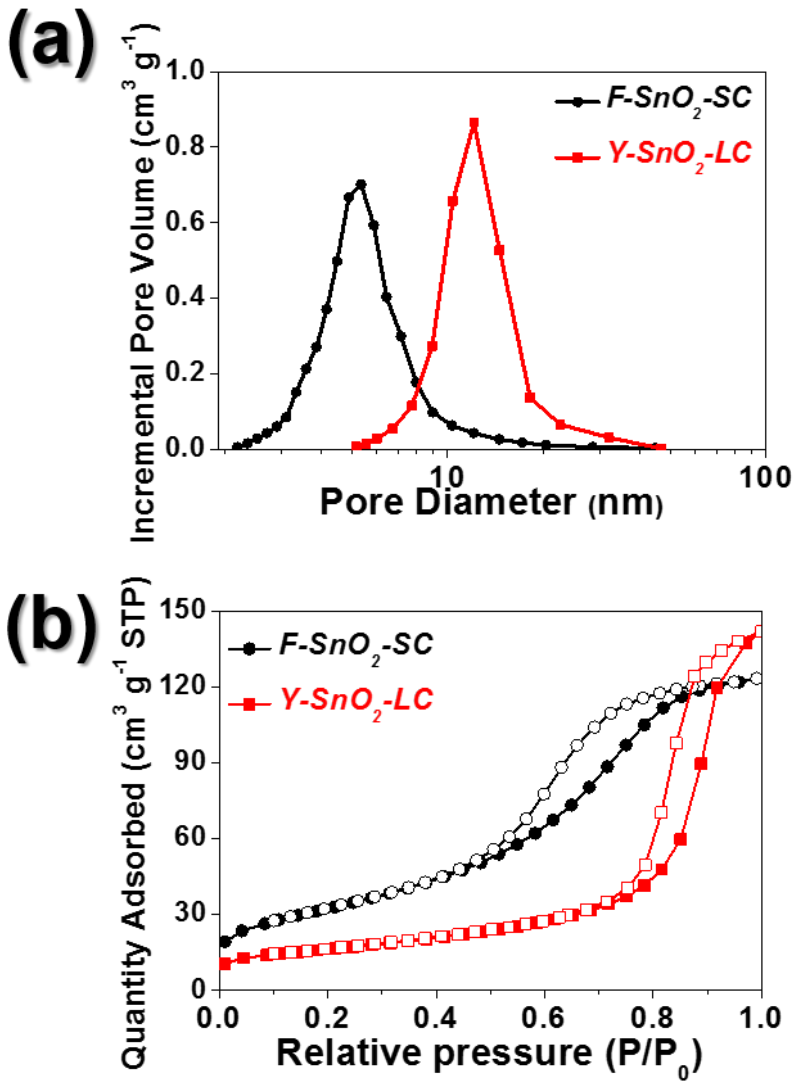

Fig. S4 (a) BJH pore size distributions and (b) N_2 adsorption and desorption isotherms of the yolk-shell and filled structured SnO_2 microspheres.

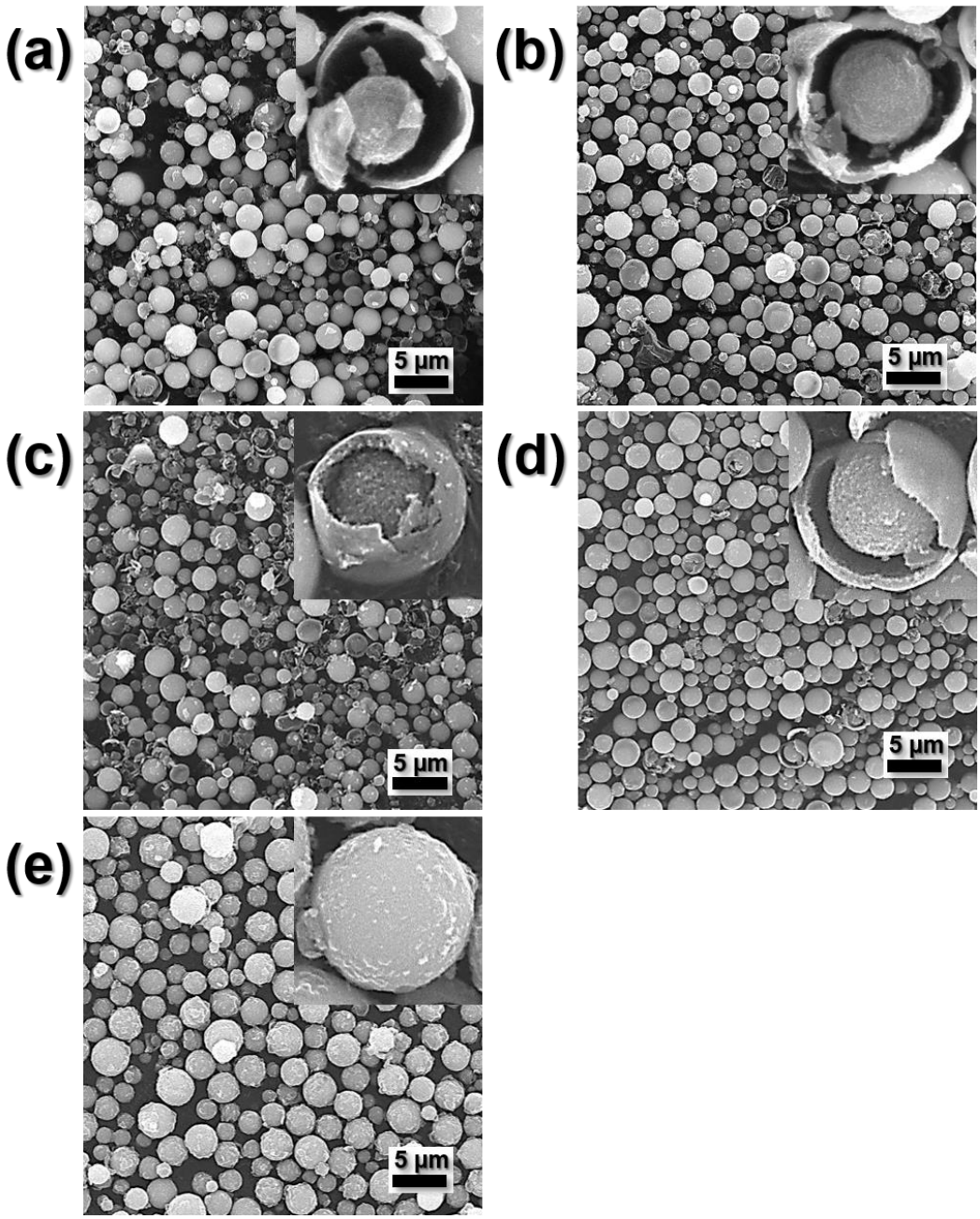

Fig. S5 Morphologies of the SnO_2 microspheres prepared from the carbonaceous template microspheres with various loading rate of tin(II) octoate by post-treatment at 500 °C in an atmosphere with high oxygen concentration and ramping rate of 10 °C min^{-1}: (a) 0.2 ml, (b) 0.4 ml, (c) 0.6 ml, (d) 1.0 ml, and (e) 1.5 ml.

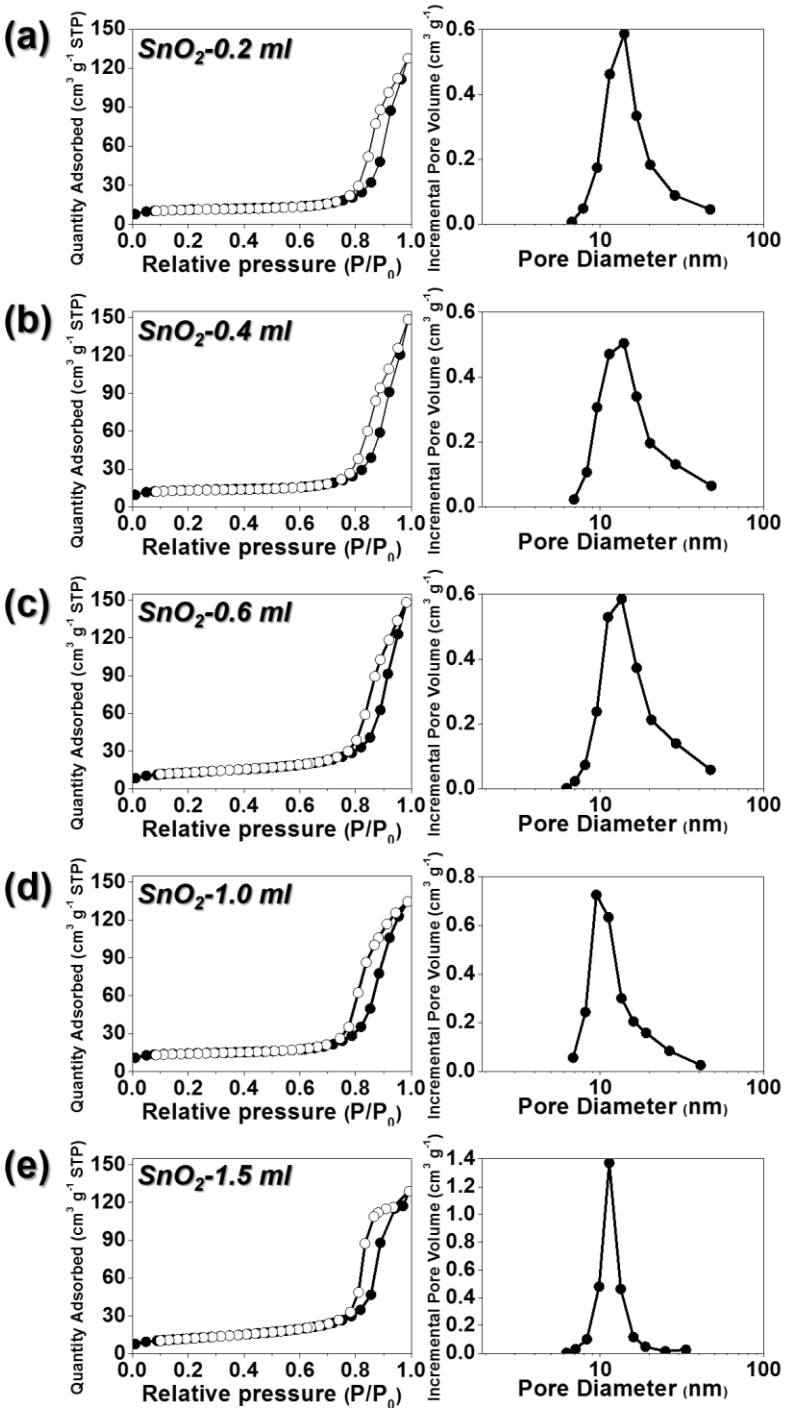

Fig. S6 Nitrogen adsorption and desorption isotherms and BJH pore size distributions of the SnO_2 microspheres formed from the carbonaceous template microspheres with various loading rate of tin(II) octoate by post-treatment at 500 °C in an atmosphere with high oxygen concentration and ramping rate of 10 °C min^{-1}: (a) 0.2 ml, (b) 0.4 ml, (c) 0.6 ml, (d) 1.0 ml, and (e) 1.5 ml.

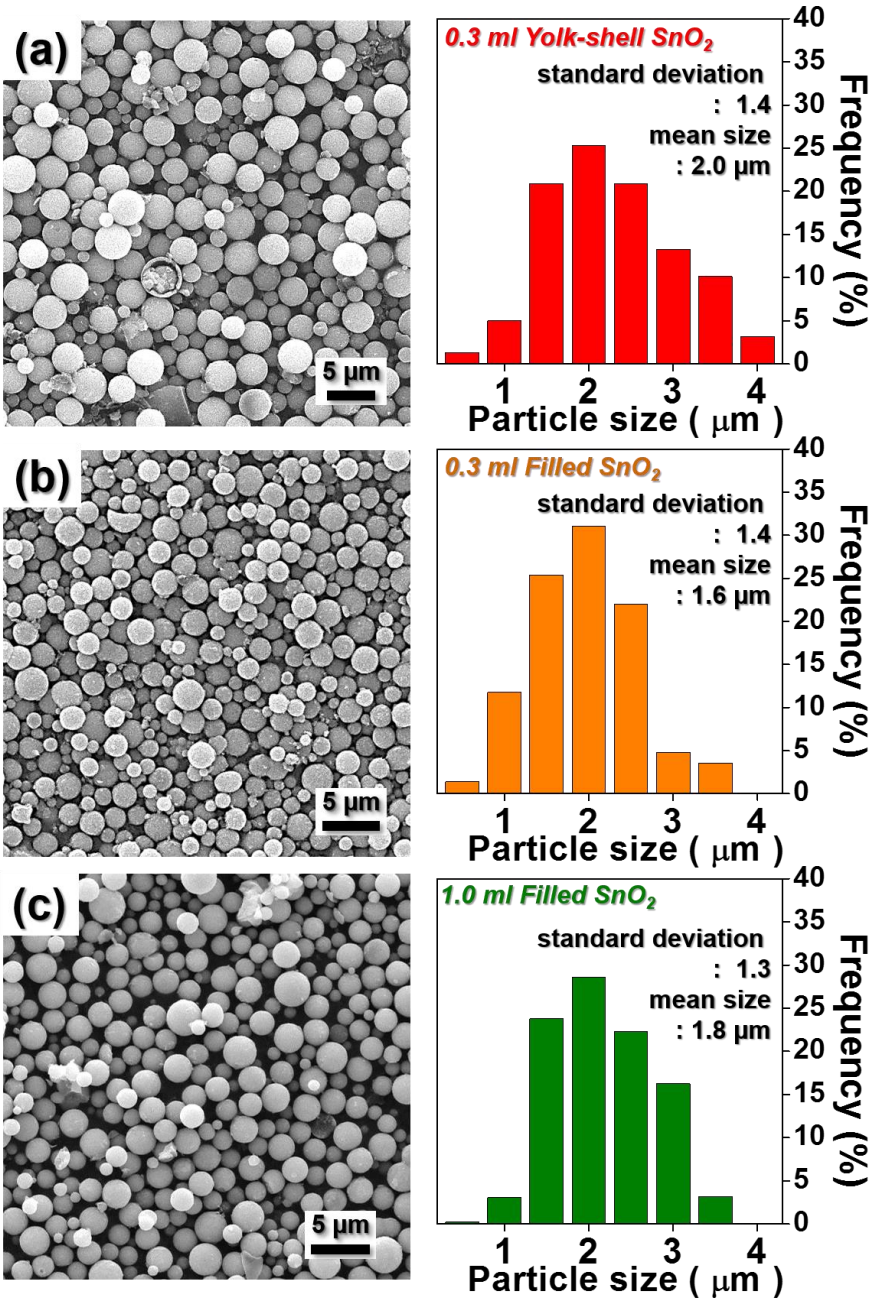

Fig. S7 Morphologies and size distributions of the (a) filled and (b) yolk-shell structured SnO_2 microspheres formed from the C-$Sn(Oct)_2$ microspheres with the loading rate of 0.3 mL, and (c) filled structured SnO_2 microspheres formed from the C-$Sn(Oct)_2$ microspheres with loading rate of 1.0 mL.

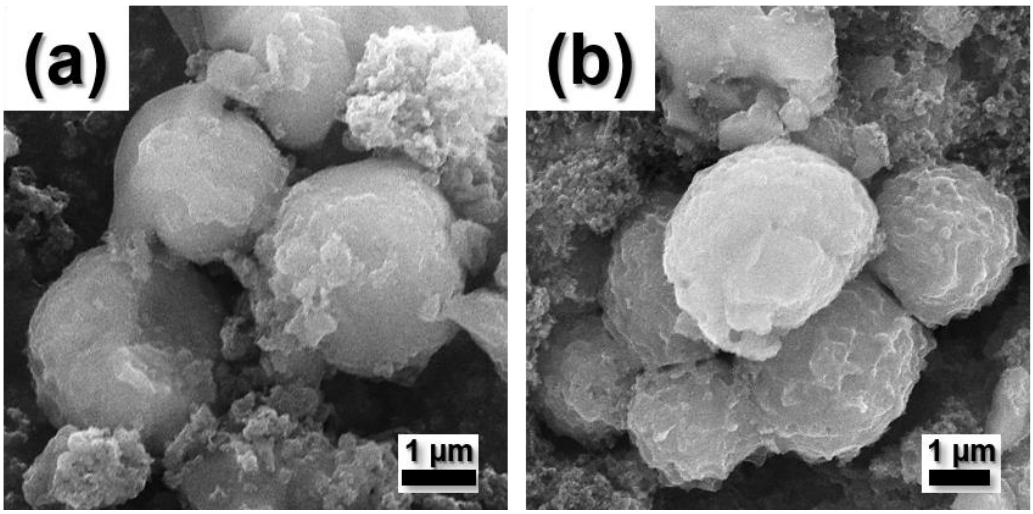

Fig. S8 SEM images of the (a) Y-SnO_2-LC and (b) F-SnO_2-SC microspheres after 100 cycles.

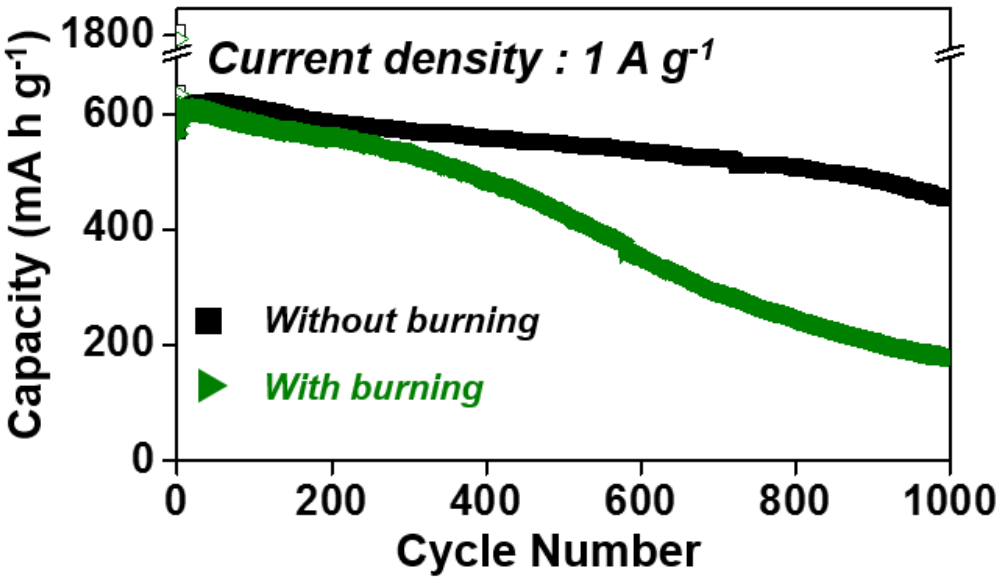

Fig. S9 Cycling performances of the filled structured SnO_2 microspheres prepared by decomposition of the carbonaceous template with and without burning at a constant current density of 1 A g^{-1}.

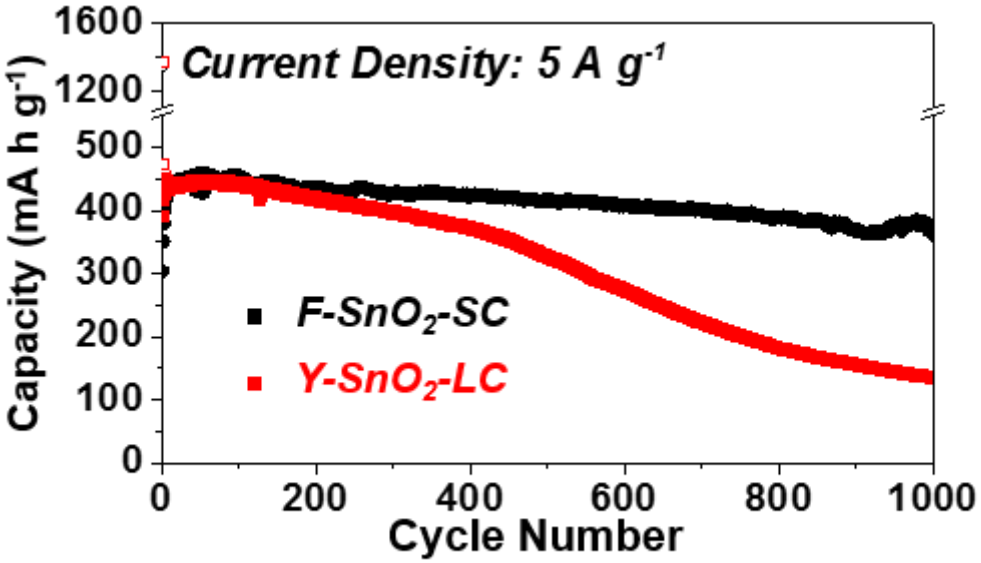

Fig. S10 Cycling performances of the filled and yolk-shell structured SnO_2 microspheres formed from the C-$Sn(Oct)_2$ microspheres with the same loading rate of 0.3 mL at a constant current density of 5 A g^{-1}.

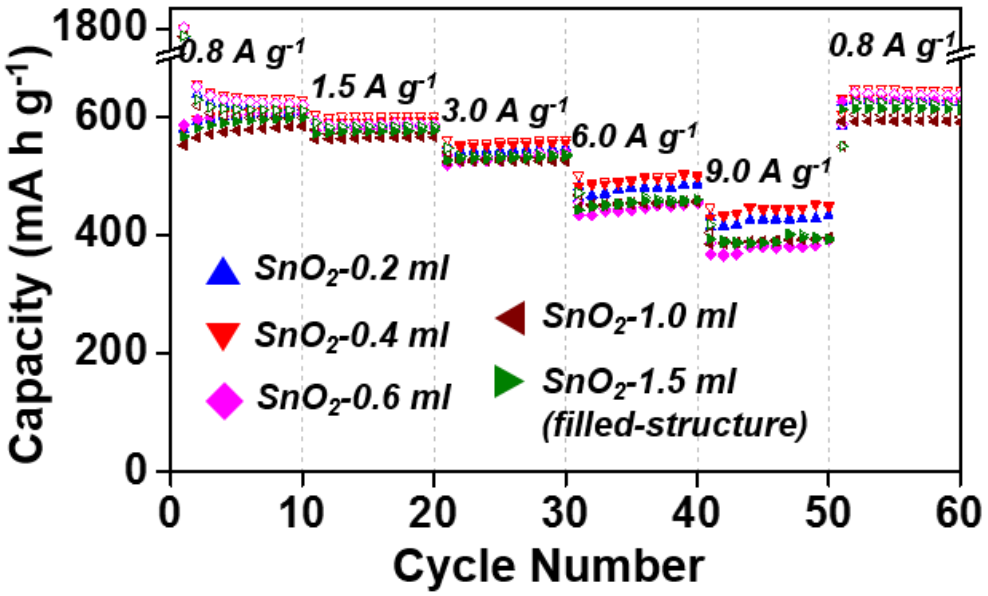

Fig. S11 Rate performances of the SnO_2 microspheres prepared from the carbonaceous template microspheres with various loading rate of tin(II) octoate by post-treatment at 500 °C in an atmosphere with high oxygen concentration and ramping rate of 10 °C min^{-1}.

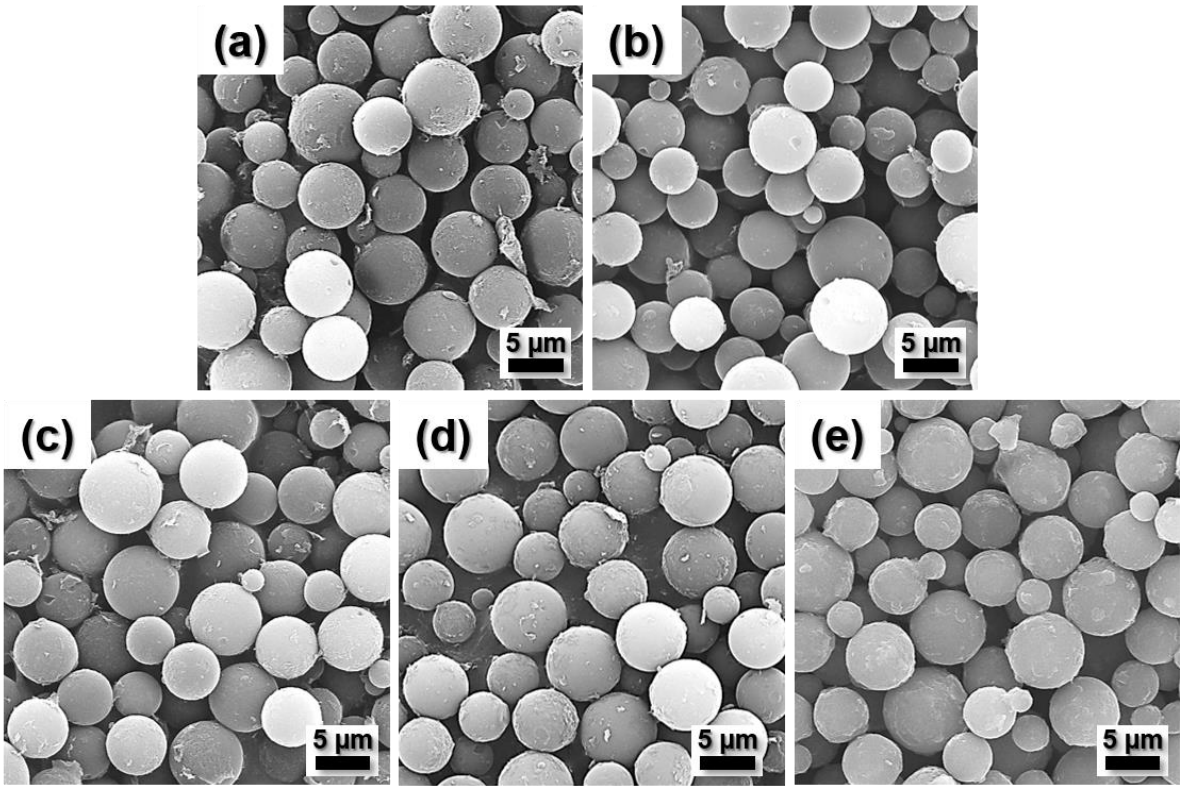

Fig. S12 Morphologies of the carbonaceous template microspheres with various loading rate of tin(II) octoate: (a) 0.2 ml, (b) 0.4 ml, (c) 0.6 ml, (d) 1.0 ml, and (e) 1.5 ml.

Table S1. Cycling and rate performances of various nanostructured SnO_2 materials in lithium-ion batteries.

Various hollow SnO_2 materials	cycling performance	rate performance	Ref
SnO_2@carbon hollow spheres	Discharge capacity of 643 mA h g^{-1} after 300 cycles (at 0.5 A g^{-1}, 0–3.0 V)	The discharge capacities were 520 and 210 mA h g^{-1} at current densities of 0.2 and 3.0 A g^{-1}, respectively. (0–3.0 V)	[57]
SnO_2 hollow spheres	Discharge capacity of 643 mA h g^{-1} after 300 cycles (at 2.0 A g^{-1}, 0.001–1.0 V)	The discharge capacities were 780 and 597 mA h g^{-1} at current densities of 0.5 and 7.0 A g^{-1}, respectively. (0.001–1.0 V)	[58]
SnO_2 fiber-in-tube	Discharge capacity of 640 mA h g^{-1} after 300 cycles (at 1.0 A g^{-1}, 0.001–1.0 V)	The discharge capacities were 774 and 591 mA h g^{-1} at current densities of 0.5 and 5.0 A g^{-1}, respectively. (0.001–1.0 V)	[59]
Three-dimensional SnO_2@TiO_2 double-shell nanotubes on carbon cloth	Discharge capacity of 400 mA h g^{-1} after 100 cycles (at 1.0 A g^{-1}, 0.01-3.0 V)	The discharge capacities were 843 and 135 mA h g^{-1} at current densities of 0.16 and 7.8 A g^{-1}, respectively. (0.01–3.0 V)	[60]
SnO_2/C microspheres	The discharge capacity 50 and 379 mA h g^{-1} after 800 cycles. (at 0.1 A g^{-1},0-3.0 V)	The discharge capacities were 378 and 230 mA h g^{-1} at current densities of 0.1 and 0.6 A g^{-1}, respectively. (0 – 3.0 V)	[61]
pillar arrays of C-coated hollow SnO_2	Discharge capacity of 488 mA h g^{-1} after 50 cycles (at 1.0 A g^{-1}, 0.005-2.0 V)	The discharge capacities were 634 and 408 mA h g^{-1} at current densities of 0.78 and 7.8 A g^{-1}, respectively. (0.005 – 2.0 V)	[62]
Carbon nanotube @SnO_2-Au coaxial nanocable	Discharge capacity of 626 mA h g^{-1} after 40cycles (at 0.18 A g^{-1}, 0.05-1.2 V)	The discharge capacities were 660 and 392 mA h g^{-1} at current densities of 0.18 and 7.2 A g^{-1}, respectively. (0.05 – 1.2 V)	[63]

SnO_2-C hollow nanostructures	Discharge capacity of 577 mA h g^{-1} after 500 cycles (at 0.2 A g^{-1}, 0-3.0 V)	The discharge capacities were 701 and 412 mA h g^{-1} at current densities of 0.4 and 5.0 A g^{-1}, respectively. (0 – 3.0 V)	[64]
Filled structured SnO_2 microspheres	*Discharge capacity of 450 mA h g^{-1} after 1000 cycles (at 1 A g^{-1}, 1.0 V)*	*The discharge capacities were 637 and 372 mA h g^{-1} at current densities of **0.8 and 9.0 A g^{-1}**, respectively. (0.01 – 1.0 V)*	***This study***