Electronic Supporting Information

Novel La_2O_3 hollow nanospheres for high performance lithium-ion rechargeable batteries

Experimental Section

Polymeric micelles solution was prepared by dissolving the required amount of the polymer in distilled water and then transferred to a volumetric flask to obtain a stock solution with a concentration of 0.5 gL^{-1}. The micelle solution was adjusted to pH 9 by using dilute NaOH. The micelle solution (10 mL) was stirred for a few minutes followed by addition of desired amounts of $LaCl_3.7H_2O$ ($LaCl_3$/PAA = 5 to 12) under vigorous stirring. Then La^{3+} was precipitated as $La(OH)_3$ by further increasing the pH to about 11. The composite particles were aged for 4 days without agitation and repeatedly washed with hot distilled water and ethanol and then dried at 60 °C. In order to remove the polymeric template as well as to crystallize the La_2O_3 hollow particles, the composite particles were heated to 550 °C for 4 h in a muffle furnace under air.

For lithium ion alloying/de-alloying studies, 5.0 mg of the hollow La_2O_3 was mixed well with 5.0 mg of teflonized acetylene black (TAB-2,) and then the mixture was pressed on a stainless steel mesh as the current collector under a pressure of 500 kg/cm^2 and dried at 160 °C for 5 hours under vacuum. The electrochemical characterizations were carried out using CR-2032 coin type cells with lithium as anode. The electrolyte used was 1M $LiPF_6$-EC:DMC (1:2 by volume, Ube Chemicals Co. Ltd.). The coin cell assembling was performed in a glove box filled with argon (dew point, lower than −80 □). The galvanostatic charge–discharge tests of the coin cell were performed at the constant current density 300 $mA.g^{-1}$. For the cyclic voltammograms 2.0 mg of La_2O_3 was mixed with 2.0 mg of TAB-2. Lithium foils were used as reference and counter electrodes. Scan rate is 20 mV/min in the range of 0.005 - 3.0 V vs Li/Li^+.

Characterization: Powder X-ray diffraction (SXRD) patterns were collected on a Rigaku Rint-ultima diffractometer with CuKα radiation (40 kV, 20 mA) from 0.7° to 5° 2θ in 0.01 steps at a scan

speed of 1° min^{-1} and wide-angle XRD was performed on a Shimadzu XRD-7000 (WXRD) diffractometer. N_2 adsorption/desorption analyses were carried out by using a Quantochrome (Autosorp 1C) apparatus. DLS measurements were carried out with an Otsuka ELS-8000 electrophoretic light scattering spectrophotometer. The TEM pictures were recorded on JEOL JEM-1210 (80 kV) and JEM-2100 (200 kV) electron microscopes. Fourier-transform infrared (FTIR) spectra were recorded on a Jasco FT/IR 7300 spectrometer. Thermogravimetry and differential thermal analysis (TG-DTA) were obtained with a MAC Science TG-DTA 2100 instrument under air. Galvanostatic charge-discharge measurements were performed on a BTS 2004 equipment, Nagano charge/discharge instrument. CV measurements were performed using an HSV-100 appratus (Hokuto Denko Ltd., Japan).

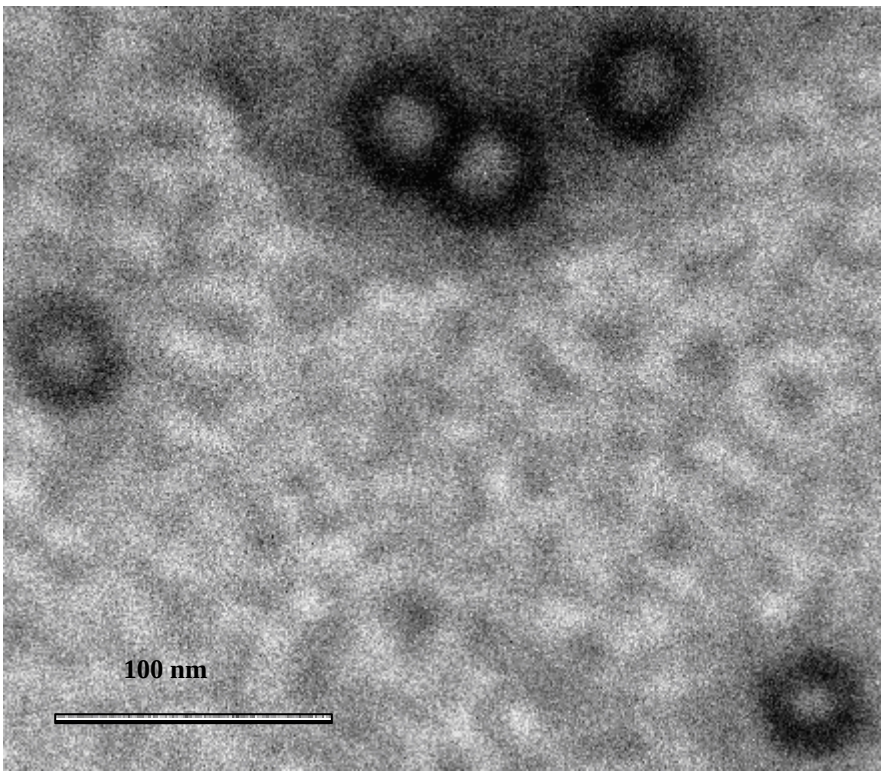

Fig. S1. TEM image of the micelles of PS–PAA–PEO stained with phosphotungstic acid.

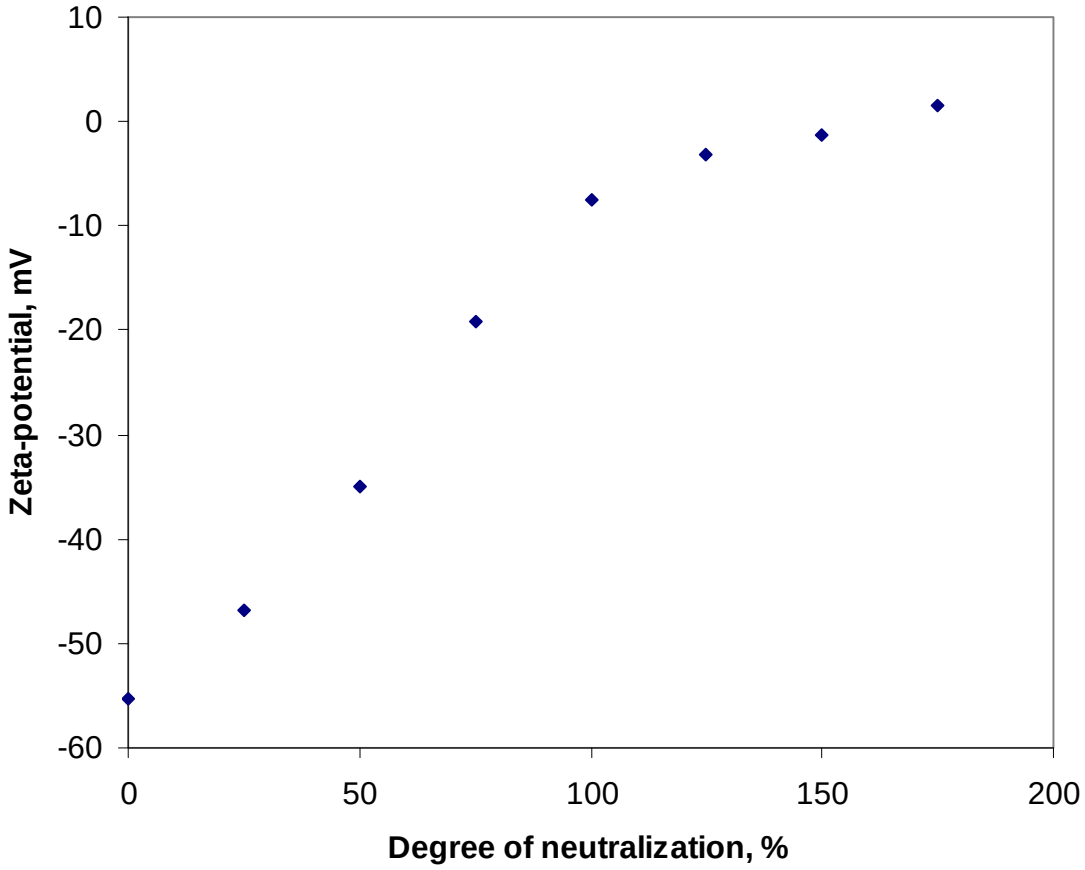

Fig. S2. Variation of zeta-potential due to charge neutralization of polyacrylic acid (COO^-) with La^{3+} ions.

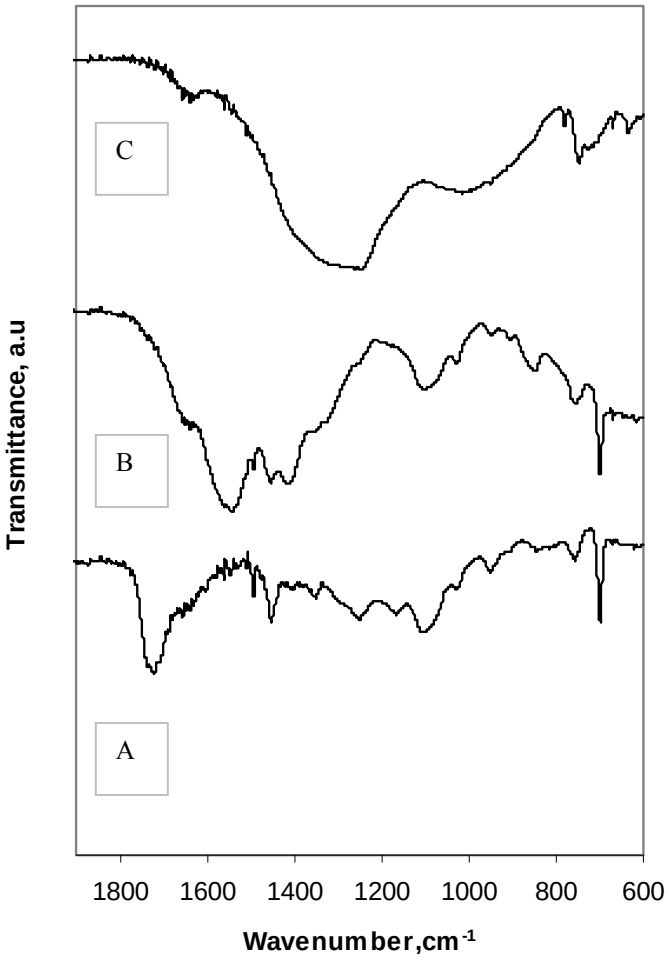

Fig. S3. FTIR spectra of: (A) PS-PAA-PEO, (B) PS-PAA-PEO + La^{3+}, and (C) La_2O_3 hollow nanosphere.

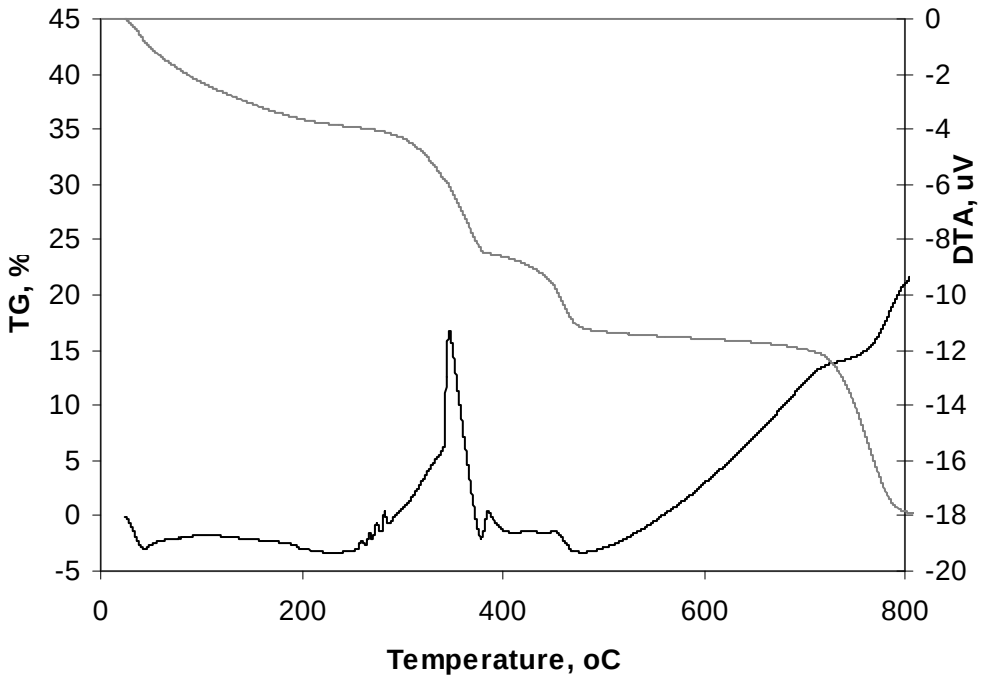

Fig. S4. TG/DTA curves of PS–PAA–PEO/La_2O_3 composite particles

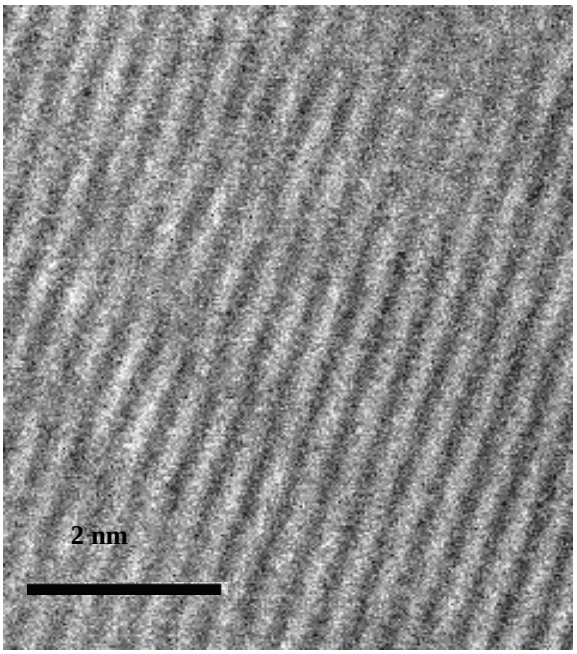

Fig. S5. High-resolution TEM of sample B.

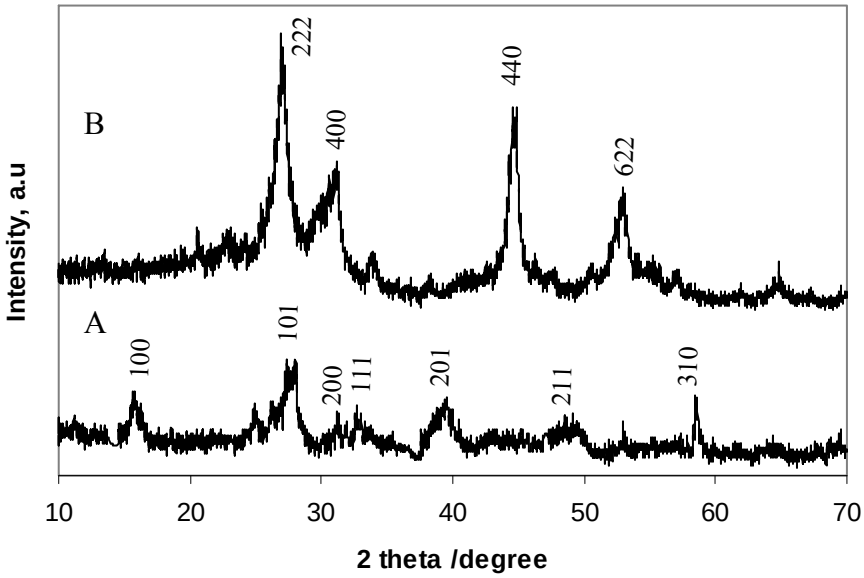

Fig. S6. XRD patterns of: (A) dried composite particles ($La(OH)_3$) and (B) calcined La_2O_3 hollow nanospheres.

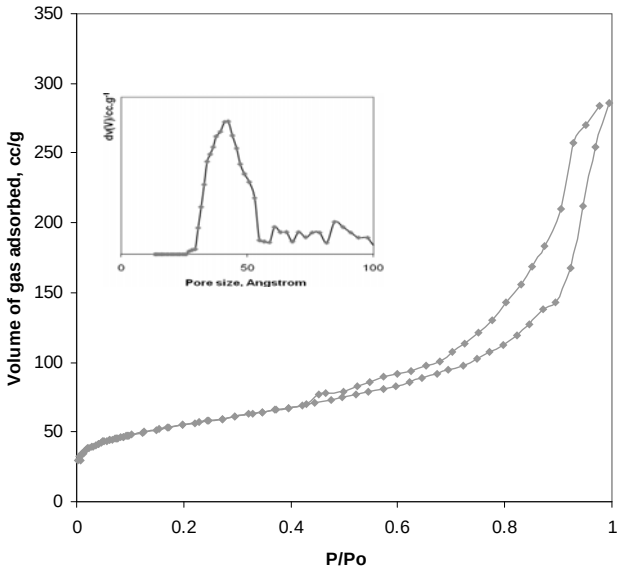

Figure S7. Nitrogen adsorption/desorption isotherms of La_2O_3 (La:PAA = 8); Inset figure represents BJH pore-size distribution curve.

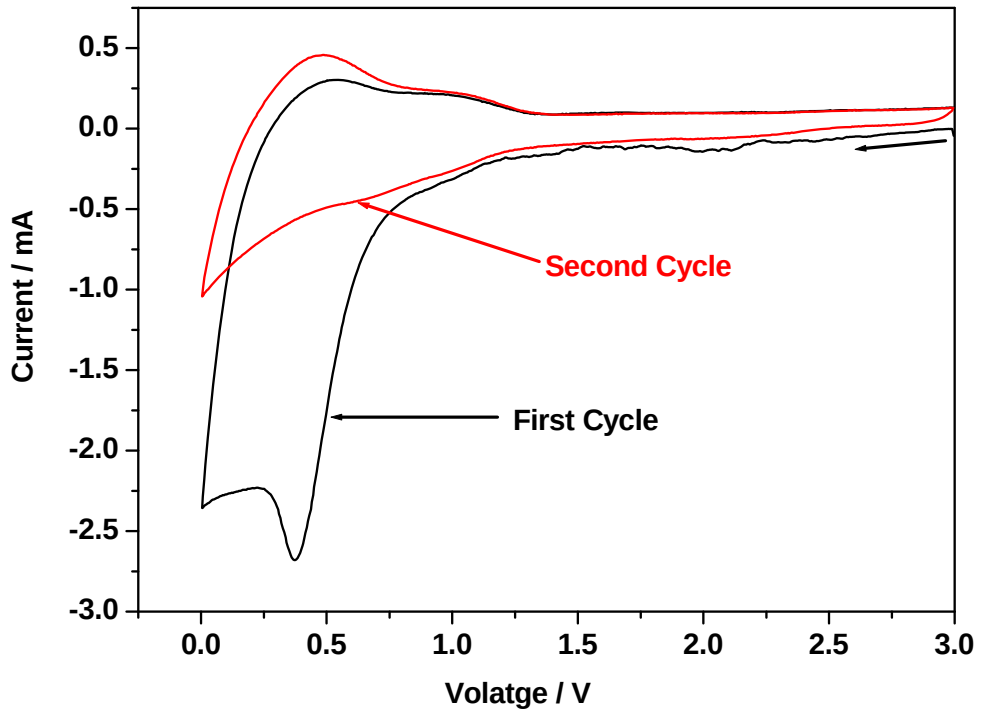

Fig. S8: Cyclic voltammogram of hollow La_2O_3 nanospheres at a 20mV/min sweep rates in the range of 0.005-3.0 V. Reference and counter electrodes are lithium foils.