Angewandte Chemie
Eine Zeitschrift der Gesellschaft Deutscher Chemiker

Supporting Information

© Wiley-VCH 2014

69451 Weinheim, Germany

Elastic and Wearable Wire-Shaped Lithium-Ion Battery with High Electrochemical Performance**

Jing Ren, Ye Zhang, Wenyu Bai, Xuli Chen, Zhitao Zhang, Xin Fang, Wei Weng, Yonggang Wang, and Huisheng Peng**

anie_201402388_sm_miscellaneous_information.pdf
anie_201402388_sm_video_s1.avi
anie_201402388_sm_video_s2.avi

Supporting Information

Supporting Videos

Video S1. The wire-shaped battery was used to power five light emission diode under bending.

Video S2. The wire-shaped battery was used to power a light emission diode under stretch with increasing strains.

Experimental Section

The structures were characterized by scanning electron microscopy (Hitachi FE-SEM S-4800 operated at 1 KV), transmission electron microscopy (JEOL JEM-2100F operated at 200 KV) and X-ray diffraction (Bruker AXS D8). The electrochemical performances were measured by an Arbin electrochemical station (MSTAT-5V/10mA/16Ch). The mechanical measurements of the stretchable battery were performed at HY-0350, Shanghai Hengyi Testing Instruments Co. LTD.

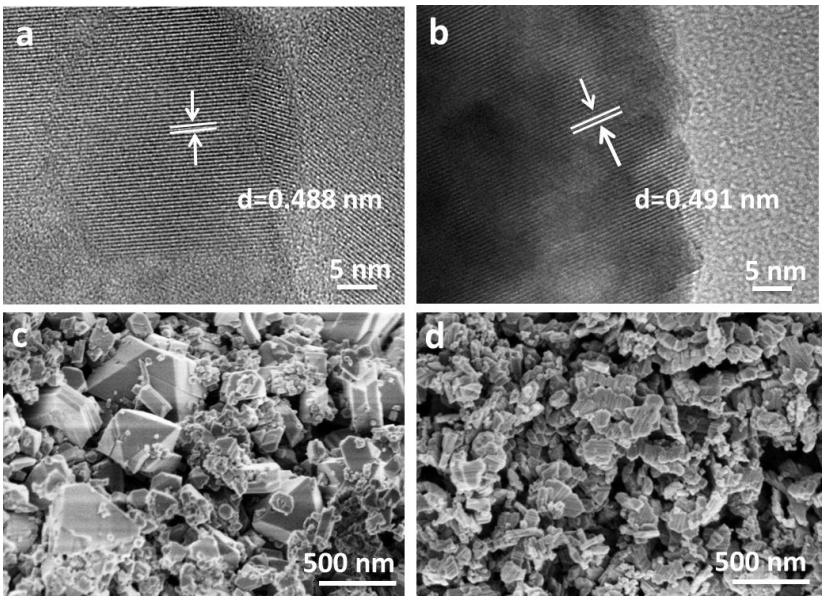

Figure S1. Structures of the active materials. **a** and **b,** TEM images of LTO and LMO nanoparticles, respectively. **c** and **d,** SEM images of LTO and LMO nanoparticles, respectively.

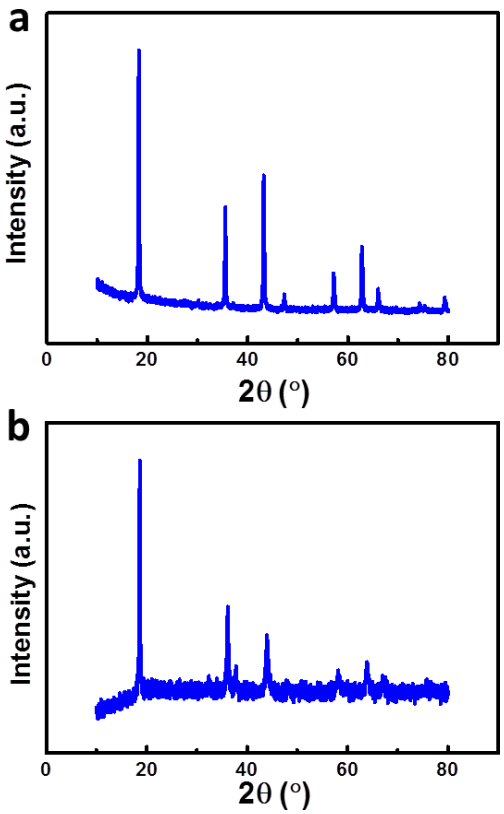

Figure S2. X-ray diffraction patterns of the LTO (**a**) and LMO (**b**) nanoparticles, respectively.

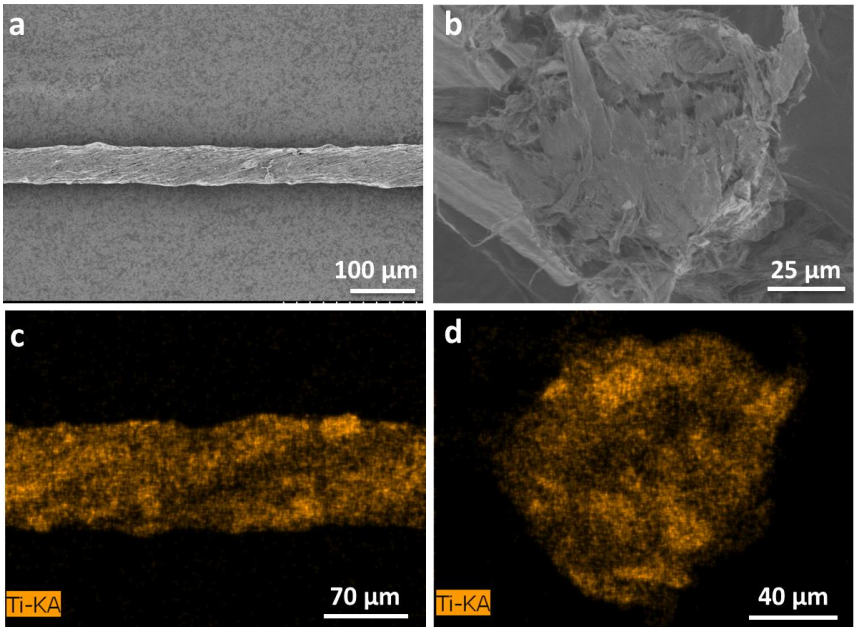

Figure S3. Aligned MWCNT/LTO composite yarn. **a** and **b,** SEM images by side and cross-sectional views, respectively. **c** and **d,** Energy-dispersive X-ray spectroscopy images by side and cross-sectional views, respectively. Here titanium is marked with orange.

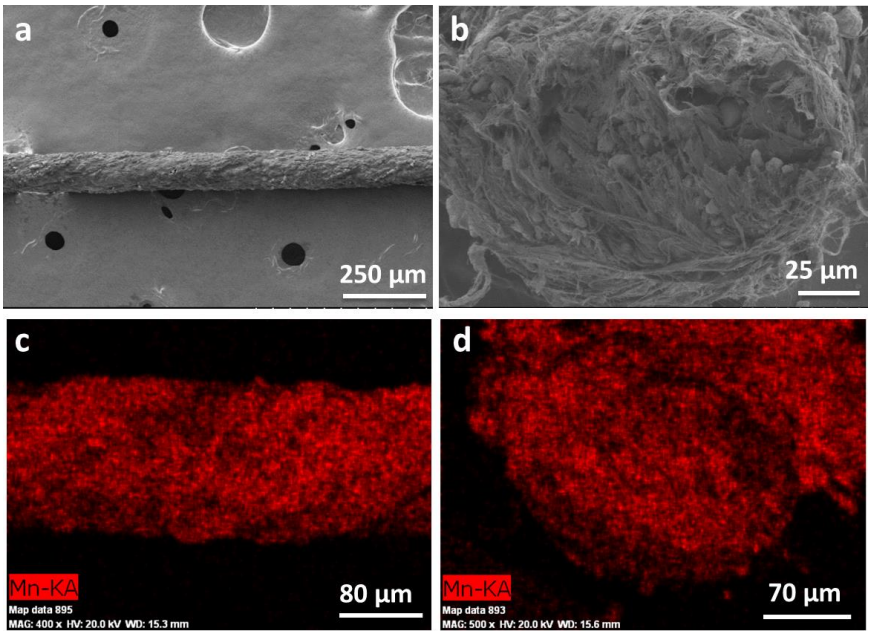

Figure S4. Aligned MWCNT/LMO composite yarn. **a** and **b,** SEM images by side and cross-sectional views, respectively. **c** and **d,** Energy-dispersive X-ray spectroscopy images by side and cross-sectional views, respectively. Here manganese is marked with red.

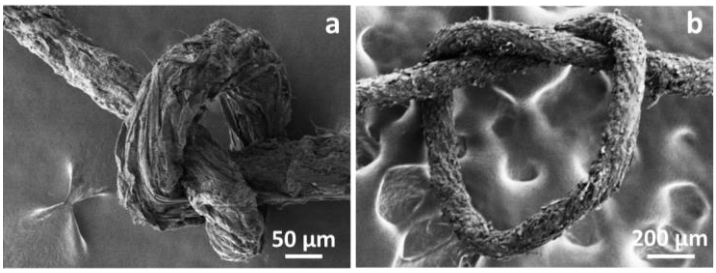

Figure S5. **a** and **b,** SEM images of the knotted fiber-shaped MWCNT/LTO and MWCNT/LMO composite yarns, respectively.

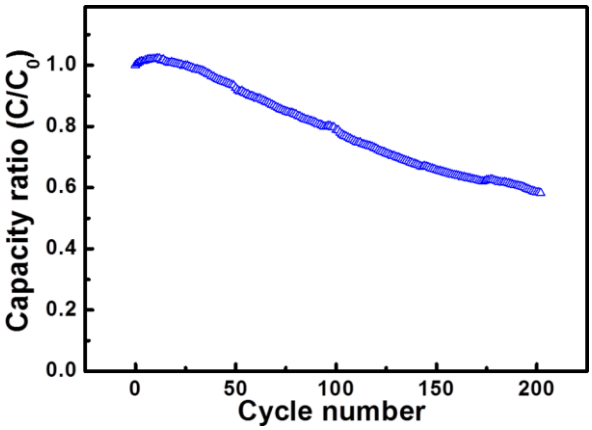

Figure S6. A half-cell based on the aligned MWCNT/LTO composite yarn electrode without graphene oxide versus lithium wire. The charge-discharge processes were performed at a current of 0.05 mA for 200 cycles.

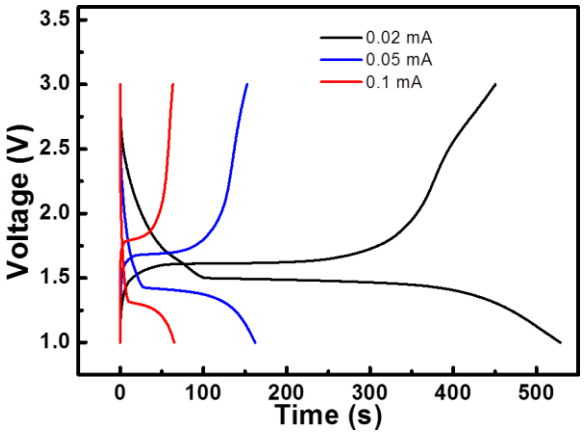

Figure S7. Charge and discharge profiles of a half-cell based on the aligned MWCNT/LTO composite yarn electrode (length of 1 cm) versus lithium wire. They were obtained at increasing currents from 0.02 and 0.05 to 0.1 mA.

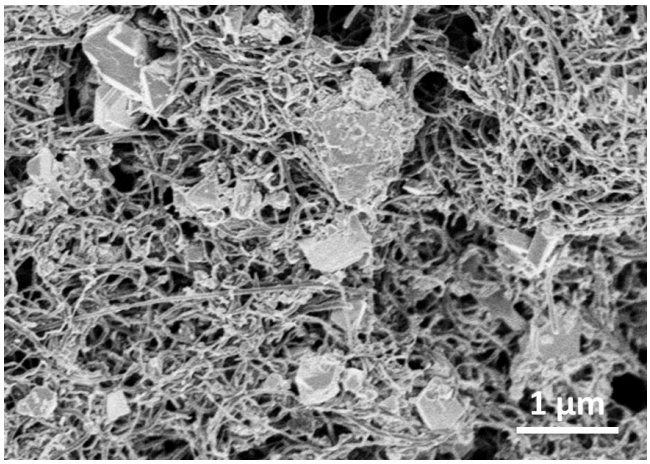

Figure S8. SEM image of LMO nanoparticles onto aligned MWCNTs before rolled into the yarn.

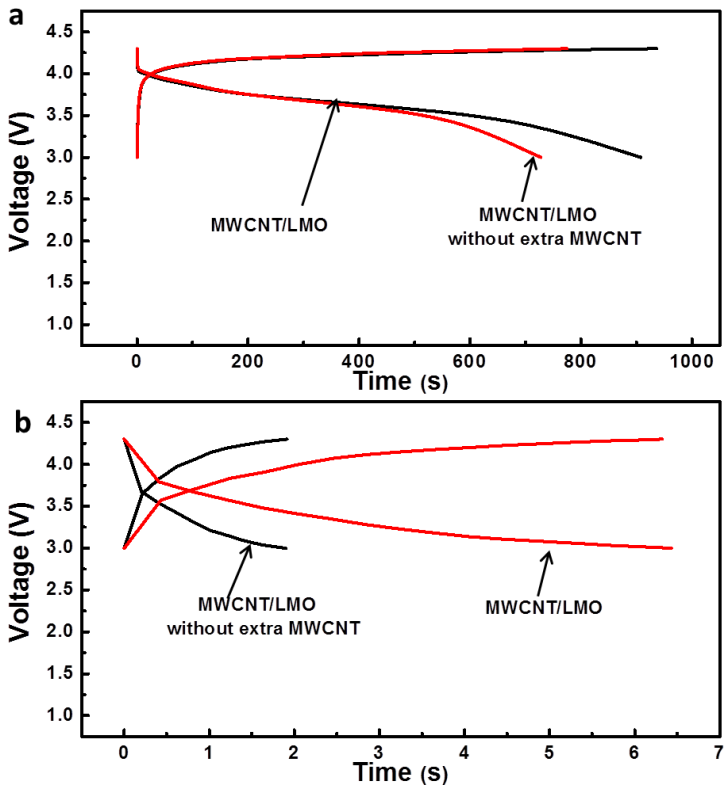

Figure S9. Electrochemical performances of a half-cell based on the aligned MWCNT/LMO composite yarn electrode (length of 1 cm) versus lithium wire before and after mixture of MWCNT powders. **a,** Charge and discharge profiles at a current of 0.02 mA. **b,** Charge and discharge profiles at a current of 0.1 mA.

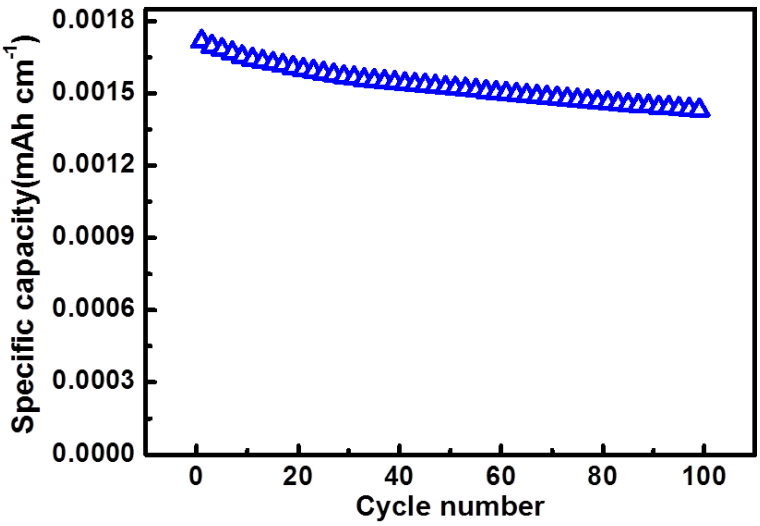

Figure S10. Capacity-cycle number curve of the wire-shaped full cell at 0.05 mA.

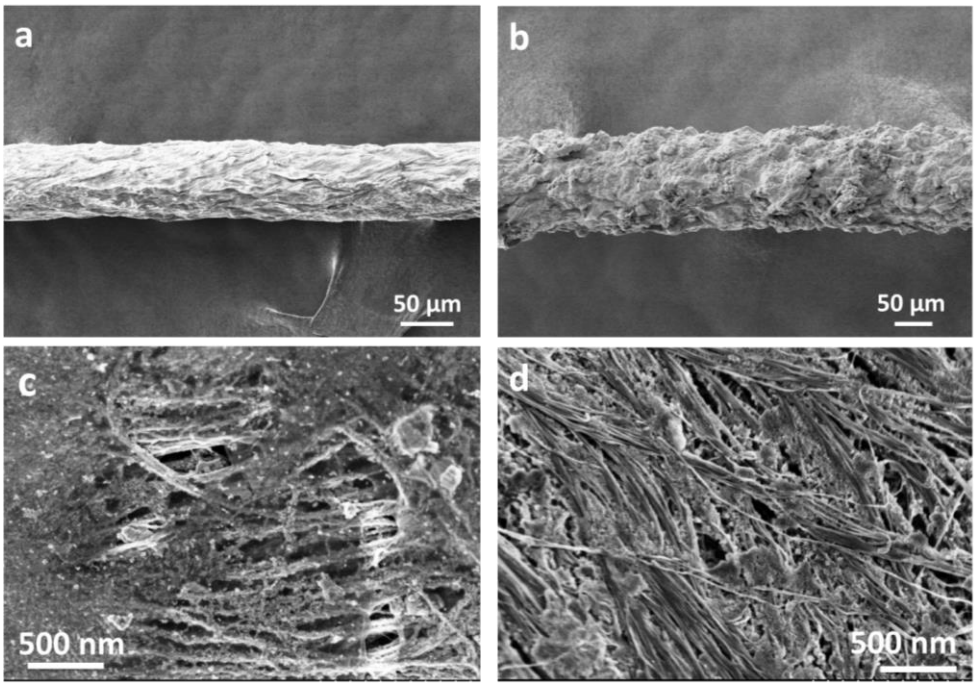

Figure S11. Structure characterization of the fiber-shaped electrodes after charge-discharge at 0.02 mA for 20 cycles. **a** and **b,** SEM images of MWCNT/LTO and MWCNT/LMO composite yarns at low magnifications, respectively. **c** and **d,** SEM images of the MWCNT/LTO and MWCNT/LMO composite yarns at high magnifications, respectively.

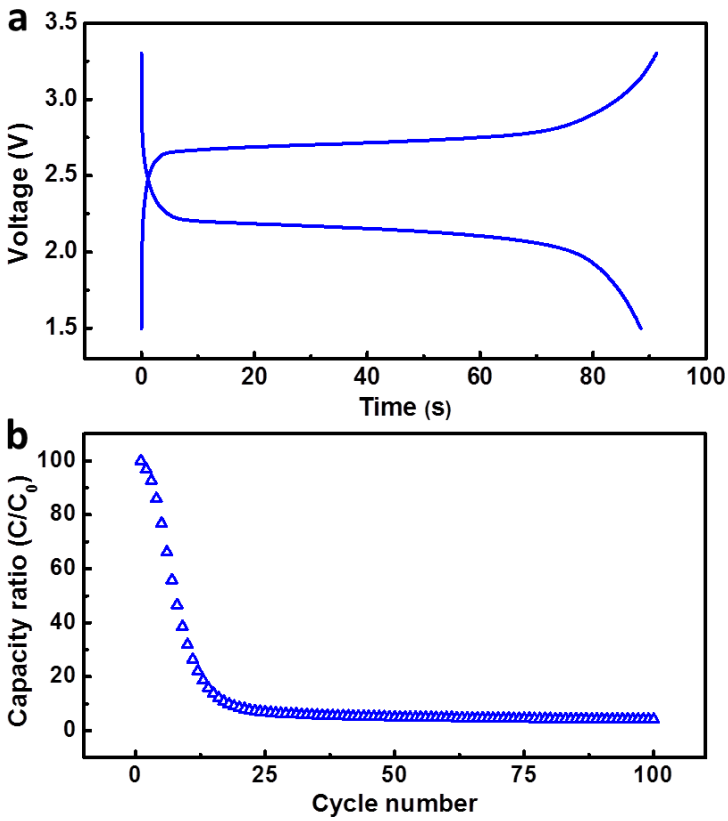

Figure S12. Electrochemical performances of a full cell at 0.1 mA. **a,** Charge and discharge profiles of a full cell (length of 1 cm) fabricated from the MWCNT/LTO and MWCNT/LMO composite yarn electrodes at the first cycle at a current of 0.1 mA. **b,** Characterization on the stability of the full cell at a current of 0.1 mA for 100 cycles.

Figure S13. Photograph of a cycled battery ring to light up a light emission diode.

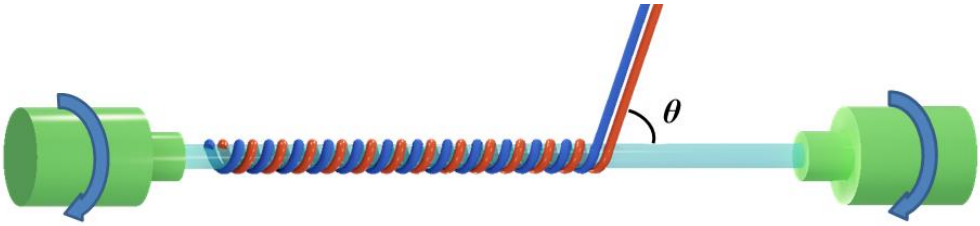

Figure S14. Schematic illustration to the fabrication of the super-stretchy lithium ion battery based on the aligned MWCNT/LTO and MWCNT/LMO composite yarns as the anode and cathode, respectively.

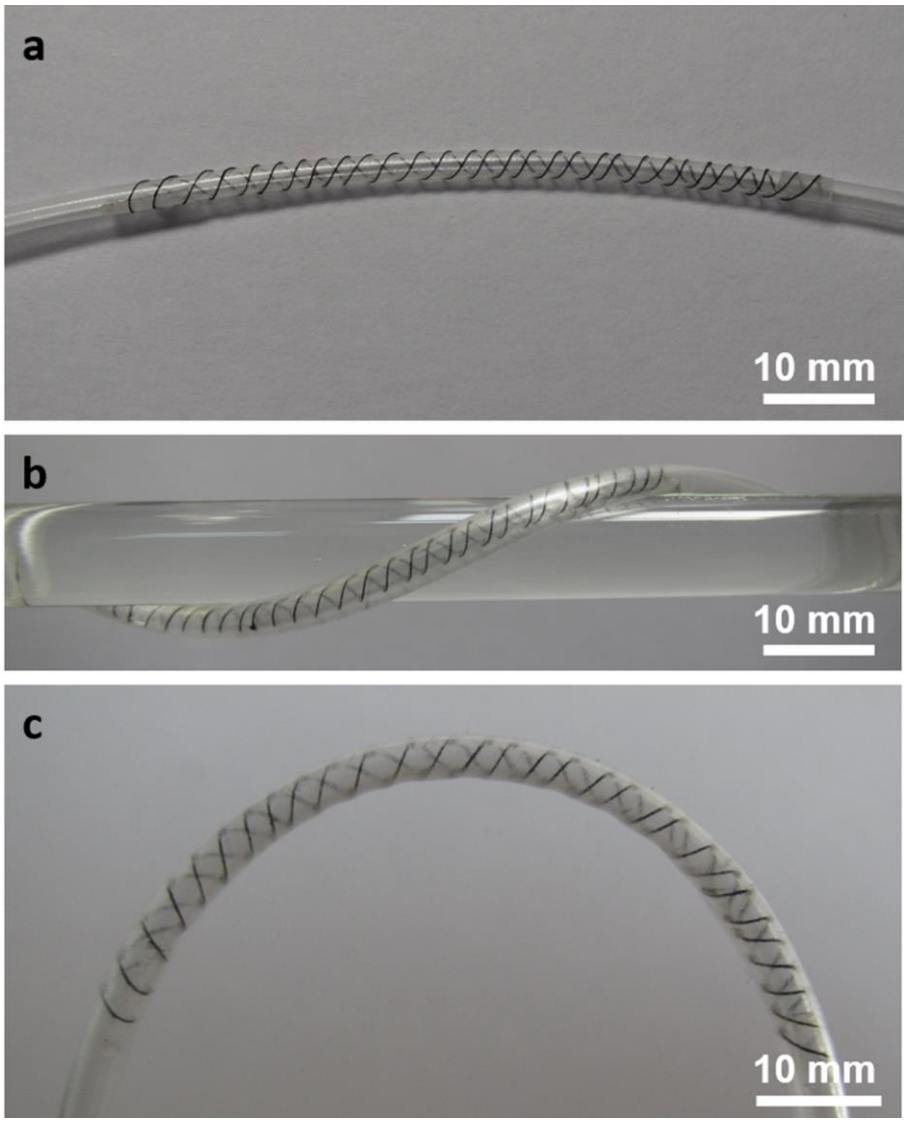

Figure S15. Photographs of the super-stretchy wire-shaped battery being deformed into various morphologies.

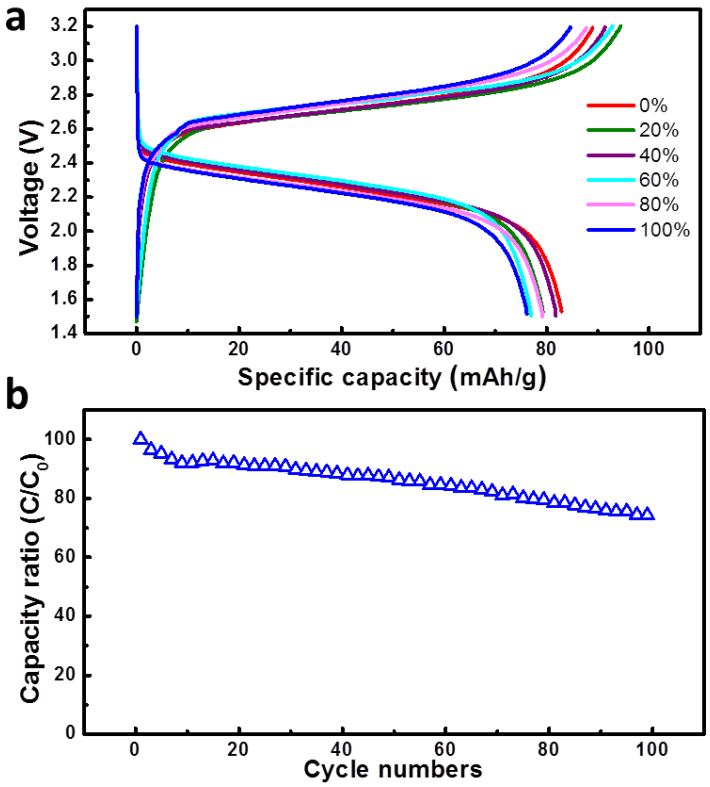

Figure S16. **a.** Charge and discharge profiles of the stretchable wire-shaped battery with increasing strains from 0%, 20%,40%,60%,80% to 100% at a current density of 0.01 mA/cm. **b**. Long-life capacity retention of the stretchable wire-shaped battery at a stretched state with strain of 100% at 0.05 mA.

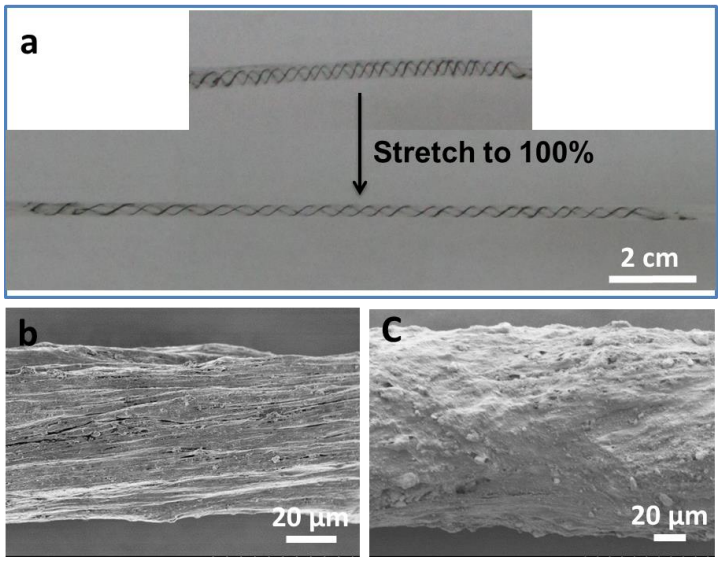

Figure S17. **a,** Photograph of a battery being stretched with the strain of 100%. **b,** and **c,** SEM images of an MWCNT/LTO cathode and an MWCNT/LMO anode after stretching at **a**, respectively.

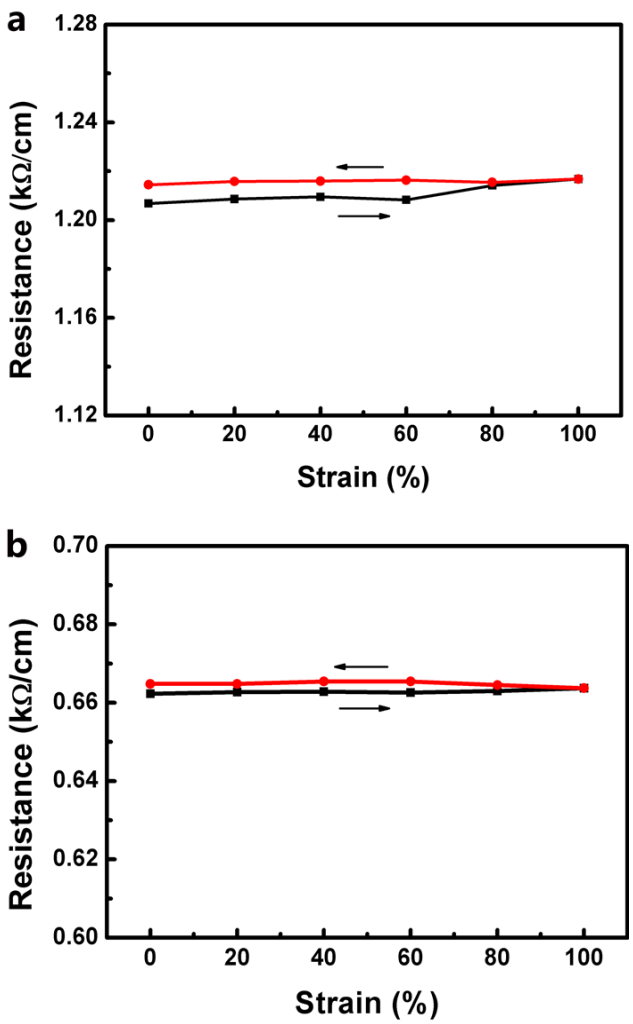

Figure S18. **a** and **b,** Resistance changes of the cathode and anode during the stretching and releasing process at a strain of 100%, respectively.

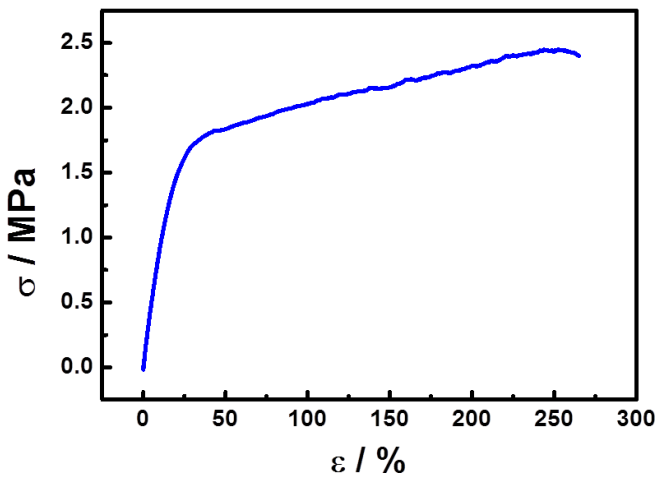

Figure S19. Stress-strain curve of the packing sheath layer.