

Electronic Supplementary Information

Ultrafine potassium titanate nanowires: a new Ti-based anode for sodium ion battery

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Experimental Information

Preparation of $K_2Ti_6O_{13}$ nanowire

$K_2Ti_6O_{13}$ nanowire was synthesized via a hydrothermal method using potassium hydroxide and tetrabutyl titanate as the potassium and titanium sources, respectively. In a typical procedure, 4.0g potassium hydroxide was dissolved in 20 mL mili Q water, and 2 mM tetrabutyl titanate was dissolved 20 mL ethylene glycol, respectively. Then, the tetrabutyl titanate solution was added into the potassium hydroxide solution slowly and stirred for 1 h. The mixed solution was transferred into in a Teflon-lined stainless steel autoclave and kept at 200 °C for 14 h. After cooled to room temperature, the precipitate was collected by centrifugation, washed with deionized water and ethyl alcohol for several minutes until the pH value of 7 and then dried at 60 °C for 12 h under ambient conditions. For the contrast, the bulk $K_2Ti_6O_{13}$ was prepared by solid state method of anatase TiO_2 and KNO_3 powder. The precursors were grinded manually in a mortar for 10 min and calcined in air at 700 °C for 10 h. The $K_2Ti_6O_{13}$ nanowires was heat treated at 800 °C for 10 h.

Characterizations of the samples

Powder X-ray diffraction (PXRD) patterns were recorded at room temperature with a PANalytical B.V. Empyrean diffractometer. The morphology of the product was examined by scanning electron microscopy (SEM, FEI Sirion 200) and high-resolution transmission electron microscopy (HRTEM, FEI Tecnai G2 F30). Fourier transform infrared (FTIR) spectra was recorded in the range 400 to 4000 cm^{-1} using a Bruker VERTEX 70FTIR spectrometer.

Electrochemical tests

Electrochemical measurements were performed using 2032 coin-type cells with thin sodium metal used as both the reference and counter electrodes. 1 M sodium sodium hexafluorophosphate ($NaPF_6$) in EC (Ethylene Carbonate): DEC (Dimethyl Carbonate) with FEC (Fluoro Ethylene Carbonate) was used as electrolyte. The $K_2Ti_6O_{13}$ electrodes were fabricated by mixing 70 wt.% of the active material, 20 wt.% of C45, and 10 wt.% poly (vinylidene fluoride) (PVDF) in N-methyl-2-Pyrrolidone (NMP). The obtained slurries were coated uniformly onto copper foils and then dried in a vacuum oven at 80 °C for 12 h to remove the solvent before pressing. Finally, the electrode film was punched into disks 10 mm in diameter for half cell tests. Cyclic voltammetry (CV) studies were carried out at room temperature using CHI660e electrochemical workstation at a scan rate of 0.1 $mV s^{-1}$ in the voltage window 0.01–3 V vs. Na^+/Na . Galvanostatic charge/discharge measurements were performed in a voltage range of 0.01–3 V vs. Na^+/Na at different current densities on the automatic battery testing system LAND CT2001A model.

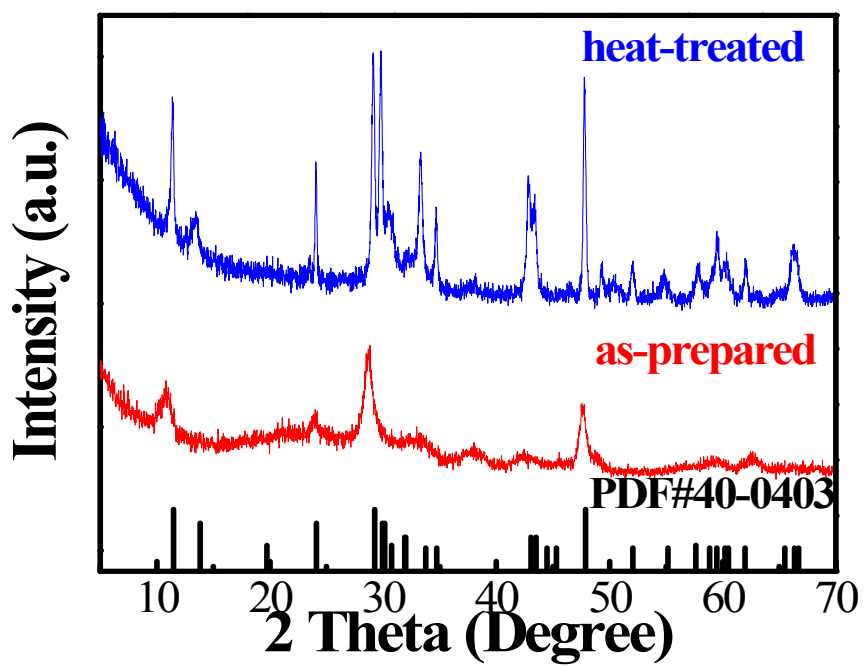


Figure S1. XRD patterns of as-prepared and heat treated sample.

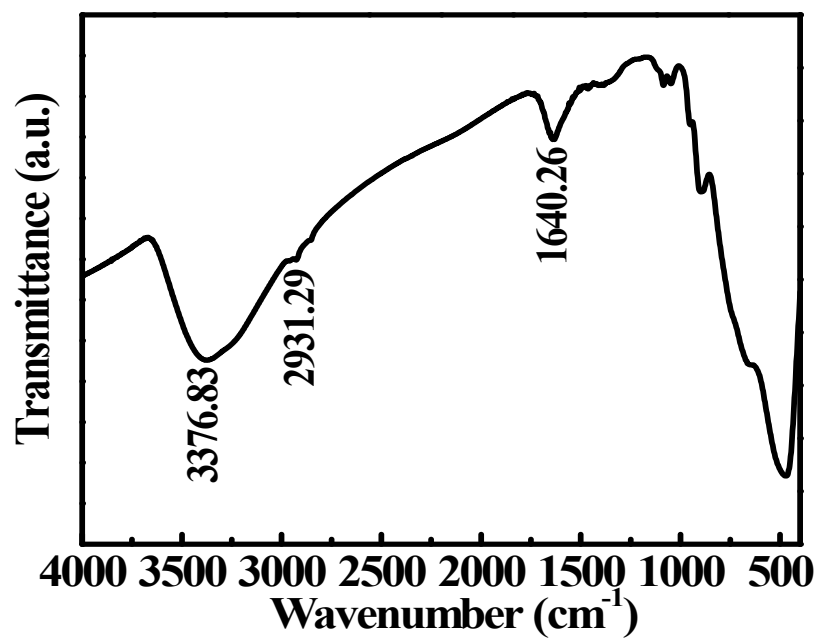


Figure S2. FT-IR spectrum of the as-prepared $K_2Ti_6O_{13}$.

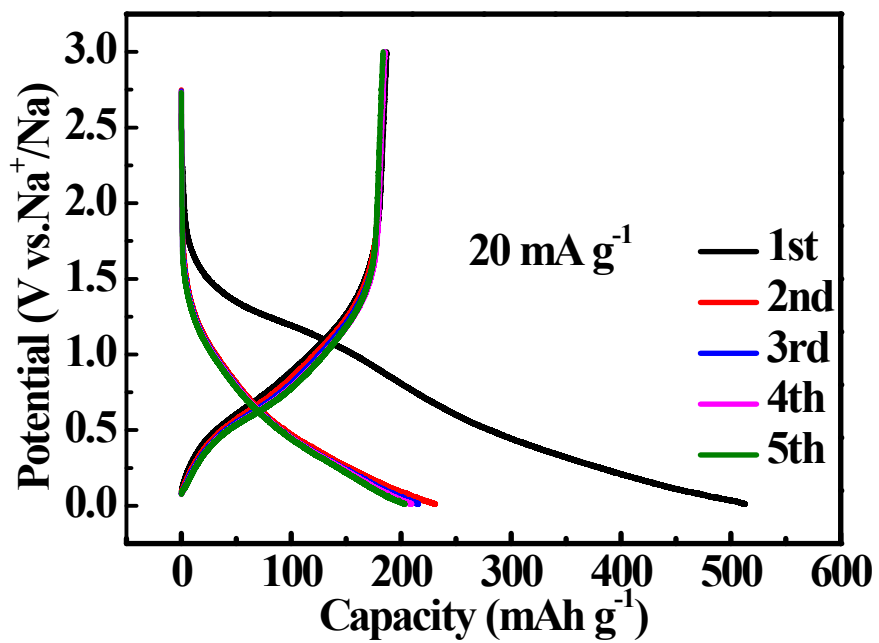


Figure S3. The charge and discharge curves at the current density of 20 mA g⁻¹.

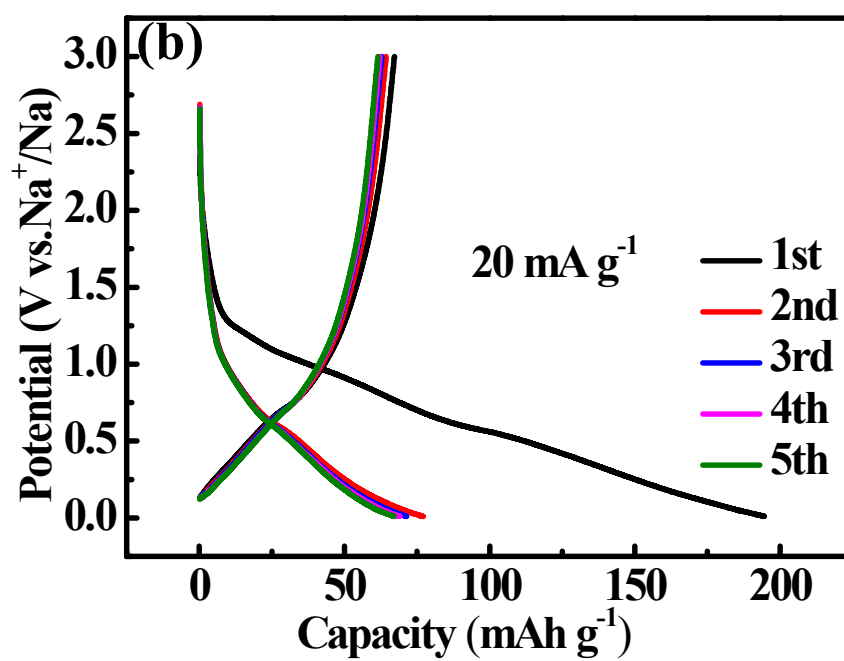
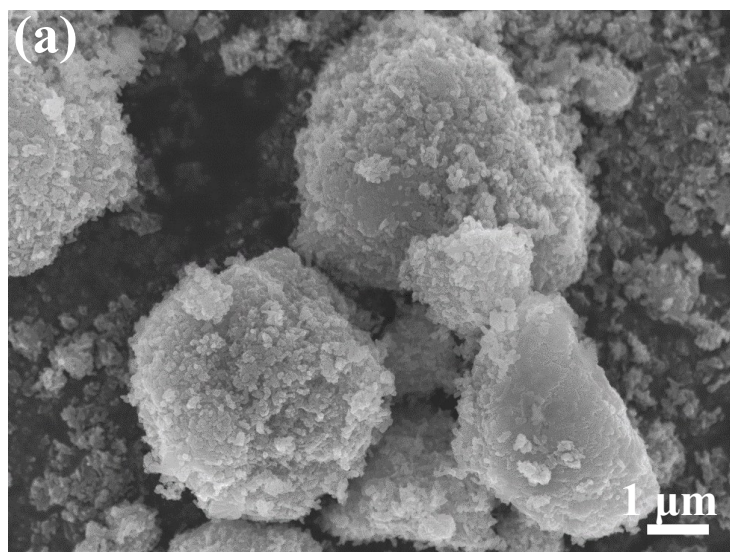


Figure S4. (a) SEM image and (b) charge and discharge curves of bulk $K_2Ti_6O_{13}$.

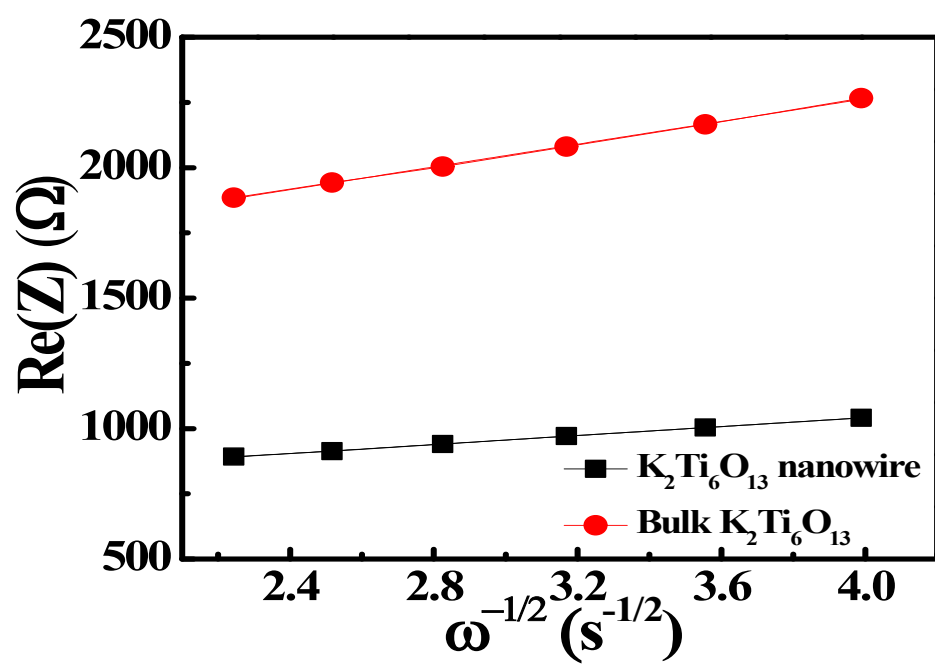


Figure S5 The plots of the real parts of the complex impedance versus $\omega^{-1/2}$.

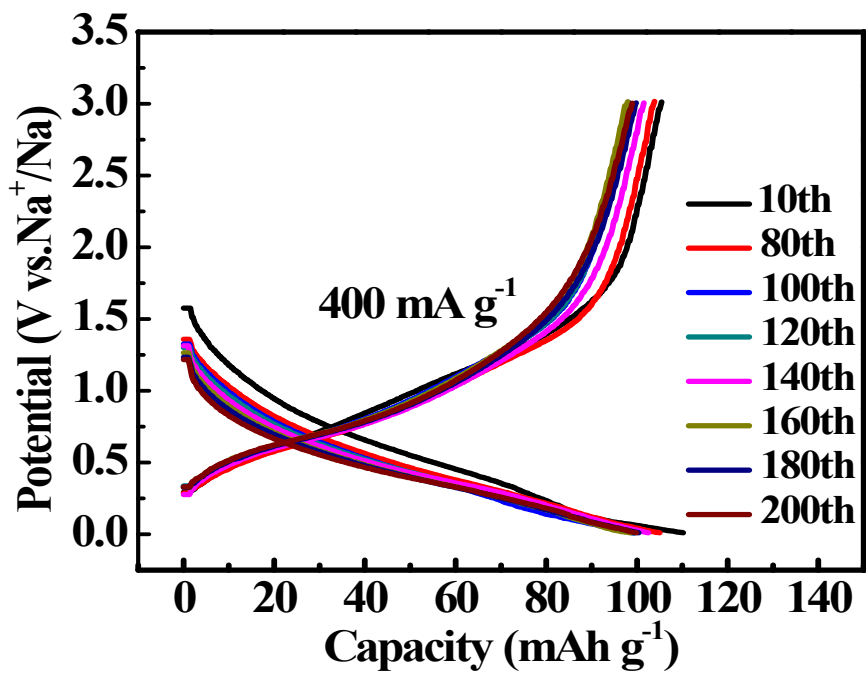


Figure S6. The charge and discharge curves at the current density of 400 mA g⁻¹.

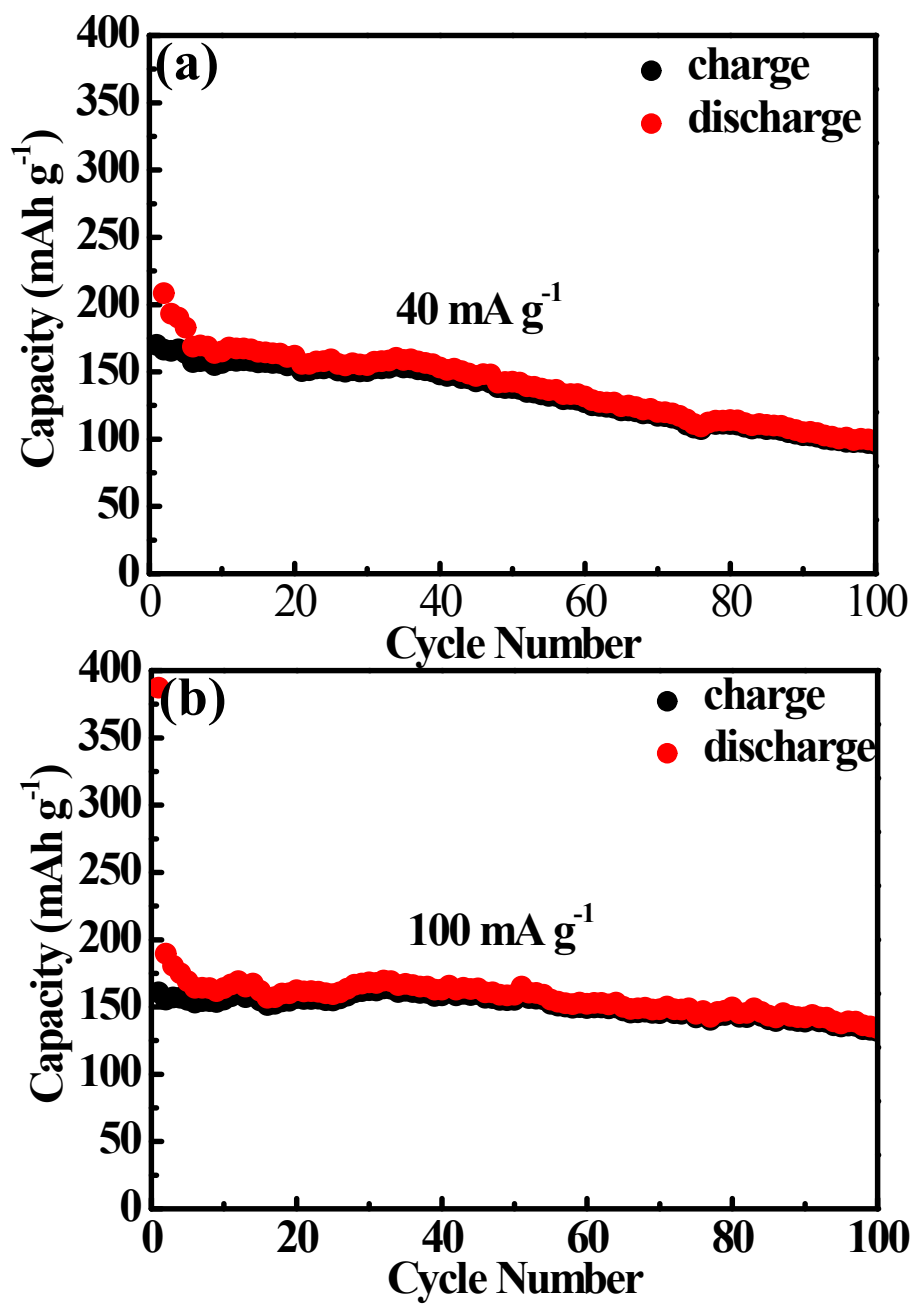


Figure S7. The cycling performance at current densities of 40 mA g⁻¹ and 100 mA g⁻¹, respectively.

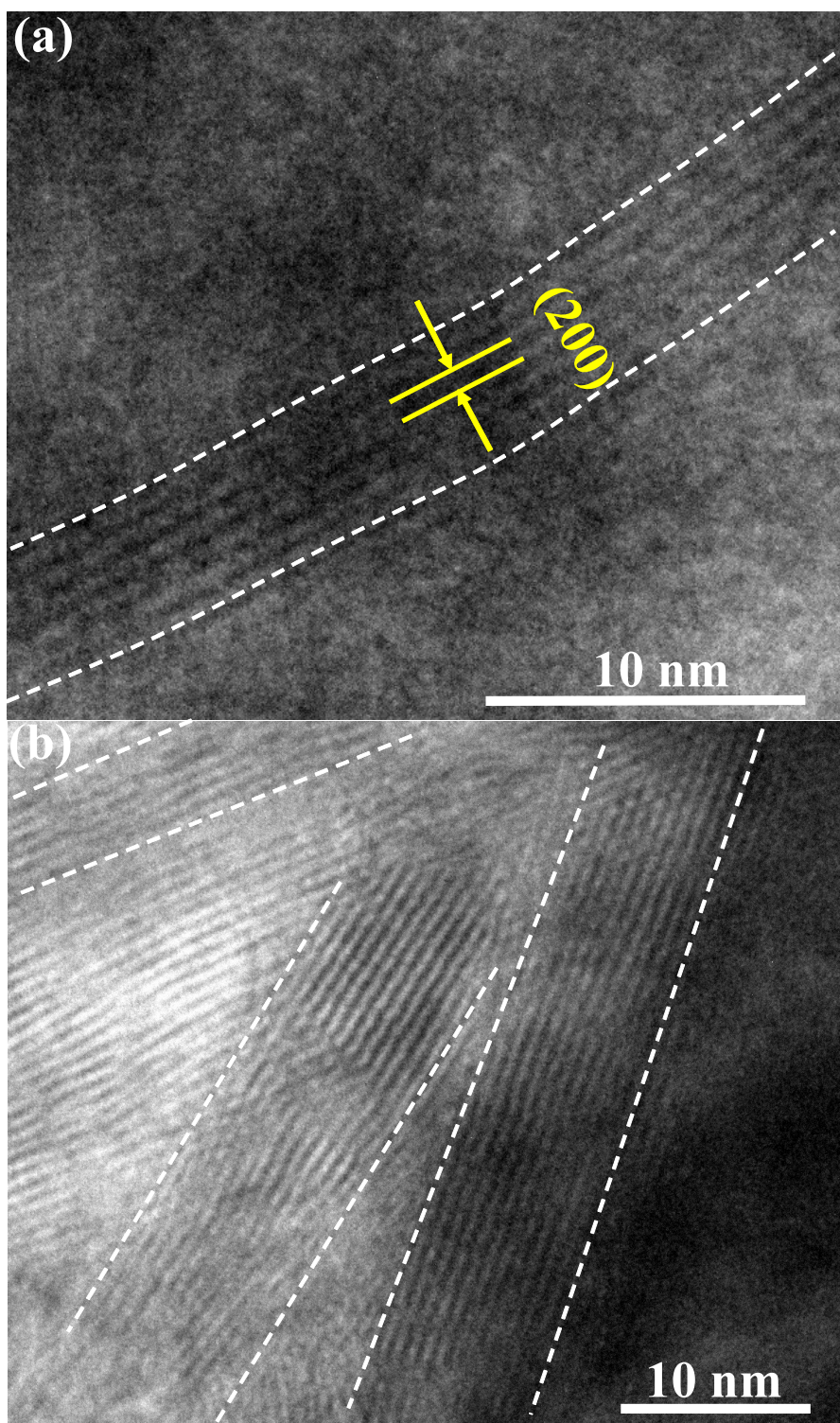


Figure S8. TEM images of $\text{K}_2\text{Ti}_6\text{O}_{13}$ nanowires electrode after 50 cycles at 400 mA g^{-1} .