

Electronic Supplementary Information (ESI)

Graphene oxide supported sodium stannate lithium ion battery anodes by the peroxide route: Low temperature and no waste processing

A. A. Mikhaylov,^{a,b} A. G. Medvedev,^{a,b} C. W. Mason,^c A. Nagasubramanian,^{c,d,e} S. Madhavi,^{c,d,e} S. K. Batabyal,^d Q. Zhang,^e J. Gun,^b P. V. Prihodchenko*^{a,d} and O. Lev*^b

^aKurnakov Institute of General and Inorganic Chemistry, Russian Academy of Sciences, Leninskii prosp.31, Moscow 119991, Russia.

^bThe Casali Center of Applied Chemistry, The Institute of Chemistry, The Hebrew University of Jerusalem, Jerusalem 91904, Israel.

^cTUM CREATE, 1 CREATE Way, 10-02 Create Tower, Singapore 138602, Singapore.

^dEnergy Research Institute @ NTU, Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798, Singapore.

^eSchool of Materials Science and Engineering, Nanyang Technological University 50 Nanyang Avenue, Singapore 639798, Singapore

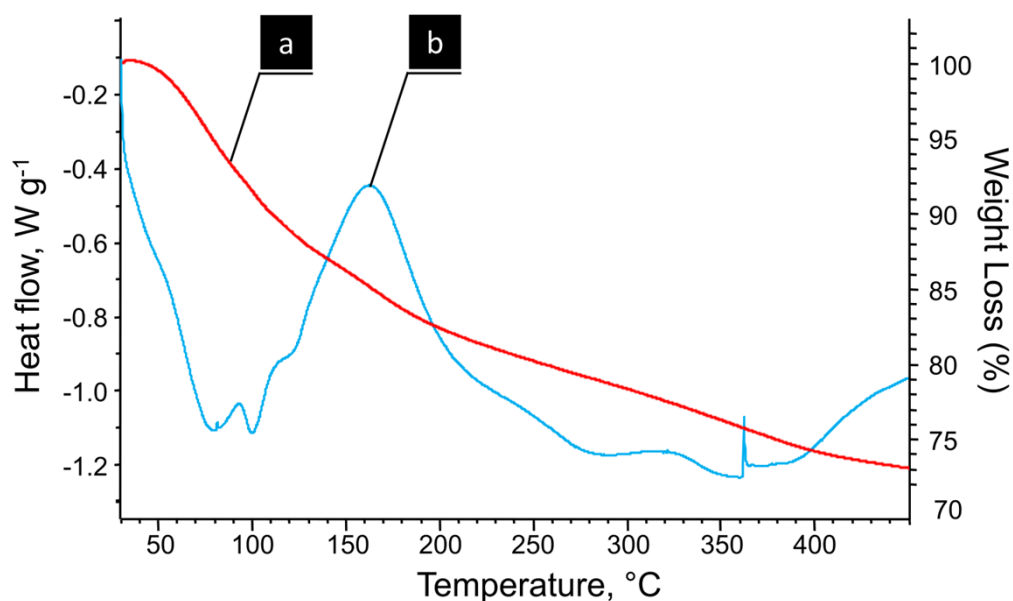


Fig. S1 Thermal analysis of GO supported sodium peroxostannate a) thermogravimetry, TG; b) differential scanning calorimetry, DSC

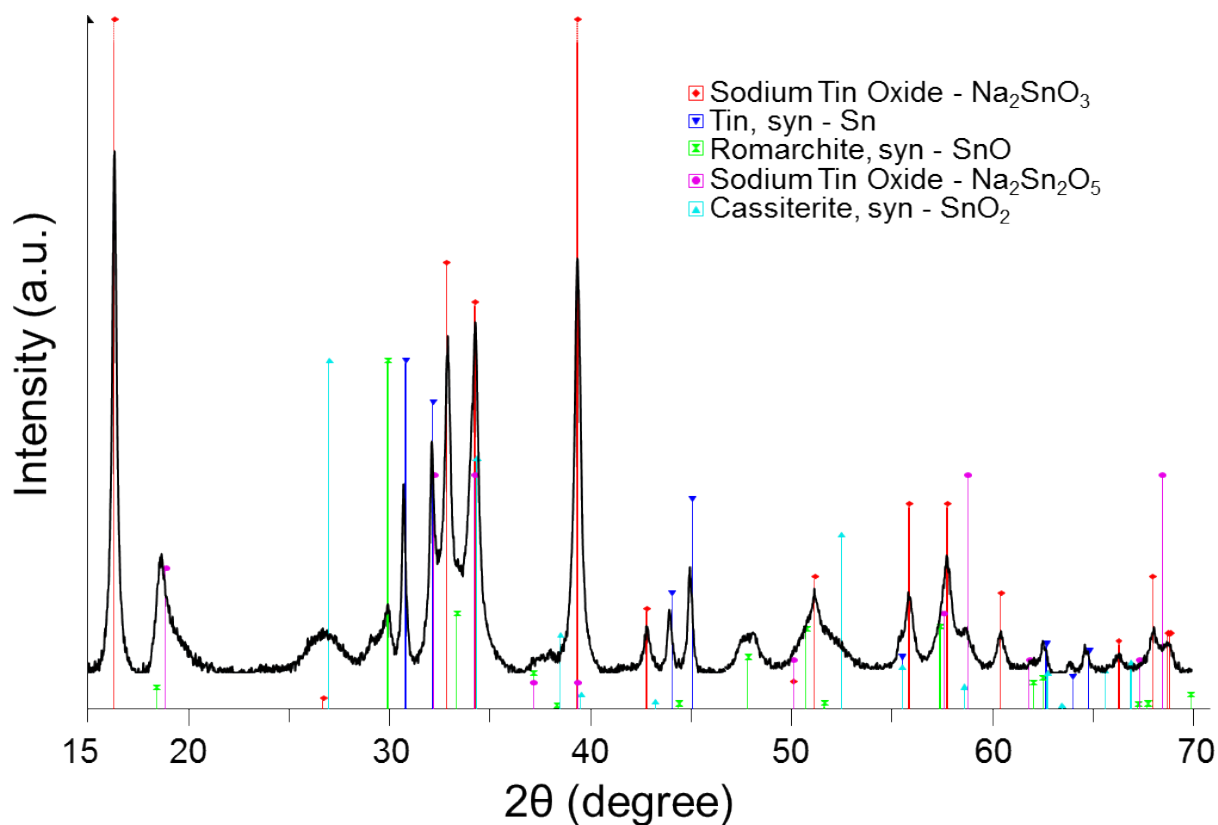


Fig. S2 X-ray diffractogram of sodium stannate heat treated in vacuum NaSnOx-GO500-2.

Results of phase analysis of NaSnOx-GO500-2.

00-030-1252 Sodium Tin Oxide Na_2SnO_3

Crystallite Size (Scherrer): 172.1 Å

System: Triclinic

Space group:

Cell param.: Initial Final

a: 3.64000 3.64414

b: 5.79600 5.78589

c: 2.81300 2.81308

alpha: 102.170 102.326

beta: 100.630 100.883

gamma: 72.830 72.883

04-003-5664 Tin Sn

Crystallite Size (Scherrer): 326.3 Å

System: Tetragonal

Space group: I41/amd (141)

Cell param.: Initial Final

a: 5.81510 5.81810

c: 3.17600 3.17666

04-008-7670 Romarchite SnO
Crystallite Size (Scherrer): 18.9 Å
System: Tetragonal
Space group: P4/nmm (129)
Cell param.: Initial Final
a: 3.80360 3.79625
c: 4.83850 4.83850

01-071-4819 Cassiterite SnO₂
Crystallite Size (Scherrer): 25.0 Å
System: Tetragonal
Space group: P42/mnm (136)
Cell param.: Initial Final
a: 4.68000 Fixed
c: 3.15000 Fixed
c: 3.15000 Fixed

00-021-1165 Sodium Tin Oxide Na₂Sn₂O₅
Crystallite Size (Scherrer): 116.7 Å

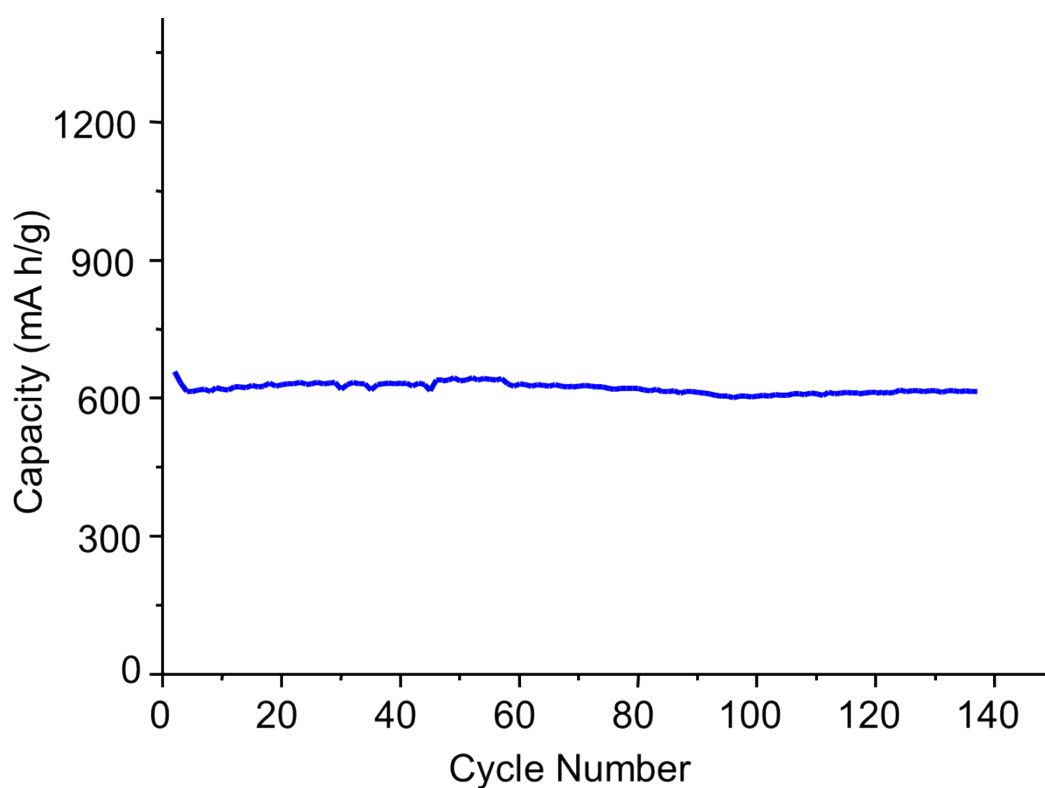


Fig. S3 Charge capacity of the NaSnO_x-GO400 anodes upon repeated cycling. The cycles were conducted at a rate of 100 mA g⁻¹ between 0–2.5 V vs. Li/Li⁺.

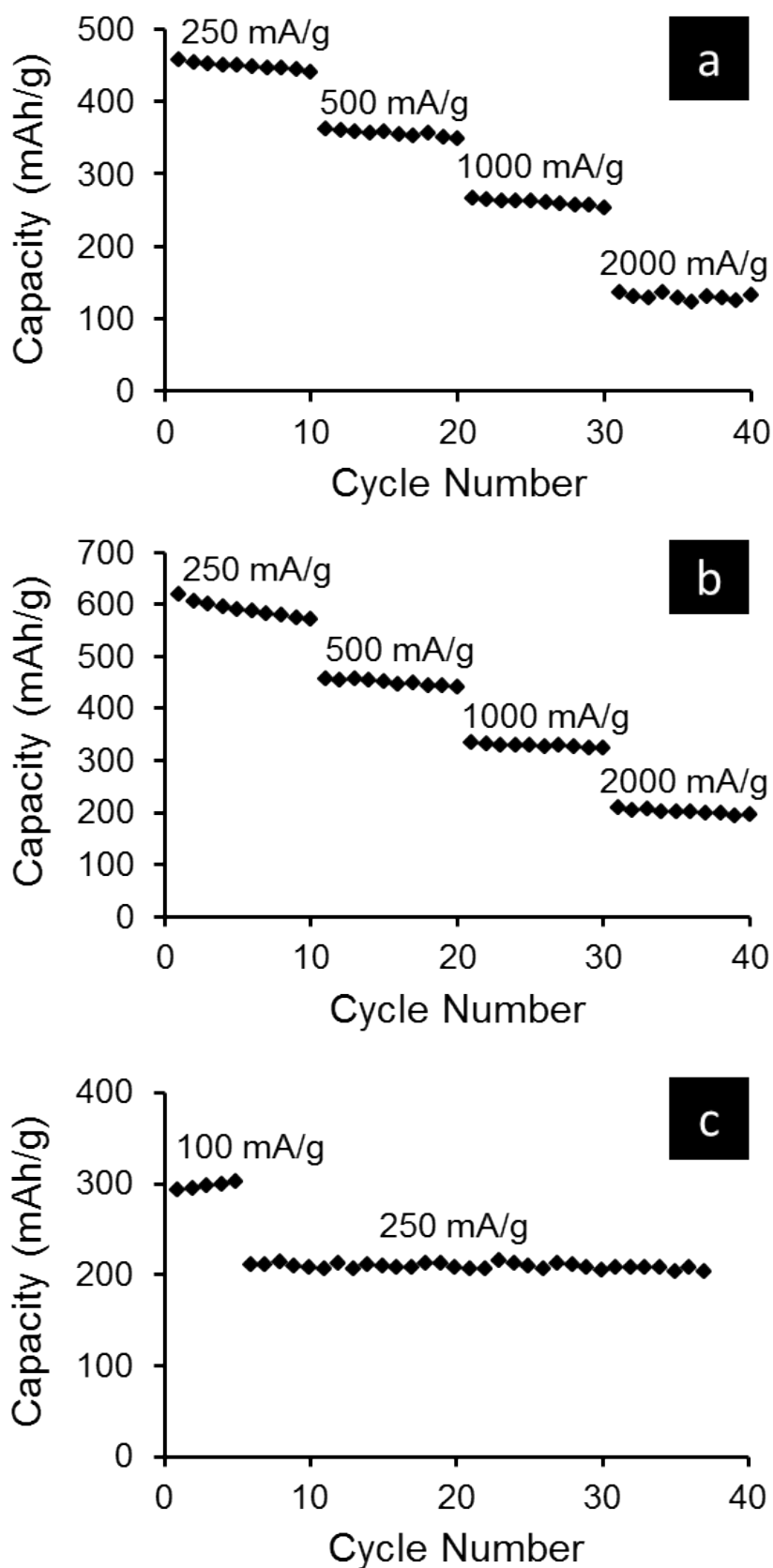


Fig. S4 Charging capacities of the NaSnO_x-GO400 anodes with different compositions 90% active material and 10% CMC without adding carbon (a), 80% active material, 10% CMC and 10% acetylene black (b), 80% active material and 20% CMC without adding carbon (c) conducted over the range 0–2.5 V vs. Li/Li⁺ electrode at different rates.

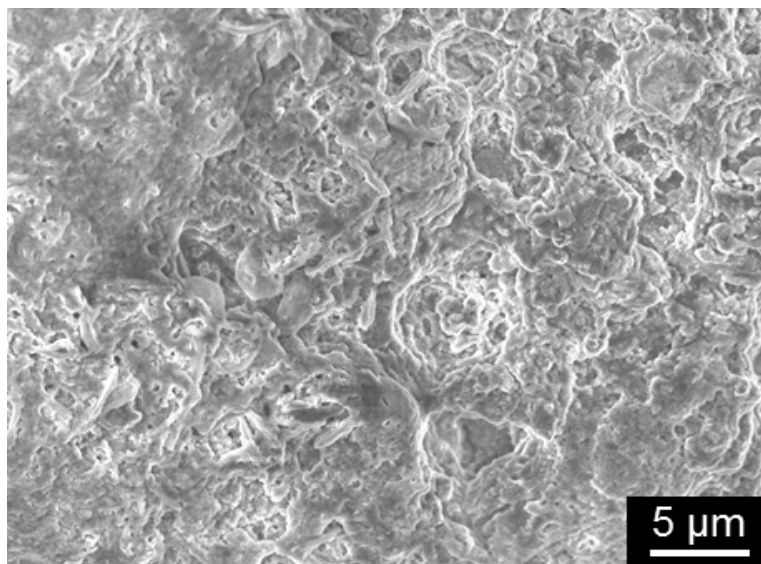


Fig. S5 STEM image of NaSnO_x-GO400 anode after cycling.

Experimental

Microscopies and spectroscopies.

High-resolution transmission electron microscope (HRTEM). We used a FEI Technai F20 G2 (Eindhoven, Holland) high-resolution transmission electron microscopes. HRTEM imaging was performed at 200 kV. A drop of the suspension of the sample in ethanol was deposited onto 400 mesh copper grids covered with a lacy carbon net.

High-resolution scanning electron microscope (HRSEM). HRSEM imaging was performed using a FEI Sirion high-resolution scanning electron microscope (Eindhoven, Holland). The accelerating voltage was set at 5–15 kV with a 5 mm working distance. Imaging was conducted using the high-resolution mode with a through-the-lens detector. The specimen was prepared by dispersion of dried samples in ethanol in an ultrasonic bath, and the suspension was then dropped on a silicon wafer to dry.

Scanning transmission electron microscope (STEM). STEM imaging was performed at 20 kV using a FEI extra high-resolution scanning electron microscope, MagellanTM 400L (Eindhoven, Holland). The specimen was prepared by deposition of a drop of the ethanol suspension of the sample onto 400 mesh copper grid.

X-ray photoelectron spectroscopy (XPS). XPS measurements were performed on a Kratos Axis Ultra x-ray photoelectron spectrometer (Manchester, UK). High-resolution spectra were acquired with a monochromated Al K α (1486.6 eV) x-ray source with 0° takeoff angle. The pressure in the test chamber was maintained at 1.7×10^{-9} Torr during the acquisition process.

Data analysis was performed with Vision processing data reduction software (Kratos Analytical Ltd) and CasaXPS (Casa Software Ltd).

X-ray powder diffraction (XRD). XRD measurements were performed on a D8 Advance Diffractometer (Bruker AXS, Karlsruhe, Germany) with a goniometer radius 217.5 mm, Gobel Mirror parallel-beam optics, 2° Soller slits and a 0.2 mm receiving slit. The powder samples were carefully filled into low-background quartz sample holders. The specimen weight was approximately 0.5 g. XRD patterns from 5° to 65° 2 θ were recorded at room temperature using Cu K α radiation ($\lambda = 1.5418$ Å) under the following measurement conditions: tube voltage of 40 kV, tube current of 40 mA, step scan mode with a step size 0.02° 2 θ and counting time of 2 s/step. XRD patterns were processed using Diffrac Plus software.