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Supplementary Information for

Inexpensive Colloidal SnSb Nanoalloys as Efficient Anode Materials for Lithium- and Sodium-Ion Batteries

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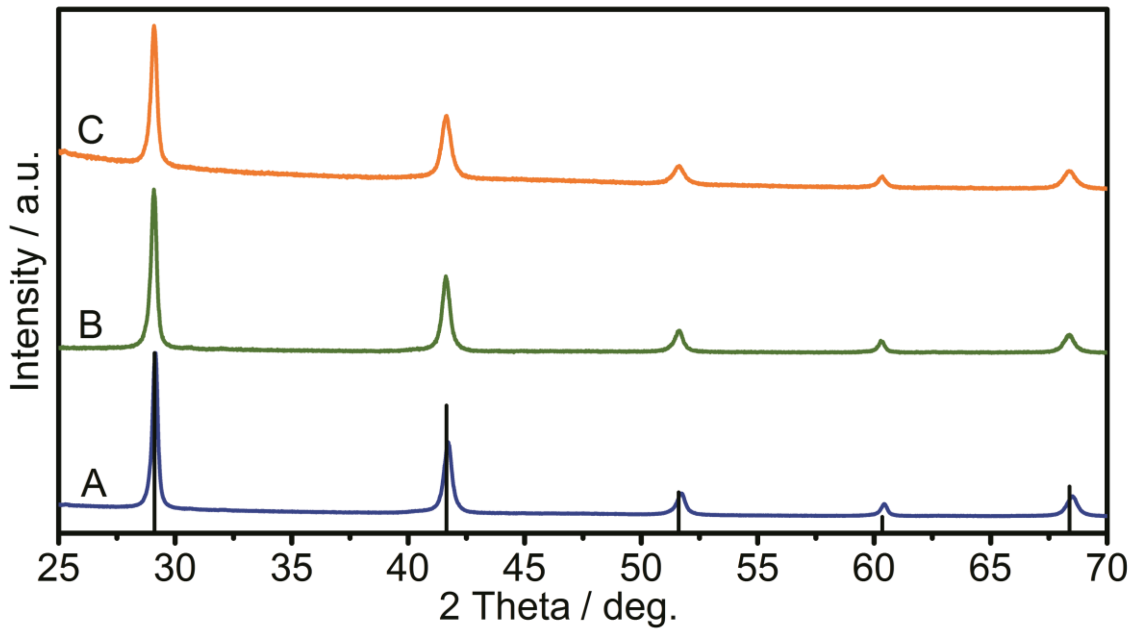

Figure S1. XRD patterns for (A) pristine SnSb NCs, (B) SnSb NCs after storage under ambient conditions for 8 months and (C) electrode material containing SnSb NCs, carbon black and CMC (indexed to cubic SnSb, COD entry 9008724).

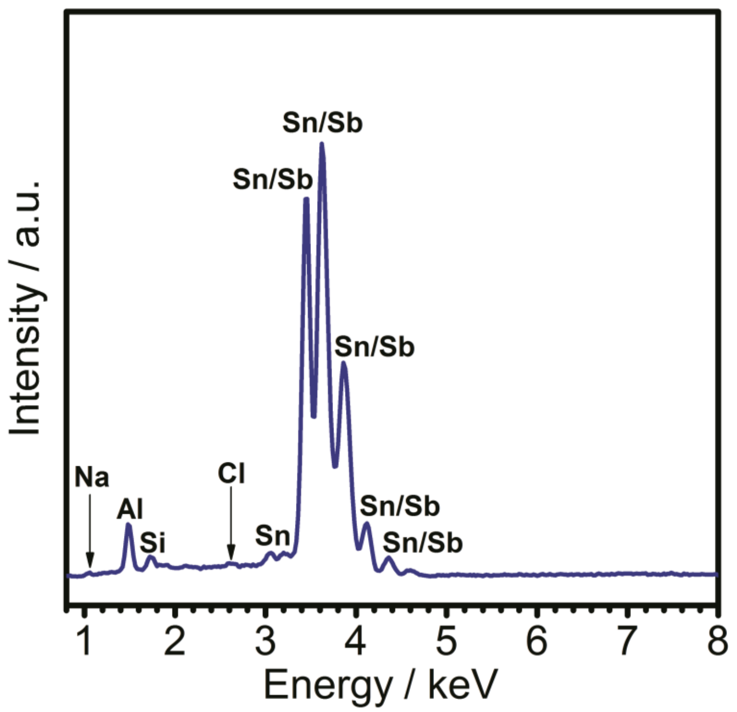

Figure S2. EDX spectrum of SnSb NCs indicating complete removal of the main side product NaCl. The Al/Si signal originates from the substrate.

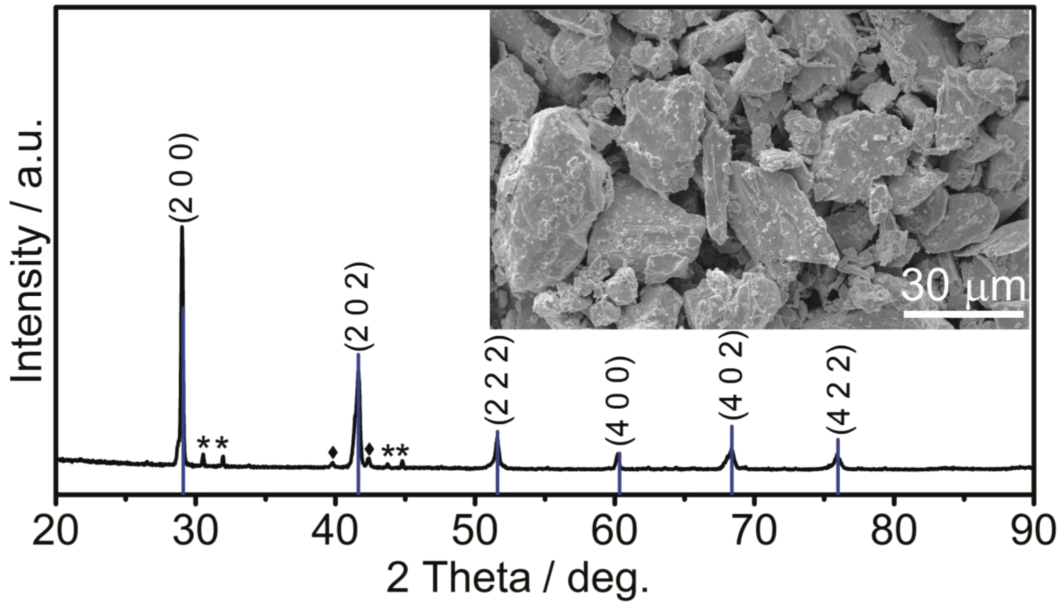

Figure S3. XRD pattern of bulk SnSb prepared by melting elemental Sn and Sb, indexed as cubic SnSb (COD entry 9008724) with the corresponding SEM image as inset. The small contribution from additional phases most likely correspond to elemental Sn(*) and Sb(♦) impurities.

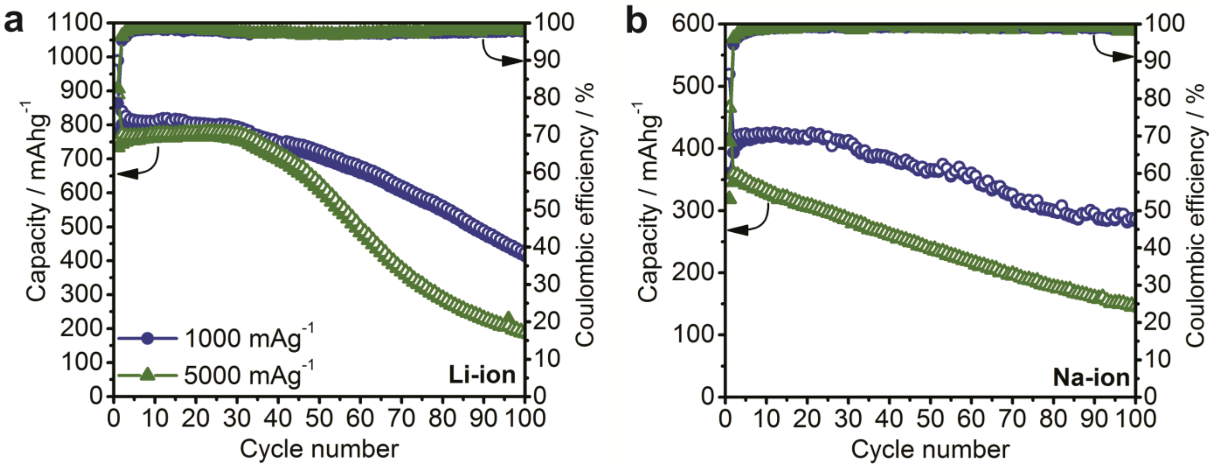

Figure S4. Capacity retention for bulk SnSb in (a) Li-ion and (b) Na-ion half-cells at a current of 1000 and 5000 mA g^{-1}. All batteries were measured in the potential range of 0.005–2.0 V.

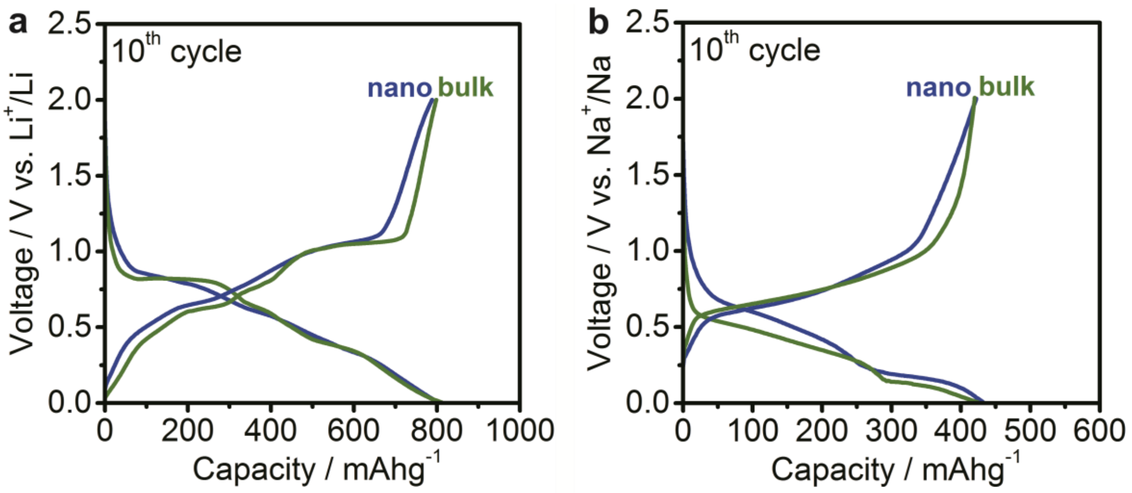

Figure S5. Comparison of the galvanostatic charge/discharge curves (10^{th} cycle) for SnSb-based electrodes in (a) Li-ion and (b) Na-ion half-cells at a current of 1000 mA g^{-1}. All batteries were measured in the potential range of 0.005–2.0 V.

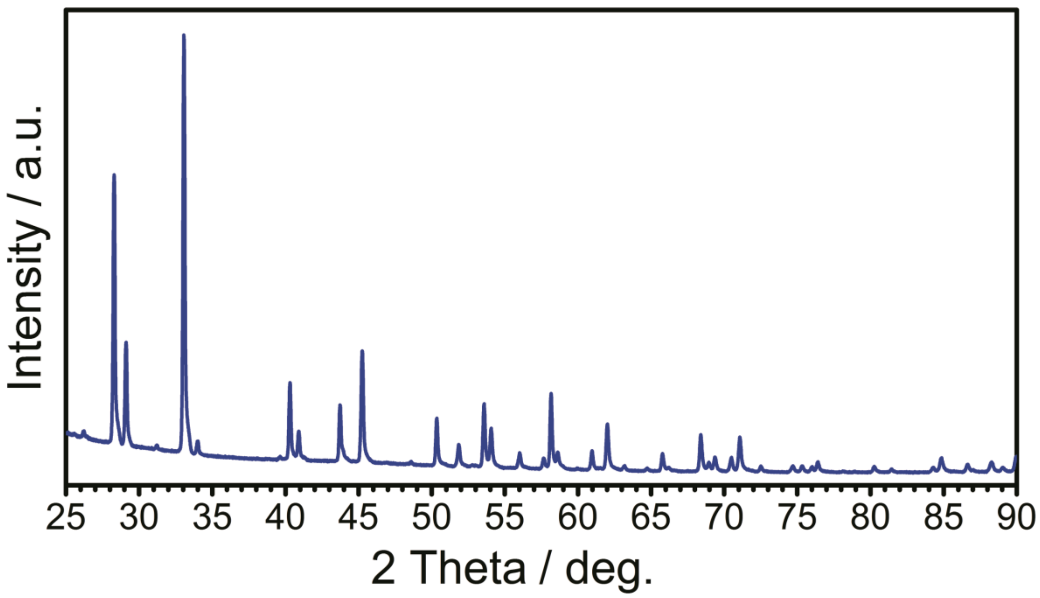

Figure S6. XRD pattern of $Na_{1.5}VPO_{4.8}F_{0.7}$, prepared in the same manner as by Park *et al.*[1]

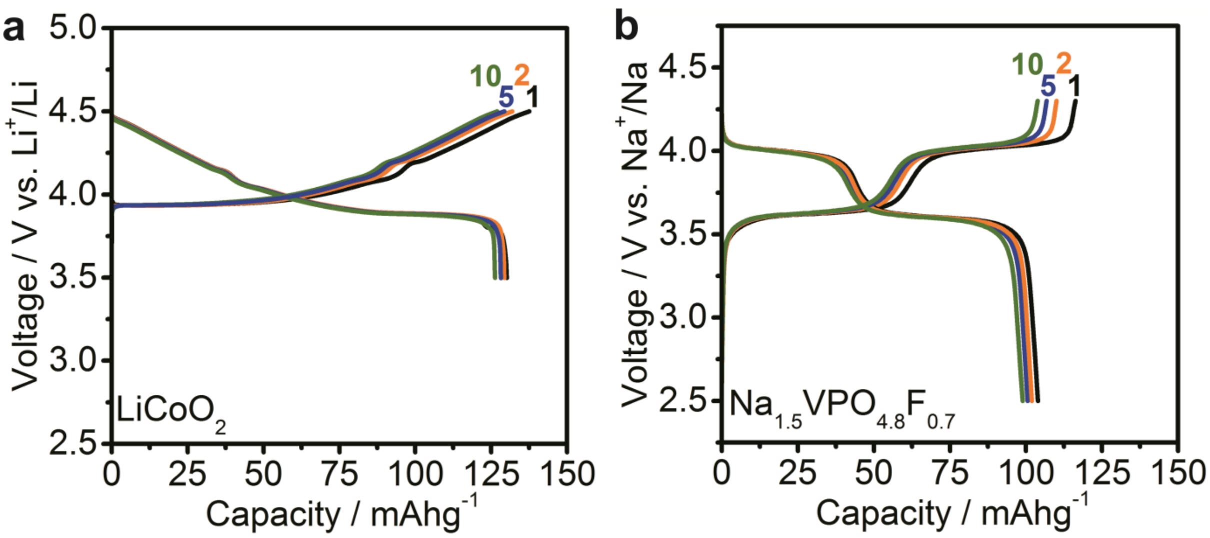

Figure S7. Galvanostatic charge/discharge curves for (a) $LiCoO_2$ and (b) $Na_{1.5}VPO_{4.8}F_{0.7}$ in Li-ion and Na-ion half-cells, respectively. Li-ion cells were cycled with a current of 14 mA g^{-1} (0.1C) in the potential range of 3.5–4.5 V with 1M $LiPF_6$ in EC:DMC (1:1) + 3% FEC as the electrolyte. Na-ion cells were cycled at a current of 64.9 mA g^{-1} (0.5C) in the potential range of 2.5–4.3 V with 1M $NaClO_4$ in PC as the electrolyte.

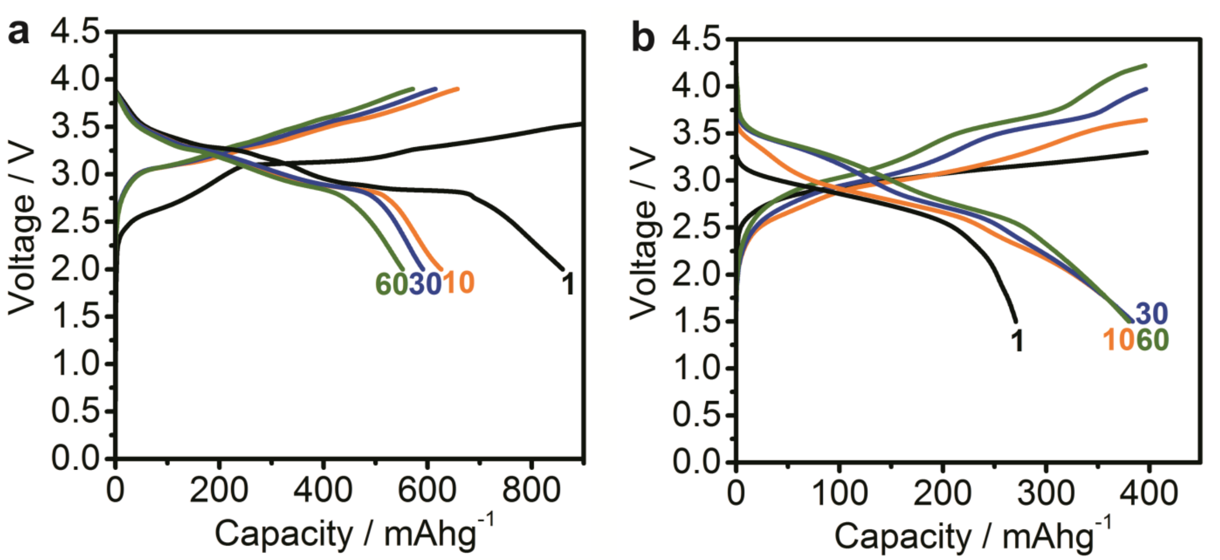

Figure S8. Galvanostatic charge/discharge curves for SnSb NCs in Li-ion and Na-ion full-cells using $LiCoO_2$ or $Na_{1.5}VPO_{4.8}F_{0.7}$ as the cathode material. Li-ion cells were cycled at a current of 400 mA g^{-1} in the potential range of 2.0–3.9 V. Na-ion cells were cycled at a current of 200 mA g^{-1} and the charge and discharge capacity was limited to 400 mAh g^{-1}in the potential range 1.5–4.3 V. All specific capacities and currents correspond to the mass of SnSb.

Table S1. Calculated material cost for the as-prepared SnSb NCs per kilogram of material. The cost of deionized water used for washing and NMP is not included, since the cost for water is negligible small and NMP can be reused after synthesis. Calculation based on chemicals from the following suppliers: Baofull Chemical Co., Ltd. ($SnCl_2$), ABCR ($SbCl_3$), Sinoright International Trade Co., Ltd. ($NaBH_4$).

Chemical	*Amount per 1 kg SnSb NCs*	*Relative Cost*	*Cost per 1 kg SnSb NCs*
$SnCl_2$	0.948 kg (5 mol)	15 USD/kg	14.2 USD
$SbCl_3$	1.141 kg (5 mol)	119.6 USD/kg	136.5 USD
$NaBH_4$	6.05 kg (160 mol)	20 USD/kg	121.0 USD
			Total: 271.7 USD/kg

Table S2. Comparison of the electrochemical performance of SnSb NCs as a Li-ion anode material (present work) with previously reported results.

Anode material	Current density (mAg^{-1})	Initial capacity ($mAhg^{-1}$)	Retained capacity ($mAhg^{-1}$)	Cycle number	Reference
SnSb NCs	200 1000 5000	980 850 730	870 710 520	100 100 100	Present work
nano-SnSb/MCMB/carbon composite	100	506	423	100	[2]
nano-Sn–Sb–Cu	100	~450	390	30	[3]
nano-SnSb/CNT	160	950	860	40	[4]
carbon-coated SnSb NPs	50	674	457	50	[5]
GNS-supported Sn–Sb@carbon particles	1600	850	680	30	[6]
SnSb NPs on SnO_2/Sn/C	50	886	515	40	[7]
SnSb/amorphous carbon	100	~550	620	50	[8]
SnSb–C	100	915	672	120	[9]
SnSb/CNT	100	680	480	50	[10]
CNT-Sn-Sb nanorods	180	708	672	80	[11]
monodisperse SnSb NCs	330 2640	~800 605	680 615	100 100	[12]

Table S3. Comparison of the electrochemical performance of SnSb NCs as a Na-ion anode material (present work) with previously reported results.

Anode material	Current density (mAg^{-1})	Initial capacity ($mAhg^{-1}$)	Retained capacity ($mAhg^{-1}$)	Cycle number	Reference
SnSb NCs	200	560	500	100	Present work
	1000	420	400	100	
	5000	380	360	100	
SnSb NPs on SnO_2/Sn/C	50	385	305	40	[7]
SnSb-carbon nanofibers	100	347	345	205	[13]
nano-SnSb/C	100	544	435	50	[14]
monodisperse SnSb NCs	660	~350	~350	100	[12]

Supporting References:

[1] Y.-U. Park, D.-H. Seo, H.-S. Kwon, B. Kim, J. Kim, H. Kim, I. Kim, H.-I. Yoo, K. Kang, *J. Am. Chem. Soc.* **2013**, *135*, 13870-13878.

[2] J. Li, Q. Ru, S. Hu, D. Sun, B. Zhang, X. Hou, *Electrochim. Acta* **2013**, *113*, 505-513.

[3] R. Yang, J. Huang, W. Zhao, W. Lai, X. Zhang, J. Zheng, X. Li, *J. Power Sources* **2010**, *195*, 6811-6816.

[4] S. Fan, T. Sun, X. Rui, Q. Yan, H. H. Hng, *J. Power Sources* **2012**, *201*, 288-293.

[5] X. Niu, H. Zhou, Z. Li, X. Shan, X. Xia, *J. Alloys Compd.* **2015**, *620*, 308-314.

[6] S. Chen, P. Chen, M. Wu, D. Pan, Y. Wang, *Electrochem. Commun.* **2010**, *12*, 1302-1306.

[7] J.-C. Kim, D.-W. Kim, *Electrochem. Commun.* **2014**, *46*, 124-127.

[8] D. Sun, B. An, B. Zhang, Q. Ru, X. Hou, S. Hu, *J. Solid State Electrochem.* **2014**, *18*, 2573-2579.

[9] L. Fan, J. Zhang, Y. Zhu, X. Zhu, J. Liang, L. Wang, Y. Qian, *RSC Adv.* **2014**, *4*, 62301-62307.

[10] M.-S. Park, S. A. Needham, G.-X. Wang, Y.-M. Kang, J.-S. Park, S.-X. Dou, H.-K. Liu, *Chem. Mater.* **2007**, *19*, 2406-2410.

[11] Y. Wang, J. Y. Lee, *Angew. Chem. Int. Ed.* **2006**, *45*, 7039-7042.

[12] M. He, M. Walter, K. V. Kravchyk, R. Erni, R. Widmer, M. V. Kovalenko, *Nanoscale* **2015**, *7*, 455-459.

[13] L. Ji, M. Gu, Y. Shao, X. Li, M. H. Engelhard, B. W. Arey, W. Wang, Z. Nie, J. Xiao, C. Wang, J.-G. Zhang, J. Liu, *Adv. Mater.* **2014**, *26*, 2901-2908.

[14] L. Xiao, Y. Cao, J. Xiao, W. Wang, L. Kovarik, Z. Nie, J. Liu, *Chem. Commun.* **2012**, *48*, 3321-3323.