Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Vertical Bismuth Oxide Nanosheets with Enhanced Crystallinity: Promising Stable Anode for Rechargeable Alkaline Batteries

Haibing Zheng,[a,c] Haodong Li,[c] Minghao Yu,[c] Min Zhang,[a,*] ShileiXie,[a] Yexiang Tong,[c] Faliang Cheng, [a] and Xihong Lu[b,c*]

[a]*Guangdong Engineering and Technology Research Center for Advanced Nanomaterials, Dongguan University of Technology, Guangdong 523808, PR China *E-mail:* minzhanggdu@sina.com *(M. Zhang);*

[b]*School of Applied Physics and Materials, Wuyi University, Jiangmen, Guangdong 529020, People's Republic of China *E-mail:* luxh6@mail.sysu.edu.cn *(X. Lu)*

[c]*MOE of the Key Laboratory of Bioinorganic and Synthetic Chemistry, School of Chemistry, Sun Yat-Sen University, Guangzhou 510275, PR China*

Calculations:

1. Single Electrode:

Areal capacitances of Bi_2O_3 electrodes were calculated from their CVs according to the following equations:

$$C_a = \frac{Q}{\Delta V \cdot S} \quad (1)$$

where C_a (mAh/cm^2) is the areal capacitance, Q (C) is the average charge during the charging and discharging process, $\triangle V$ (V) is the potential window and S (cm^2) is the area of Bi_2O_3 electrode (0.5 cm^2).

Specific capacities of the Bi_2O_3 electrodes were calculated from their CVs according to the following equation:

$$C_s = \frac{\int_0^V I \times dV}{3600 \times v \times m} \quad (2)$$

where C_s (mAh/g) is the specific capacity, V (V) is the voltage, I (mA) is the current, v (V/s) is scan rate and m (g) is the mass of Bi_2O_3 electrode.

Alternatively, specific capacities of electrode were measured by galvanostatic charge/discharge method based on the following equation:

$$C_a = \frac{\int_0^{\triangle t} I \times dt}{m} \quad (3)$$

where C_s (mAh/g) is the specific capacity, I (mA) is the constant discharge current, $\triangle t$ (h) is the discharging time and m (g) is the mass of Bi_2O_3 electrode.

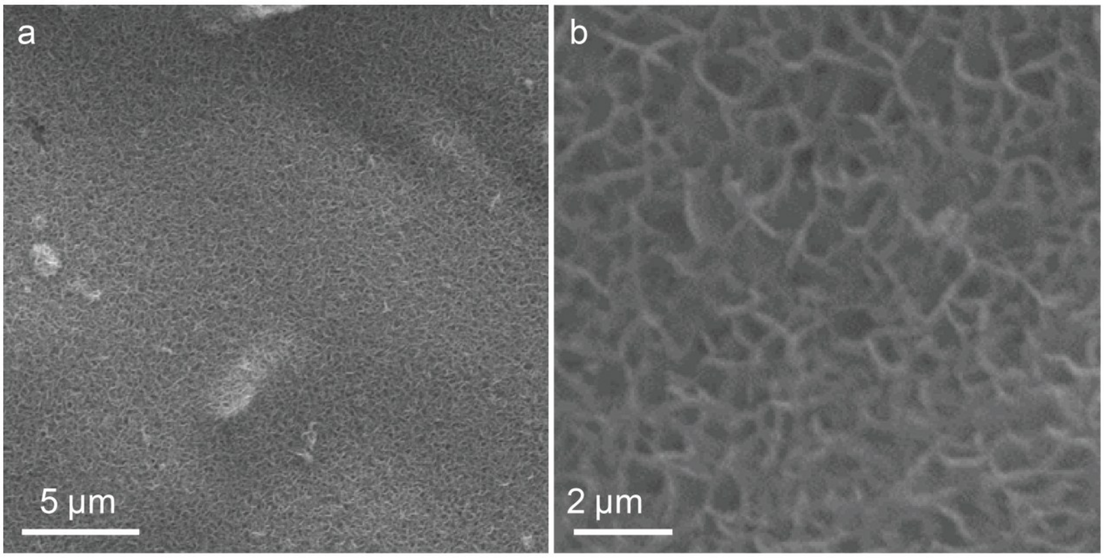

Figure S1. (a) SEM images of the L-Bi_2O_3. (b) High-magnification SEM image of the L-Bi_2O_3.

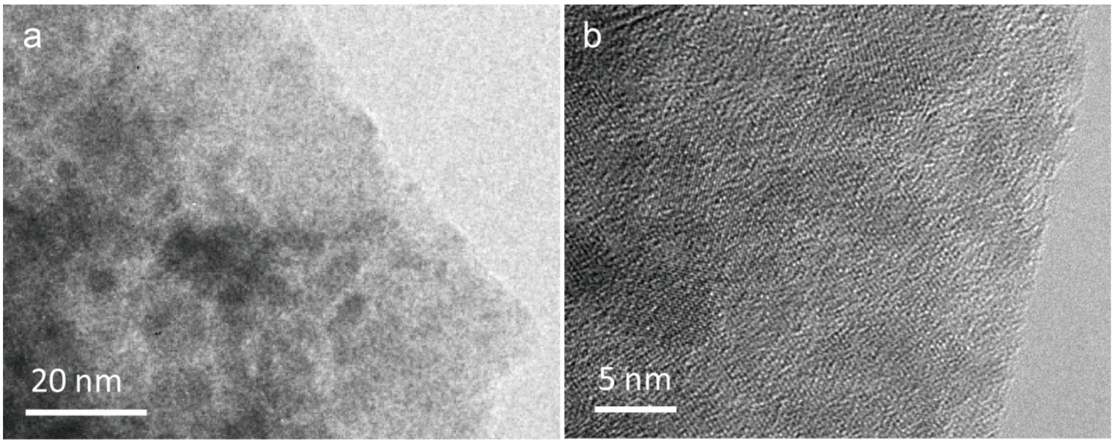

Figure S2. (a) TEM images of the L-Bi_2O_3. (b) High-magnification TEM image of the L-Bi_2O_3.

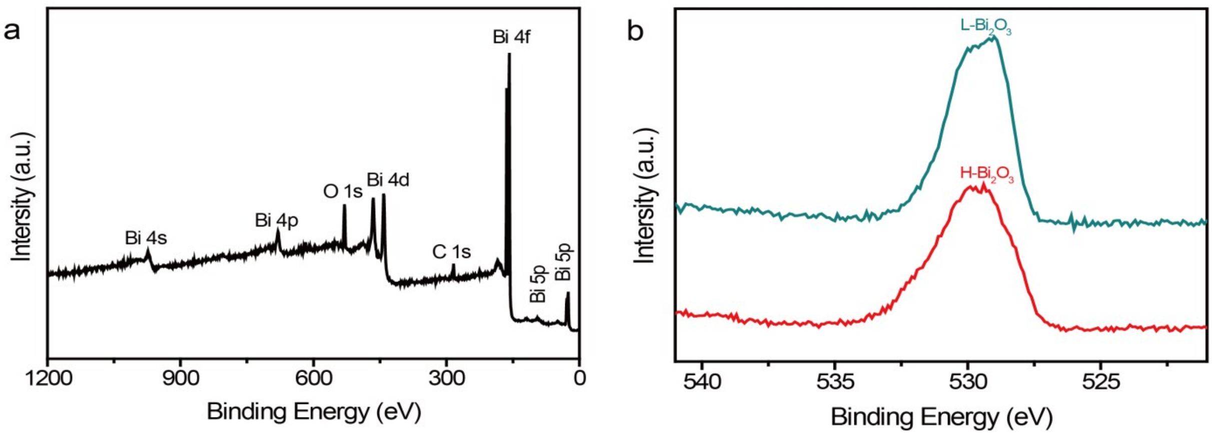

Figure S3. (a) Survey XPS spectrum of Bi_2O_3 samples. (b) O 1s XPS spectra of the L-Bi_2O_3 and H-Bi_2O_3 samples.

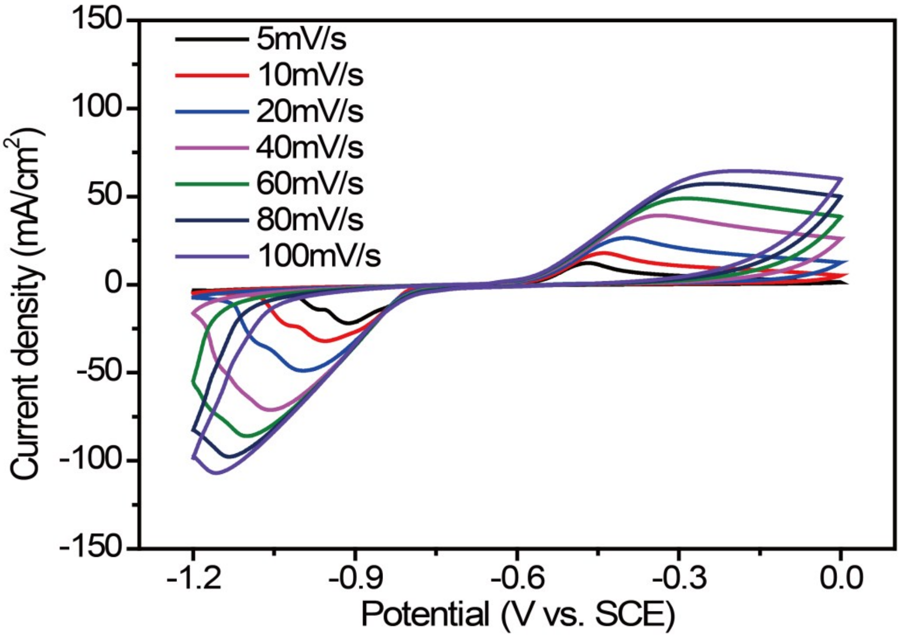

Figure S4. CV curves at various scan rates of H-Bi_2O_3 samples

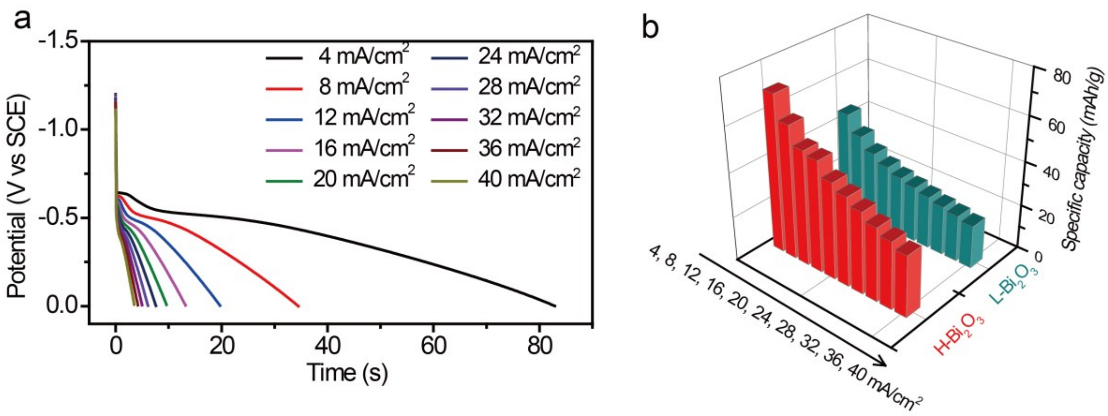

Figure S5. (a) Galvanostatic discharge curves of the L-Bi_2O_3 electrodes at a different current densities. (b) Mass capacity of the L-Bi_2O_3 and H-Bi_2O_3 electrodes obtained from galvanostatic discharge curves.

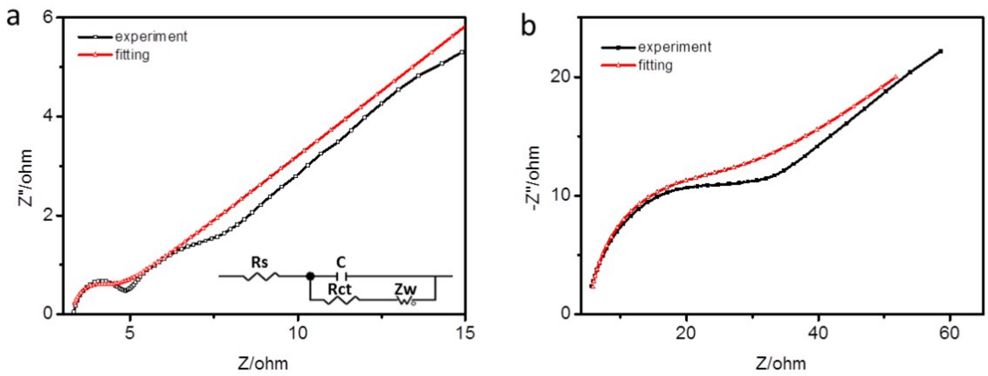

Figure S6. (a) EIS plots for H-Bi_2O_3 (black), and their corresponding simulation results (red). (b) for L-Bi_2O_3 and their simulation result.

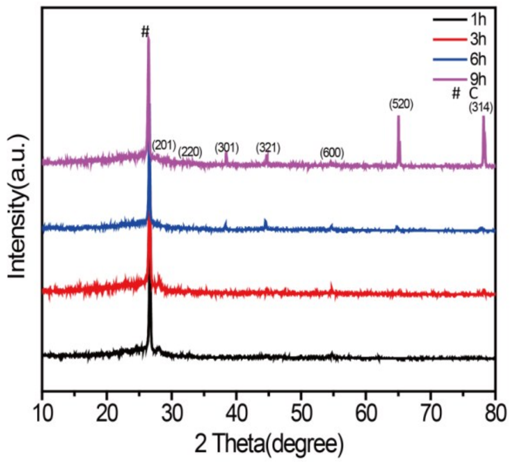

Figure S7. XRD spectra of the Bi_2O_3 after different annealing time.

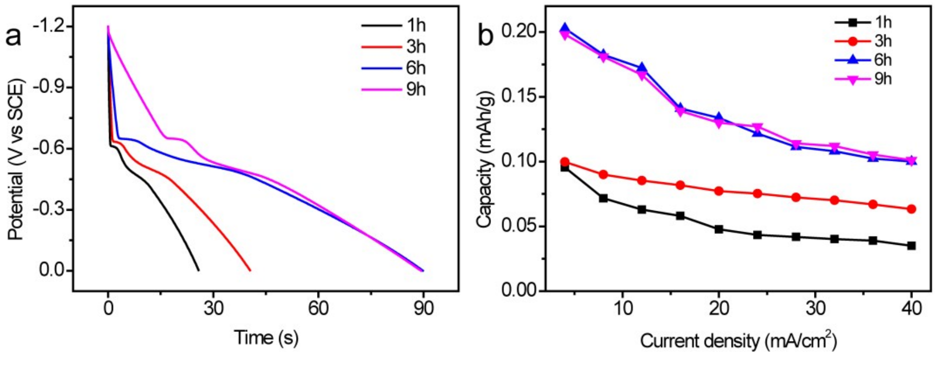

Figure S8. (a) Galvanostatic discharge curves at 16 mA/cm^2, and (b) Capacity as a function of the H-Bi_2O_3 electrodes obtained at different annealing times.

Table S1. The BET surface area and of L-Bi_2O_3 and H-Bi_2O_3 electrodes.

Samples	L-Bi_2O_3	H-Bi_2O_3
BET Surface Area (m^2/g)	5.9	21.3
Pore Volume (cm^3/g)	0.013587	0.002842

Table S2. A summary of the electrochemcial performance of the anodes.

Electrode	Capacity	Stability	Electrolyte	Ref.
AC-Bi_2O_3	332.6 F/g (1 A/g)	—	6 M KOH	1
Bi_2O_3 NT5-GF	69.3 mF/cm^2 (0.1 mA/cm^2)	99% (1000 cycles)	6 M KOH	2
Bi_2O_3/GN	3683 mF/cm^2 (20 mA/cm^2)	90% (1000 cycles)	6 M KOH	3
graphene-Bi_2O_3	255 F/g (1 A/g)	65% (1000 cycles)	6 M KOH	4
ESCNF@Bi_2O_3	530 mF/cm^2 (1 mA/cm^2)	87% (1000 cycles)	1 M KOH	5
Bi-200	90.5 mAh/g (4.5 A/g)	96% (10000 cycles)	1 M KOH	6
VO	0.28 F/cm^2 (10 mv/s)	—	5 M LiCl	7
OCFP	1.56 F/cm^2 (5 mA/cm^2)	99% (20000 cycles)	1 M H_2SO_4	8

Highly Functionalized Activated Carbons	297 F/g (30 A/g)	90.6 % (10000 cycles)	1 M KOH	[9]
VN-RGO	270 mAh/g (0.1 A/g)	90 % (2000 cycles)	1 M $LiPF_6$ (EC/DEC)	[10]
H-Bi_2O_3	0.14 mAh/cm^2 (4 mA/cm^2)	71.4% (5000 cycles)	1 M KOH	This work

Table S3. Values of the equivalent circuit components used for the EIS date of L-Bi_2O_3 and H-Bi_2O_3 sample.

component		Rs (Ω)	Rct (Ω)	W (S $s^{1/2}$)			C (F)
				R	T	P	
Fitted values	L-Bi_2O_3	4.646	25.7	73.32	337.1	0.285	0.0000218
	H-Bi_2O_3	3.417	1.471	1729	1768	0.522	0.000897

Table S4. The Bi concentration in the electrolyte for L-Bi_2O_3 and H-Bi_2O_3 electrodes after 5000 cycles.

samples	**L-Bi_2O_3**	**H-Bi_2O_3**
Bi concentration (mg/L)	3.25	1.11

References

1. S. X. Wang, C. C. Jin and W. J. Qian, *J. Alloy. Compd.*, 2014, 615, 12-17.
2. K. Gopalsamy, Z. Xu, B. Zheng, T. Huang, L. Kou, X. Zhao and C. Gao, *Nanoscale*, 2014, 6, 8595-8600.
3. R. Liu, L. Ma, G. Niu, X. Li, E. Li, Y. Bai and G. Yuan, *Adv. Funct. Mater.*, 2017, 27, 1701635.
4. H. W. Wang, Z. A. Hu, Y. Q. Chang, Y. L. Chen, Z. Q. Lei, Z. Y. Zhang and Y. Y. Yang, *Electrochim. Acta*, 2010, 55, 8974-8980.
5. L. Li, X. Zhang, Z. Zhang, M. Zhang, L. Cong, Y. Pan and S. Lin, *J. Mater. Chem. A*, 2016, 4, 16635-16644.
6. Y. Zeng, Z. Lin, Y. Meng, Y. Wang, M. Yu, X. Lu and Y. Tong, *Adv. Mater.*, 2016, 28, 9188-9195.
7. T. Zhai, X. Lu, Y. Ling, M. Yu, G. Wang, T. Liu, C. Liang, Y. Tong and Y. Li, *Adv. Mater.*, 2014, 26, 5869.
8. Z. Wang, Y. Han, Y. Zeng, Y. Qie, Y. Wang, D. Zheng, X. Lu and Y. Tong, *J. Mater. Chem. A*, 2016, 4, 5828-5833.
9. Z. Li, Z. Xu, H. Wang, J. Ding, B. Zahiri, C. M. B. Holt, X. Tan and D. Mitlin, *Energy Environ. Sci.*, 2014, 7, 1708-1718.
10. R. Wang, J. Lang, P. Zhang, Z. Lin and X. Yan, *Adv. Funct. Mater.*, 2015, 25, 2270-2278.