Supporting Information

Decorating WSe_2 nanosheets with ultrafine Ru nanoparticles for boosting electrocatalytic hydrogen evolution in alkaline electrolyte

Yuanmeng Zhao,[a†] Guixiang Mao,[a†] Chaozhang Huang,[b] Ping Cai,[a*]

Gongzhen Cheng,[a] and Wei Luo[a*]

[a]College of Chemistry and Molecular Sciences, Wuhan University, Wuhan, Hubei, 430072, P. R. China, Tel.: +86-27-68752366.

*Corresponding author. E-mail addresses: *caiping@whu.edu.cn*; *wluo@whu.edu.cn*

[b]China Tobacco Fujian Industrial Co., Ltd., Xiamen, 361022, P. R. China

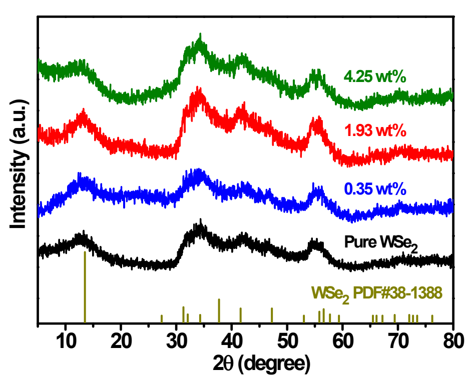

Figure S1. The XRD patterns of Ru-WSe_2 nanocomposites with different contents of Ru and pure WSe_2.

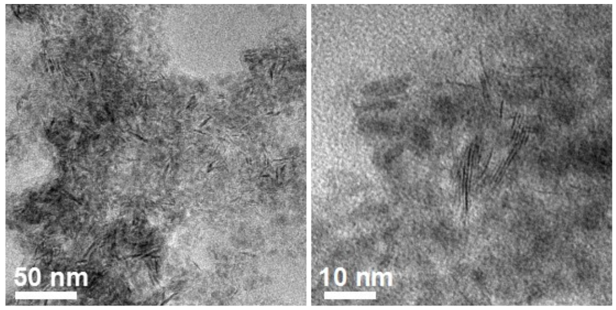

Figure S2. TEM images of as-synthesized 0.35 wt% Ru-WSe_2.

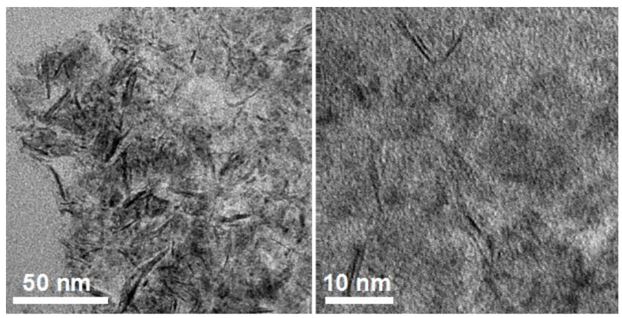

Figure S3. TEM images of as-synthesized 4.25 wt% Ru-WSe_2.

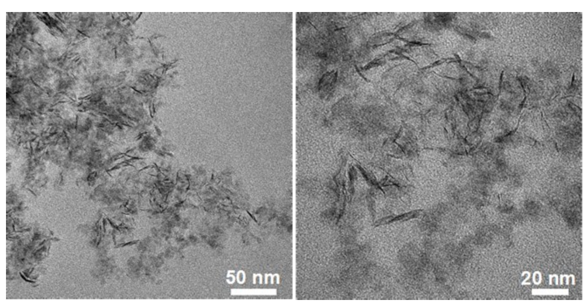

Figure S4. TEM images of as-synthesized pure WSe_2.

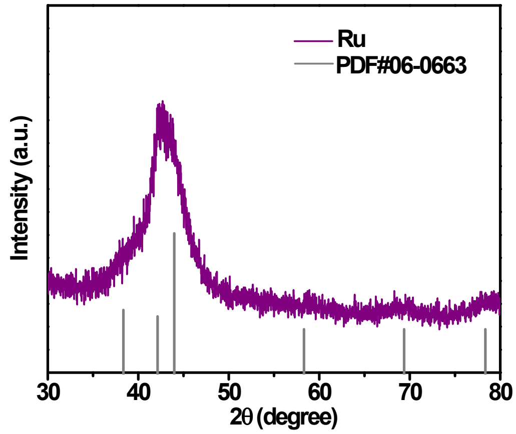

Figure S5. The XRD patterns of Ru nanorods.

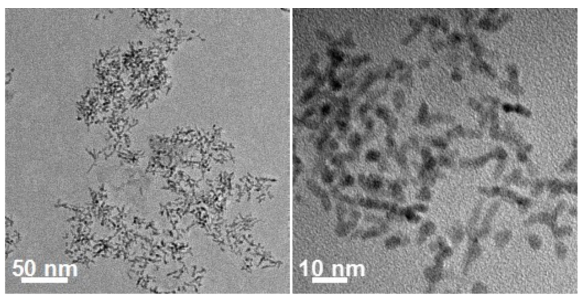

Figure S6. TEM images of as-synthesized Ru nanorods.

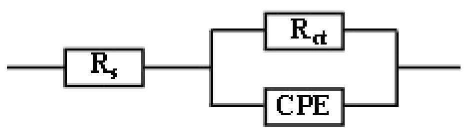

Figure S7. The equivalent electrical circuit. In the Nyquist plots, the first semi-circle refers to the resistance of the solution (R_s) and the second semi-circle refers to charge transfer resistance (R_{ct}).

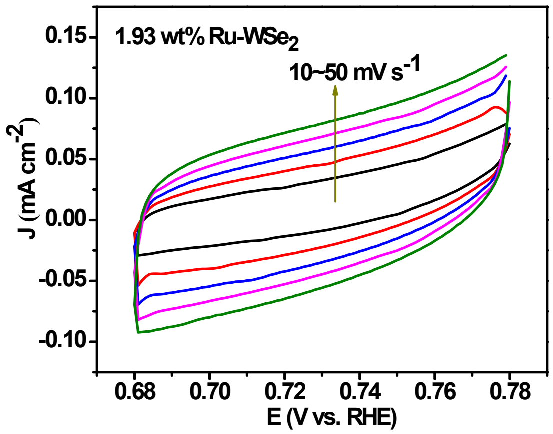

Figure S8. Electrochemical double layer capacitance curves on 1.93 wt% Ru-WSe_2 with different scan rates from 50 mV s^{-1} to 10 mV s^{-1} in 1.0 M KOH.

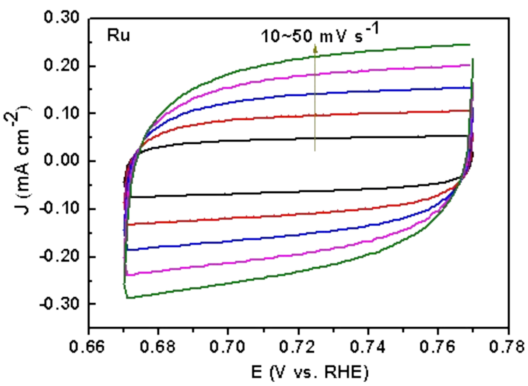

Figure S9. Electrochemical double layer capacitance curves on Ru nanorods with different scan rates from 50 mV s^{-1} to 10 mV s^{-1} in 1.0 M KOH.

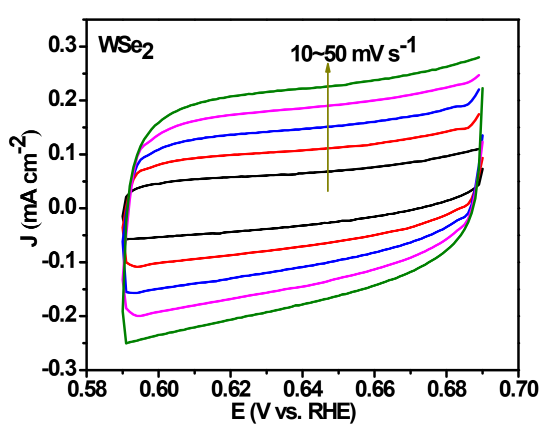

Figure S10. Electrochemical double layer capacitance curves on WSe_2 with different scan rates from 50 mV s^{-1} to 10 mV s^{-1} in 1.0 M KOH.

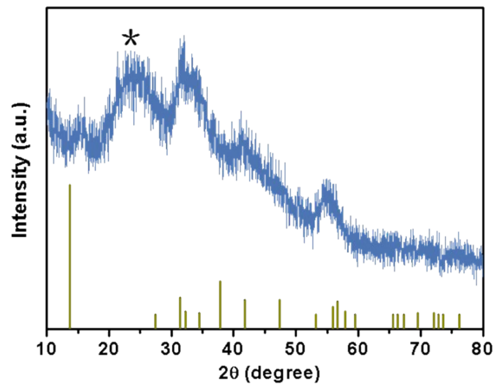

Figure S11. XRD pattern of the 1.93 wt% Ru-WSe_2 nanosheets after chronopotentiometry test (⋆represents the peak of XC-72).

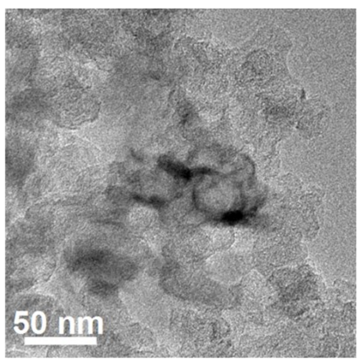

Figure S12. TEM image of the 1.93 wt% Ru-WSe_2 nanosheets after chronopotentiometry test.

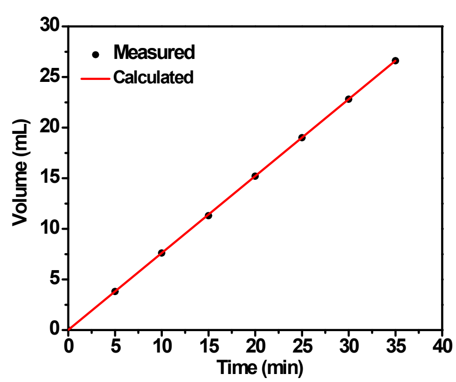

Figure S13. The amount of hydrogen theoretically calculated and experimentally measured versus time for 1.93 wt% Ru-WSe_2 in 1.0 M KOH.

Table S1 The raw material of $Ru(acac)_3$ and the corresponding contents of Ru in Ru-WSe_2 nanosheets.

Raw material $Ru(acac)_3$ (mg)	Ru content in Ru-WSe_2 Ru (wt%)
4	0.35
8	1.93
16	4.25

Table S2 Comparison of representative TMDs-based catalysts in 1.0 M KOH.

Catalyst	Substrate	Loading (mg cm^{-2})	η_{10}/(mV)	Reference
Ru-WSe_2	GCE	0.45	73	This work
Co-WSe_2/MWNTs	GCE	0.25	241	1
$MoSe_2$-NiSe@carbon	GCE	0.28	180	2
CS-MS/rGO-C	GCE	0.57	215	3
MS-CS NTs	GCE	0.57	237	4
MoS_2/$MoSe_2$-0.5	GCE	0.204	235	5
Ni_{SA}-MoS_2/CC	carbon cloth	NM	95	6
2D-MoS_2/$Co(OH)_2$	GCE	~0.285	128	7
Co_9S_8@MoS_2	GCE	~0.4	143	8
$CoNiSe_2$@CoNi-LDHs/NF	nickel foam	10	106	9
NiSe/Ni_3Se_2/NF-12	nickel foam	5.7	92	10
$Ni(OH)_2$/MoS_2	carbon cloth	4.8	80	11
MoWSe alloys	GCE	1	262	12

$MoSe_2@Ni_{0.85}Se$	nickel foam	6.48	117	13
c-$CoSe_2$/CC	carbon cloth	NM	190	14
CoS/MoS_2	GCE	0.18	214	15
$Co_3S_4/MoS_2/Ni_2P$ NTs	GCE	0.18	178	15
MoS_2/Ni_3S_2	Nickel foam	9.7	110	16
Ni-MoS_2	carbon cloth	0.89	98	17
$Co_9S_8@MoS_2$/CNFs	GCE	0.212	190	18

Reference

1 G. Zhang, X. Zheng, Q. Xu, J. Zhang, W. Liu and J. Chen, J. Mater. Chem. A, 2018, **6**, 4793.

2 C. Liu, K. Wang, X. Zheng, X. Liu, Q. Liang, Z. Chen, Carbon, 2018, **139**, 1.

3 B. Wang, Z. Wang, X. Wang, B. Zheng, W. Zhang and Y. Chen, J. Mater. Chem. A, 2018, **6**, 12701.

4 X. Wang, B. Zheng, B. Yu, B. Wang, W. Hou, W. Zhang and Y. Chen, J. Mater. Chem. A, 2018, **6**, 7842.

5 Q. Zhou, G. Zhao, K. Rui, Y. Chen, X. Xu, S. X. Dou and W. Sun, Nanoscale, 2019, **11**, 717.

6 Q. Wang, Z. L. Zhao, S. Dong, D. He, M. J. Lawrence, S. Han, C. Cai, S. Xiang, P. Rodriguez, B. Xiang, Z. Wang, Y. Liang and M. Gu, Nano Energy, 2018, **53**, 458.

7 Z. Zhu, H. Yin, C. -T. He, M. Al-Mamun, P. Liu, L. Jiang, Y. Zhao, Y. Wang, H. -G. Yang, Z. Tang, D. Wang, X. -M. Chen and H. Zhao, Adv. Mater., 2018, **30**, 1801171.

8 J. Bai, T. Meng, D. Guo, S. Wang, B. Mao, and M. Cao, ACS Appl. Mater. Interfaces, 2018, **10**, 1678.

9 Y. Yang, W. Zhang, Y. Xiao, Z. Shi, X. Cao, Y. Tang and Q. Gao, Appl. Catal. B-Environ., 2019, **242**, 132.

10 F. Zhang, Y. Pei, Y. Ge, H. Chu, S. Craig, P. Dong, J. Cao, P. M. Ajayan, M. Ye and J. Shen, Adv. Mater. Interfaces, 2018, **5**, 1701507.

11 B. Zhang, J. Liu, J. Wang, Y. Ruan, X. Ji, K. Xu, C. Chen, H. Wan, L. Miao and J. Jiang, Nano Energy, 2017, **37**, 74.

12 O. E. Meiron, V. Kuraganti, I. Hod, R. Bar-Ziv and M. Bar-Sadan, Nanoscale, 2017, **9**, 13998.

13 C. Wang, P. Zhang, J. Lei, W. Dong and J. Wang, Electrochim. Acta, 2017, **246**, 712.

14 P. Chen, K. Xu, S. Tao, T. Zhou, Y. Tong, H. Ding, L. Zhang, W. Chu, C. Wu and Y. Xie, Adv. Mater., 2016, **28**, 7527.

15 H. Lin, H. Li, Y. Li, J. Liu, X. Wang and L. Wang, J. Mater. Chem. A, 2017, **5**, 25410.

16 J. Zhang, T. Wang, D. Pohl, B. Rellinghaus, R. Dong, S. Liu, X. Zhuang and X. Feng, Angew. Chem. Int. Ed., 2016, **55**, 6702.

17 J. Zhang, T. Wang, P. Liu, S. Liu, R. Dong, X. Zhuang, M. Chen and X. Feng, Energy Environ. Sci., 2016, **9**, 2789.

18 H. Zhu, J. Zhang, R. Yanzhang, M. Du, Q. Wang, G. Gao, J. Wu, G. Wu, M. Zhang, B. Liu, J. Yao and X. Zhang, Adv. Mater., 2015, **27**, 4752.