Electronic Supplementary Information for

Fluorinated MXene Accelerates the Hydrogen Evolution Activity of *in-situ* Induced Snowflake-like Nano-Pt

Xue Zhao,[a,||] Mengshan Chen,[b,||] Yingtang Zhou,*[b] Haibo Zhang,*[c] and Guangzhi Hu*[d]*

[a] Faculty of chemistry and chemical engineering, Yunnan Normal University, Kunming 650092, China

[b] National Engineering Research Center for Marine Aquaculture, Marine Science and Technology College, Zhejiang Ocean University, Zhoushan 316004, China

[c] College of Chemistry and Molecular Sciences, Wuhan University, Wuhan 430072, China

[d] Institute for Ecological Research and Pollution Control of Plateau Lakes, School of Ecology and Environmental Science, Yunnan University, Kunming 650504, China

[||] These authors contributed equally

*The corresponding author Email: xuezhao0208@gmail.com (Dr. X. Zhao); zhouyingtang@zjou.edu.cn (Prof. Y. T. Zhou); haibozhang1980@gmail.com (Prof. H. Zhang); guangzhihu@ynu.edu.cn (Prof. G. Hu)

Characterization Method Details

The powder X-ray diffraction signal was collected on the X-ray powder diffractometer (Rigaku, Japan) at a scanning speed of 5°/min, where Cu Kα is the excitation source. Specifically, the material was evenly spread in the groove on the quartz sample stage, and then the surface of the material were flattened with a glass slide and placed in an X-ray powder diffractometer to collect XRD signals with a working voltage of 40 kV and a current of 40 A.

The X-ray photoelectron spectroscopy (XPS) signal was collected by X-ray photoelectron spectrometer (Thermo Scientific K-Alpha), and the binding energy of the final signal was corrected by standard C (284.8 eV). Among them, the entire acquisition process was completed in a near-vacuum chamber with a working voltage of 12 kV, a filament current of 6 mA, and an excitation source of Al Kα ray (0.6 eV).

Field emission scanning electron microscope (SEM, the instrument model is ZEISS SIGMA) and transmission electron microscope (TEM, the instrument model is Titan G260-300) were used to observe the microstructure of materials. When collecting SEM images, the material were directly covered on the surface of the conductive adhesive pasted on the sample stage, the vacuum degree of the instrument reaches 5×10^{-5} mbar, the working voltage was 3 kV, and the signal acquisition mode is InLens. When collecting TEM images, the material were directly dispersed (ultrasound for 10 min) to form a suspension in ethanol solution, and then dropped onto the ultra-thin micro-grid support film. The operating voltage of the TEM instrument was 300 kV.

The Zeta potential of the material was determined by a Zeta potentiometer (model is Malvern Zetasizer Nano ZS). Among them, the material was directly dispersed in 5 mL ultrapure water (sonicated for 30 min), and then placed in a Zeta potentiometer to collect Zeta signals.

Inductively coupled plasma emission spectrometer was used to detect the exact Pt content in the material, where the loadings of Pt in MXene/B-Pt and Pt/C are 3.35 wt% and 20.00 wt%, respectively. The test details are as follows:
The sample was dispersed in 100 mL of aqua regia, and after ultrasonic treatment for 30 min, it was left to stand for 24 h to convert all the Pt species in the sample into water-soluble ionic states. After diluting by a certain factor, the signal was collected on the ICP-OES instrument, and the accurate loading amount of Pt was obtained by the standard curve interpolation method.

Note: The above characterization methods are all ex-situ tests.

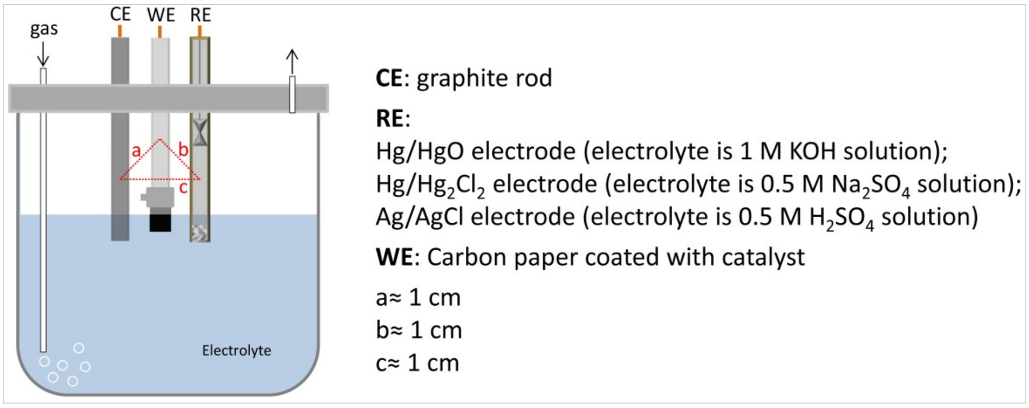

Figure S1. Schematic diagram of electrochemical experiment device

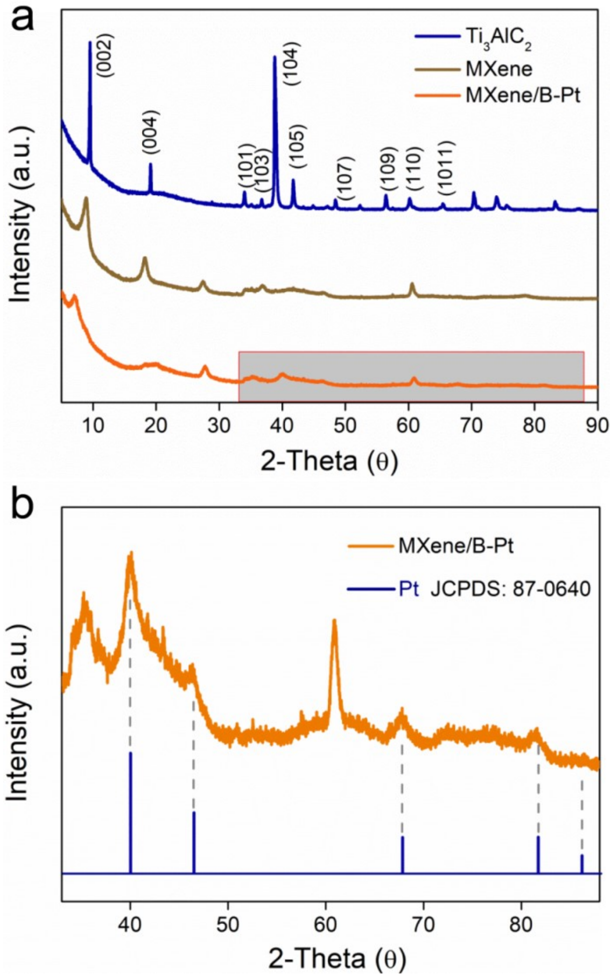

Figure S2 (a) PXRD signals of Ti_3AlC_2, MXene, and MXene/B-Pt; (b) Local amplification of the PXRD signal of MXene/B-Pt.

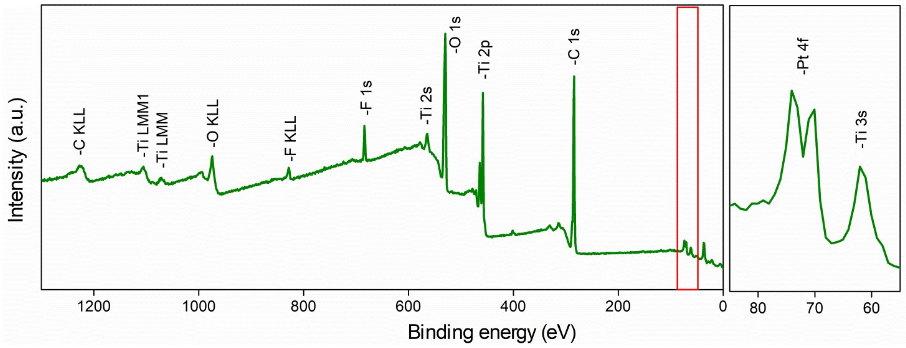

Figure S3 XPS signal (full spectrum) of MXene/B-Pt.

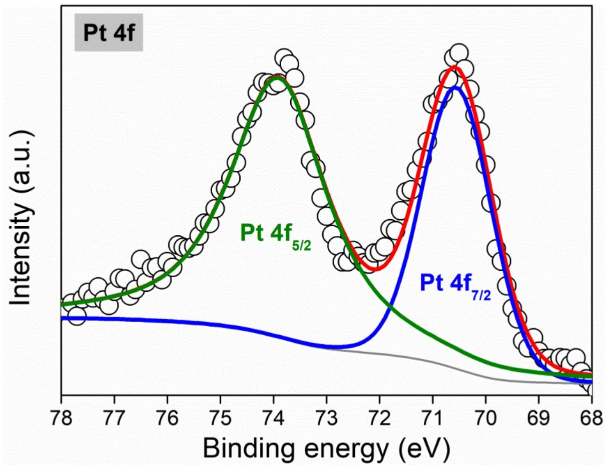

Figure S4 XPS signal (fine spectrum of Pt element) of MXene/B-Pt.

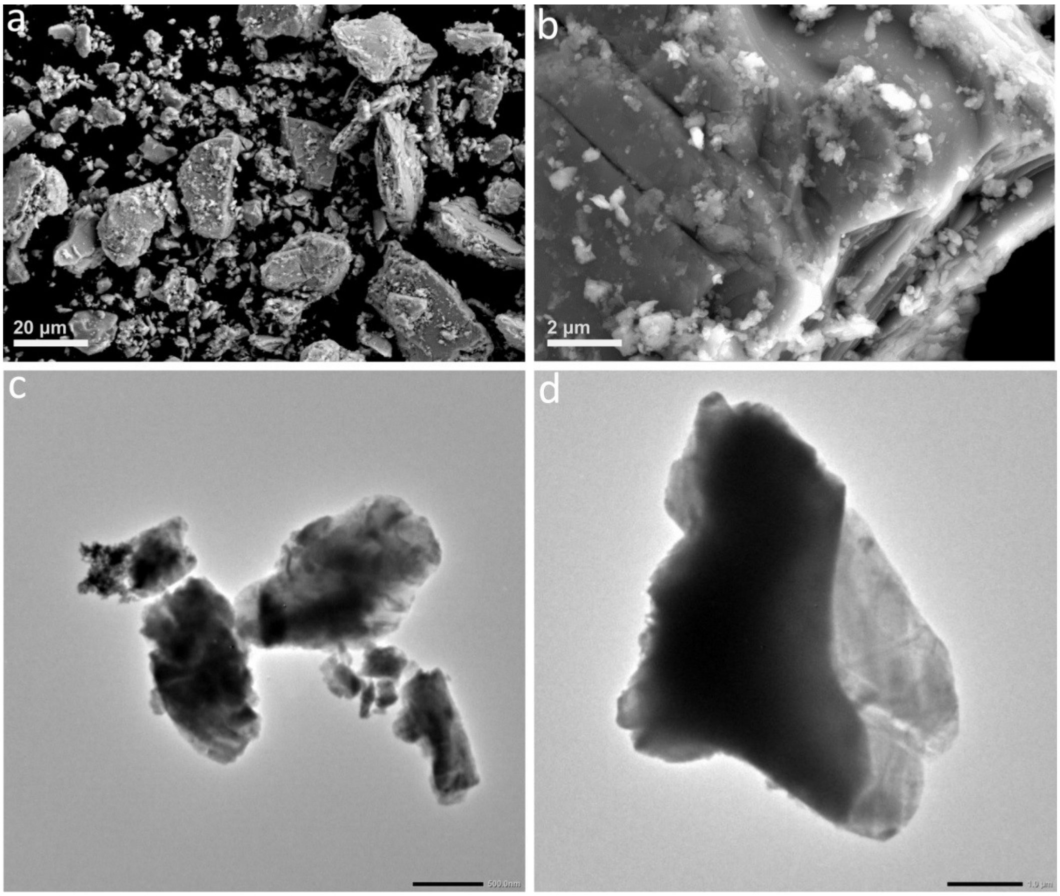

Figure S5 (a-b) SEM images of Ti_3AlC_2; (c-d) TEM images of Ti_3AlC_2.

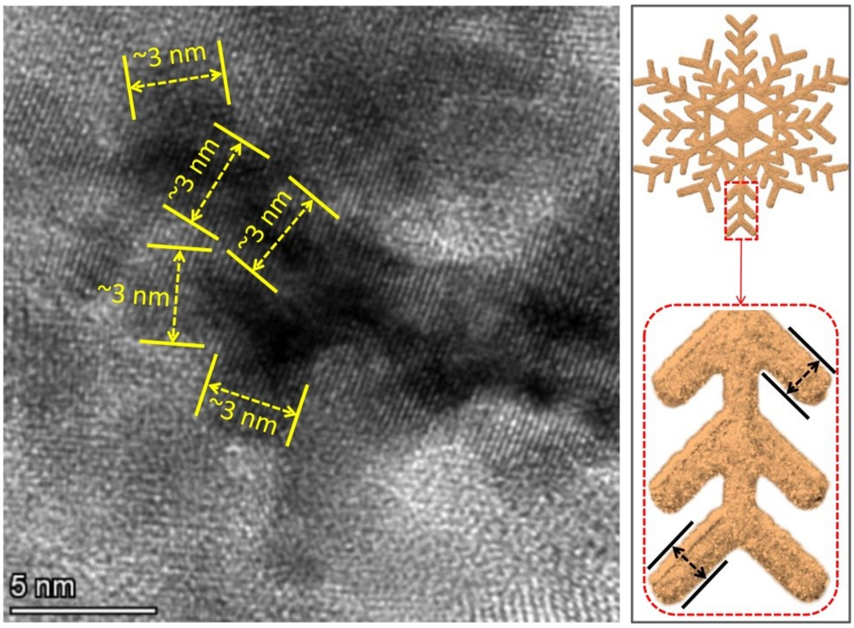

Figure S6. The branch width of the snowflake-like Pt nanoparticles is about 3 nm.

Table S1. Overpotentials of MXene/B-Pt with other recently reported Pt-based HER catalysts. (1 M KOH)			
Catalyst	**Electrolyte**	**η10 (mV)**	**Information Sources**
Pt/CNW@PCN-222	1 M KOH	115	Small, 2020, 16, 2005111
Pt@PCM	1 M KOH	105	Science Advances, 2018, 4, eaao6657
PtNWs/SL-$Ni(OH)_2$	1 M KOH	70	Nature Communications, 2015, 6, 6430
CDs/Pt PANI	1 M KOH	56	Applied Catalysis B: Environmental, 2019, 257, 117905
Mo_2C@NC@Pt	1 M KOH	47	ACS Applied Materials & Interfaces, 2019,11, 4047-4056
Pt_5/HMCS	1 M KOH	46.2	Advanced Materials, 2020, 32, 1901349
Pt on WS_2	1 M KOH	45	Advanced Materials, 2018, 30, 1704779
PtCoFe@CN	1 M KOH	45	ACS Applied Materials & Interfaces, 2017, 9, 3596-3601
Pt/$Ni(HCO_3)_2$	1 M KOH	44	Angewandte Chemie International Edition, 2019, 58, 5432-5437
Pt_3Ni_2-NWs/SC	1 M KOH	42	Nature Communications, 2017, 8, 14580
NiOx/Pt_3Ni	1 M KOH	40	Angewandte Chemie International Edition, 2016, 55, 12859
Pt1/NMHCS	1 M KOH	40	Advanced Materials, 2021, 2008599
PtNi-O/C	1 M KOH	39.8	Journal of the American Chemical Society, 2018, 140, 9046-9050
Pt/OLC	1 M KOH	38	Nature Energy, 2019, 4, 512-518
Pt/NiO@Ni/NF	1 M KOH	34	ACS Catalysis, 2018, 18, 8866-8872
A-CoPt-NC	1 M KOH	32	Angewandte Chemie International Edition, 2019, 58, 9404
C Pt@ZIF-67	1 M KOH	32	Journal of Materials Chemistry A, 2018, 6, 1376-1381
Pt/GHSs	1 M KOH	27	Small Structures, 2021, 2, 2000017
Pt/MBOPs	1 M KOH	22.8	Journal of Materials Chemistry A, 2020, 8, 7171
Pd/Cu-Pt	1 M KOH	22.8	Angewandte Chemie International Edition, 2017, 56, 16047
MXene/B-Pt	1 M KOH	20	**This Work**

Table S2. Overpotentials of MXene/B-Pt with other recently reported Pt-based HER catalysts (in acid medium).

Catalyst	Electrolyte	η10 (mV)	Information Sources
PEDOT-g-PAA/Pt 15s	0.5 M H_2SO_4	190	ACS Appl. Energy Mater., 2019, 2, 1436
Pt/3D sulfur-doped graphene	0.5 M H_2SO_4	112	Int. J. Hydrogen Energy, 2018, 43, 23231
$Ti_3C_2T_x$@Pt/SWCNTs	0.5 M H_2SO_4	104	Adv. Funct. Mater., 2020, 30, 2000693
Pt/NaTiO	0.1 M $HClO_4$	~75	J. Mater. Chem. A, 2020, 8, 16582
Pt-MoO_{3-x} nanoflakes |MoS_2	0.5 M H_2SO_4	69	J. Catal., 2020, 381, 1
S-M-5Pt	0.5 M H_2SO_4	62	Adv. Funct. Mater., 2020, 30, 2000693
TBA-$Ti_3C_2T_x$-Pt-20	0.5 M H_2SO_4	55	ACS Sustainable Chem. Eng., 2019, 7, 4266
Pt/graphene film	0.5 M H_2SO_4	52	ACS Sustainable Chem. Eng., 2019, 7, 11721
CoPt@ZIF-67	0.5 M H_2SO_4	50	J. Mater. Chem. A, 2019, 7, 6543
10Pt@high proportion polyaniline doped bacterial cellulose	0.5 M H_2SO_4	47	Int. J. Hydrogen Energy, 2018, 43, 6167
Pt/defective WO_3@CFC	0.5 M H_2SO_4	42	J. Mater. Chem. A, 2019, 7, 6285
LPWGA with WO_{3-x}-Pt	0.5 M H_2SO_4	42	Small, 2021, DOI: 10.1002/smll.202102159
Pt-WO_3	0.5 M H_2SO_4	39	Nano Energy, 2020, 71, 104653
Pt single atom/ mesoporous WO_{3-x}	0.5 M H_2SO_4	38	Angew. Chem. Int. Ed., 2019, 58, 16038
Pt-carbon quantum dots-coloaded	0.5 M H_2SO_4	38	J. Power Sources, 2020, 451, 227770
Pt–TiO_{2-x} nanosheets	0.5 M H_2SO_4	35	Nanoscale, 2020, 12, 11055
Pt-FeNi@ porous graphene shells	0.5 M H_2SO_4	~35	J. Mater. Chem. A, 2019, 7, 24347
$Mo_2TiC_2T_x$-VMo	0.5 M H_2SO_4	30	Nature Catalysis
carbon dots-Pt modified polyaniline nanosheets grown on carbon cloth	0.5 M H_2SO_4	30	Appl. Catal., B, 2019, 257, 117905
Mo_2C@NC@Pt	0.5 M H_2SO_4	27	ACS Appl. Mater. Interfaces, 2019, 11, 4047
Pt-WC1,10/Zn-Co-ZIFs	0.5 M H_2SO_4	23	Electrochim. Acta, 2019, 328, 135077
MXene/B-Pt	0.5 H_2SO_4	14	**This Work**