Electronic Supplementary Information

Scalable Synthesis of Two-Dimensional Nano-Sheet Materials with Chlorophyll Extracts: Enhancing the Hydrogen Evolution Reaction

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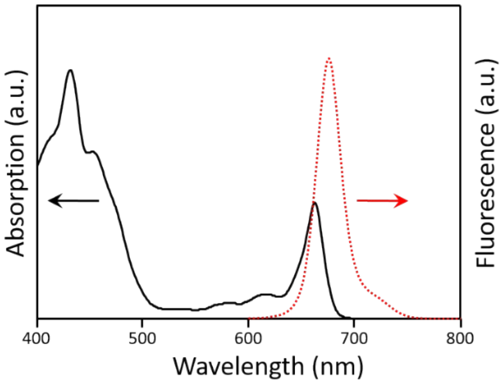

Figure S1. The UV-vis (black solid line) and fluorescence spectrum (red dot line; an excitation wavelength at 450 nm) of the chlorophyll extracts solution.

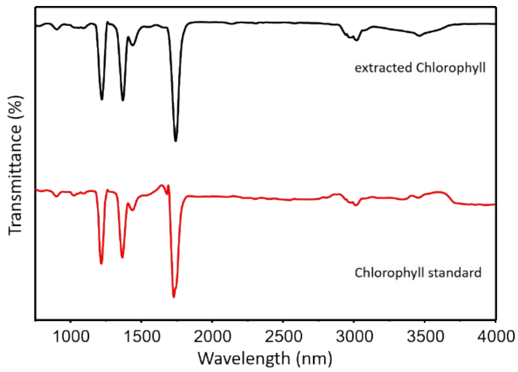

Figure S2. ATR-FTIR spectrum of the extracted chlorophyll (black line) and chlorophyll standard (red line).

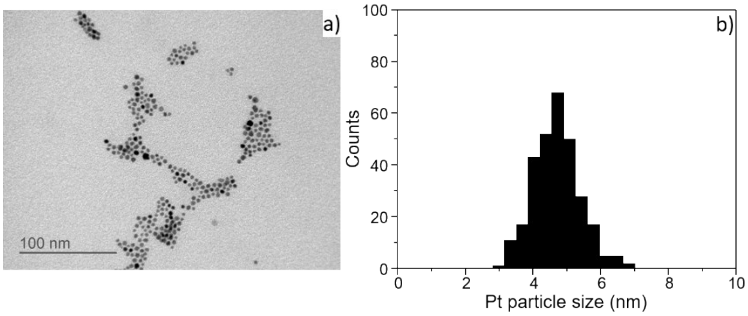

Figure S3. (a) The TEM images of the synthesized PtNPs. (b) The PtNPs size distributions.

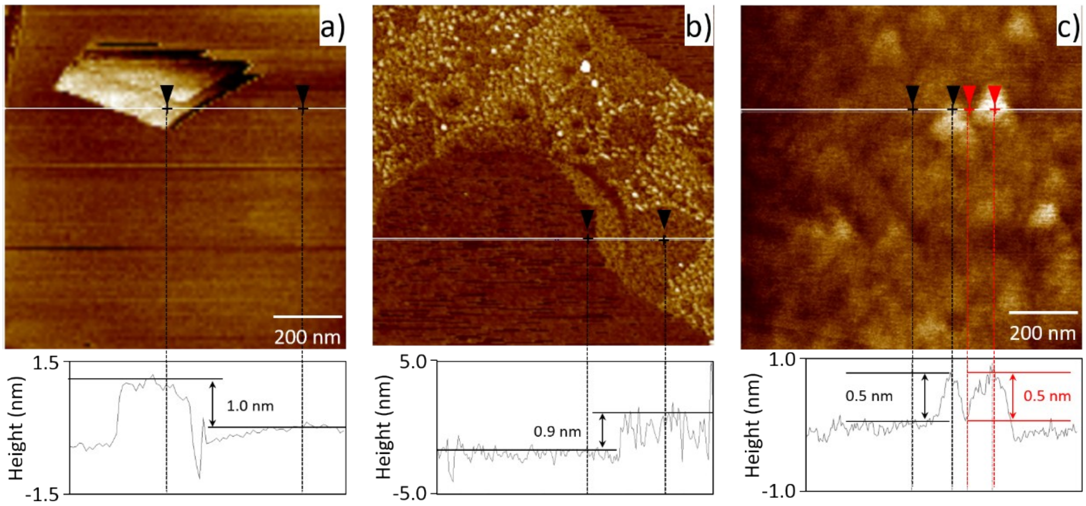

Figure S4. AFM image of the exfoliated (a) graphene, (b) MoS_2 and (c) h-BN transferred onto Si substrate.

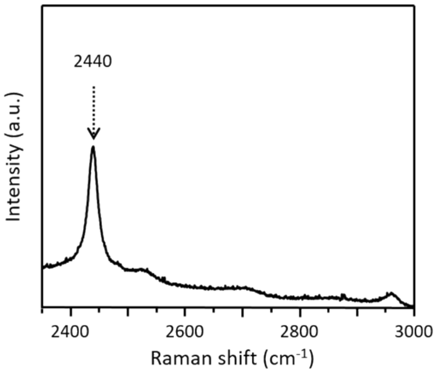

Figure S5. Raman spectrum of chlorophyll extracts.

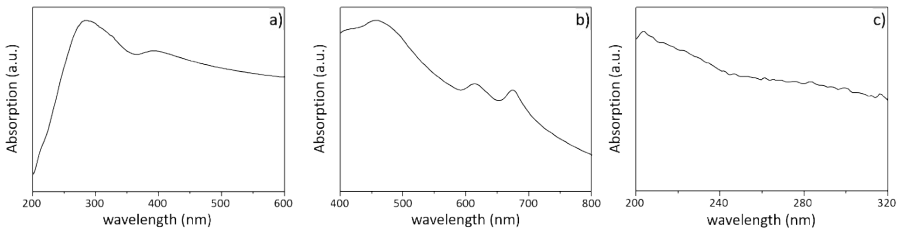

Figure S6. UV-vis spectrum of the exfoliated (a) graphene, (b) MoS_2 and (c) h-BN suspension.

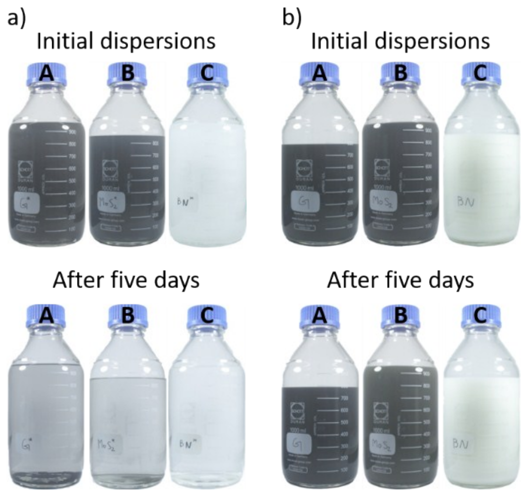

Figure S7. Comparative stability of the suspension of the exfoliated graphene (bottle A), MoS_2 (bottle B), and h-BN (bottle C). (a) without and (b) with chlorophyll extracts.

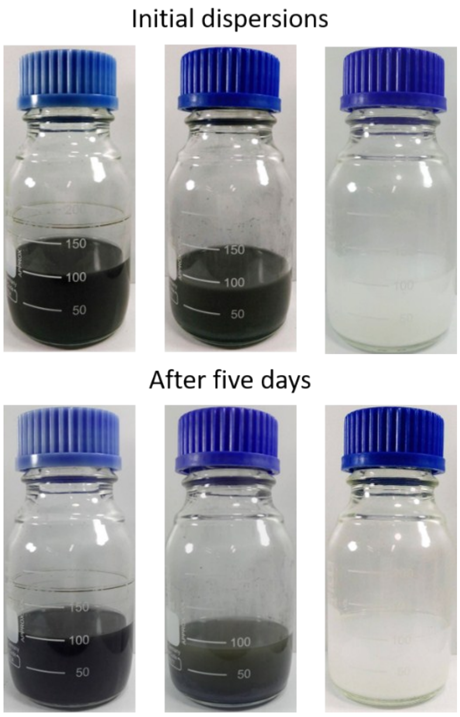

Figure S8. Stability of the suspension of the commercial available chlorophyll-assisted exfoliated graphene (left), MoS_2 (middle), and h-BN (right) suspensions.

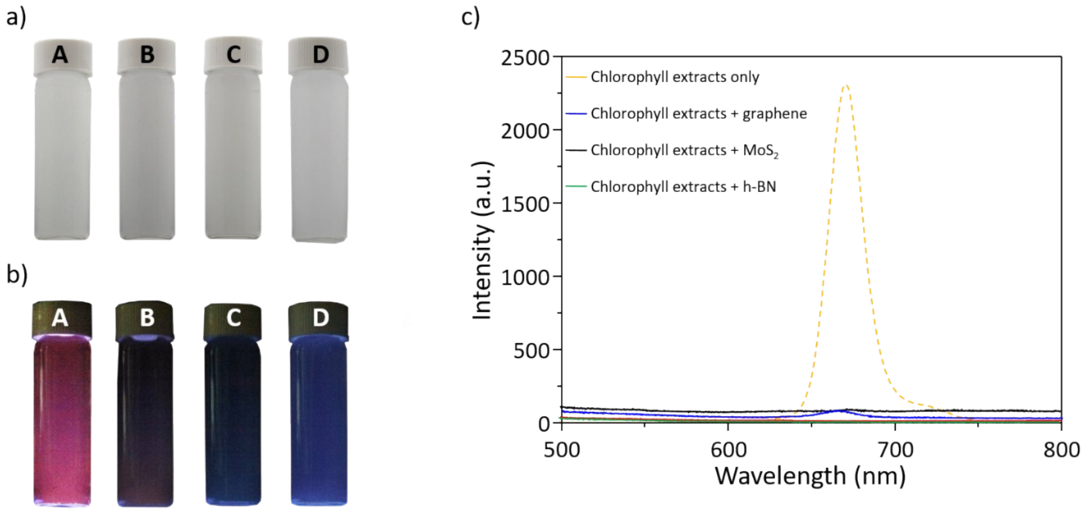

Figure S9. (a) Photographs and (b) Fluorescence of chlorophyll extracts (bottle A), chlorophyll extracts + graphene (bottle B), chlorophyll extracts + MoS_2 (bottle C), and chlorophyll extracts + h-BN (bottle D). (c) The fluorescence spectra of chlorophyll extracts and chlorophyll extracts mixed with different 2D material solutions.

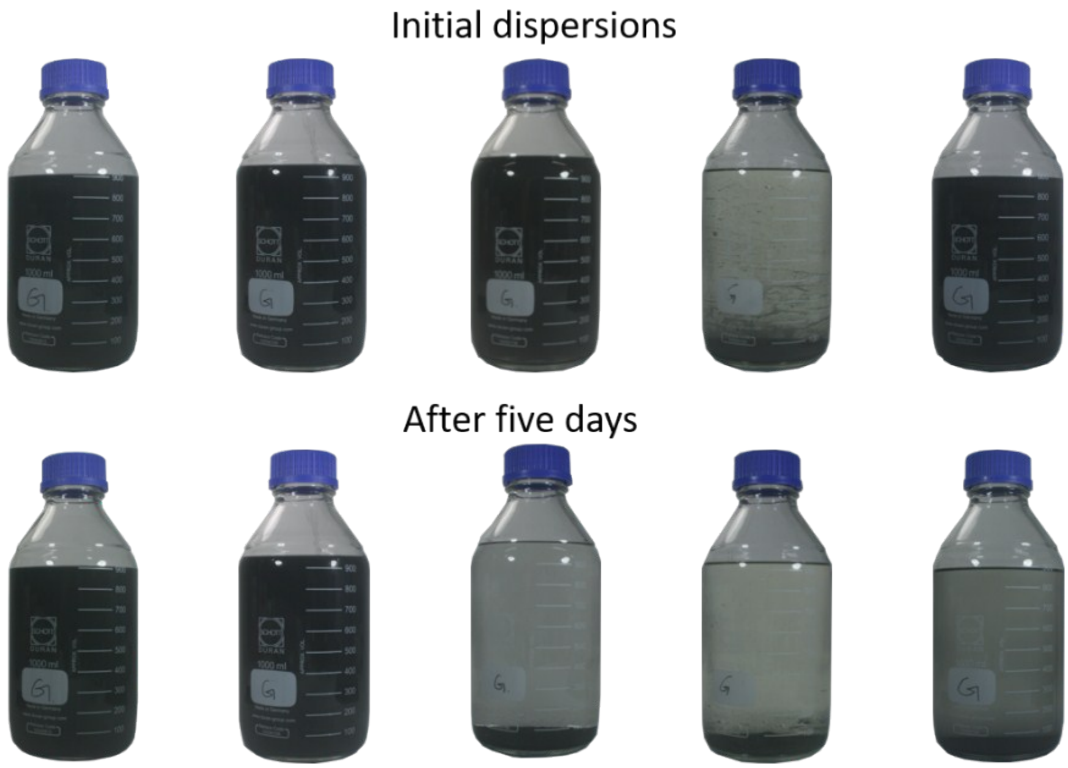

Figure S10. Stability of chlorophyll extracts-assisted exfoliated graphene in solvents. Stable homogeneous suspensions of chlorophyll-assisted exfoliated graphene in various solvents after five days, from left to right: tetrahydrofuran, ethyl acetate, ethanol, hexane, and toluene.

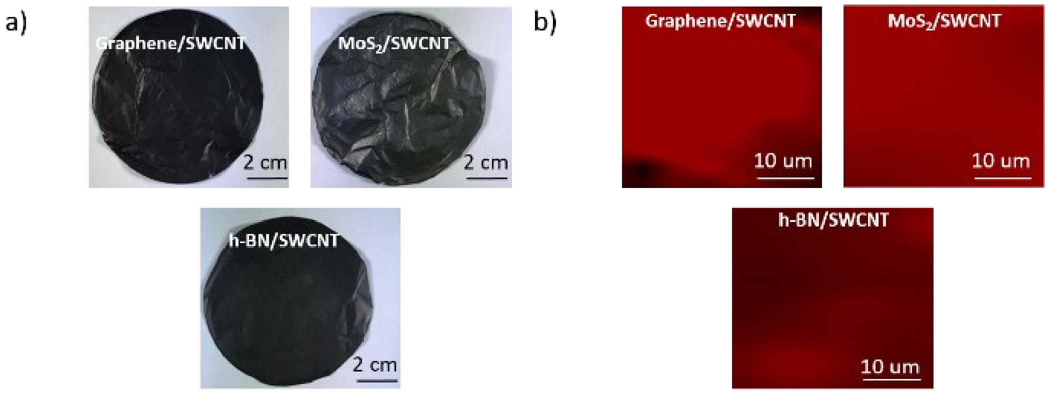

Figure S11. (a) Photograph of free-standing composite paper of graphene/SWCNT, MoS_2/SWCNT, and h-BN/SWCNT. (b) Raman mapping image of the four composite papers by extracting the frequency of the characteristic peak of each 2D material. The Raman 2D mapping area is 30 × 30 μm.

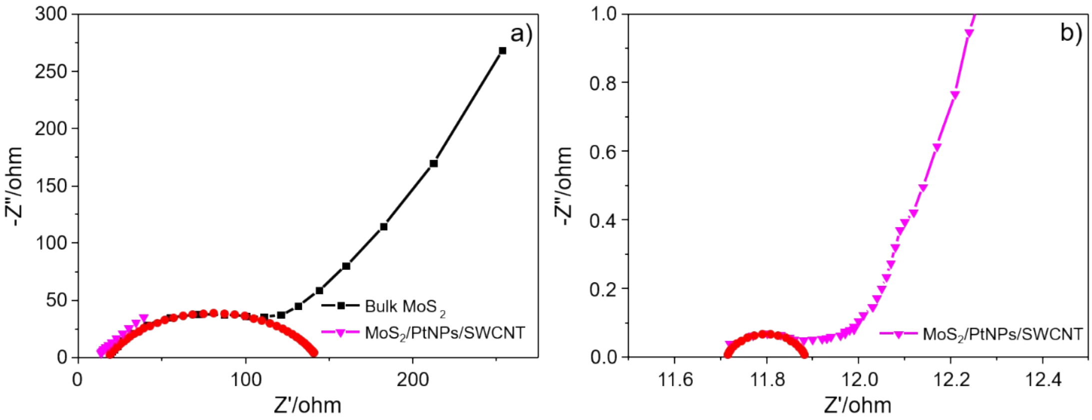

Figure S12. EIS spectra of the bulk MoS_2 (black square) and MoS_2/PtNPs/SWCNT (pink triangle) at low frequency with -0.1 V vs RHE in 0.5 M H_2SO_4 electrolyte. Red dots indicate fitting curve of the bulk MoS_2 and MoS_2/PtNPs/SWCNT paper.

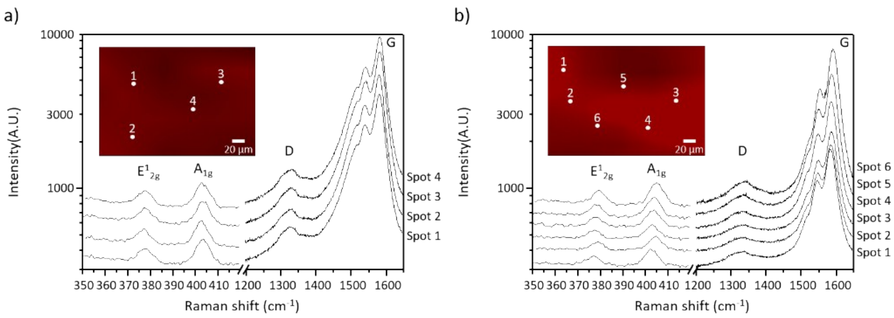

Figure S13. Raman spectra of the MoS_2/PtNPs/SWCNT paper were recorded a) before and b) after 100 h stability tests at a constant potential of -50 mV in 0.5 M H_2SO_4 solution.

Table S1. Summary of literature reported exchange current density of various HER catalysts.

Catalyst	Onset potential (mV)	Tafel slope (mV/dec)	Exchange current density (mA/cm^2)	Year	Journal	Ref.
MoS_2/PtNPs/SWCNT paper	-11	38	7.1 x 10^{-1}	This work		
Chlorophyll extracts - assisted exfoliated MoS_2 thin sheets	-58	46	1.4 x 10^{-1}	This work		
P-doped 2H-MoS_2	-103	49	N/A	2017	*Adv. Funct. Mater.*	1
Hydrothermal synthesis stepped edge-MoS_2 on carbon fiber	~-75	59	2 x 10^{-1}	2017	*Energy Environ. Sci.*	2
Molybdenum Disulfide-Black Phosphorus	~-40	68	6.6 x 10^{-1}	2017	*Nano Lett.*	3
strained MoS_2 with S-vacancy	~-140	60	2~4 x 10^{-2}	2016	*Nat. Mater.*	4
2H Basel plane of monolayer MoS_2	N.A.	~ 50	7~16 x 10^{-3}	2016	*Nat. Mater.*	5
ground MoS_2 microflake in the 900 °C annealing	~-240	76	9 x 10^{-2}	2016	*Nano Lett.*	6
MoS_2 annealed under 500 °C	~-300	147	N/A	2016	*Nano Lett.*	7
semiconductor phase of MoS_2 (S-MoS_2)	~-225	135	4 x 10^{-2}	2016	*Nat. Commun.*	8
Metallic-phase MoS_2 (M-MoS_2)	~-150	41	1 x 10^{-1}	2016	*Nat. Commun.*	8
edge-terminated MoS_2	-103	49	9.62 x 10^{-3}	2015	*Nat. Commun.*	9
MoS_2	-237	101	9.1 x 10^{-4}	2015	*Nat.*	10

					Commun.	
$MoS_2/CoSe_2$	-11	36	7.3 x 10^{-2}	2015	*Nat. Commun.*	10
Ni-Mo-S/C	~-140	85.3	4.89 x 10^{-2}	2015	*Sci. Adv.*	11
Defect-rich ultrathin MoS_2 nanosheets	-120	50	8.91 x 10^{-3}	2013	*Adv. Mater.*	12
Chlorophyll extracts - assisted exfoliated graphene thin sheets	-183	124	3.3 x 10^{-2}	This work		
Chlorophyll extracts - assisted exfoliated h-BN thin sheets	-179	159	6 x 10^{-2}	This work		

Reference:

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Table S2. EDS analysis of the MoS_2/PtNPs/SWCNT paper.

Element	Atomic (%)	Weight (%)
Platinum	0.03	0.26
Molybdenum	7.04	32.18
Sulfur	12.89	19.69