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Supplementary Data

Vertically Oriented MoS₂/WS₂ Heterostructures on Reduced Graphene Oxide Sheets as Electrocatalysts for Hydrogen Evolution Reaction

Hoon Ju Lee^a, Suk Woo Lee^{b,c}, Hyuntae Hwang^a, Seong In Yoon^a, Zonghoon Lee^{b,c*}, and Hyeon Suk Shin^{a,b,e*}

^aDepartment of Energy Engineering, Ulsan National Institute of Science and Technology (UNIST), UNIST-gil 50, Ulsan 44919, Republic of Korea ^bCenter for Multidimensional Carbon Materials, Institute for Basic Science (IBS), Ulsan 44919, Republic of Korea

^cDepartment of Materials Science and Engineering, Ulsan National Institute of Science and Technology (UNIST), Ulsan 44919, Republic of Korea.

^dDepartment of Chemistry, Ulsan National institute of Science and Technology (UNIST), UNIST-gil 50, Ulsan 44919, Korea ^eLow Dimensional Carbon Materials, Ulsan National Institute of Science and Technology (UNIST), UNIST-gil 50, Ulsan 44919, Republic of Korea

*Corresponding Author: shin@unist.ac.kr



Figure S1. (a-c) FE-TEM images of rGMW at different points. (d) Intensity line profile showing interlayer distances of the vertically aligned regions from the area in Figure. 1d (white dotted line).



Figure S2. (a) HAADF-STEM image of rGMW and (b) corresponding elemental image of rGMW, indicating the vertically aligned MoS₂/WS₂ heterostructures on rGO sheets.



Figure S3. (a) SEM of the region with an absence of WS₂ on rGO (major) and (b) vertically grown WS₂ on rGO region (minor). rGW was synthesized through reduction of $(NH_4)_2WS_4$ (10mg) with rGO in DMF solution at 240 °C by microwave-assisted synthetic method (further procedure is totally the same as rGMW).



Figure S4. (a) Raman spectra of GO prepared by Hummer's methods and (b) XPS spectrum for C 1s of GO.

Supporting Figure 5



Figure S5. (a) Normalized polarization curve for HER on modified glassy carbon electrode comprising rGW at a potential sweep rate of 10 mV s⁻¹. (b) Tafel plot obtained from the polarization curve. (c) Nyquist plot of the corresponding catalyst from (a).

| | Onset potential [mV] | η ₁₀ [mV] | Tafel [mV dec ⁻¹] | Reference |
|---|-------------------------|----------------------|----------------------------------|-----------|
| Edge-terminated MoS ₂ | -103 | - | 49 | 4 |
| Vertical Aligned MoS ₂ | ~220 | - | 86 | 12 |
| Ammonated MoS ₂ | - | 320 | 45 | 14 |
| Vertically aligned MoS ₂ /rGO | -117 | | 43.5 | 15 |
| MoS ₂ -WS ₂ Heterostructure | | -137 | 72 | 26 |
| Our study (MoS ₂ /WS ₂ /rGO) | -113 | -157 | 44 | - |

 Table S1. Some of the efficient TMD-based HER electrocatalyst