Tailoring 2D MoS$_2$ heterointerfaces for promising oxygen reduction reaction electrocatalysis

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1. Experimental details

Materials. Ammonium molybdate tetrahydrate, thiourea, melamine and nickel (II) chloride hexahydrate were purchased from Sinopharm Chemical Reagent. The Pt/C catalyst (20 wt% Pt on Vulcan XC72R carbon) was purchased from Johnson Matthey Corporation. Other chemicals were
purchased from Beijing Chemical Reagent Company.

Synthesis of C$_3$N$_4$ template. Melamine is used as precursor for preparing C$_3$N$_4$, which is heated in a muffle furnace at 550 °C for 3 h with a programming rate of 4 °C min$^{-1}$. The yellow colored C$_3$N$_4$ powder is obtained after cooling to room temperature, and ready for further use.

Synthesis of ultrathin Ni$_3$S$_2$/MoS$_2$-0.2 nanosheets. 4.0 g of C$_3$N$_4$ intermediate, 2.0 g of thiourea, 0.16 g of ammonium molybdate tetrahydrate and 0.054 g of Nickel (II) chloride hexahydrate are mixed by grinding, and the mixture is firstly heated at 600 °C for 4 h with a programming rate of 2.5 °C min$^{-1}$. After that, the temperature was increased to 780 °C and maintained for another 5 h.

The calcination is carried out in a nitrogen atmosphere. HCN is formed in this step, please pay attention to tail gas treatment.

Synthesis of ultrathin Ni$_3$S$_2$/MoS$_2$-0.05 nanosheets. The synthetic approach is similar to the ultrathin Ni$_3$S$_2$/MoS$_2$-0.2 nanosheets. The amount of Nickel (II) chloride hexahydrate is 0.014 g, the amount of ammonium molybdate tetrahydrate is 0.19 g.

Synthesis of ultrathin Ni$_3$S$_2$/MoS$_2$-0.1 nanosheets. The synthetic approach is similar to the ultrathin Ni$_3$S$_2$/MoS$_2$-0.2 nanosheets. The amount of Nickel (II) chloride hexahydrate is 0.027 g, the amount of ammonium molybdate tetrahydrate is 0.18 g.

Synthesis of ultrathin Ni$_3$S$_2$/MoS$_2$-0.15 nanosheets. The synthetic approach is similar to the ultrathin Ni$_3$S$_2$/MoS$_2$-0.2 nanosheets. The amount of Nickel (II) chloride hexahydrate is 0.041 g, the amount of ammonium molybdate tetrahydrate is 0.17 g.

Synthesis of ultrathin Ni$_3$S$_2$/MoS$_2$-0.3 nanosheets. The synthetic approach is similar to the ultrathin Ni$_3$S$_2$/MoS$_2$-0.2 nanosheets. The amount of Nickel (II) chloride hexahydrate is 0.081 g, the amount of ammonium molybdate tetrahydrate is 0.14 g.
Synthesis of ultrathin Ni$_3$S$_2$/MoS$_2$-0.4 nanosheets. The synthetic approach is similar to the ultrathin Ni$_3$S$_2$/MoS$_2$-0.2 nanosheets. The amount of Nickel (II) chloride hexahydrate is 0.108 g, the amount of ammonium molybdate tetrahydrate is 0.12 g.

**Table S1.** The content of raw materials for achieving different Ni$_3$S$_2$/MoS$_2$ samples.

<table>
<thead>
<tr>
<th>sample name</th>
<th>C$_3$N$_4$</th>
<th>thiourea</th>
<th>ammonium molybdate tetrahydrate</th>
<th>Nickel (II) chloride hexahydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni$_3$S$_2$/MoS$_2$-0.05</td>
<td>4.0 g</td>
<td>2.0 g</td>
<td>0.19 g</td>
<td>0.014 g</td>
</tr>
<tr>
<td>Ni$_3$S$_2$/MoS$_2$-0.1</td>
<td>4.0 g</td>
<td>2.0 g</td>
<td>0.18 g</td>
<td>0.027 g</td>
</tr>
<tr>
<td>Ni$_3$S$_2$/MoS$_2$-0.15</td>
<td>4.0 g</td>
<td>2.0 g</td>
<td>0.17 g</td>
<td>0.041 g</td>
</tr>
<tr>
<td>Ni$_3$S$_2$/MoS$_2$-0.2</td>
<td>4.0 g</td>
<td>2.0 g</td>
<td>0.16 g</td>
<td>0.054 g</td>
</tr>
<tr>
<td>Ni$_3$S$_2$/MoS$_2$-0.3</td>
<td>4.0 g</td>
<td>2.0 g</td>
<td>0.14 g</td>
<td>0.081 g</td>
</tr>
<tr>
<td>Ni$_3$S$_2$/MoS$_2$-0.4</td>
<td>4.0 g</td>
<td>2.0 g</td>
<td>0.12 g</td>
<td>0.108 g</td>
</tr>
</tbody>
</table>

Synthesis of ultrathin MoS$_2$ nanosheets. 4.0 g of C$_3$N$_4$ intermediate, 2.0 g of thiourea and 0.2 g of ammonium molybdate tetrahydrate were mixed by grinding, and the resulting powder was transferred into the furnace. The furnace was heated to 600°C at a rate of 2.5°C min$^{-1}$ under nitrogen and maintained for 240 min, followed by elevating the temperature to 780°C and maintaining for 300 min.

Synthesis of ultrathin Ni$_3$S$_2$/MoS$_2$-0.2-700 nanosheets. 4.0 g of C$_3$N$_4$ intermediate, 2.0 g of thiourea, 0.16 g of ammonium molybdate tetrahydrate and 0.054 g of Nickel (II) chloride hexahydrate are mixed by grinding, and the mixture is firstly heated at 600°C for 4 h with a programming rate of 2.5 °C min$^{-1}$. After that, the temperature was increased to 700°C and kept for another 5 h. The calcination is carried out in a nitrogen atmosphere.

Synthesis of ultrathin Ni$_3$S$_2$/MoS$_2$-0.2-900 nanosheets. 4.0 g of C$_3$N$_4$ intermediate, 2.0 g of
thiourea, 0.16 g of ammonium molybdate tetrahydrate and 0.054 g of Nickel (II) chloride hexahydrate are mixed by grinding, and the mixture is firstly heated at 600 °C for 4 h with a programming rate of 2.5 °C min⁻¹. After that, the temperature was increased to 900 °C and kept for another 5 h. The calcination is carried out in a nitrogen atmosphere.

2. Characterizations

Physical characterization. Scanning electron microscopy (SEM) measurements and energy dispersive X-ray (EDX) spectra were performed on a HITACHI SU8000 microscope. Transmission electron microscopy (TEM), high-resolution (HR)TEM and selected area electron diffraction (SAED) images were obtained on a JEOL JEM-2200FS microscope. The X-ray powder diffraction (XRD) patterns were measured in reflection mode (Cu Kα radiation) on a PANalytical B.V. Empyrean. X-ray Photoelectron Spectroscopy (XPS) spectra were recorded by using an ESCALAB 250 spectrometer with a monochromatic X-ray source with Al Kα excitation (1486.6 eV). Raman spectra were measured with a Horiba LabRAM HR Evolution spectrometer. Nitrogen sorption experiments were performed with a Quadrasorb-evo at 77K, and the sample was degassed at 150°C for 20 h before measurements. The data were analysed with Quantachrome software.

Oxygen reduction reaction (ORR) measurements. The electrochemical tests were conducted using CHI 760e (Shanghai Chenhua Instrument Factory, China) with a typical three-electrode cell at 298 K. A platinum wire was used as the counter-electrode and a saturated calomel electrode (SCE) as the reference electrode. The working electrode was prepared by applying the catalyst turbid solution onto a pre-polished glassy carbon rotating disk electrode (RDE) (3 mm diameter). For each sample, 3 mg (20 wt% Pt/C is taken 1.5 mg) catalyst was dispersed in a mixed solvent of
0.5 mL ultrapure water and 0.5 mL DMF (volume ratio 1: 1). The mixture was ultrasonicated for 30~60 min to obtain the homogeneous dispersion. Then, 10 μL well-dispersed sample ink was dropped onto the glassy carbon electrode disk. The loading for each Ni₃S₂/MoS₂ sample and 20 wt% Pt/C catalyst was ~0.4 mg cm⁻² and ~0.2 mg cm⁻², respectively. After drying at 298 K, 5 μL of 0.5 wt% Nafion solution in ethanol was dropped onto the surface of the catalyst layer to form a thin protective film. The addition of a little Nafion can effectively improve the distribution of the catalyst and enhance its binding onto the electrode surface. Before experiment, the electrolyte solutions were purged with O₂ for 30 min. The headspace of the electrochemical cell was continuously purged with O₂ during the electrochemical detection. All the experiments were conducted at ambient conditions. In this work, the onset potential is defined as the potential that the cathodic catalytic current exceeds 0.05 mA cm⁻². The Koutecky-Levich (K-L) plots were taking points at different electrode potentials. Based on the K-L equation, the electron transfer number (n) can be calculated from the slope of the K-L plot:

\[
\frac{1}{J} = \frac{1}{J_K} + \frac{1}{B\omega^{1/2}} \\
B = 0.62nFC_0(D_0)^{2/3}(\nu)^{-1/6}
\]

where \( J \) is the measured current density, \( J_K \) is the kinetic current density, \( \omega \) is the rotation rate of the disk electrode, \( n \) is the number of electron transfers per O₂ molecule, \( F \) is the Faraday constant (96 485 C mol⁻¹), \( C_0 \) is the bulk oxygen concentration in 0.1 M KOH (1.2 × 10⁻⁶ mol cm⁻³), \( D_0 \) is the oxygen diffusion coefficient in 0.1 M KOH (1.9 × 10⁻⁵ cm² s⁻¹), and \( \nu \) is the kinematic viscosity of the electrolyte (0.01 cm² s⁻¹). All the potentials reported were referenced to a reversible hydrogen electrode (RHE).
Table S2. Elemental content in Ni$_3$S$_2$/MoS$_2$-0.2 and acid etched Ni$_3$S$_2$/MoS$_2$-0.2 by XPS analysis.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Chemical composition (at%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S</td>
</tr>
<tr>
<td>Ni$_3$S$_2$/MoS$_2$-0.2</td>
<td>45.34</td>
</tr>
<tr>
<td>acid etched Ni$_3$S$_2$/MoS$_2$-0.2</td>
<td>56.16</td>
</tr>
</tbody>
</table>

Fig. S1 Photograph of ultrathin Ni$_3$S$_2$/MoS$_2$ nanosheets (0.18 g).
The C and N may mainly originate from surface contamination. In literature, the 1s level hydrocarbon contaminant carbon is reported at 284.6 eV, which is in good agreement with the C 1s peak at 284.6 ± 0.2 eV in the XPS spectrum in Fig. S2a. The surface pollution to the sample is hard to avoid before XPS measurement. Meanwhile, the presence of the O 1s and N 1s peaks also evidence the surface pollution of the sample.

We have performed the acid etching experiment by dispersing 0.1 g Ni$_3$S$_2$/MoS$_2$-0.2 in 10 ml
1M HCl and stirring for 24 h at room temperature. The resulting solid was firstly filtrated and washed with abundant ultrapure water, and then dried at 60 °C overnight in vacuum drying oven.

The XPS survey spectrum of acid etched Ni$_3$S$_2$/MoS$_2$-0.2 is shown in Fig. S2b, and the element content determined by XPS is presented in Table S2. Obviously, both of the C and N content in the acid etching sample are greatly reduced, which corresponds to the surface pollution of the sample. Meanwhile, similar results are also found by comparing the high-resolution C 1s and N 1s XPS spectra of the freshly-prepared (Fig. S2c, e) and acid etching samples (Fig. S2d, f). The hydrochloric acid washing removed most of the surface C and N. In regards to the remaining C 1s signal at 284.6 eV in the acid etched Ni$_3$S$_2$/MoS$_2$-0.2, we have discussed with the specialized XPS scientist, who thinks it may be the carbon residual in the measuring apparatus. In conclusion, above acid etching results prove that at least most of the C and N comes from contamination.

**Fig. S3** SEM images at 15,000 times and 40000 times magnification of pristine MoS$_2$ ultrathin nanosheets.
Fig. S4 SEM images at 15,000 times and 40000 times magnification of Ni$_3$S$_2$/MoS$_2$-0.05.

Fig. S5 SEM images at 15,000 times and 40000 times magnification of Ni$_3$S$_2$/MoS$_2$-0.1.

Fig. S6 SEM images at 15,000 times and 40000 times magnification of Ni$_3$S$_2$/MoS$_2$-0.15.
Fig. S7 SEM images at 15,000 times and 40,000 times magnification of Ni$_3$S$_2$/MoS$_2$-0.2.

Fig. S8 SEM images at 15,000 times and 40,000 times magnification of Ni$_3$S$_2$/MoS$_2$-0.3.

Fig. S9 SEM images at 15,000 times and 40,000 times magnification of Ni$_3$S$_2$/MoS$_2$-0.4.
The Brunauer-Emmett-Teller (BET) specific surface area of the Ni₃S₂/MoS₂ sample is investigated via nitrogen isothermal adsorption/desorption measurements. As shown in Fig. S10, the BET specific surface area is 68 m² g⁻¹, and the pore volume is 0.24 cm³ g⁻¹. This is the type H3 hysteresis loops. This character is associated with the metastability of the adsorbed multilayer (and delayed capillary condensation) and is due to the low degree of pore curvature and non-rigidity of the aggregate structure. It means that micrometer-sized 3D structure stacked by nanosheets is successfully produced.
Selected area electron diffraction (SAED) of the sample is shown in the inset of Fig. S11. The different rings are composed of diffraction points. This result is in agreement with the crystal orientations of Ni$_3$S$_2$ and MoS$_2$. Since the luminance of the (002) planes of 2H-MoS$_2$ ring is weak, we know that the Ni$_3$S$_2$/MoS$_2$ nanosheets are ultrathin.
The ORR activity of series of Ni$_3$S$_2$/MoS$_2$ samples are assessed by CV in O$_2$-saturated and N$_2$-saturated 0.1 M KOH electrolyte at a scan rate of 50 mV s$^{-1}$. As a control, the ORR performances of MoS$_2$ nanosheets and commercial Pt/C catalyst were also presented in Fig. S12. For samples Ni$_3$S$_2$/MoS$_2$-0.05, 0.1, 0.15 and 0.2, the onset and peak potentials shift towards the positive

**Fig. S12** CVs of various Ni$_3$S$_2$/MoS$_2$ samples, MoS$_2$ nanosheets and commercial Pt/C catalyst in N$_2$ (black) and O$_2$ (red) saturated electrolyte in 0.1M KOH with a scan rate of 50 mV s$^{-1}$. 
direction upon increasing the amount of Ni$_3$S$_2$. Meanwhile, the ORR current densities also increase gradually with increasing the amount of Ni$_3$S$_2$ between these 4 samples. The results presented above suggest that the heterointerfaces play a key role in ORR. However, the current densities of Ni$_3$S$_2$/MoS$_2$-0.2, 0.3 and 0.4 decrease with increasing the amount of Ni$_3$S$_2$. The high content of Ni$_3$S$_2$ may either be not sufficient for catalysis or delay charge transport among the conductive MoS$_2$ skeleton during the catalytic process.$^3$

To get a rough insight into the correlation of nanotopography with ORR activity, the morphological evolution of the samples with tunable ratio of the two components is investigated (Fig. S3 ~ S9). Their ORR activity are also evaluated (Fig. 3a and Fig. S12). From these experimental data, we deduce that the 2D nanostructure damage in the sample would destroy the Ni$_3$S$_2$/MoS$_2$ heterointerface, leading to deterioration of the ORR performance. We also find that maintaining intact 2D nanostructure and providing rich heterointerfaces are vital to ORR activity proliferation. The advantages of Ni$_3$S$_2$/MoS$_2$ nanosheets include but not limited to these points. In summary, above morphological evolution study suggests that the heterointerface-related activity improvement is reasonable.
**Fig. S13** XRD patterns of Ni$_3$S$_2$/MoS$_2$-0.2, Ni$_3$S$_2$/MoS$_2$-0.2-700 and Ni$_3$S$_2$/MoS$_2$-0.2-900.

**Fig. S14** SEM image of Ni$_3$S$_2$/MoS$_2$ ultrathin nanosheets. (a) Ni$_3$S$_2$/MoS$_2$-0.2-700. (b) Ni$_3$S$_2$/MoS$_2$-0.2-900.
Fig. S15 CVs of Ni₃S₂/MoS₂-0.2-700 and Ni₃S₂/MoS₂-0.2-900 in N₂ - (black) and O₂ - (red) saturated electrolyte in 0.1M KOH with a scan rate of 50 mV s⁻¹, and LSVs of Ni₃S₂/MoS₂-0.2-700 and Ni₃S₂/MoS₂-0.2-900 (scan rate: 10 mV s⁻¹).

Fig. S16 LSVs of Ni₃S₂/MoS₂-0.2-700, Ni₃S₂/MoS₂-0.2-900 at 1600 rpm in O₂-saturated 0.1 M KOH (scan rate: 10 mV s⁻¹).
The characterization and electrochemical results of the two samples synthesized at treating temperature of 700 °C and 900 °C are shown in Fig. S13~Fig.S17. One can see that as the pyrolysis temperature increases, the crystallinity of the materials increases significantly. The morphology of the two samples appears more irregular. When the pyrolysis temperature is 700 °C, the low crystallinity causes an irregular nanostructure. When the heating temperature rises to 900 °C, Ni$_3$S$_2$ melts at 797 °C and the nanostructures of the material is destroyed. The ORR performances of both samples are obviously much worse compared to Ni$_3$S$_2$/MoS$_2$-0.2. By analyzing the K-L plots in Fig. S17, the estimated electron transfer number of Ni$_3$S$_2$/MoS$_2$-0.2-700 and Ni$_3$S$_2$/MoS$_2$-0.2-900 is 4.5 and 3.6, respectively. The crystallinity of the former is low. The amorphous Ni$_3$S$_2$ and MoS$_2$ in alkaline solution are instable. It may cause side reactions on the working electrode during the ORR processes, so the electron transfer number is more than 4. While for the latter, since the pyrolysis temperature exceeds the melting point of Ni$_3$S$_2$, the Ni$_3$S$_2$ will melt and re-accumulate. The nanostructure and the heterointerfaces may thus be destroyed. This leads to deterioration of ORR performance and decrease in the electron transfer number.

**Fig. S17** The Koutecky–Levich plots of the Ni$_3$S$_2$/MoS$_2$-0.2-700 and Ni$_3$S$_2$/MoS$_2$-0.2-900.
The amount of the catalytically active sites of Ni$_3$S$_2$/MoS$_2$-0.2 and MoS$_2$ nanosheets for ORR are estimated from the $C_{dl}$ by collecting cyclic voltammograms in the non-Faradaic region (Fig. S18). The MoS$_2$ nanosheets exhibits a smaller $C_{dl}$ value than that of Ni$_3$S$_2$/MoS$_2$-0.2, suggesting a higher ECSA for Ni$_3$S$_2$/MoS$_2$-0.2. As a consequence, the Ni$_3$S$_2$/MoS$_2$-0.2 catalyst possesses richer effective active sites for ORR.
Fig. S19 shows the electrochemical impedance spectroscopy (EIS) tests of the Ni$_3$S$_2$/MoS$_2$ catalyst and MoS$_2$ nanosheets. It was shown that the modulated results suited well with the tested results. R$_0$ (29.31 $\Omega$) is the Ohmic resistance that is originated from the contact resistance of the catalyst with the electrode surface. R$_1$ and R$_2$ were oxygen reduction reaction resistances. The values of R$_1$ and R$_2$ were 32.36 $\Omega$ and 5627 $\Omega$. It is usually believed that the oxygen reduction involves 4-electron and 2-electron reactions. The oxygen molecular was directly transformed into hydroxide ion in 4-electron reaction style and the intermediate of H$_2$O$_2$ was produced in the 2-electron reaction process and then transformed into hydroxide ion in the ORR reaction in alkaline electrolyte. The R1 corresponds to the mixed reaction of 4-electron and the first step of 2-electron ORR. Thus, the R2 corresponds to the second step of 2-electron ORR.
The value of R1 was much lower than that of R2, based on which it could be deduced that the intermediate $\text{H}_2\text{O}_2$ should be in a low concentration.\textsuperscript{4} Considering the aforementioned results from Fig. S12 and Fig. S19, the catalytic process is mainly happened at the heterointerfaces, along which the embedded Ni-S sites and Mo edges chemisorb oxygen, and the Mo edges on 2D-MoS\textsubscript{2} display a four-electron process with the main product of hydroxide that is similar to the commercial Pt/C catalyst.

**Fig. S20** Chronoamperometric response of Ni$_3$S$_2$/MoS$_2$ and 20% Pt/C catalyst (the arrow indicates introduction of 10 vol% methanol).
**Fig. S21** Stability of Ni$_3$S$_2$/MoS$_2$ catalyst by comparing the CV measurements of the initial sample and after 1000/6000 consecutive cycles in 0.1 M KOH solution with a scan rate of 50 mV s$^{-1}$ and LSV measurements at 1600 rpm with a scan rate of 10 mV s$^{-1}$ of the initial sample and after 6000 consecutive cycles (0.21 V-1.21 V, CV, 50 mV s$^{-1}$) in 0.1M KOH solution.

**Table S3.** ORR performance comparison under alkaline conditions for Ni$_3$S$_2$/MoS$_2$ and related MoS$_2$-based materials.

<table>
<thead>
<tr>
<th>Catalyst</th>
<th>Onset Potential (V vs. RHE)</th>
<th>$E_{1/2}$ (V vs. RHE)</th>
<th>Current density (mA cm$^{-2}$) @E/V (vs RHE)</th>
<th>Electron transfer number @E/V (vs RHE)</th>
<th>Refs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni$_3$S$_2$/MoS$_2$ nanosheets</td>
<td>0.950</td>
<td>0.885</td>
<td>5.16@0.4</td>
<td>4.01@0.8</td>
<td>This work</td>
</tr>
<tr>
<td>MoS$_2$-CNT</td>
<td>about 0.75</td>
<td>about 0.65</td>
<td>about 5.6@0.264</td>
<td>about 4.2@0.6</td>
<td>5</td>
</tr>
<tr>
<td>Material</td>
<td>E (vs. RHE)</td>
<td>pH</td>
<td>Potential (V)</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------</td>
<td>----</td>
<td>-----------------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>P-MoS&lt;sub&gt;2&lt;/sub&gt;</td>
<td>0.96</td>
<td>0.80</td>
<td>about 3.3@0.4</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>MoS&lt;sub&gt;2&lt;/sub&gt;-Co-C</td>
<td>about 0.9</td>
<td>0.82</td>
<td>about 4.7@0.364</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>MoS&lt;sub&gt;2&lt;/sub&gt;-coupled polymer</td>
<td>about 0.9</td>
<td>0.824</td>
<td>4.9@0.064</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>AuNP–MoS&lt;sub&gt;2&lt;/sub&gt; films</td>
<td>0.909</td>
<td>about 0.8</td>
<td>3.9@0.4</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Flower-like MoS&lt;sub&gt;2&lt;/sub&gt;</td>
<td>0.824</td>
<td>about 0.7</td>
<td>2.4@0.164</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>MoS&lt;sub&gt;2&lt;/sub&gt;-RGO</td>
<td>0.8</td>
<td>about 0.7</td>
<td>2.72@0.3</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>O-MoS&lt;sub&gt;2&lt;/sub&gt;</td>
<td>0.94</td>
<td>0.80</td>
<td>3.8@0.3</td>
<td>12</td>
<td></td>
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<tr>
<td>MoS&lt;sub&gt;2&lt;/sub&gt;/NG</td>
<td>0.889</td>
<td>about 0.7</td>
<td>3.9@0.2</td>
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</tr>
<tr>
<td>MoS&lt;sub&gt;2&lt;/sub&gt;QDs@Ti&lt;sub&gt;3&lt;/sub&gt;C&lt;sub&gt;2&lt;/sub&gt;TxQDs @MMWCNTs</td>
<td>0.87</td>
<td>0.75</td>
<td>3.9@0.4</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>CoO&lt;sub&gt;x&lt;/sub&gt;/mC@MoS&lt;sub&gt;2&lt;/sub&gt;@g-C&lt;sub&gt;3&lt;/sub&gt;N&lt;sub&gt;4&lt;/sub&gt;</td>
<td>0.89</td>
<td>about 0.7</td>
<td>4.4@0.4</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>N-GQDs/MoS&lt;sub&gt;2&lt;/sub&gt;–rGO</td>
<td>0.81</td>
<td>about 0.6</td>
<td>2.56@0</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>G@N-MoS&lt;sub&gt;2&lt;/sub&gt;</td>
<td>0.82</td>
<td>about 0.7</td>
<td>4.8@0</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Mo–N/C@MoS&lt;sub&gt;2&lt;/sub&gt;</td>
<td>0.90</td>
<td>0.81</td>
<td>5.1@0.4</td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

# RHE potentials conversion from the original potentials in the reference.

\[ E \text{ (vs. RHE)} = E \text{ (vs. Hg/HgO)} + 0.0591pH + 0.098, \]

\[ E \text{ (vs. RHE)} = E \text{ (vs. Ag/AgCl)} + 0.0591pH + 0.197, \]

\[ E \text{ (vs. RHE)} = E \text{ (vs. SCE)} + 0.0591pH + 0.242, \]

\[ E \text{ (vs. RHE)} = E \text{ (vs. NHE)} + 0.0591pH. \]
Reference: