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Table S1. HER activities of synthesized MoS₂ catalysts.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Onset Potential (mV)</th>
<th>Tafel Slope (mV)</th>
<th>Surface Area (m²·g⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZT-MoS₂-H</td>
<td>-160</td>
<td>90.3</td>
<td>405.3 ± 4.6</td>
</tr>
<tr>
<td>ZT-MoS₂</td>
<td>-110</td>
<td>63</td>
<td>462.1 ± 5.2</td>
</tr>
<tr>
<td>ZT-MoS₂-T</td>
<td>-185</td>
<td>135.5</td>
<td>389.4 ± 7.1</td>
</tr>
</tbody>
</table>

Figure S1: (a) SEM image and (b) corresponding magnified SEM image of ZnO NRs.

Figure S2. Energy Dispersive X-ray Spectrometer (EDS) spectrum of ZT-MoS₂.
To obtain more information of the intrinsic catalytic activity, the turnover frequency (TOF) for the active sites of ZT-MoS₂ catalysts was further calculated using the roughness factor method according to the following equation.

\[
D_c = D_s \times \frac{C_{dlc}}{C_{dls}}
\]

(1)

\[
TOF(s^{-1}) = \frac{j / (2 \times q)}{D_c}
\]

(2)

where \(D_c\) and \(D_s\) was the density of active sites for catalyst (Sites/cm²) and standard sample (Sites/cm²), the \(C_{dlc}\) and \(C_{dls}\) was the double layer capacitor (F/cm) for catalysts calculated and for standard MoS₂ (60 µF/cm) by the CV experiment at different scan rates (Figure S5), the \(j\) (A/cm²) was the current density of LSV at −500 mV and \(q\) was the elementary charge (1.6 × 10⁻¹⁹ C). The active sites of ZT-MoS₂ was 3.53 × 10¹⁷ sites/cm², which was 1.3 times higher than the MoS₂ (2.75 × 10¹⁷ sites/cm²). The ZT-MoS₂ presented a superior TOF of 1.25 s⁻¹ to P-MoS₂ (0.69 s⁻¹), further indicating advanced HER catalytic activity of ZT-MoS₂.
**Figure S5.** Electrochemical measurement for determining TOF: (a) a cyclic voltammetry (CV) curve of ZT-MoS$_2$ at different scan rates. (b) Current density of CV experiment at overpotential 500 mV vs RHE as a function of scan rates.

**Figure S6.** Polarization curves of different ZT-MoS$_2$: (a) ZT-MoS$_2$-H, (b) ZT-MoS$_2$ and (c) ZT-MoS$_2$-T.