Synthesis of MoS$_{2(1-x)}$Se$_{2x}$ and WS$_{2(1-x)}$Se$_{2x}$ alloy for enhanced hydrogen evolution reaction performance

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Table S1. Comparison of electrochemical parameters for different electrocatalysts by using Pt as counter electrode.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Overpotential (mV vs RHE) @ 10 mA·cm⁻²</th>
<th>Tafel slope (mV·decade⁻¹)</th>
<th>Exchange current Density (jₒ, mA·cm⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt</td>
<td>40</td>
<td>52</td>
<td>3.01</td>
</tr>
<tr>
<td>MoS₂</td>
<td>252</td>
<td>87</td>
<td>1.23 x 10⁻²</td>
</tr>
<tr>
<td>MoS₂(1-x)Se₂ₓ</td>
<td>141</td>
<td>79</td>
<td>2.04 x 10⁻¹</td>
</tr>
<tr>
<td>WS₂</td>
<td>283</td>
<td>134</td>
<td>6.36 x 10⁻²</td>
</tr>
<tr>
<td>WS₂(1-x)Se₂ₓ</td>
<td>167</td>
<td>108</td>
<td>2.63 x 10⁻¹</td>
</tr>
</tbody>
</table>
Figure S1 (a-b). EDS spectra of elemental composition for (a) MoS$_{2(1-x)}$Se$_{2x}$ and (b) WS$_{2(1-x)}$Se$_{2x}$ alloys.
Figure S2. (a) FESEM image of MoS$_2$ and (b-e) their elemental mapping images (b) O (c) Sn (d) Mo and (e) S elements.
Figure S3. (a) FESEM image of MoS$_{2(1-x)}$Se$_{2x}$ alloy and (b-f) their elemental mapping images (b) O, (c) Sn, (d) S, (e) Mo and (f) Se elements.
Figure S4. (a) FESEM image of WS$_2$ and (b-e) their elemental mapping images (b) O (c) Sn (d) W and (e) S elements.
Figure S5. (a) FESEM image of WS$_{2(1-x)}$Se$_{2x}$ alloy and (b-f) their elemental mapping images (b) O, (c) Sn, (d) S, (e) W and (f) Se elements.
Figure S6. (a) TEM cross-sectional micrograph and (b) zoom-in view of FTO/MoS$_{2(1-x)}$Se$_{2x}$ structure. (c-f) TEM cross-sectional micrograph and its elemental mapping images (d) Mo, (e) S and (f) Se elements for MoS$_{2(1-x)}$Se$_{2x}$. 
Figure S7. (a) TEM cross-sectional micrograph and (b) zoom-in view of FTO/WS$_{2(1-x)}$Se$_{2x}$ structure. (c-f) TEM cross-sectional micrograph and its elemental mapping images (d) W, (e) S and (f) Se elements for WS$_{2(1-x)}$Se$_{2x}$. 
Figure S8. Polarization curves of MoS$_{2(1-x)}$Se$_{2x}$ film prepared using 30 min and 1 h post-annealing time in selenium environment at 500°C.
Figure S9. Polarization curves of WS$_{2(1-x)}$Se$_{2x}$ film prepared using 30 min and 1 h post-annealing time in selenium environment at 500°C.
Figure S10. Stability test for MoS$_{2(1-x)}$Se$_{2x}$ and WS$_{2(1-x)}$Se$_{2x}$ alloy catalyst. (a-b) Polarization curves of MoS$_{2(1-x)}$Se$_{2x}$ and WS$_{2(1-x)}$Se$_{2x}$ alloy catalysts for before and after 20h HER performance.
Figure S11. FE-SEM and EDS element analysis after 20 h HER operation. (a, c) MoS$_{2(1-x)}$Se$_{2x}$ and (b, d) WS$_{2(1-x)}$Se$_{2x}$ alloys.