Supplementary Materials

NiS nanoparticle-MoS$_2$ nanosheet core-shell spheres: PVP-assisted synthesis and efficient electrocatalyst for hydrogen evolution reaction

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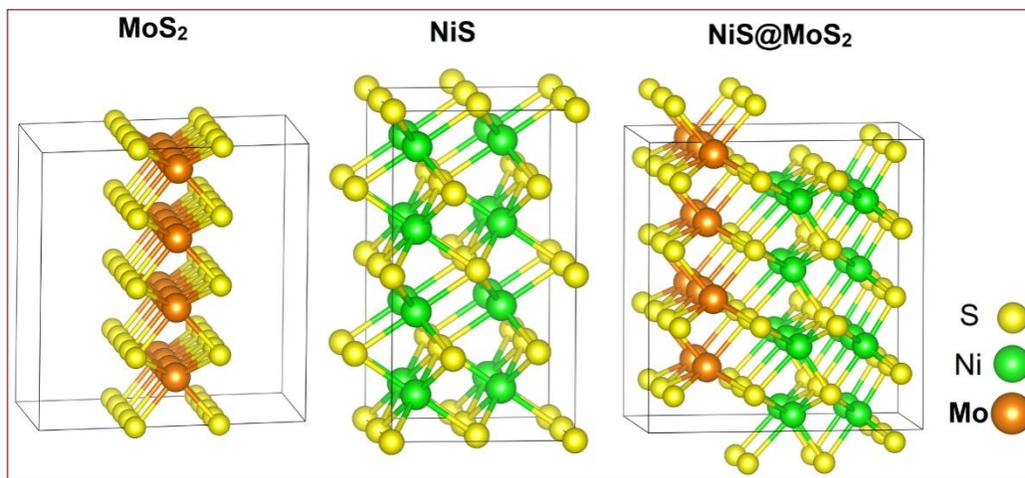
Fig. S1. Optimized structures for MoS_2, NiS, and the heterojunction $NiS@MoS_2$.
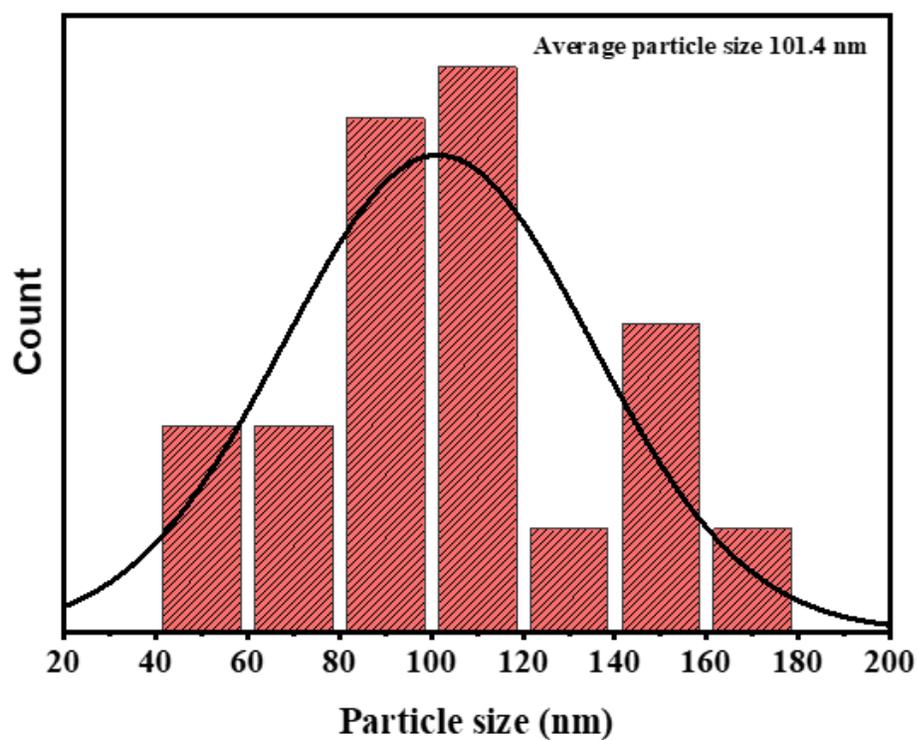

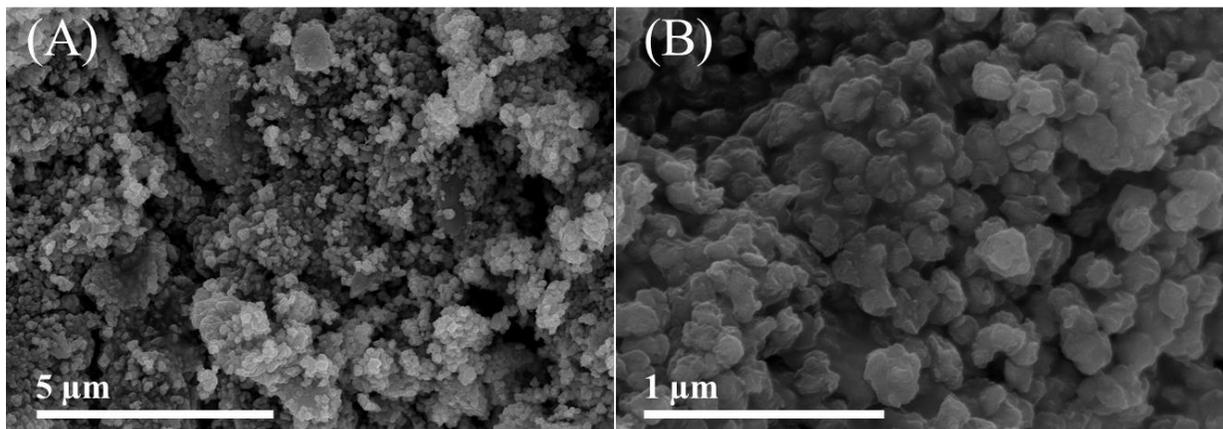**Fig. S2.** Histogram showing the sphere size distribution of the SEM image of the $NiS@MoS_2/NC_{50}$ composite.

Fig. S3. SEM of the NiS@MoS$_2$/NC$_{25}$ composite at lower and higher magnification respectively.

Fig. S4. SEM of the NiS@MoS$_2$/NC$_{75}$ composite at lower and higher magnification respectively.
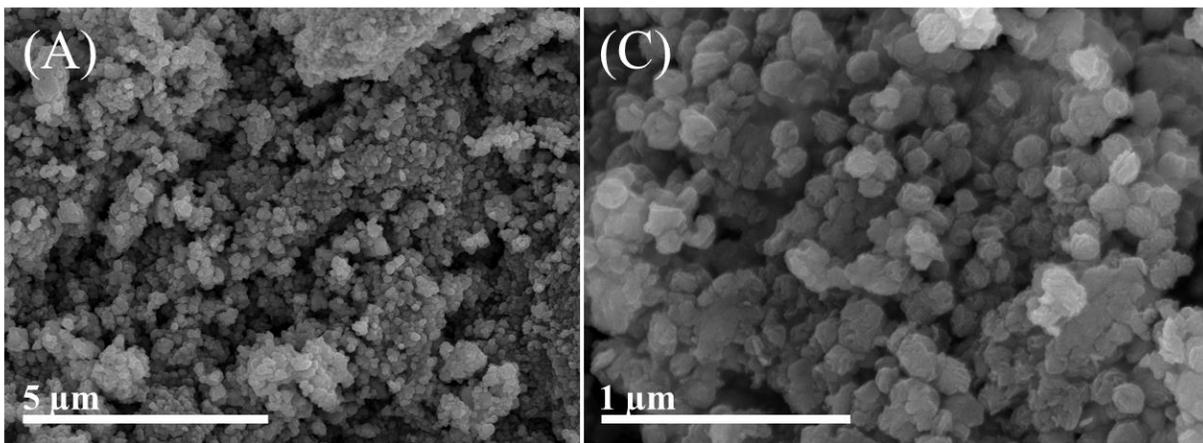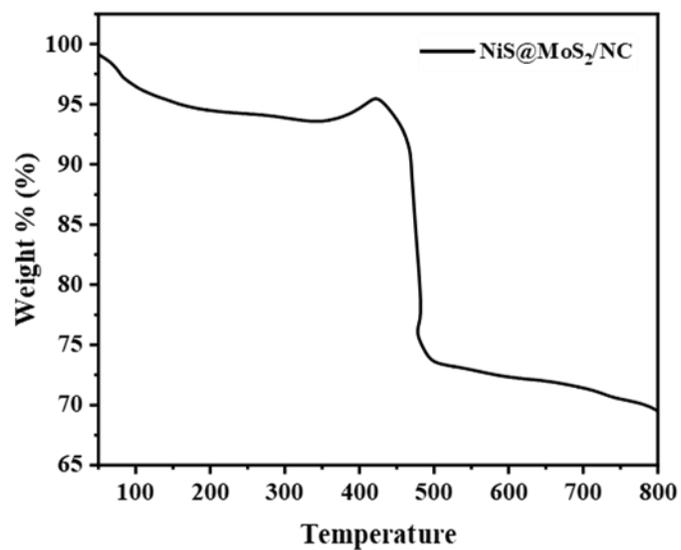
Fig. S5. SEM of the NiS@MoS$_2$/NC$_{100}$ composite at lower and higher magnification respectively.
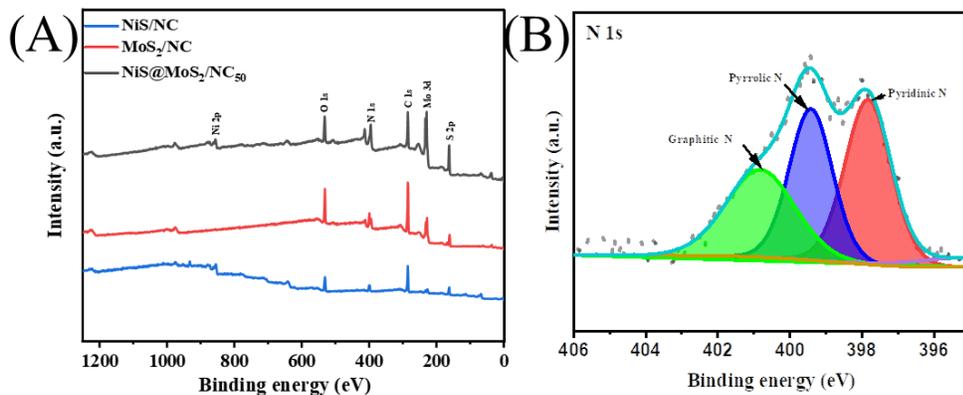

Fig. S6. TGA curves of the NiS@MoS$_2$/NC$_{50}$ composite.

Fig. S7. (A). XPS survey spectra of NiS@MoS$_2$/NC$_{50}$, NiS/NC, and MoS$_2$/NC composites. (B). N spectra of NiS@MoS$_2$/NC$_{50}$.

Fig. S8. (A-G) CV curves of the synthesized composites between -0.1 and 0 V vs. Hg/HgO at different scan rates in an acidic solution. (H) The C_{dl} values and determined by plotting the $\Delta J = (J_a - J_c)$ at -0.05 V vs. Hg/HgO against various scan rates, the C_{dl} is equal to the slop/2. The electrochemical surface area of catalysts can be determined from the C_{dl}.

Fig. S9. ECSA normalized LSV curves of the as-prepared catalysts.

Fig. S10. LSV curves of the NiS@MoS$_2$/NC$_{50}$ catalyst after the cv cycles and before and after the i-t test.

Fig. S11. XRD of the composite NiS@MoS$_2$/NC$_{50}$ before and after cv 5000 cycles.

Fig. S12. SEM at lower and higher magnification of the NiS@MoS$_2$/NC$_{50}$ composite after cv 5000 cycles.

Fig. S13. TEM at lower and higher magnification of the NiS@MoS$_2$/NC$_{50}$ composite after cv 5000 cycles.

Fig. S14. Comparative ELF of MoS$_2$, NiS, and NiS@MoS$_2$ samples.

Table S1. The precursor composition for synthesis of catalysts.

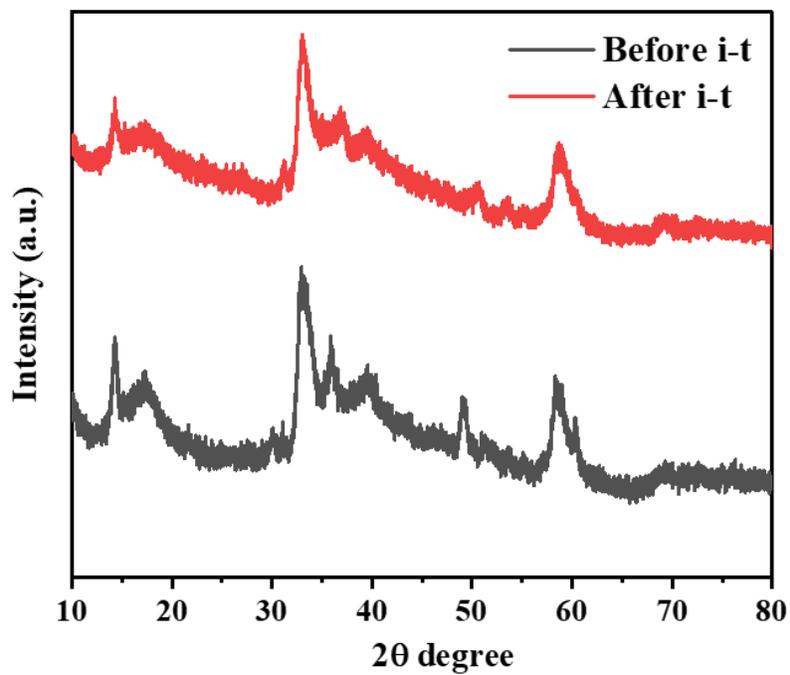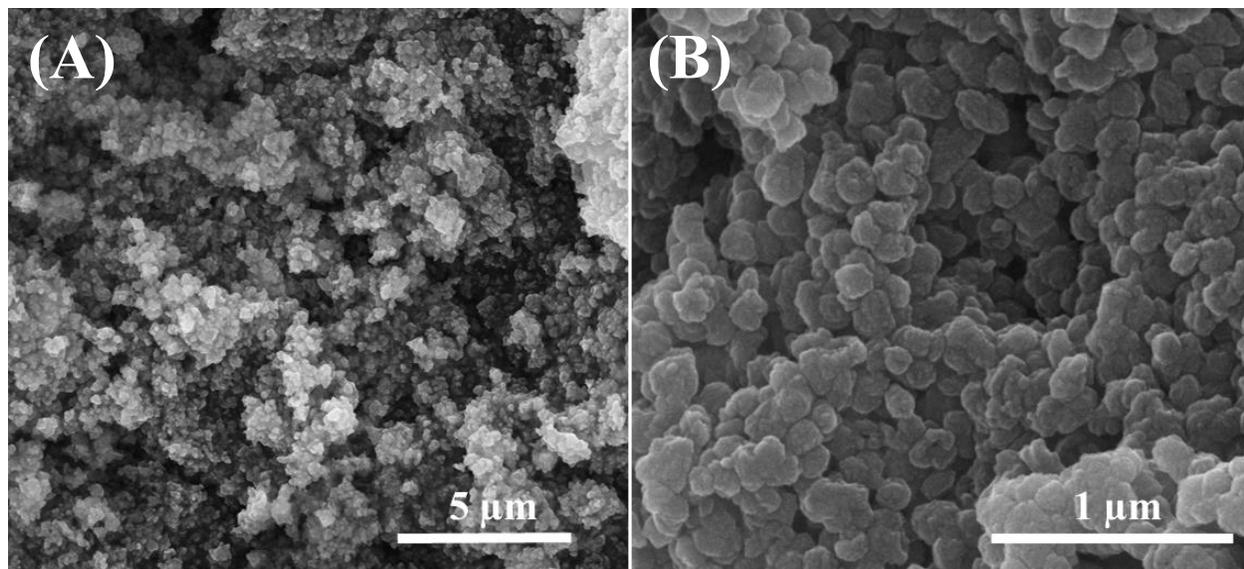| Samples	Polyvinylpyrrolidone mg	$NiSO_4 \cdot 6H_2O$ mg	CH_4N_2S mg	$(NH_4)_6Mo_7O_{24} \cdot 4H_2O)$ mg
NiS@MoS$_2$/NC$_{25}$	200	50	1000	25
NiS@MoS$_2$/NC$_{50}$	200	50	1000	50
NiS@MoS$_2$/NC$_{75}$	200	50	1000	75
NiS@MoS$_2$/NC$_{100}$	200	50	1000	100
NiS@MoS$_2$	0	50	1000	50
MoS$_2$/NC	200	0	1000	50
NiS/NC	200	50	1000	0

Table S2. HER catalytic parameters of as-prepared and 20 % Pt/C catalysts.

Catalyst	(η)mV@(j)10mA cm^{-2}	Tafel slop (mV dec^{-1})	R_{ct} (Ω)	C_{dl} (mF cm^{-2})
20%Pt/C	40	35.14	-	-
NiS@MoS$_2$/NC$_{25}$	197	62.15	51.15	5.22
NiS@MoS$_2$/NC$_{50}$	189	56.67	38.88	8.18

NiS@MoS$_2$/NC$_{75}$	215	69.21	55.29	3.97
NiS@MoS$_2$/NC$_{100}$	238	73.62	67.23	3.49
NiS@MoS$_2$	333	91.63	204.3	2.18
NiS/NC	464	105.11	586.3	2.65
MoS$_2$/NC	555	128.54	737.2	1.98

Table S3. HER comparison performance of MoS$_2$-based catalysts.

Catalytic materials	Overpotential (mV) @10 mA cm^{-2}	Tafel slope (mV dec^{-1})	C$_{dl}$ (mF cm^{-2})	R$_{ct}$ (Ω)	Ref.
NiS/MoS$_2$@CC	87	69.4	20.9	-	[1]
NiS@MoS$_2$ Glassy carbon	152	66.5	75.32	194.9	[2]
MoS$_2$/NiS	244	97	13.86	-	[3]
MoS$_2$-NiS$_2$/NGF	172	70	25.1	-	[4]
1.0Ni-MoS$_2$	173	69	-	-	[5]
Ni$_3$S$_2$/AT-Ni foam	200	107	-	-	[6]
NiCo$_2$S$_4$ nanowires on Ni foam	210	58.9	-	18	[7]
Mo-Ni$_3$S$_2$/NF	216	104	45	-	[8]
N-rGO-MoS$_2$-Ni (OH)$_2$	223	86.0	-	-	[9]

MoNiCNTs-4	238	84	-	-	[10]
NiMo$_3$S$_4$	257	98	-	182	[11]
NiS@MoS$_2$/NC$_{50}$	189	56.67	8.18	38.88	**This work**

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