Supplementary Information (SI) for New Journal of Chemistry.

Supporting Information

Heterogeneous S-$NiFe_2O_4$@$NiSe_2$ nanospheres for oxygen evolution reaction with long-term stability

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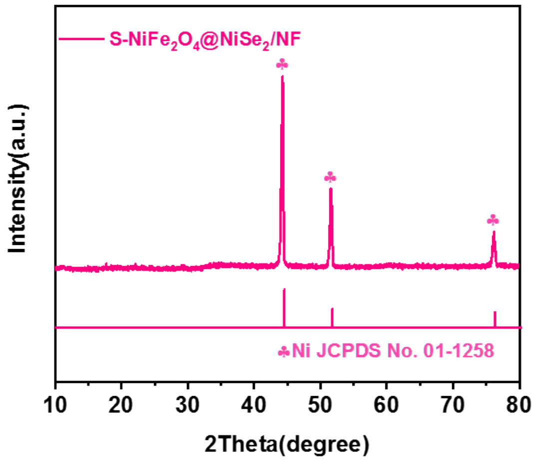

Figure S1 XRD pattern of S-$NiFe_2O_4$@$NiSe_2$/NF electrocatalyst after OER stability test.

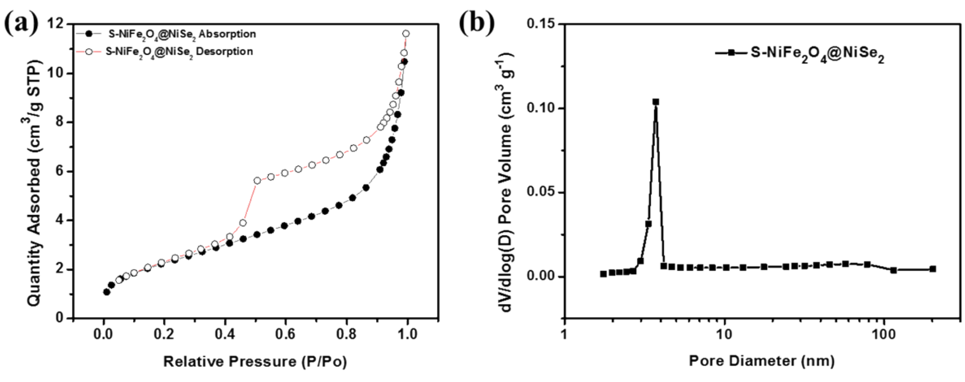

Figure S2 The N_2 adsorption/desorption isotherm (a) and pore-size distribution (b) of S-$NiFe_2O_4$@$NiSe_2$ electrocatalyst.

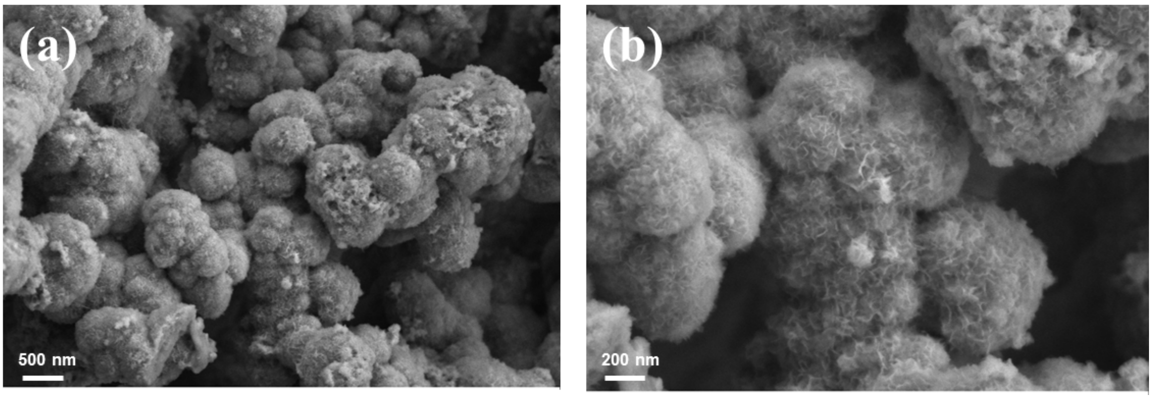

Figure S3 SEM images of S-$NiFe_2O_4$@$NiSe_2$ electrocatalyst after OER stability test.

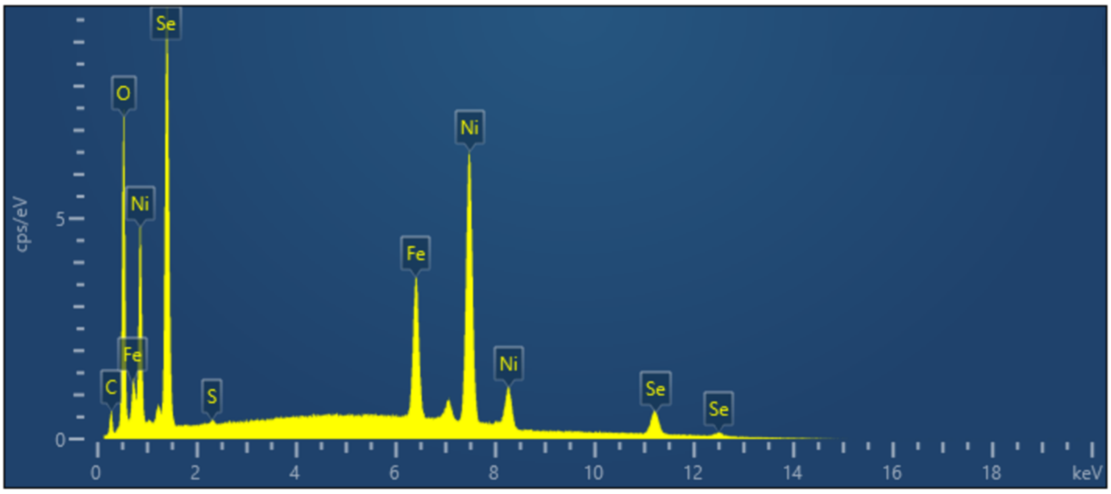

Figure S4 EDS `spectrum of S-$NiFe_2O_4$@$NiSe_2$ electrocatalyst.

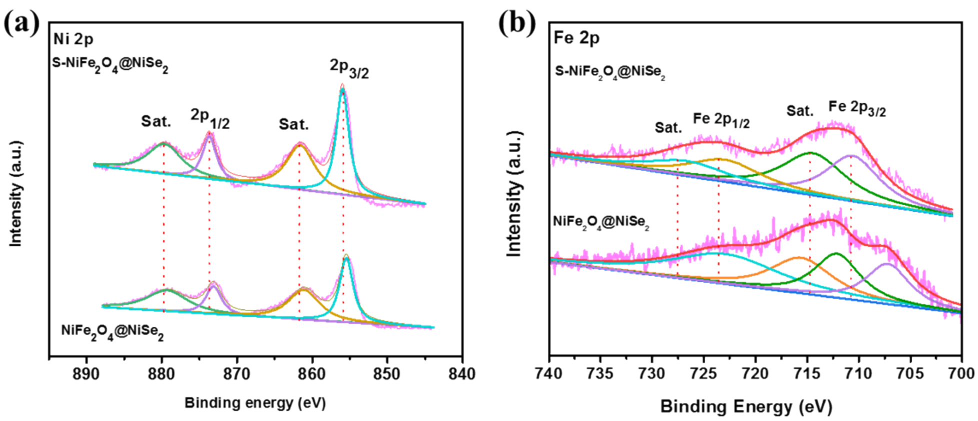

Figure S5 XPS spectra of Ni 2p (a) and Fe 2p (b) of S-$NiFe_2O_4$@$NiSe_2$ and $NiFe_2O_4$@$NiSe_2$.

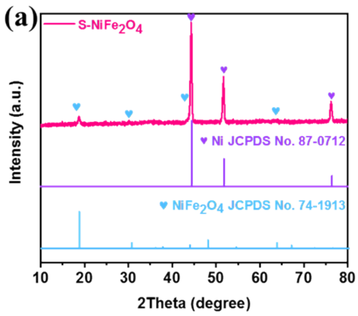

Figure S6 XRD patterns of S-$NiFe_2O_4$ and S-$NiSe_2$ electrocatalysts.

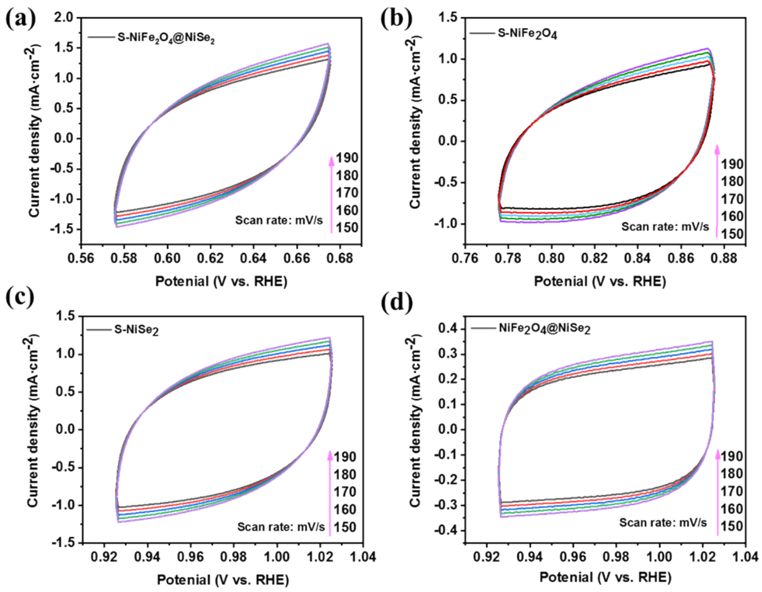

Figure S7 Cyclic voltammetry curves of S-$NiFe_2O_4$@$NiSe_2$, S-$NiFe_2O_4$, S-$NiSe_2$, and $NiFe_2O_4$@$NiSe_2$ electrocatalysts with the scan rate of 150-190 mV s^{-1} in non-Faradic region.

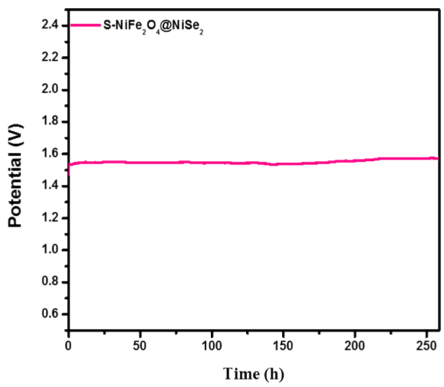

Figure S8 The V-t curve of S-$NiFe_2O_4$@$NiSe_2$ for OER at 50 mA cm^{-2}.

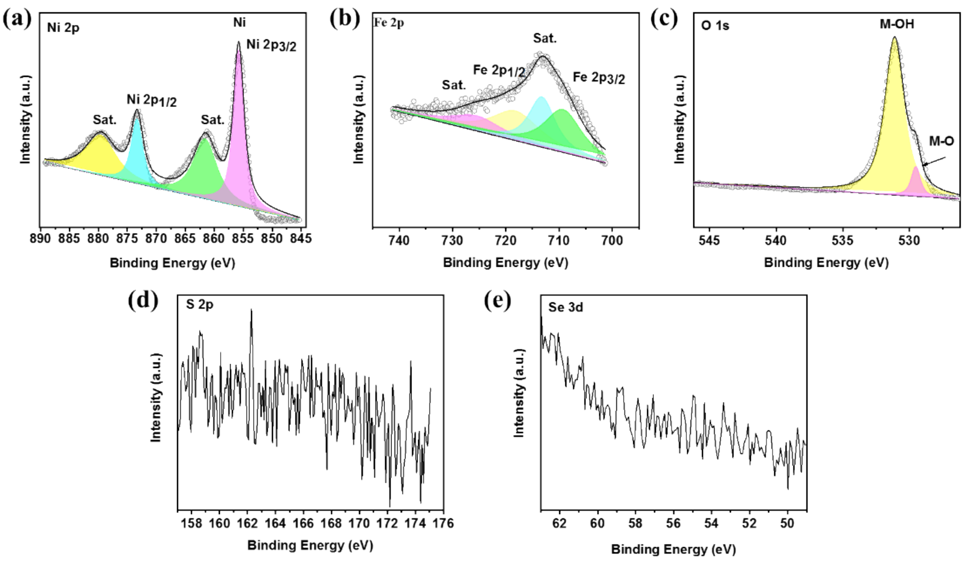

Figure S9 High resolution XPS spectra of Ni 2p (a), Fe 2p (b), O 1s (c), S 2p (d) and Se 3d in S-$NiFe_2O_4$@$NiSe_2$ electrocatalyst after OER stability test.

To calculate the turnover rate (TOF), we used the formula reported previously. TOF $=\frac{i}{4nF}$, where i (A) is the current at a particular overpotential, F is the Faraday constant (96485 C/mol) and n is the number of moles of the active sites. The unit of TOF is s^{-1}.

Based on the previous calculations, we used 2 $\times 10^{15}$ /cm^2 for the flat standard electrode. Thus, the number of moles of surface active sites for the electrocatalyst is estimated to be:

ECSA = C_{dl}/Cs (Cs = 40 μF cm^{-2})

ECSA (S-$NiFe_2O_4$@$NiSe_2$) = 3.64 mF cm^{-2}/40 μF cm^{-2} ×1cm^2 = 91 cm^2

ECSA (S-$NiFe_2O_4$) = 3.08 mF cm^{-2}/40 μF cm^{-2} ×1cm^2= 77 cm^2

ECSA (S-$NiSe_2$) = 3.14 mF cm^{-2}/40 μF cm^{-2} ×1cm^2= 78.5 cm^2

ECSA ($NiFe_2O_4$@$NiSe_2$) = 1.33 mF cm^{-2}/40 μF cm^{-2} ×1cm^2= 33.25 cm^2

n (S-$NiFe_2O_4$@$NiSe_2$) = 91 cm^2× 2 × 10^{15}/cm^2 ÷(6.022×10^{23})= 3.02 × 10^{-7} mol

n (S-$NiFe_2O_4$) = 77 cm^2× 2 × 10^{15}/cm^2 ÷(6.022×10^{23})= 2.56 × 10^{-7} mol

n (S-$NiSe_2$) = 78.5 cm^2× 2 × 10^{15}/cm^2 ÷(6.022×10^{23})= 2.61 × 10^{-7} mol

n ($NiFe_2O_4$@$NiSe_2$) = 33.25 cm^2× 2 × 10^{15}/cm^2 ÷(6.022×10^{23})= 1.1 × 10^{-7} mol

Therefore, the TOF per active site is calculated as follows and i is the current (A):

TOF (S-$NiFe_2O_4$@$NiSe_2$) = i/(4×3.02×10^{-7}×96485) =8.58 i

TOF (S-$NiFe_2O_4$) = i/(4×2.56×10^{-7}×96485) =10.12 i

TOF (S-$NiSe_2$) = i/(4×2.61×10^{-7}×96485) =9.93 i

TOF ($NiFe_2O_4@NiSe_2$) = i/(4×1.1×10^{-7}×96485) =23.56 i

At the potential of 1.5 V (vs RHE), the TOF values of S-$NiFe_2O_4@NiSe_2$, S-$NiFe_2O_4$, S-$NiSe_2$ and $NiFe_2O_4@NiSe_2$ are 0.4314 s^{-1}, 0.0062 s^{-1}, 0.005 s^{-1}, and 0.401 s^{-1}, respectively.

Table S1 OER performance comparisonof different non-noble based electrocatalysts.

Electrocatalyst	**j (mA cm^{-2})**	**Overpotential (mV)**	**Reference**	**TOF**
S-$NiFe_2O_4$-$NiSe_2$	10	190	This work	0.4314 s^{-1} (1.5V)
(a-CoSe/Ti)	10	292	S1	-
$Co_{0.85}Se$	10	324	S2	0.0012 s^{-1} (300 mV)
($NiCo_{0.85}$)Se	10	255	S2	0.003 s^{-1} (300 mV)
$Co_{0.13}Ni_{0.87}Se_2$/Ti	100	320	S3	-
$NiSe_2$/Ti	100	350	S3	-
$NiSe_2$	10	250	S4	-
Ni_3Se_2/Cu foam	50	340	S5	-
Fe-doped NiSe	100	264	S6	-
MnSe@MWCNT	10	290	S7	-
P-$Ni_{0.75}Fe_{0.25}Se_2$	10	185	S8	0.18 s^{-1}(500 mV)
NiSe@NiOOH/NF	50	332	S9	-
$Cr_xNi_{1-x}Se_2$	10	272	S10	5.03×10^{-4} s^{-1} (300 mV)
NiFeCoSe/SSM	20	228	S11	-
FeSe/Co_2P/NF	10	235	S12	0.024 s^{-1} (1.53V)
NiFeV LDHs	10	192	S13	0.04 s^{-1} (1.48V)
$Ni_3Fe_{0.9}Cr_{0.1}$/CACC	10	239	S14	-
NC-$NiFeO_x$@NiFe-P	10	285	S15	-
Co-Fe Selenide	10	270	S16	-
$CoNi_2Se_4$	10	160	S17	-
NiFe-Se/CFP	10	281	S18	-

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