Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Carbon-incorporated Ni_2P-Fe_2P hollow nanorods as superior electrocatalysts for oxygen evolution reaction

Siva Kumar Ramesh, [a], † Jihye Son, [a], † Vinoth Ganesan, [b] and Jinkwon Kim*,[a]

[a]*Department of Chemistry, Kongju National University, 56 Gongjudaehak-ro, Gongju-si, Chungnam-do, 32588, Republic of Korea.*

[b]*School of Materials Science and Engineering, Kumoh National Institute of Technology, Gumi-si, Gyeongbuk 39177, Republic of Korea*

† *These authors contributed equally to this work.*

*Corresponding author.

Tel.: +82-41-850-8496. Fax: +82-41-850-8613. E-mail: jkim@kongju.ac.kr

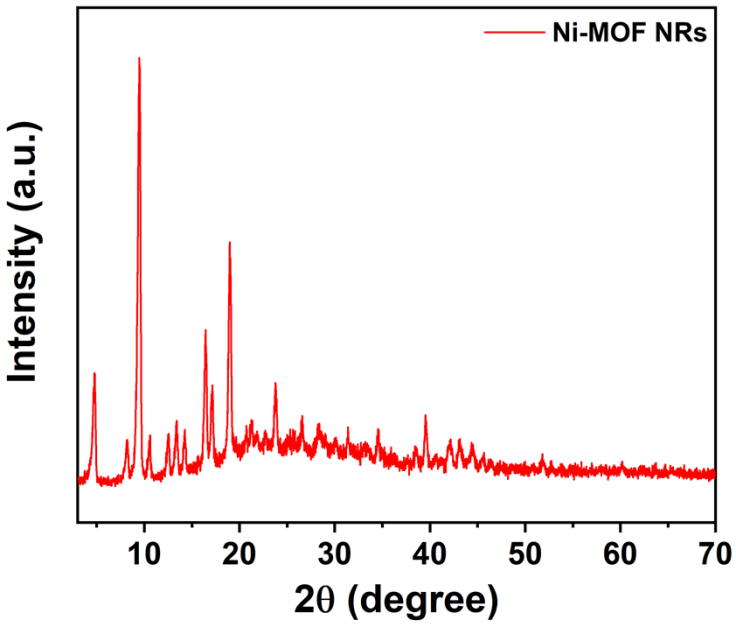

Fig. S1. XRD pattern of Ni-MOF NRs

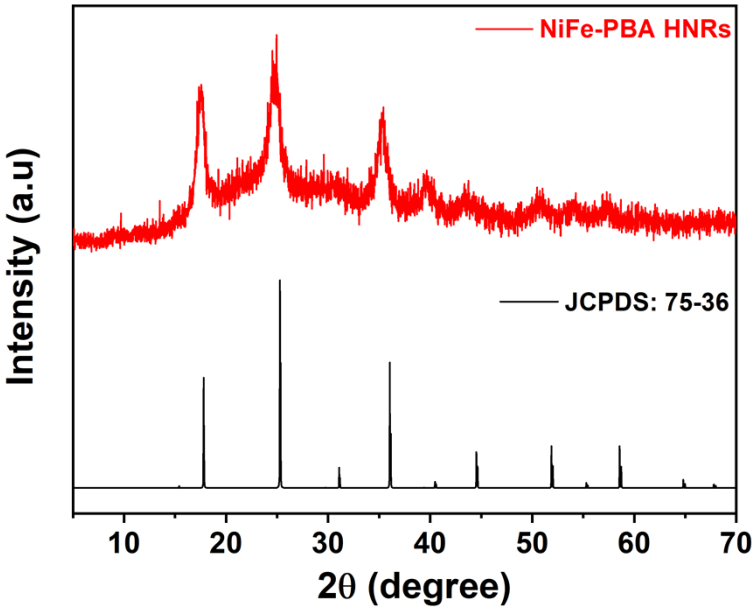

Fig. S2. XRD pattern of NiFe-PBA HNRs

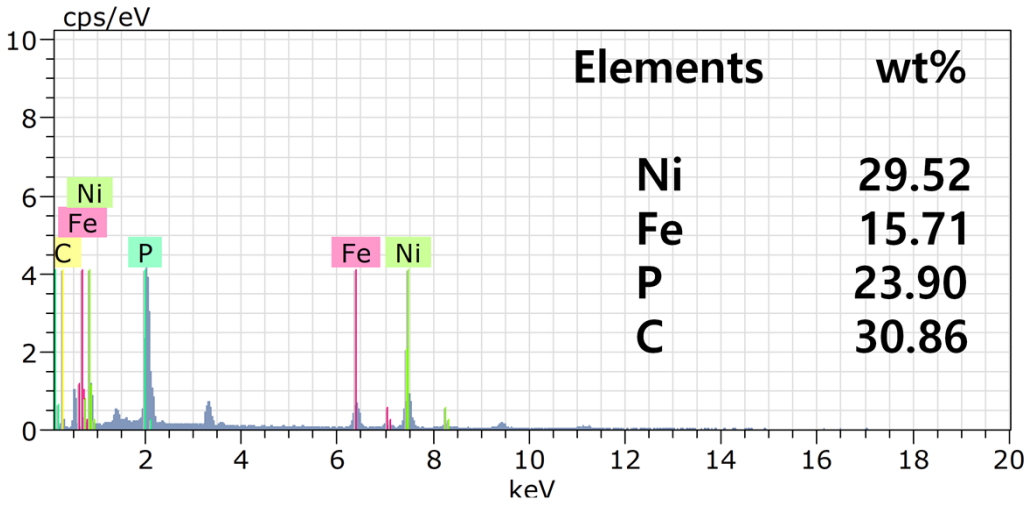

Fig. S3. EDS spectrum of $(Ni,Fe)_2P$/C HNRs

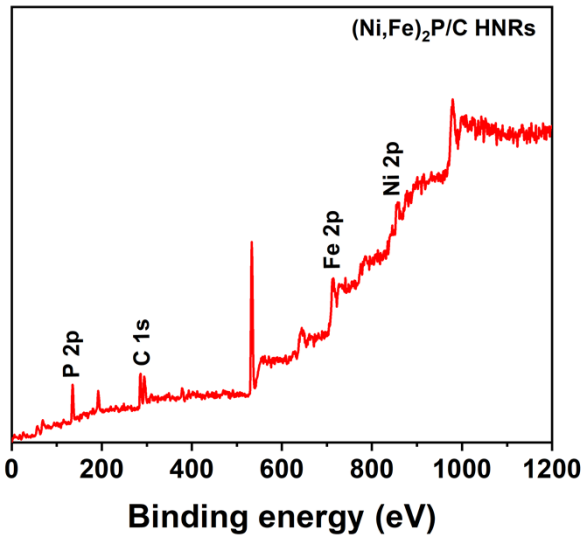

Fig. S4. Survey spectrum of $(Ni,Fe)_2P$/C HNRs

Synthesis of $(Ni,Fe)_2P$/C NPs.

NiFe-PBA were synthesized according to the previously reported procedure.[1] 3 mmol $Ni(NO_3)_2 \cdot 6H_2O$ is dissolved into 50 mL DI water, and 1 mmol $K_3[Fe(CN)_6]$ is dissolved in 20 mL DI water. Then, the $K_3[Fe(CN)_6]$ solution is mixed into the above solution and stirred for 30 min. Next, the solution mixture is transferred to a Teflon-lined stainless-steel autoclave at 100 °C for 20 h. Finally, the products are washed with DI water and EtOH via centrifugation several times and dried at vacuum overnight. Then the obtained NiFe-PBA and NaH_2PO_2 were placed in two separate positions with a mass ratio of 1: 2. Under Ar flow, the furnace was heated at 350 °C with a heating rate of 5 °C min^{-1}. The temperature was maintained for 2 h and cooled down to ambient temperature to obtain the final product.

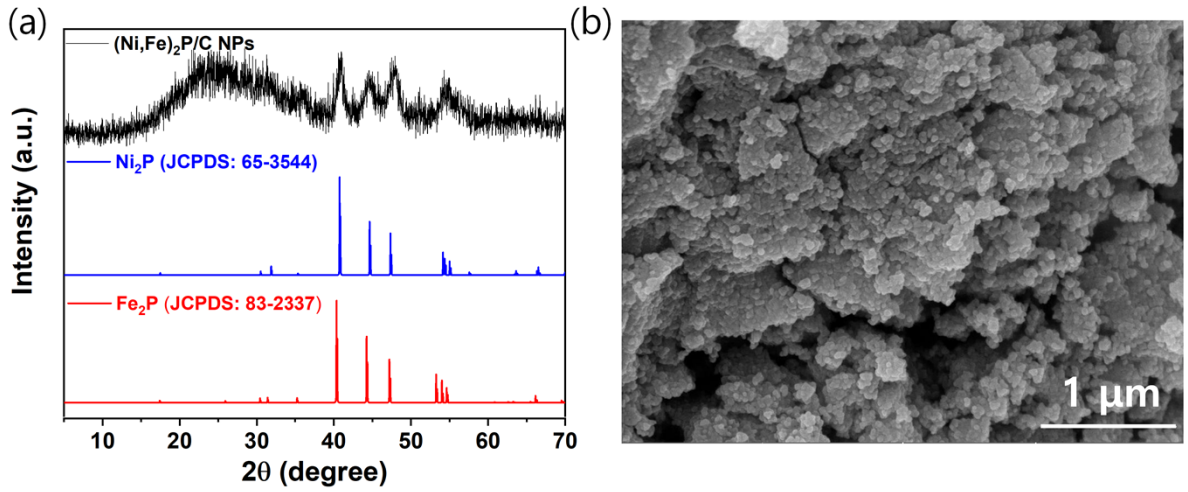

Fig. S5. XRD pattern and Sem image of $(Ni,Fe)_2P$/C NPs.

Synthesis of Fe_2P:

Fe_2P were synthesized according to the previously reported procedure.[2] 2 mmol $Fe(NO_3)_3 \cdot 6H_2O$, 0.5 mmol $NH_4H_2PO_4$ and 1 g of melamine were grounded to form a homogenous mixture. Under Ar flow, the obtained powder was heated at 800 °C with a heating rate of 5 °C min^{-1}. The temperature was maintained for 2 h and cooled down to ambient temperature to obtain the product. The final product was centrifuged with ethanol and DI water several times and then dried under vacuum overnight.

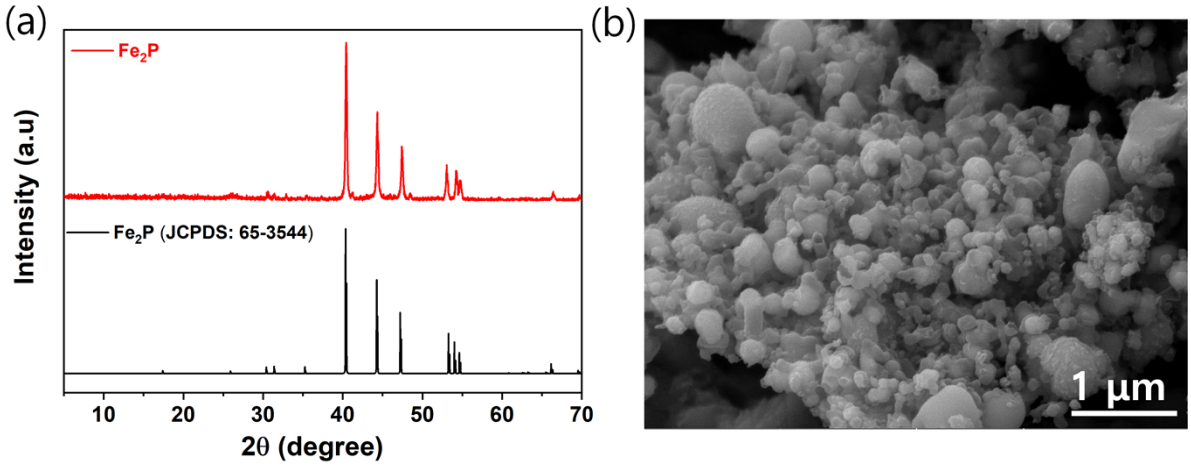

Fig. S6. XRD pattern and Sem image of Fe_2P.

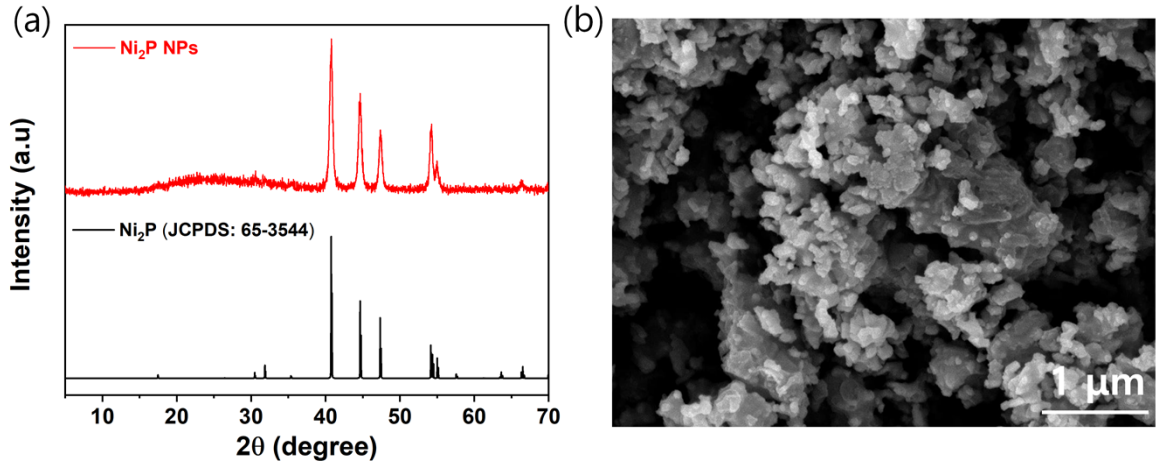

Fig. S7. XRD pattern and Sem image of Ni_2P NPs.

The TOF was calculated by assuming that every metal atom deposited on the electrode, according to the following equation:

$$\text{TOF} = \frac{j \times A}{4 \times F \times n}$$

where j is the current density at a given overpotential of 260 mV, A is the surface area of the electrode, the number 4 represents four electron transfer for per mole of O_2, F is the Faraday constant, and n is the number of moles of the metal atom on the electrode calculated from m and the molecular weight of the coated catalysts.

The mass activity (A g^{-1}) values were calculated from the current density at a given overpotential (260 mV) and the catalyst loading m (mg cm^{-2}):

$$\text{Mass activity (A g}^{-1}\text{)} = \frac{j}{m}$$

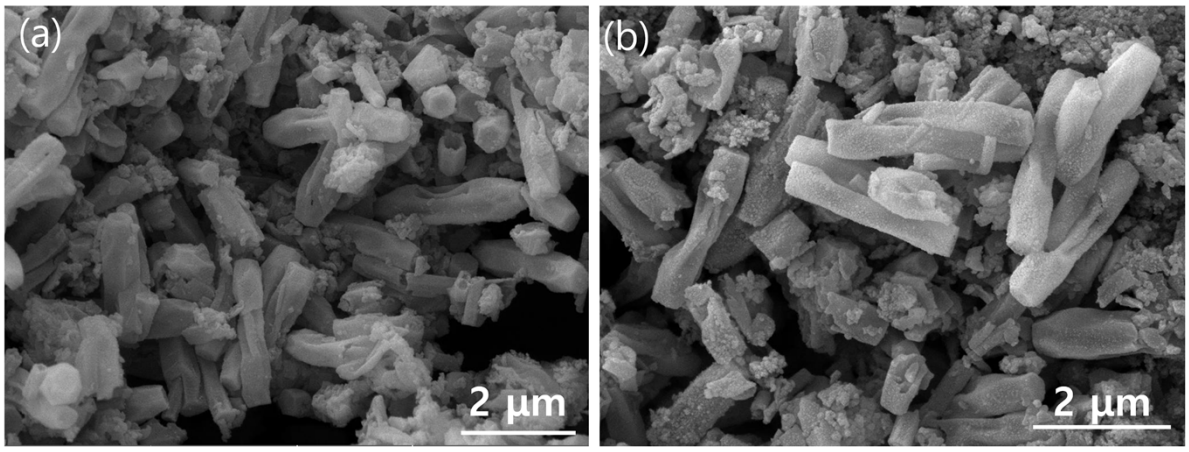

Fig. S8. (a,b) SEM images of $(Ni,Fe)_2P$/C HNRs after stability test.

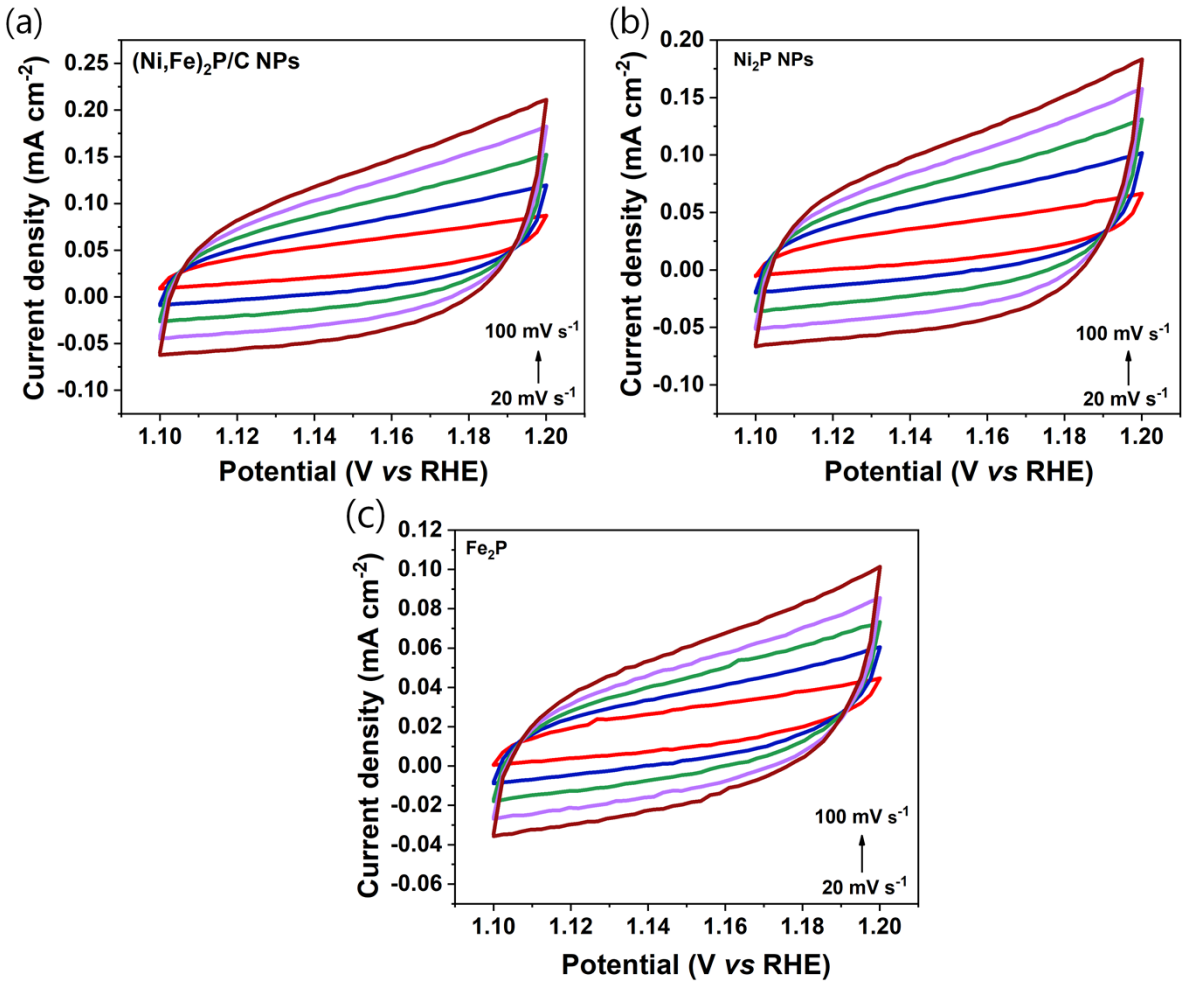

Fig. S9. CV curves at different scan rates of (20-100 mV s^{-1}). (a) $(Ni,Fe)_2P$/C NPs ,(b) Ni_2P NPs, and (c) Fe_2P

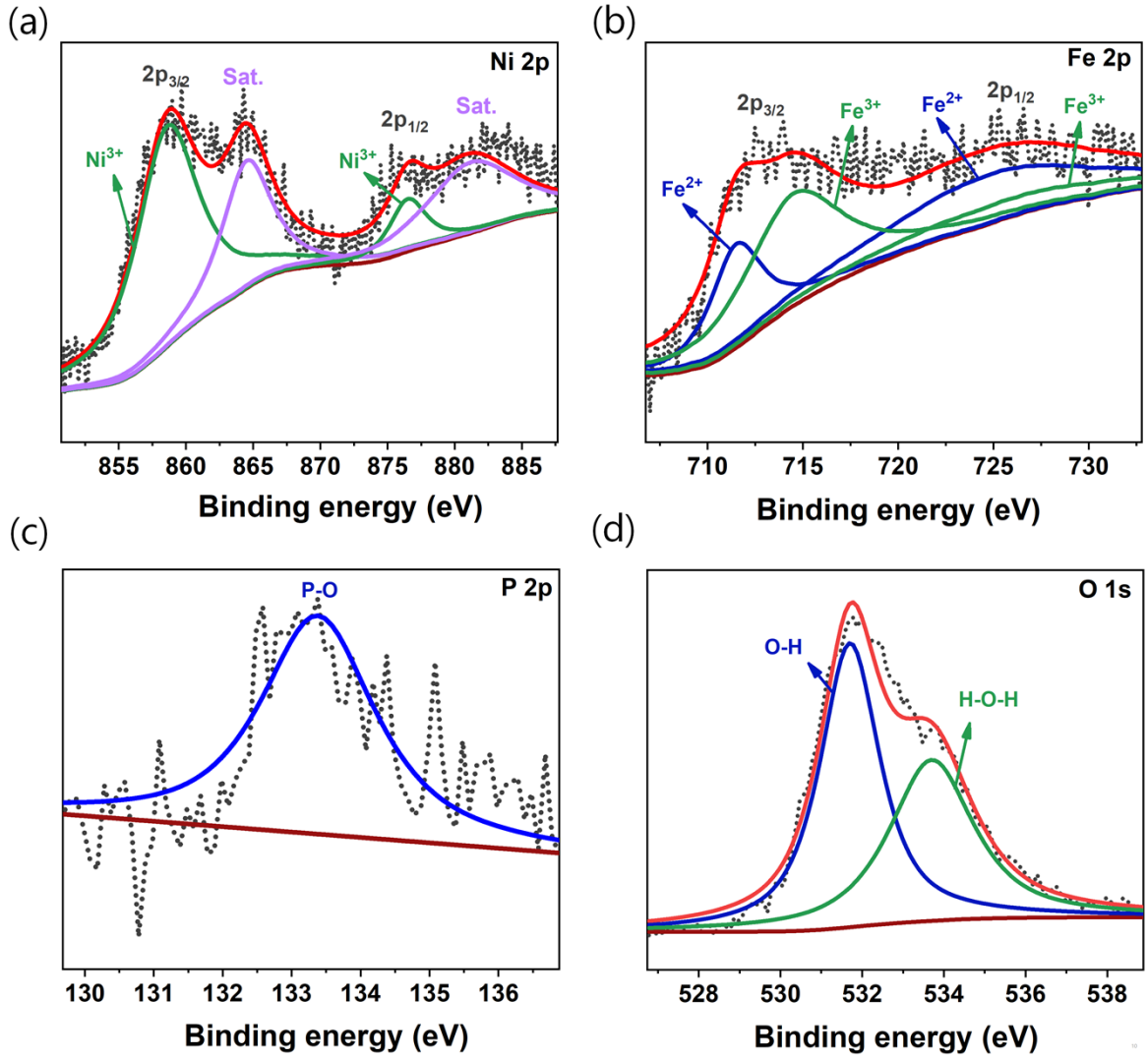

Fig. S10. High-resolution XPS spectra of (a) Ni 2p, (b) Fe 2p, (c) P 2p and (d) O 1s for $(Ni,Fe)_2P$/C HNRs after stability test.

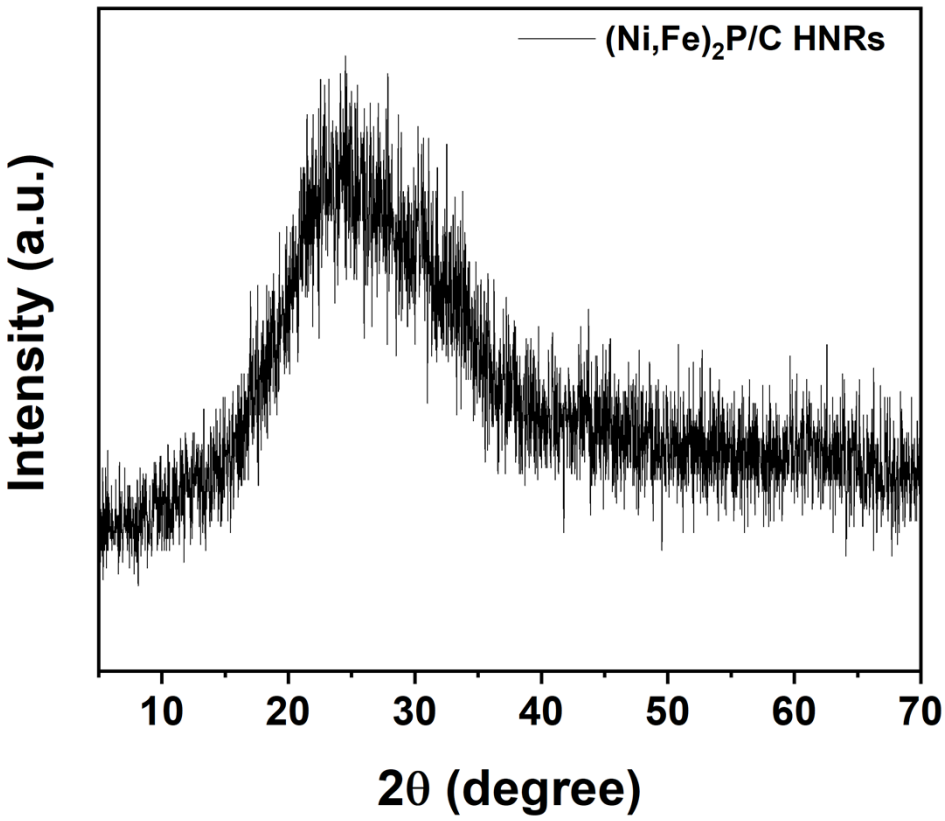

Fig S11. XRD pattern of $(Ni,Fe)_2P$/C HNRs after stability test.

References

1 L. Wei, Y. Zhang, Y. Yang, M. Ye, C. Li, *ChemistrySelect,* 2021, ***6,*** 3683-3691.

2 Z. Pu, C. Zhang. I. S. Amiinu, W. Li, L. Wu, S. Mu, *ACS Appl. Mater. Interfaces*, 2017, 9, 16187-16193.