Electronic Supplementary Material (ESI) for Nanoscale.


# Supporting Information

## $C_{60}$-decorated nickle-cobalt phosphide as an efficient and robust electrocatalyst for hydrogen evolution reacton

Zhiling Du[a], Nahar Jannatun[a], Danyang Yu[b], Juan Ren[b], Wenhuan Huang[b*] and Xing Lu [a*]

[a] State Key Laboratory of Materials Processing and Die & Mould Technology School of Materials Science and Engineering Huazhong University of Science and Technology Wuhan 430074, China. E-mail: lux@hust.edu.cn

[b] *Shaanxi Key Laboratory of Chemical Additives for Industry, College of Chemistry & Chemical Engineering, Shaanxi University of Science & Technology, Xi'an, 710021, China, Tel: +86-29-86168830; E-mail: huangwenhuan@sust.edu.cn*

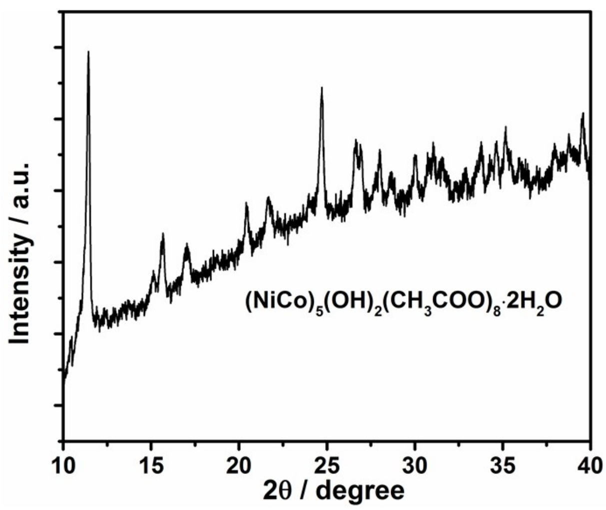


Figure S1. XRD pattern of $(NiCo)_5(OH)_2(CH_3COO)_8{\cdot}2H_2O$.

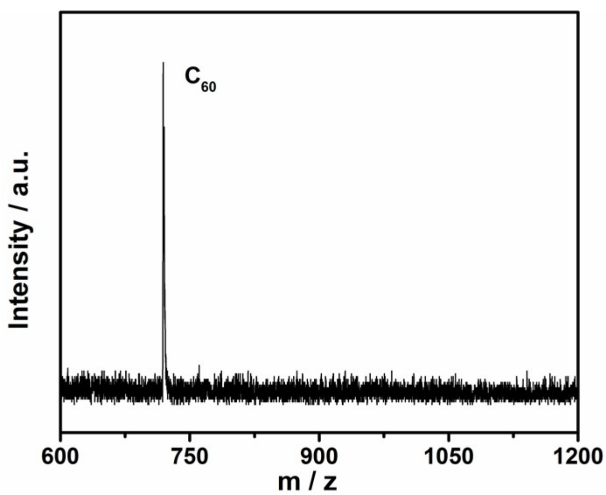


Figure S2. LDI-TOF-mass spectra of $C_{60}$ obtained by dissolving Ni-Co-P/$C_{60}$ in toluene.

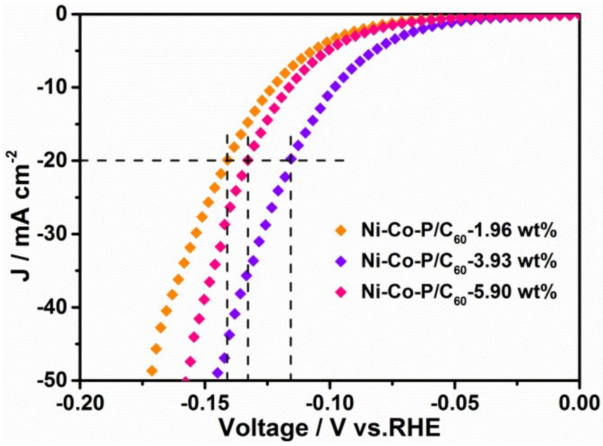


Figure S3. Polarization curves of Ni-Co-P/$C_{60}$ with different $C_{60}$ contents of 1.96 wt%, 3.93 wt% and 5.90 wt%, respectively.

Figure S2 shows the LSV curves for the three $C_{60}$-decorated Ni-Co-P catalysts with different $C_{60}$ contents of 1.96 wt%, 3.93 wt% and 5.90 wt%, respectively. Ni-Co-P/$C_{60}$ with a $C_{60}$-content of 3.93 wt% needs the lewest overpotential of 115 mV to attain the same current density of 20 mA cm$^{-2}$ among the three catalysts, which indicates that the optimum $C_{60}$-doping content is 3.93 wt%. The result indicates that the moderate $C_{60}$-doping content can improve the electrocatalytic activity of catalysts due to that excessive $C_{60}$-doping content can result in the coverage of active sites, and deficiency $C_{60}$-doping content cannot display the strengths of $C_{60}$.

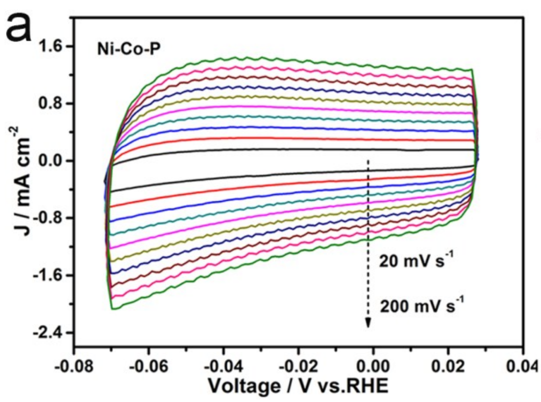


Figure S4. CV curves of Ni-Co-P and Ni-Co-P/$C_{60}$ at different scan rates from 20 mV $s^{-1}$ to 200 mV $s^{-1}$ with a gradient increase of 20 mV $s^{-1}$: (a) Ni-Co-P and (b) Ni-Co-P/$C_{60}$ with a $C_{60}$-content of 3.93 wt%.

**Table S1.** Electrochemical activity data of Ni-Co-P and Ni-Co-P/$C_{60}$ with a $C_{60}$-content of 3.93 wt%.

| Material | Loading (mg $cm^{-2}$) | Tafel slop (mV $dec^{-1}$) | $\eta_{onset}$ (mV) | $C_{dl}$ (mF $cm^{-2}$) | $j_0$ (mA $cm^{-2}$) | $R_{ct}$ (Ohm) |
|---|---|---|---|---|---|---|
| Ni-Co-P/$C_{60}$ | 0.354 | 48 | 23.8 | 16.51 | 0.100 | 0.25 |
| Ni-Co-P | 0.354 | 58 | 103.0 | 6.54 | 0.025 | 0.60 |

**Table S2.** Comparison of HER performance in acidic electrolytes for Ni-Co-P and Ni-Co-P/$C_{60}$ with recently reported electrocatalysts.

| Material | Tafel slop (mV $dec^{-1}$) | η at the corresponding j (mV) | Exchange current density (mA $cm^{-2}$) | Reference |
|---|---|---|---|---|
| Ni-Co-P/$C_{60}$ | 48 | 97 (10)<br>115 (20)<br>144 (50) | 0.100 | This work |
| Ni-Co-P | 58 | 148 (10)<br>166 (20)<br>200 (50) | 0.025 | |
| $SnS_2$-1500C | 69 | 117 (10) | 0.394 | ACS Appl. Mater. Interfaces 9, 37750-37759 (2017) |
| $Mo_xC$-IOL | 60 | 117 (10) | 0.18 | ACS Nano 11, 7527-7533 (2017) |
| N,B-CN | 76.9 | 290 (10) | N.A | ACS Nano 11, 7293-7300 (2017) |
| 10% VNS | 45 | 110 (10) | N.A | ACS Nano 11, 11574-11583 (2017) |
| D-TiO2/Co@CNT | 73.5 | 167 (10) | 0.21 | Nano Res. 10, 2599-2609 (2017) |
| C@Ni-Co-P | 43 | 118 (20) | 0.210 | Chem. Eur. J. 22, 1021-1029 (2016) |
| Co-Mo-P | 50 | 215 (10)<br>254 (20) | N.A | Appl. Catal. A: Gen. 511, 11-15 (2016) |
| $CoMoS_3$-prism | 56.9 | 171 (10) | 0.011 | Adv. Mater. 28, 92-97 (2016) |
| $CoTe_2$ NPs | 41 | 198 (10) | $5.9*10^{-5}$ | Chem. Commun. 51, 17012-17015 (2015) |
| WC-CNTs | 72 | 145 (10) | N.A | ACS Nano 9, 5125-5134 (2015) |
| $Ni_2P$/CNT | 53 | 124 (10) | N.A | J. Mater. Chem. A 3, 13087-13094 (2015) |
| $Fe_{0.9}Co_{0.1}S_2$/CNT | 46 | 120 (20) | N.A | J. Am. Chem. Soc. 137, 1587-1592 (2015) |
| $MoS_2$-MoN/N-C | 52 | 200 (52) | 0.46 | Chem. Eng. Sci. 134, 572-580 (2015) |
| Ni-Al-P | 65 | 111 (10)<br>142 (20) | 0.6 | ACS Catal. 5, 6503-6508 (2015) |
| CoP/CNT | 54 | 122 (10) | 0.130 | Angew. Chem. Int. Ed. 53, 6710-6714 (2014) |
| $CoS_2$ NW | 51.4 | 145 (10) | 0.015 | J. Am. Chem. Soc. 136, 10053-10061 (2014) |
| $Ni_2P$ nanoparticles | 46 | 130 (20) | $3.3*10^{-3}$ | J. Am. Chem. Soc. 135, 9267-9270 (2013) |