Electronic Supplementary Information

Direct conversion of coordination compounds into Ni_2P nanoparticles entrapped in 3D mesoporous graphene for efficient hydrogen evolution reaction

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1. Supplementary Table S1 and Figures S1-S12

Table S1. Activity comparison table for HER in acidic media by nickel phosphide based catalysts. η_{10} indicates the overpotential required to drive a current density of -10 mA cm^{-2}.

Reference	Catalyst	Loading (mg cm^{-2})	Electrolyte	η_{10} (mV)	Tafel slope (mV dec^{-1})
This work	Ni_2P@mesoG	1	0.5 M H_2SO_4	98	56
		3	0.5 M H_2SO_4	79	83
[S1]	Ni_2P NPs/Ti	~1	0.5 M H_2SO_4	~118	~46
[S2]	Ni_2P NPs	0.38	1 M H_2SO_4	122	87
[S3]	$Ni_{12}P_5$ NPs/Ti	3	0.5 M H_2SO_4	107	63
[S4]	Ni_2P/Ti	2	1 M H_2SO_4	122	60
[S5]	NiP_2 NS/CC	2.6	0.5 M H_2SO_4	75	~51
[S6]	Ni_5P_4	177	1 M H_2SO_4	23	33
[S7]	Ni_5P_4-Ni_2P NS/Ni foam	-	0.5 M H_2SO_4	120	79.1
[S8]	Ni_2P-G@Ni foam	-	0.5 M H_2SO_4	55	~30/107
[S9]	Ni_5P_4	1.99	0.5 M H_2SO_4	118	42

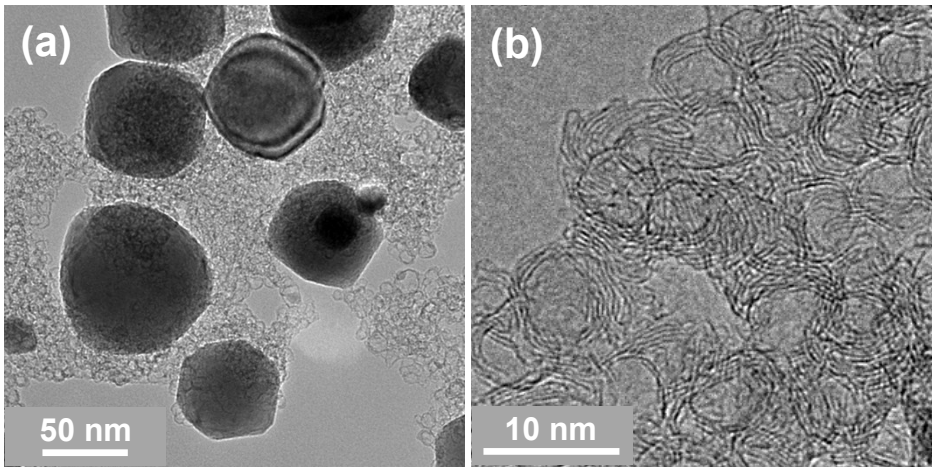

Figure S1. TEM images of mesoG before (a) and after (b) acid etching.

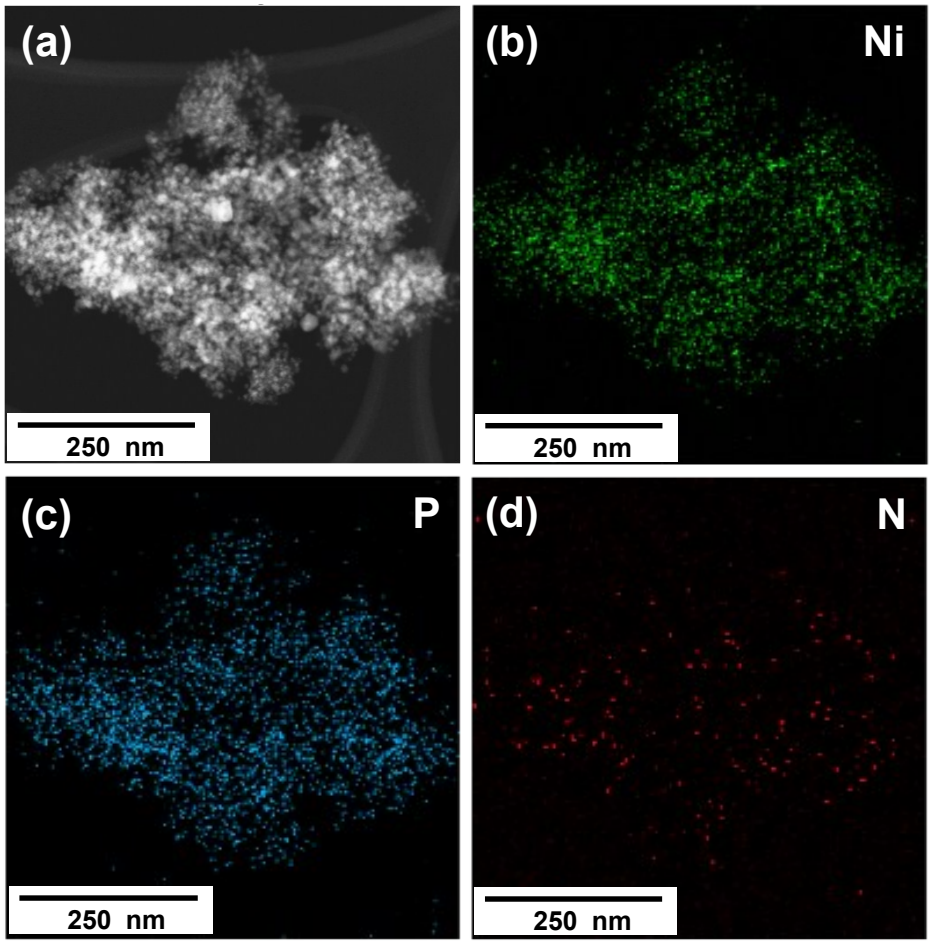

Figure S2. (a) STEM image of Ni_2P@mesoG and (b-d) corresponding EDS mapping images for (b) nickel, (c) phosphorus, and (d) nitrogen.

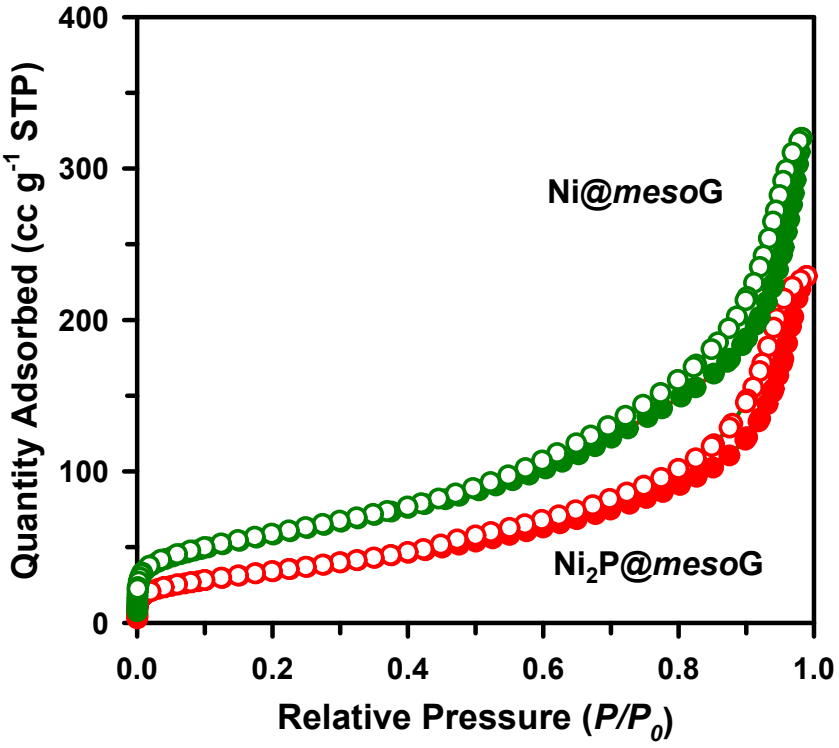

Figure S3. N_2 adsorption-desorption isotherms of Ni@mesoG and Ni_2P@mesoG.

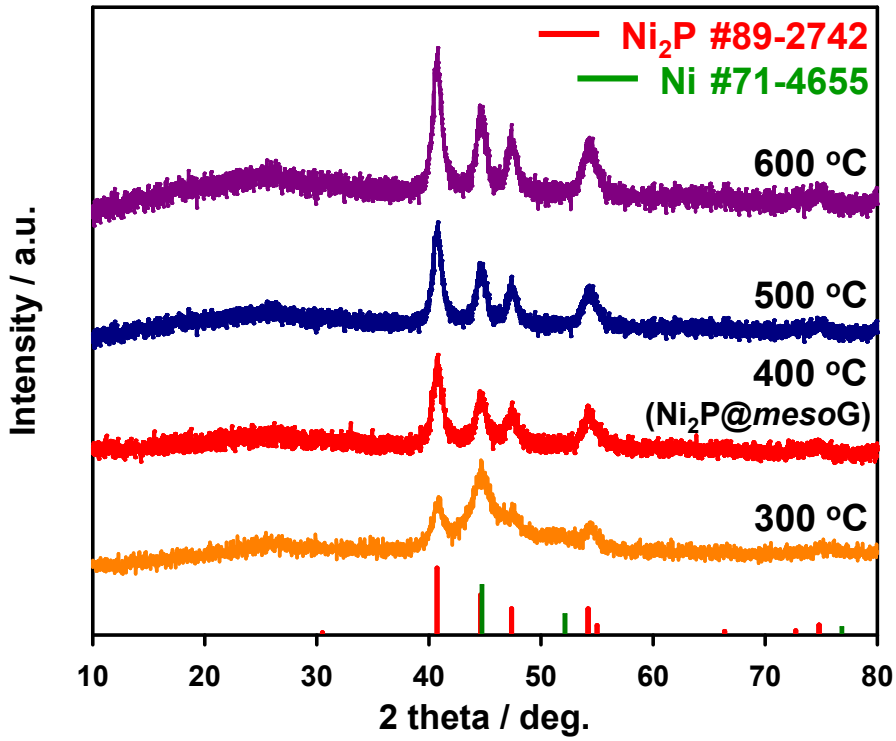

Figure S4. XRPD patterns of Ni@mesoG samples phosphidated at 300, 400 (Ni_2P@mesoG), 500, and 600 °C.

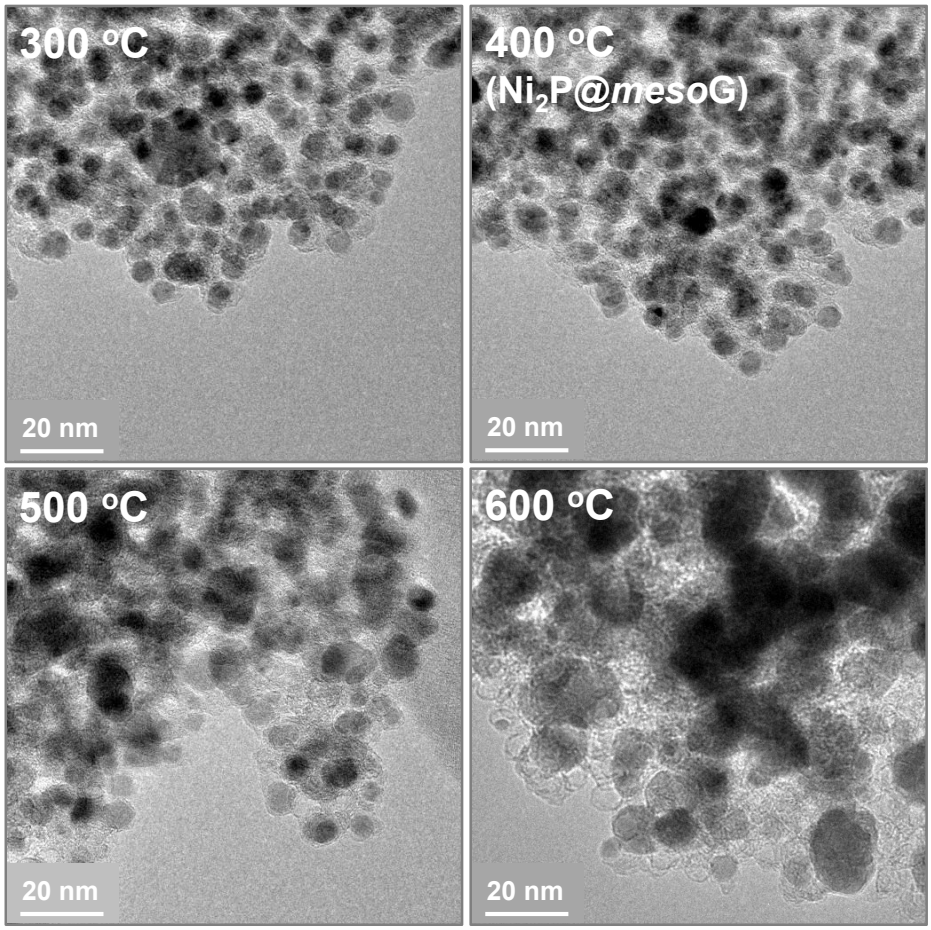

Figure S5. TEM images of Ni@mesoG samples phosphidated at 300, 400 (Ni_2P@mesoG), 500, and 600 °C.

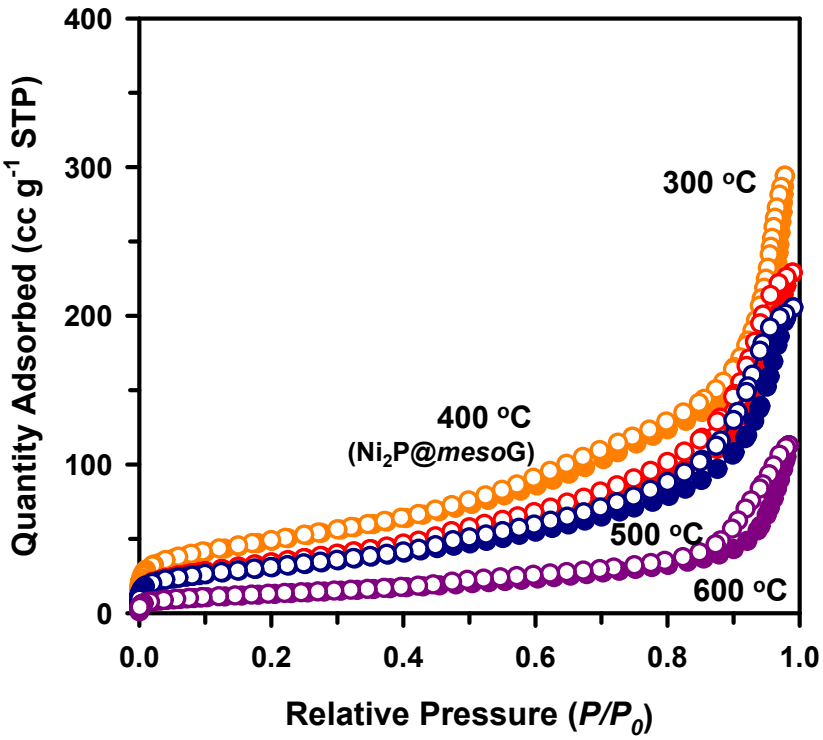

Figure S6. N_2 adsorption-desorption isotherms of Ni@mesoG samples phosphidated at 300, 400 (Ni_2P@mesoG), 500, 600 °C.

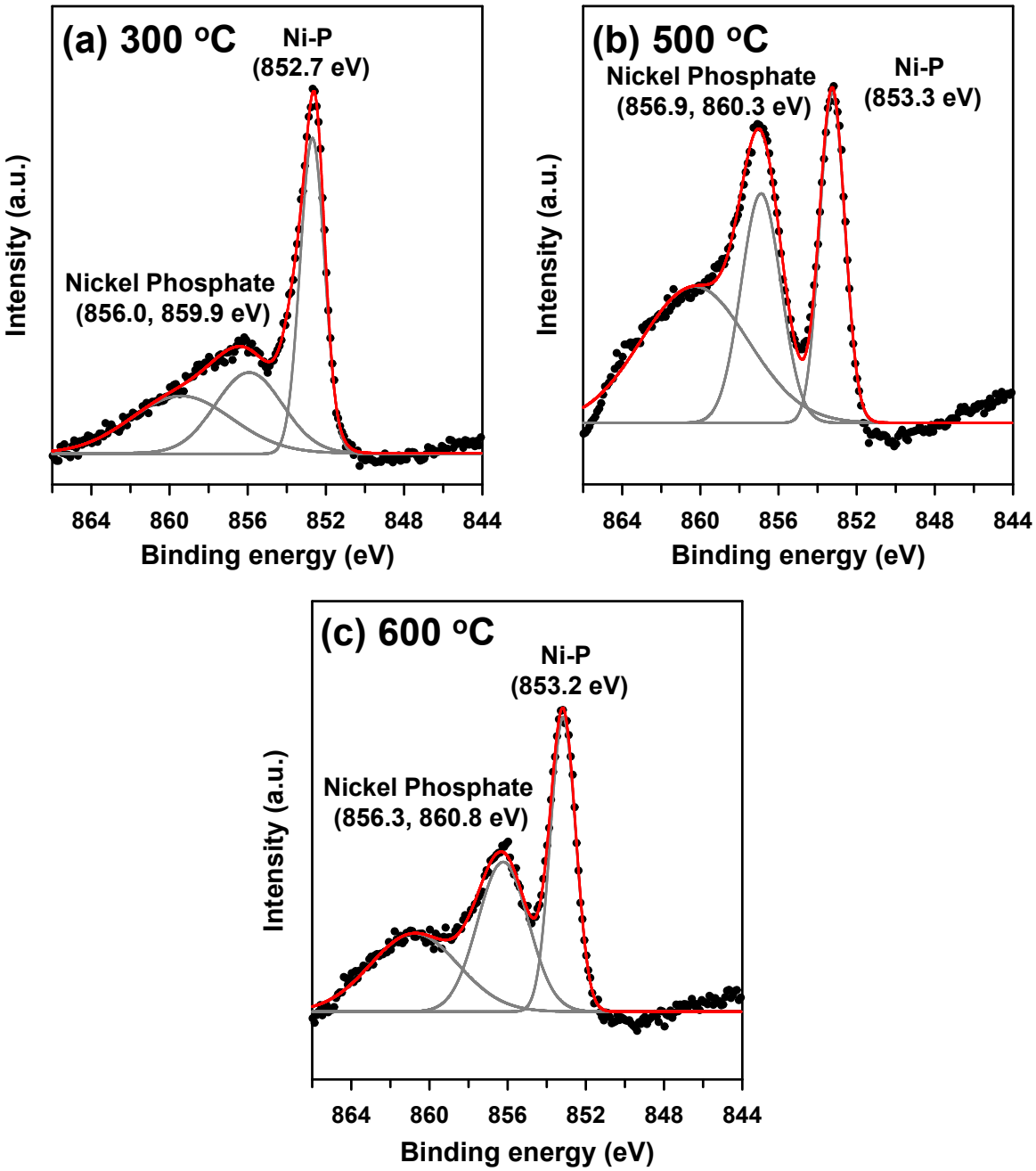

Figure S7. Ni $2p_{3/2}$ XPS spectra of Ni@mesoG samples phosphidated at (a) 300, (b) 500, and (c) 600 °C.

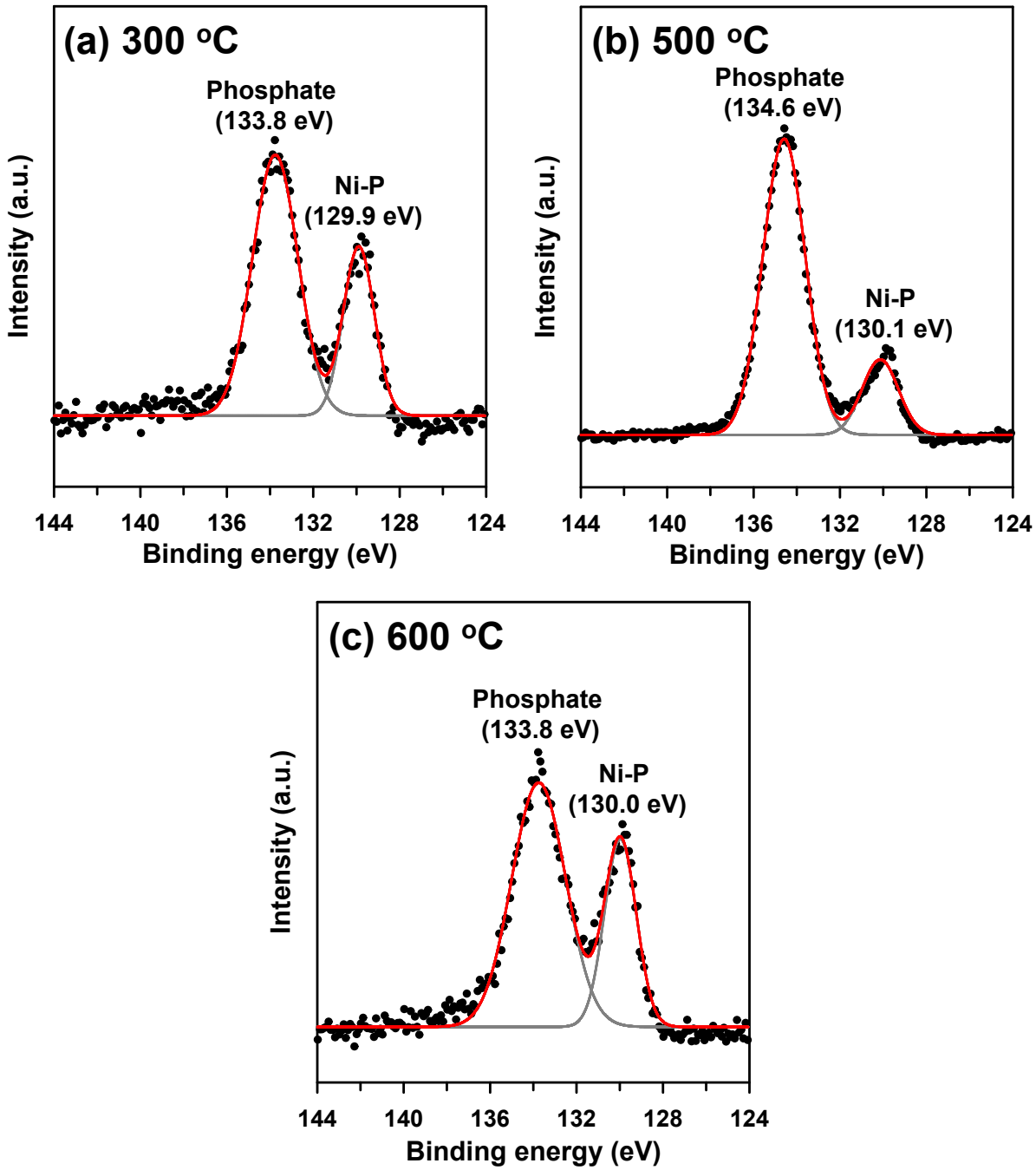

Figure S8. P $2p_{3/2}$ XPS spectra of Ni@mesoG samples phosphidated at (a) 300, (b) 500, and (c) 600 °C.

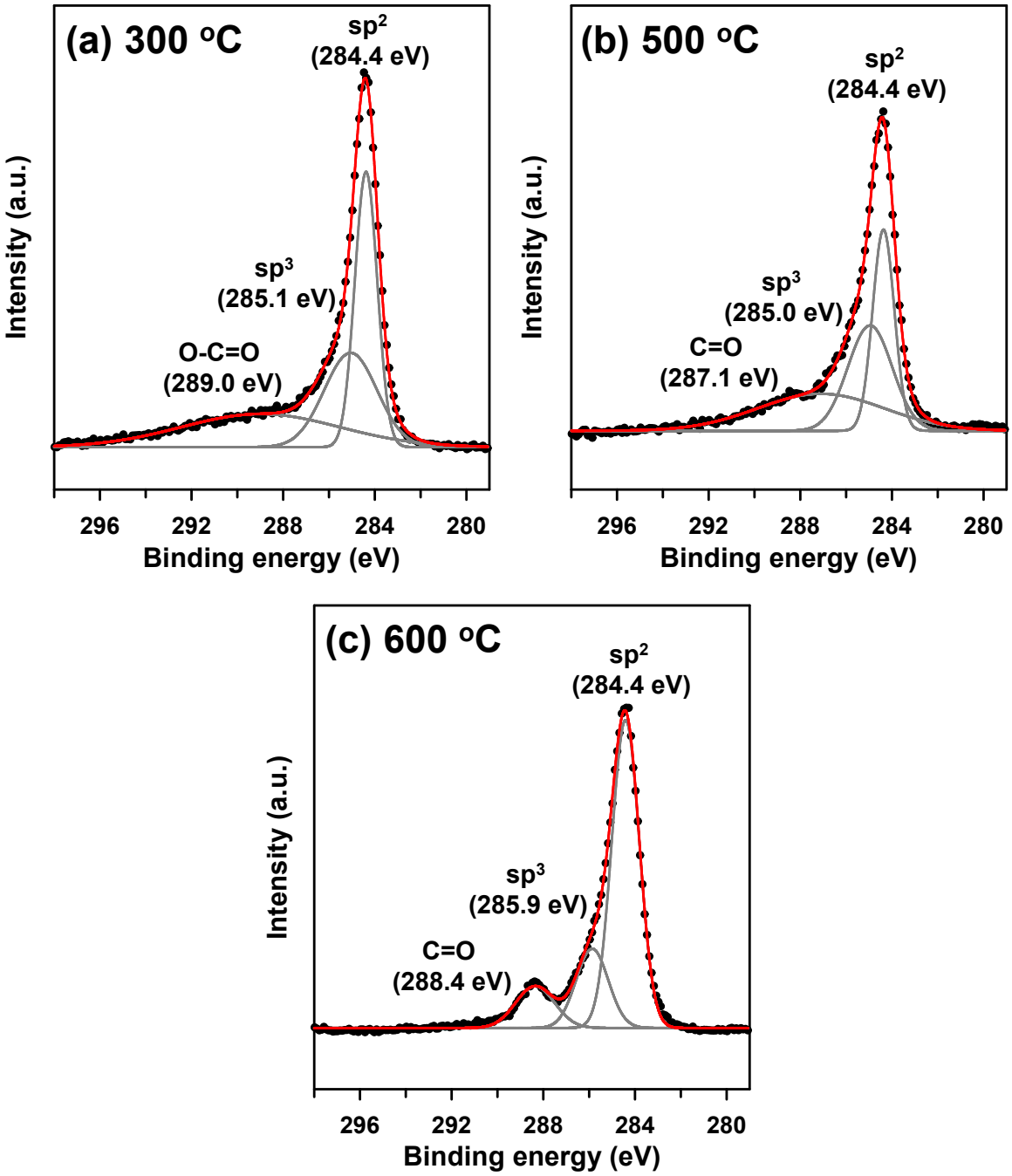

Figure S9. C 1*s* XPS spectra of Ni@mesoG samples phosphidated at (a) 300, (b) 500, and (c) 600 °C.

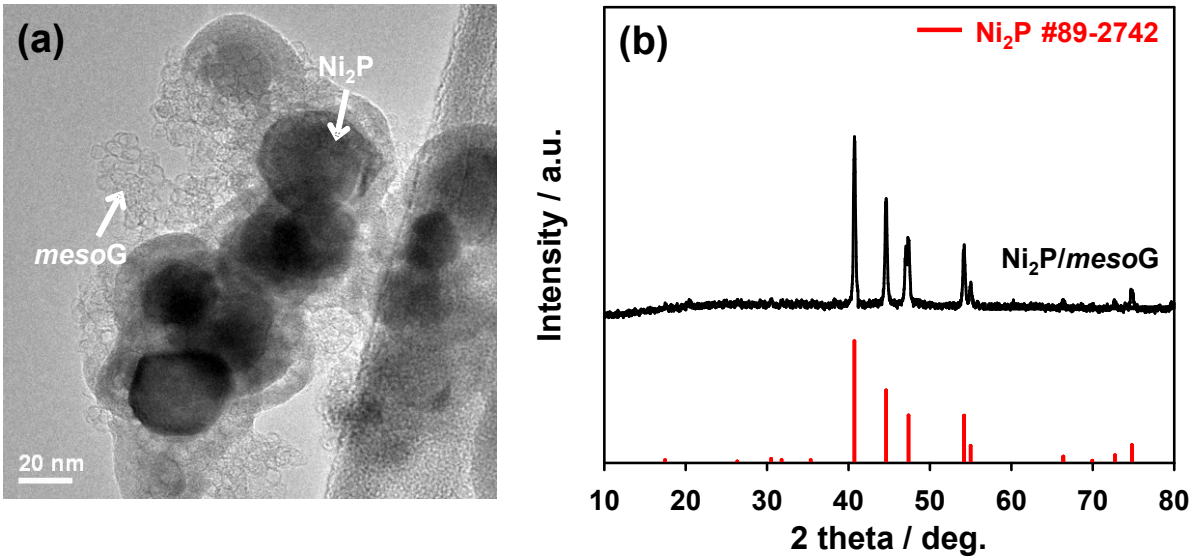

Figure S10. (a) TEM image and (b) XRPD pattern of Ni_2P/mesoG.

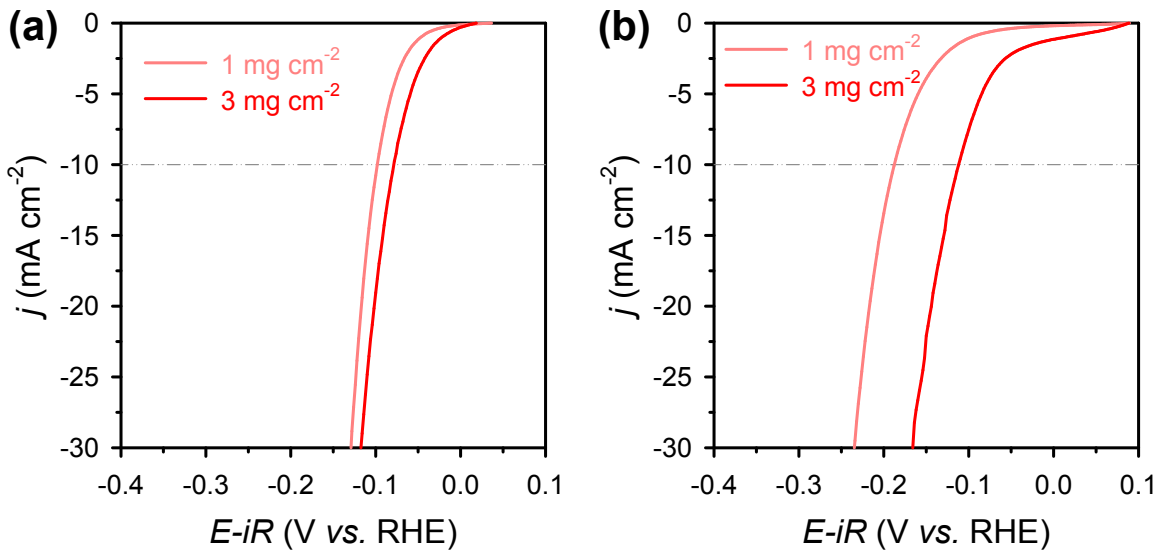

Figure S11. Polarization curves for Ni_2P@mesoG with different catalyst loadings in (a) 0.5 M H_2SO_4, and (b) 1 M KOH.

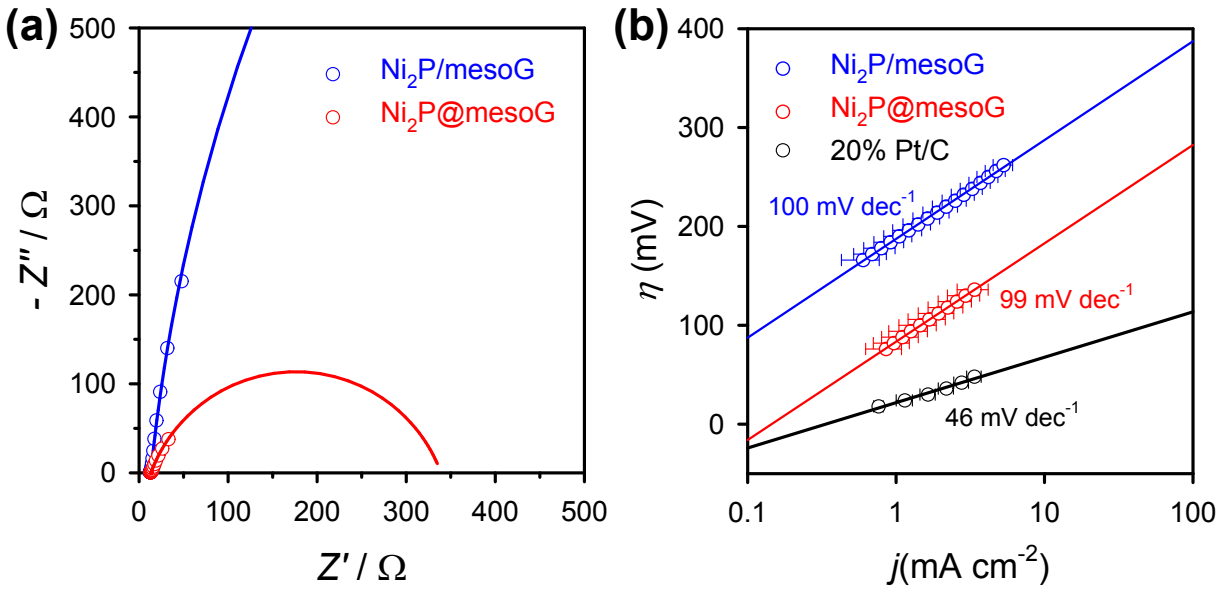

Figure S12. (a) Nyquist plots for the impedance spectra obtained at η = 100 mV (vs RHE) in 1 M KOH. The empty triangles and the solid lines represent numerical raw data and fitting results, respectively. (b) Tafel plots in 1 M KOH. The Tafel plots were depicted with error bar and without correction for ohmic drop.

2. References for Electronic Supplementary Information

S1. E. J. Popczun, J. R. McKone, C. G. Read, A. J. Biacchi, A. M. Wiltrout, N. S. Lewis and R. E. Schaak, *J. Am. Chem. Soc.*, 2013, **135**, 9267.

S2. L. Feng, H. Vrubel, M. Bensimon and X. Hu, *Phys. Chem. Chem. Phys.*, 2014, **16**, 5917.

S3. Z. Huang, Z. Chen, Z. Chen, C. Lv, H. Meng and C. Zhang, *ACS Nano*, 2014, **8**, 8121.

S4. Z. Pu, Z. Liu, C. Tang, A. M. Asiri and X. Sun, *Nanoscale*, 2014, **6**, 11031.

S5. P. Jiang, Q. Liu and X. Sun, *Nanoscale*, 2014, **6**, 13440.

S6. A. B. Laursen, K. R. Patraju, M. J. Whitaker, M. Retuerto, T. Sarkar, N. Yao, K. V. Ramanujachary, M. Greenblatt and G. C. Dismukes, *Energy Environ. Sci.*, 2015, **8**, 1027.

S7. X. Wang, Y. V. Kolen'ko, X.-Q. Bao, K. Kovnir and L. Liu, *Angew. Chem. Int. Ed.*, 2015, **54**, 8188.

S8. A. Han, S. Jin, H. Chen, H. Ji, Z. Sun and P. Du, *J. Mater. Chem. A*, 2015, **3**, 1941.

S9. Y. Pan, Y. Liu, J. Zhao, K. Yang, J. Liang, D. Liu, W. Hu, D. Liu, Y. Liu and C. Liu, *J. Mater. Chem. A*, 2015, **3**, 1656.