Supporting Information

Multi-Shelled Cobalt-Nickel Oxide/Phosphide Hollow Spheres for Efficient Oxygen Evolution Reaction

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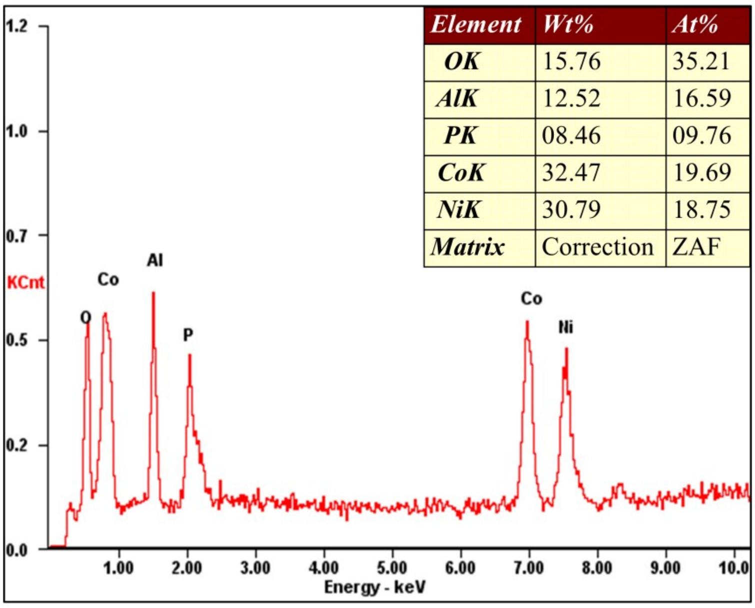

Figure S1. The energy dispersive X-ray spectrum for the multi-shelled $Co_{0.5}Ni_{0.5}$ oxide/phosphide. The signal of Al in the EDX spectrum was derived from the conductive aluminum foil substrate used for the FESEM measurement.

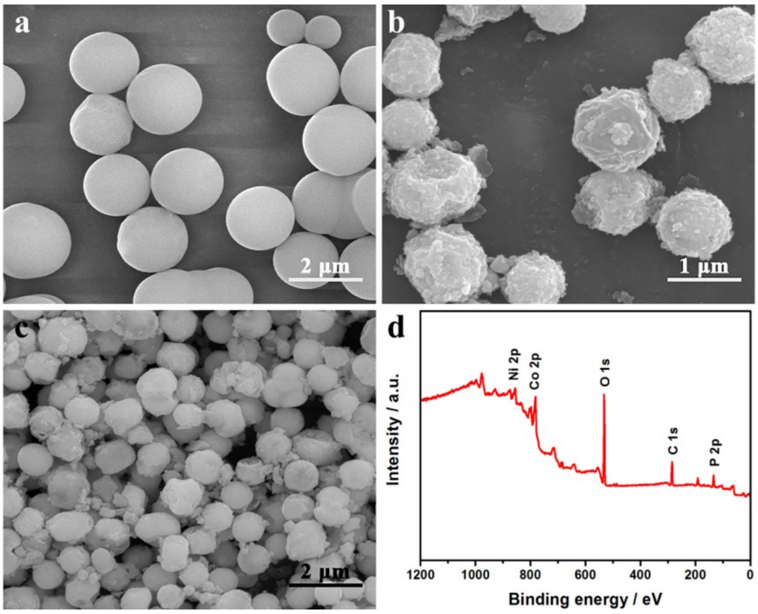

Figure S2. FESEM images of (a) $Co_{0.5}Ni_{0.5}$ CPS, (b) multi-shelled $Co_{0.5}Ni_{0.5}$ oxide and (c) multi-shelled $Co_{0.5}Ni_{0.5}$ oxide/phosphide. (d) XPS spectrum of elements surveys for multi-shelled $Co_{0.5}Ni_{0.5}$ oxide/phosphide.

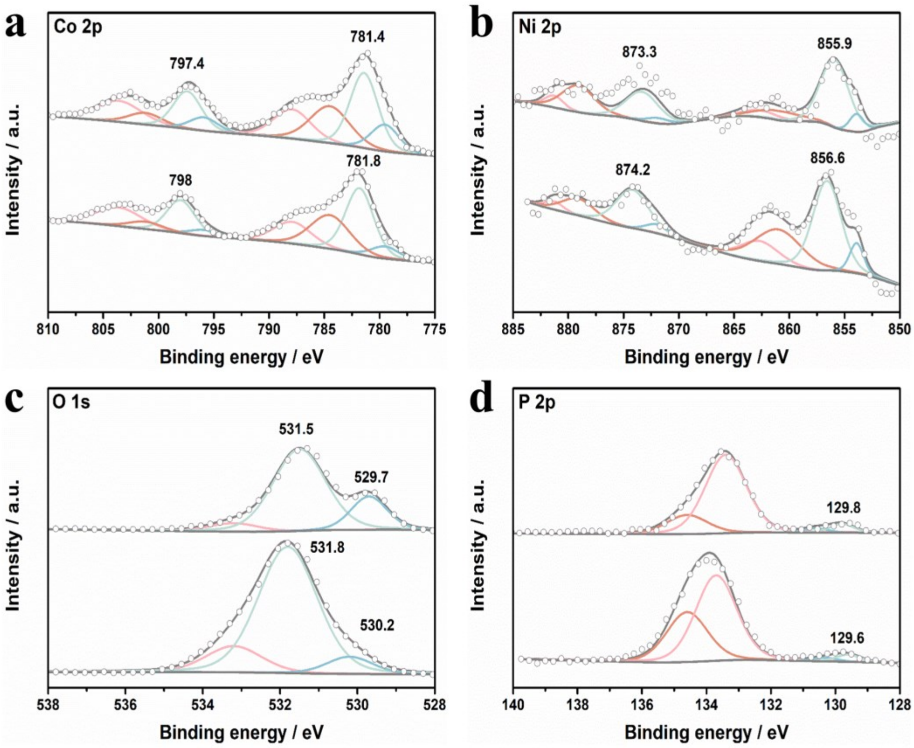

Figure S3. XPS high-resolution spectra of (a) Co 2p, (b) Ni 2p, (c) O 1s and (d) P 2p for multi-shelled $Co_{0.9}Ni_{0.1}$ oxide/phosphide (upper), and multi-shelled $Co_{0.5}Ni_{0.5}$ oxide/phosphide (bottom).

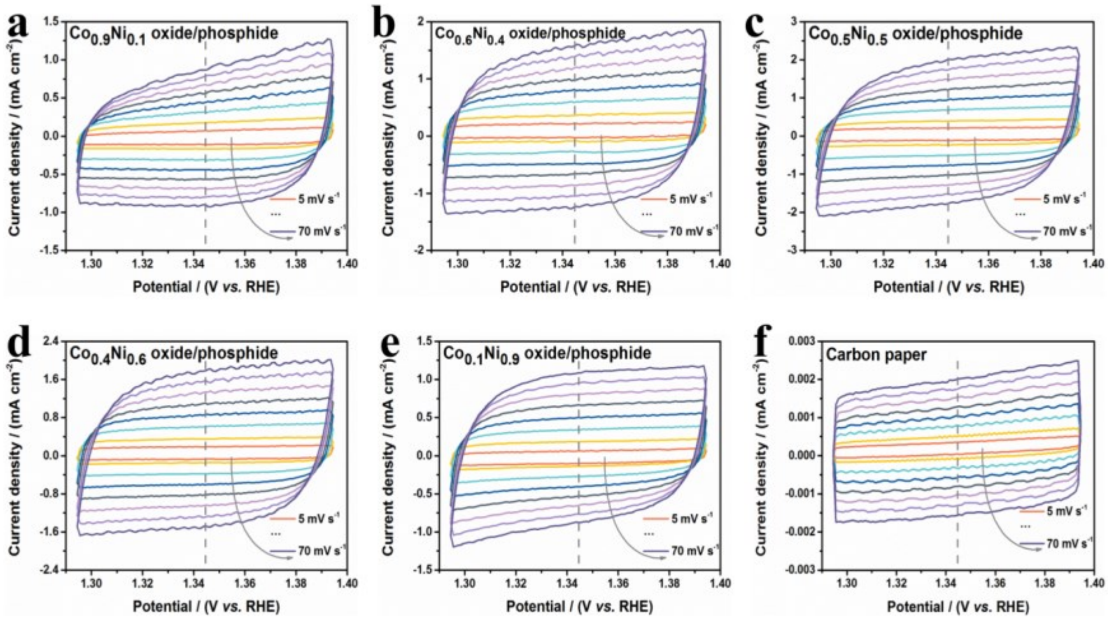

Figure S4. Cyclic voltammetry (CV) curves for (a) $Co_{0.9}Ni_{0.1}$ oxide/phosphide, (b) $Co_{0.6}Ni_{0.4}$ oxide/phosphide, (c) $Co_{0.5}Ni_{0.5}$ oxide/phosphide, (d) $Co_{0.4}Ni_{0.6}$ oxide/phosphide, (e) $Co_{0.1}Ni_{0.9}$ oxide/phosphide and (f) bare carbon paper at incremental scan rates in the potential range of 1.3 - 1.4 V vs RHE.

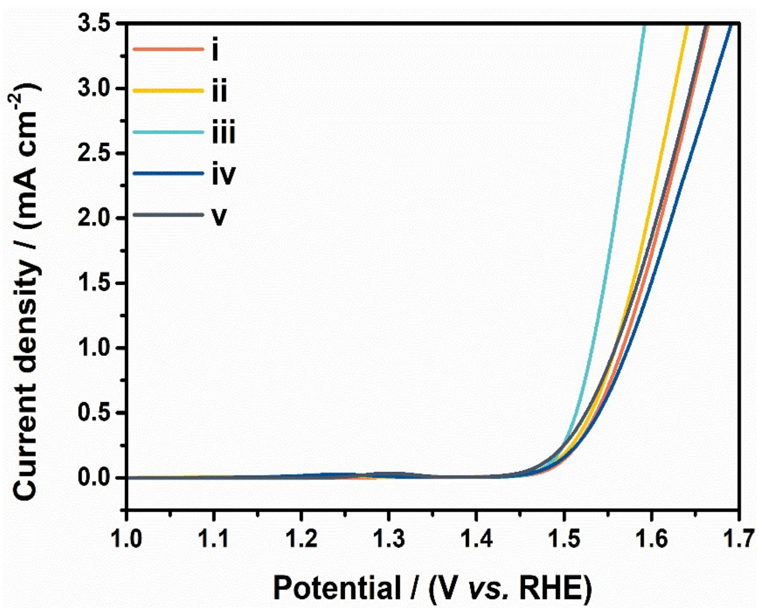

Figure S5. Polarization curves after being normalized by ECSA for multi-shelled Co_xNi_{1-x} oxide/phosphide electrocatalysts. (i) $Co_{0.9}Ni_{0.1}$ oxide/phosphide, (ii) $Co_{0.6}Ni_{0.4}$ oxide/phosphide, (iii) $Co_{0.5}Ni_{0.5}$ oxide/phosphide, (iv) $Co_{0.4}Ni_{0.6}$ oxide/phosphide and (v) $Co_{0.1}Ni_{0.9}$ oxide/phosphide.

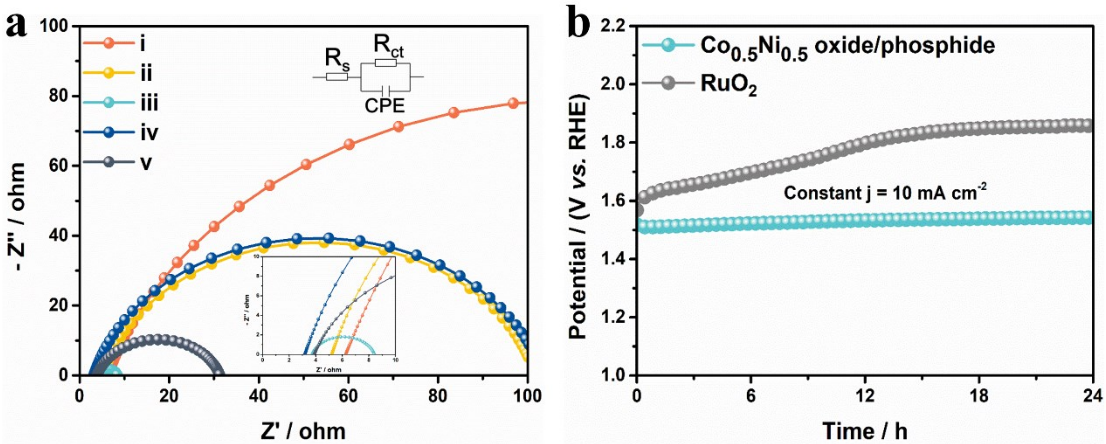

Figure S6. (a) Nyquist plots obtained at overpotentials@10 mA cm^{-2} and (b) Chronopotentiometric curve of multi-shelled $Co_{0.5}Ni_{0.5}$ oxide/phosphide catalyst at a constant current density of 10 mA cm^{-2}. (i) $Co_{0.9}Ni_{0.1}$ oxide/phosphide, (ii) $Co_{0.6}Ni_{0.4}$ oxide/phosphide, (iii) $Co_{0.5}Ni_{0.5}$ oxide/phosphide, (iv) $Co_{0.4}Ni_{0.6}$ oxide/phosphide and (v) $Co_{0.1}Ni_{0.9}$ oxide/phosphide.

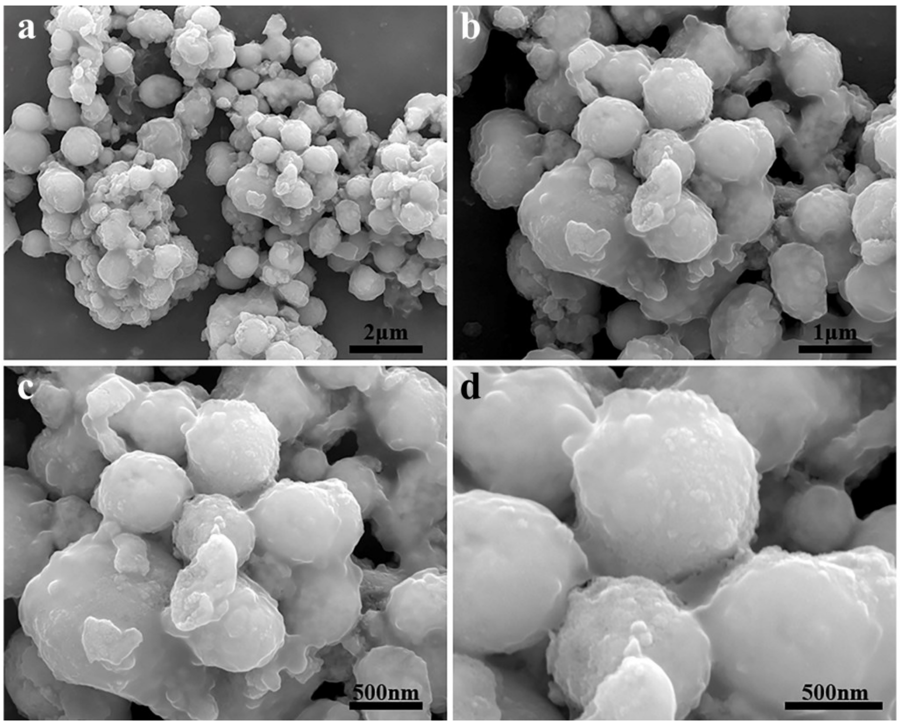

Figure S7. FESEM images of multi-shelled $Co_{0.5}Ni_{0.5}$ oxide/phosphide after OER test under different magnifications.

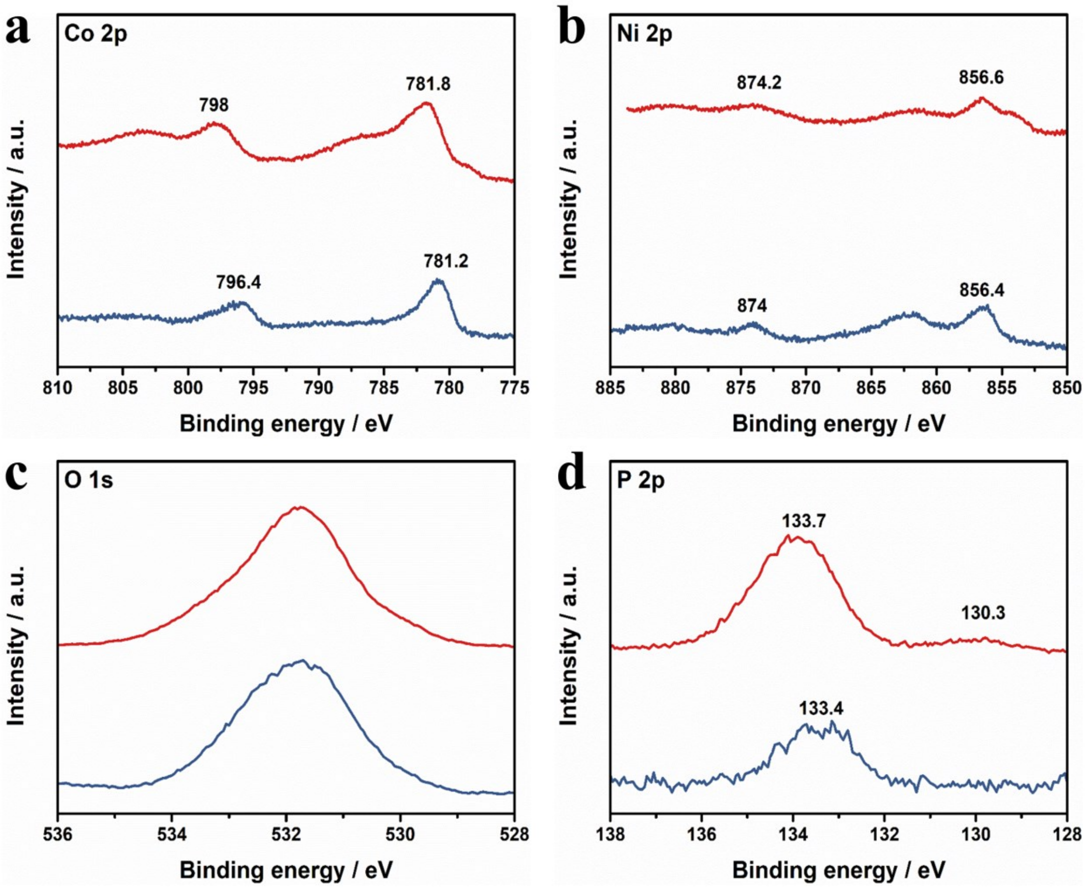

Figure S8. XPS high-resolution spectra of (a) Co 2p, (b) Ni 2p, (c) O 1s and (d) P 2p for multi-shelled $Co_{0.5}Ni_{0.5}$ oxide/phosphide before (upper) and after (bottom) OER test.

Table S1. The estimated values of R_s, and R_{ct}.

Materials	R_s (Ω)	R_{ct} (Ω)
$Co_{0.9}Ni_{0.1}$ oxide/phosphide	6.2	210.9
$Co_{0.6}Ni_{0.4}$ oxide/phosphide	5.2	96.5
$Co_{0.5}Ni_{0.5}$ oxide/phosphide	3.7	4.7
$Co_{0.4}Ni_{0.6}$ oxide/phosphide	3.2	100.2
$Co_{0.1}Ni_{0.9}$ oxide/phosphide	3.9	27.4

Table S2. Comparison of electrocatalytic performance of different typical materials (in 1 M KOH).

Materials	Overpotentials (mV)	Tafel slopes (mV dec^{-1})	References
NiCoP Film	275	87	References[1]
$Co_{0.9}Ni_{0.1}P$@NNCS hierarchical nanostructure	221	54	References[2]
Ni/Co-P-1/1 nanoparticles	360	60	Reference[3]
Ni-Co-P hollow nanobricks	270	76	Reference[4]
Ni-Co-P nanosheets	290	88	Reference[4]
$NiFeO_x$@NiFe-P core-shell metal oxides/phosphides	477	75	Reference[5]
Multi-shelled $Co_{0.5}Ni_{0.5}$ oxide/phosphide hollow spheres	268	41.4	This work

Table S3. Comparison of EDS test results for the multi-shelled Co_xNi_{1-x} oxide/phosphide.

Materials	Co (wt%)	Ni (wt%)
$Co_{0.9}Ni_{0.1}$ oxide/phosphide	35.18	4.38
$Co_{0.6}Ni_{0.4}$ oxide/phosphide	18.29	10.84
$Co_{0.5}Ni_{0.5}$ oxide/phosphide	32.47	30.79
$Co_{0.4}Ni_{0.6}$ oxide/phosphide	18.25	26.23
$Co_{0.1}Ni_{0.9}$ oxide/phosphide	7.17	63.13

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