Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Synergistically coupling ultrasmall PtCu nanoalloys with highly porous CoP nanosheets as enhanced electrocatalyst for electrochemical hydrogen evolution

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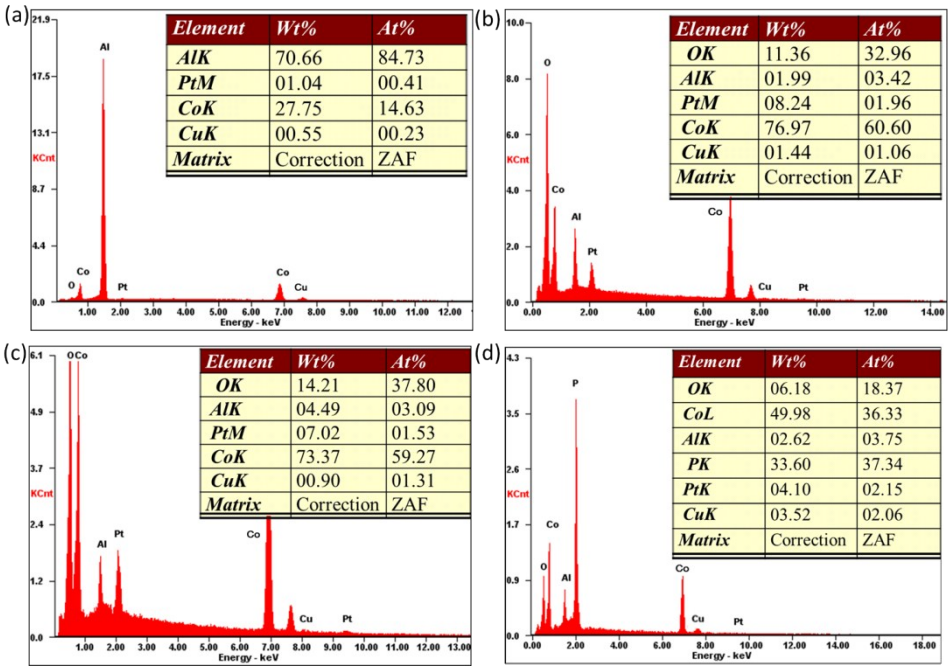

Fig S1. EDS spectrum of (a) AlCoPtCu precursor alloy, (b) freshly dealloyed PtCu/$Co(OH)_2$, (c) PtCu/Co_3O_4, and (d) PtCu/CoP.

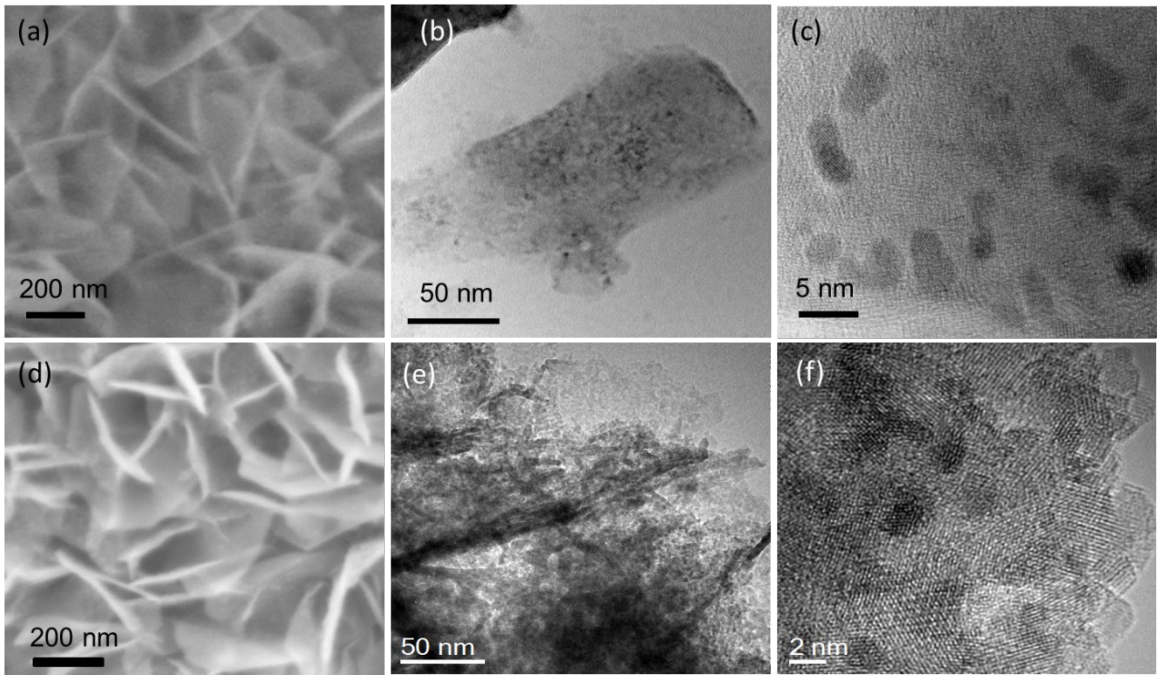

Fig S2. (a) SEM and (b, c) TEM images of the $PtCu/Co(OH)_2$. (d) SEM and (e, f) TEM images of the $PtCu/Co_3O_4$.

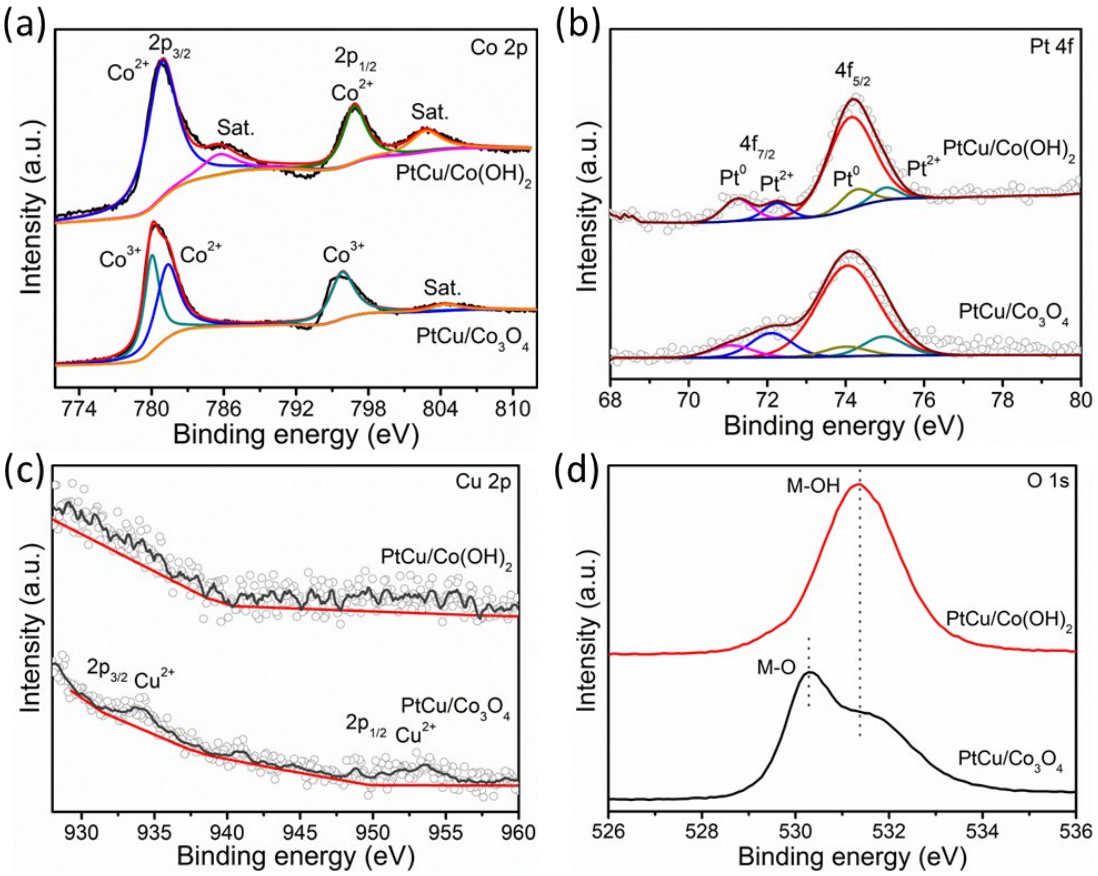

Fig S3. XPS spectra of (a) Co 2p, (b) Pt 4f, (c) Cu 2p and (d) O 1s of $PtCu/Co(OH)_2$ and $PtCu/Co_3O_4$.

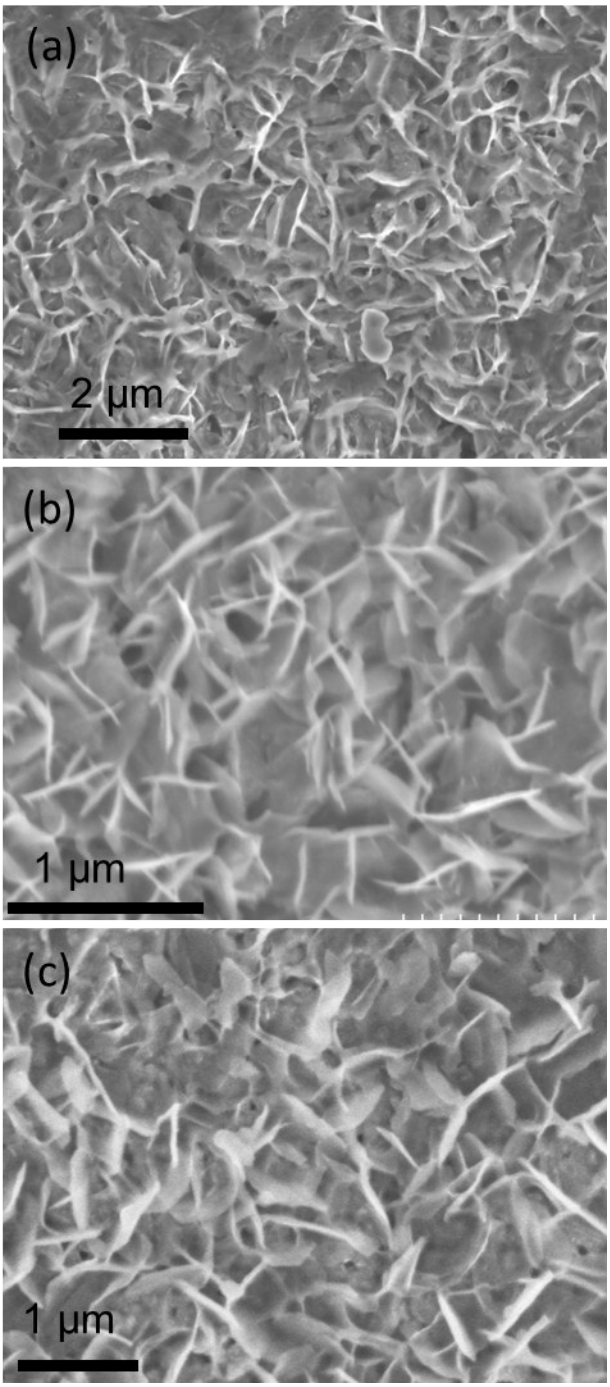

Fig S4. SEM images of the (a) CoP, (b) Pt/CoP, (c) Cu/CoP.

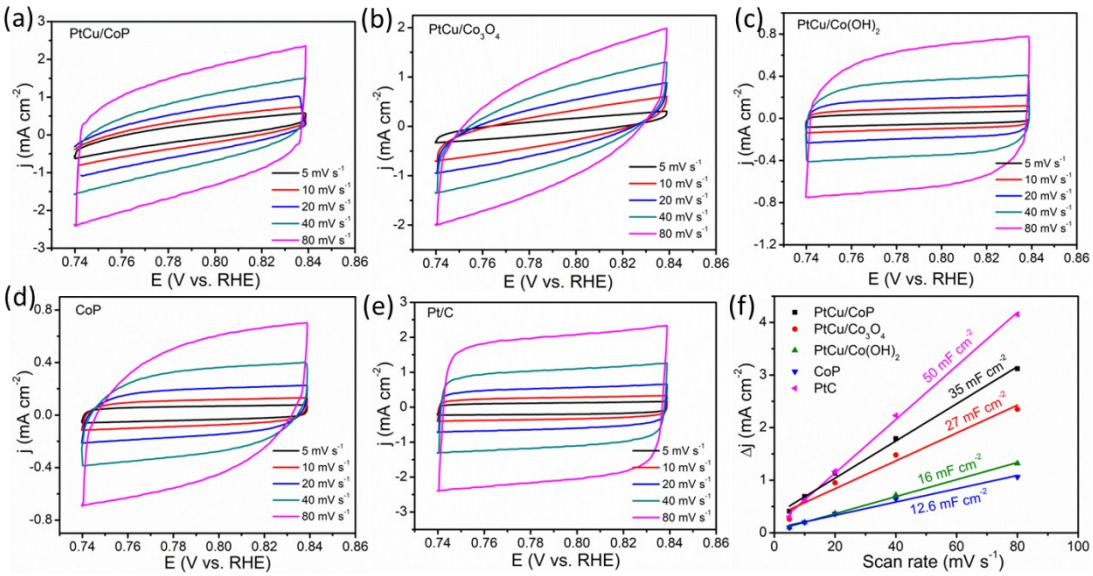

Fig S5. Typical CV curves of (a) PtCu/CoP, (b) PtCu/Co_3O_4 (c) PtCu/$Co(OH)_2$, (d) CoP and (e) commercial Pt/C catalysts in 0.5 M H_2SO_4 with different scan rates (5, 10, 20, 40 and 80 mV s^{-1}). (f) The current densities at 0.79 V with respect to scan rates for above five catalysts.

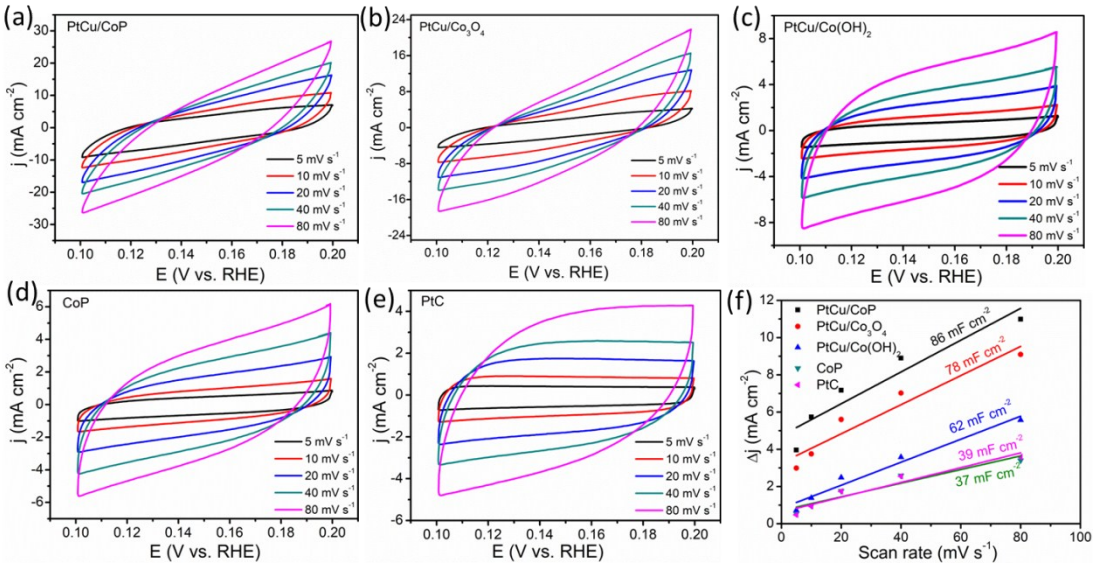

Fig S6. Typical CV curves of (a) PtCu/CoP, (b) PtCu/Co_3O_4 (c) PtCu/$Co(OH)_2$, (d) CoP and (e) commercial Pt/C catalysts in 1.0 M KOH with different scan rates (5, 10, 20, 40 and 80 mV s^{-1}). (f) The current density at 0.15 V with respect to scan rate for above five catalysts.

Table S1. Comparison of the PtCu/CoP with some recently reported HER electrocatalysts in 0.5 M H_2SO_4 solution.

Catalysts	Tafel slope (mV dec^{-1})	η@10 mA cm^{-2} (mV)	References
Pd/Cu-Pt	25	22.8	*Angew. Chem. Int. Ed.* **2017**, 56, 16047 –16051
ALD 50 Pt/NGNs	29	40	*Nat. Commun.* **2016**, 7, 13638
Ru@GnP	30	13	*Adv. Mater.* **2018**, 30, 1803676
PdP_2@CB	29.5	27.5	*Angew. Chem. Int. Ed.* **2018**, 57, 14862 –14867
Ru@CN	30	22	*Nat. Nanotech.* **2017**, 12, 441-446
Au@PdAg	30	26.2	*J. Am. Chem. Soc.* **2016**, 138, 1414–1419
PtCoFe@CN	32	45	*ACS Appl. Mater. Interfaces,* **2017**, 9, 3596–3601
400-SWNT/Pt	38	27	*ACS Catal.* **2017**, 7, 3121–3130
PdCu@Pd NCs	35	68	*ACS Appl. Mater. Interfaces* **2017**, 9, 8151–8160
Pt-MoS_2	40	53	*Nat. Commun.* **2013**, 4, 1444
PtCu/CoP	**28**	**15**	**This work**

Table S2. Comparison of the PtCu/CoP with some recently reported HER electrocatalysts in 1.0 M KOH solution.

Catalysts	Tafel slope (mV dec^{-1})	η@10 mA cm^{-2} (mV)	References
Pt/NiO@Ni/NF	40	34	*ACS Catal.* **2018**, 8, 8866-8872
RuP_2@NPC	69	52	*Angew. Chem. Int. Ed.* **2017**, 56, 11559 –11564
Ru@GnP	28	22	*Adv. Mater.* **2018**, 30, 1803676
PdP_2@CB	42.1	35.4	*Angew. Chem. Int. Ed.* **2018**, 57, 14862 –14867
N,P-doped Mo_2C@C	71	47	*ACS Nano* **2016,** 10, 8851–8860
H-NiCoP NWAs/NF	38.6	44	*Small* **2018**, 14, 1800421
CoP-400-E15	86	73	*Adv. Energy Mater.* **2018**, 8, 1802445
CoP/NCNHP	66	115	*J. Am. Chem. Soc.* **2018**, 140, 2610-2618
Co_2P/Co-Foil	59	157	*J. Mater. Chem. A* **2017**, 5, 10561-10566
MoP@C	54	49	*Adv. Energy Mater.* **2018**, 8, 1801258
PtCu/CoP	**49**	**40**	**This work**