Supporting Information

Graphene oxide−molecular Cu porphyrin integrated $BiVO_4$ photoanode for improved photoelectrochemical water oxidation performance

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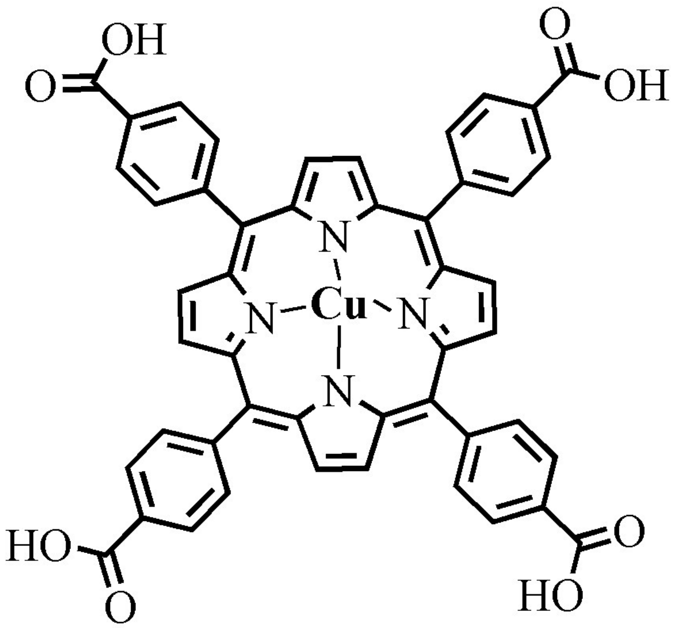

Figure S1. Structure of molecular Cu porphyrin (CuTCPP).

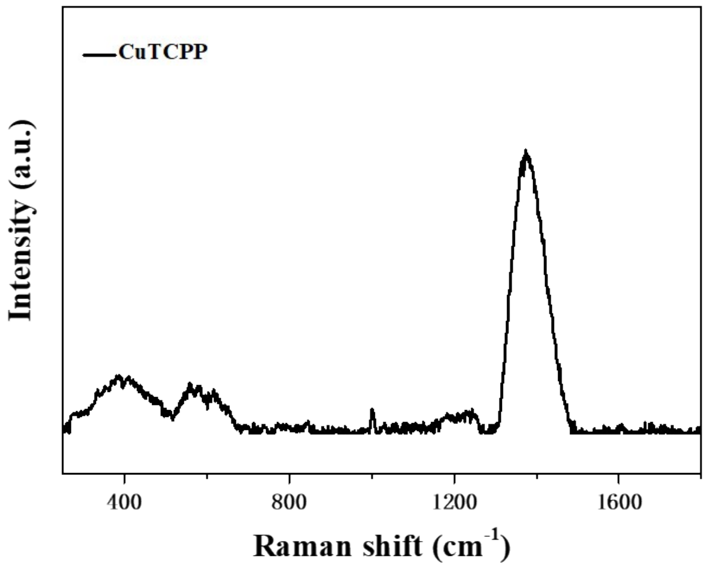

Figure S2. Raman spectrum of CuTCPP powder.

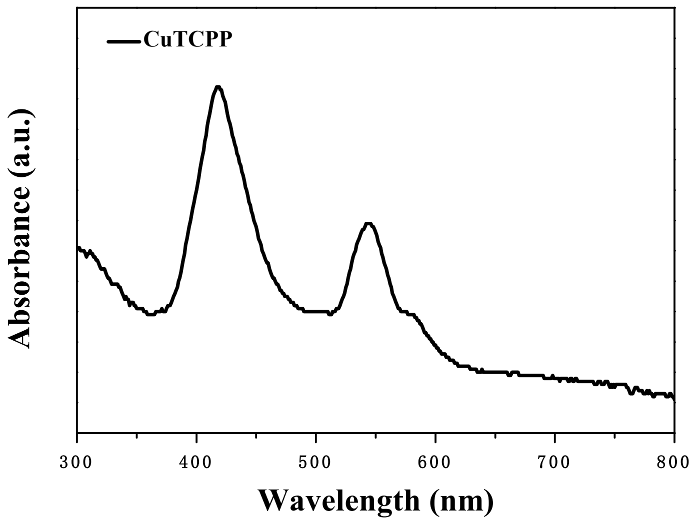

Figure S3. UV-vis diffuse reflectance spectrum of CuTCPP powder.

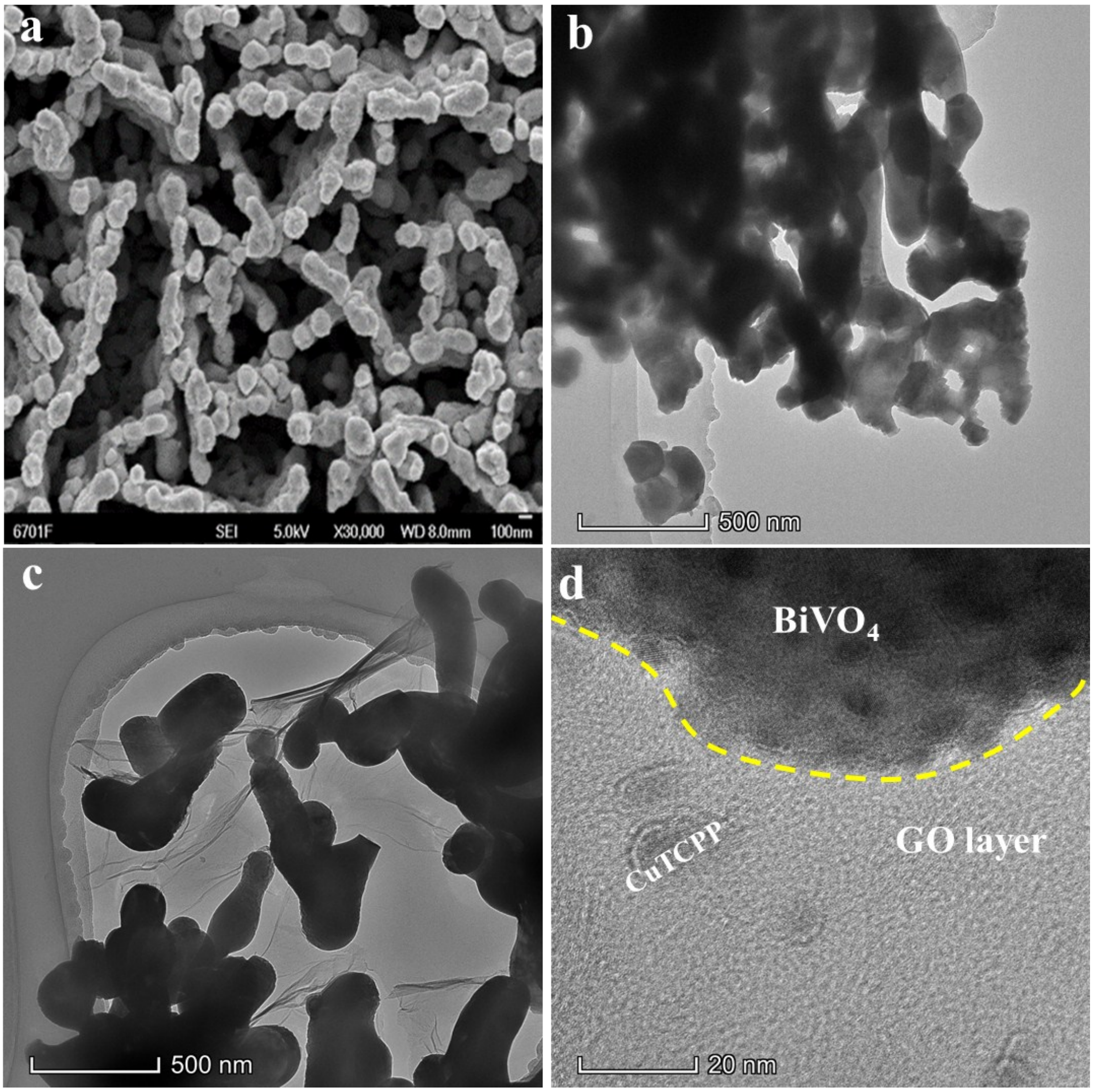

Figure S4. SEM image of (a) bare $BiVO_4$ electrode and TEM images of (b) bare $BiVO_4$ electrode, (c) GO/$BiVO_4$ electrode, (d) HRTEM of CuTCPP/GO/$BiVO_4$ electrode after reaction.

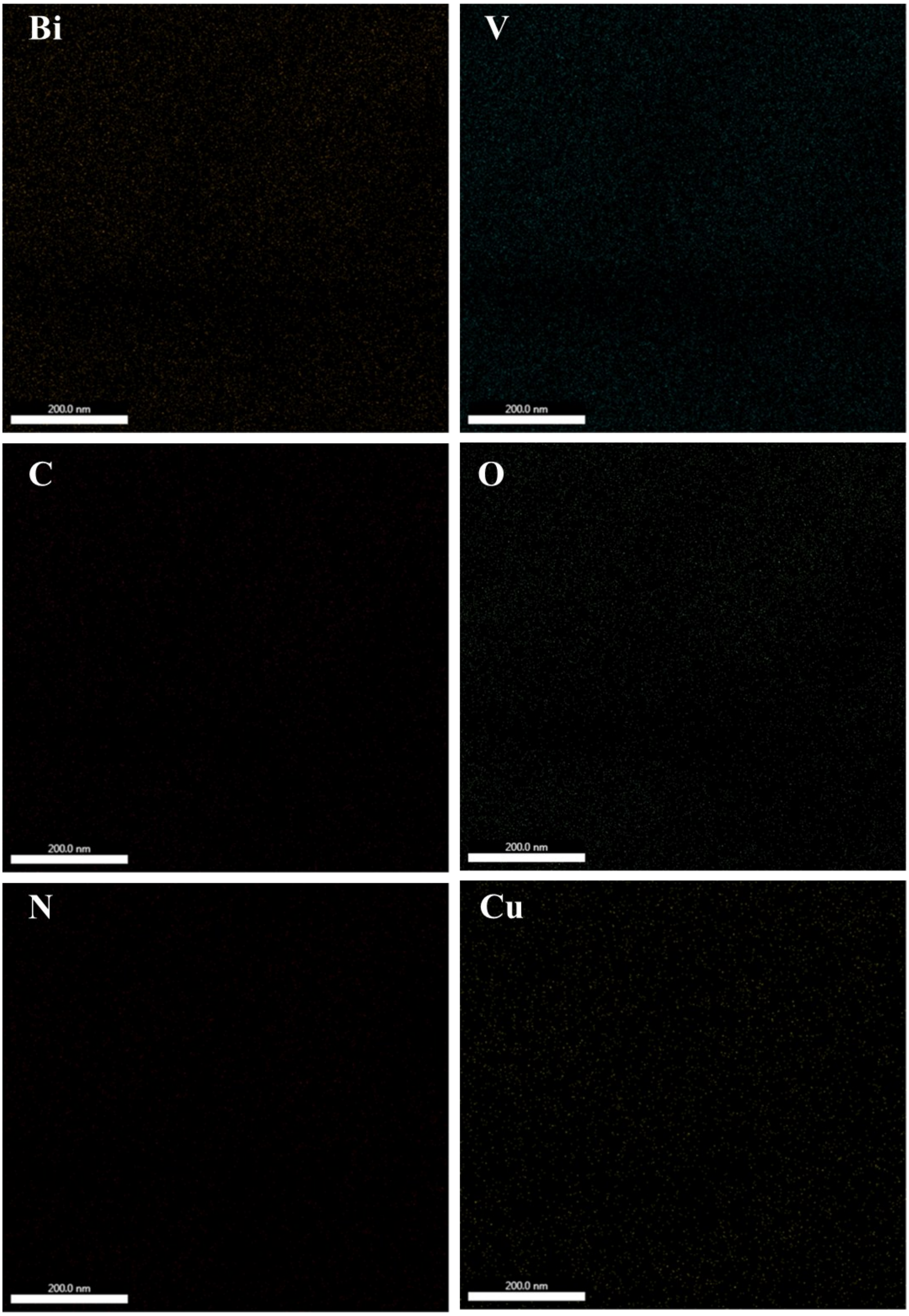

Figure S5. EDS mapping images of CuTCPP/GO/$BiVO_4$ electrode.

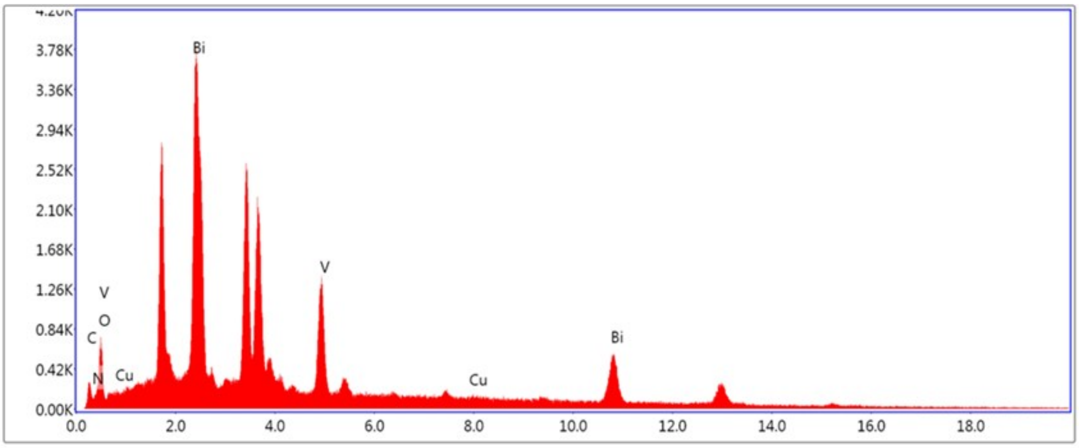

Figure S6. EDS element distribution of CuTCPP/GO/$BiVO_4$ photoanode.

Table S1. EDS analysis data of CuTCPP/GO/$BiVO_4$ photoanode.

Element	Weight %	Atomic %	Net Int.	Error %	Kratio	Z	R	A	F
C K	9.87	27.28	65.02	9.53	0.0579	1.2760	0.7973	0.4601	1.0000
N K	4.49	10.64	14.29	24.68	0.0107	1.2551	0.8092	0.1901	1.0000
O K	21.67	44.98	115.82	13.21	0.0347	1.2366	0.8201	0.1294	1.0000
V K	13.46	8.77	535.36	5.01	0.1093	0.9944	0.9470	0.7646	1.0679
CuK	0.81	0.43	26.38	34.33	0.0097	0.9849	0.9854	0.9201	1.3155
BiL	49.71	7.90	349.02	9.35	0.4475	0.7578	1.1735	1.0352	1.1476

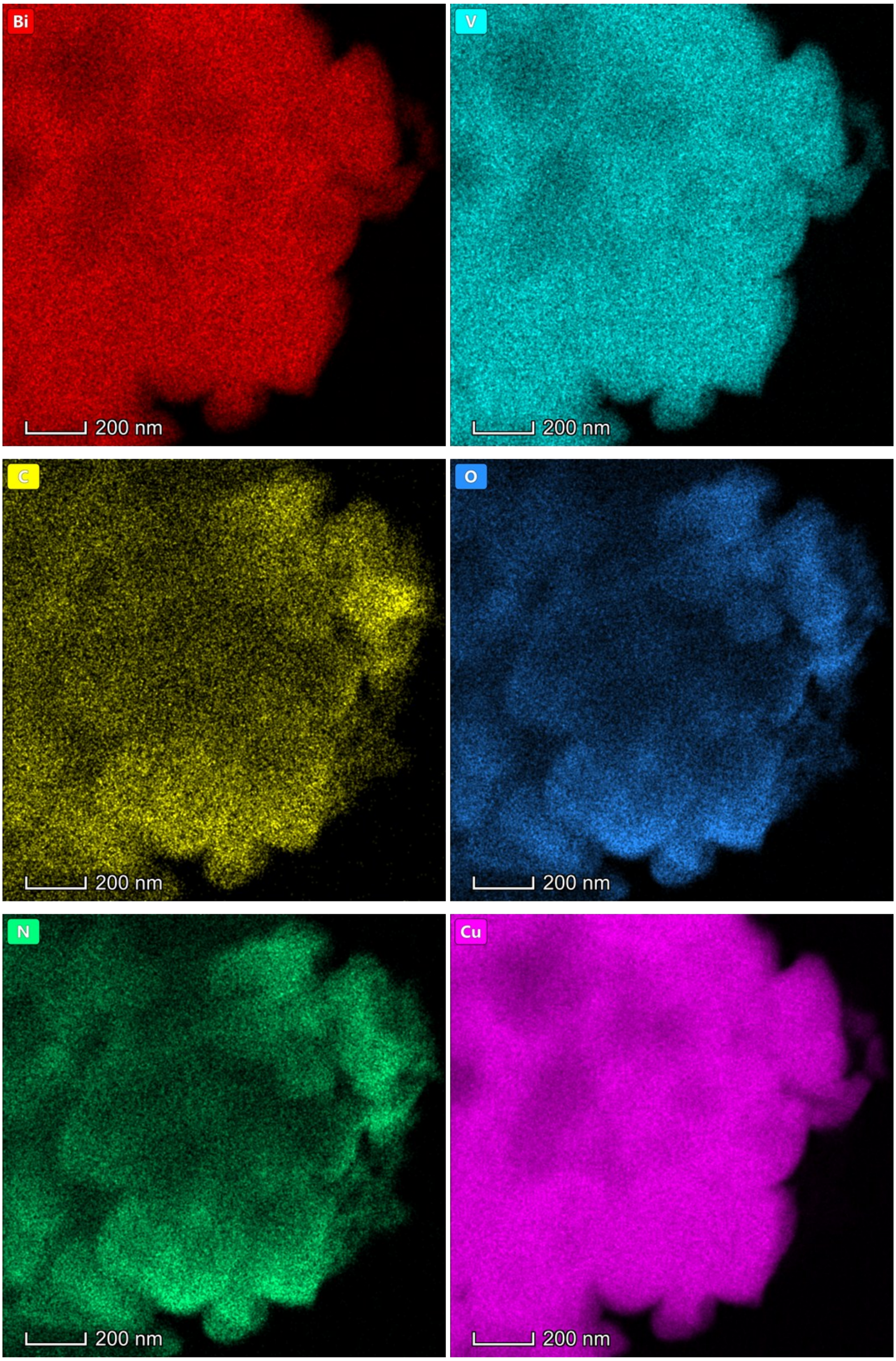

Figure S7. Elements mapping of CuTCPP/GO/$BiVO_4$ photoanode.

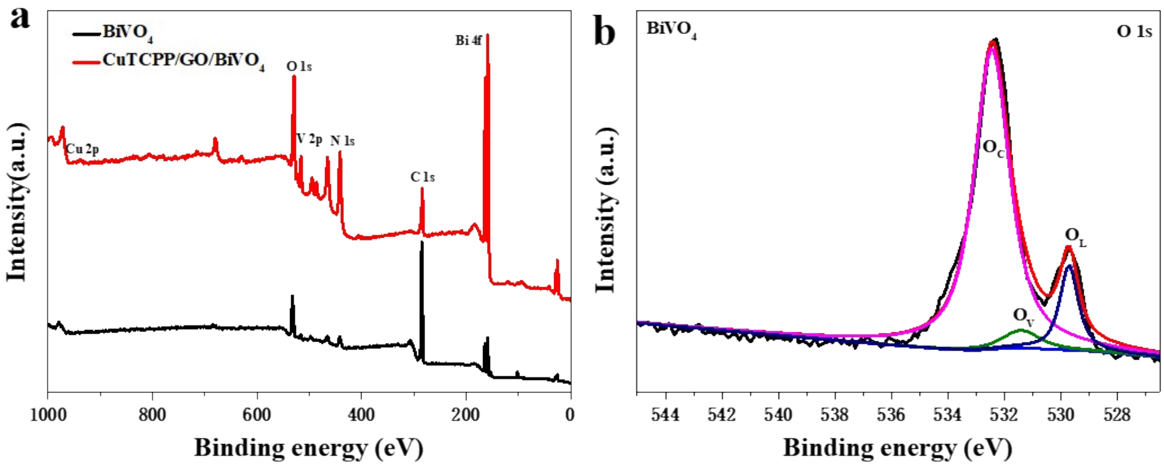

Figure S8. XPS of $BiVO_4$ and the CuTCPP/GO/$BiVO_4$ photoanodes a) survey and b) XPS high-resolution spectra of O 1s of $BiVO_4$.

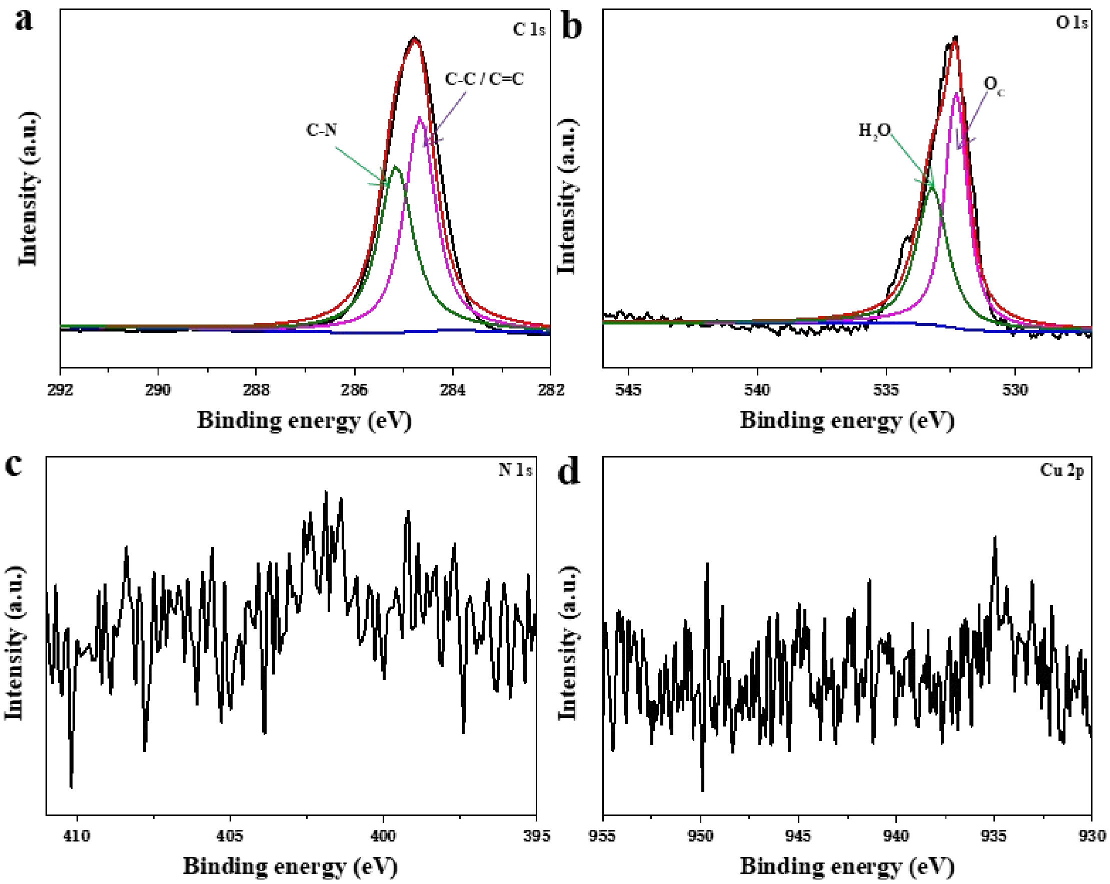

Figure S9. XPS high-resolution spectra of CuTCPP powder: a) C 1s, b) O 1s, c) N 1s and d) Cu 2p.

The water (~ 533.4eV) and O_C (~532.5 eV) peaks of the XPS O 1s spectra of CuTCPP could be evidently detected [1,2].

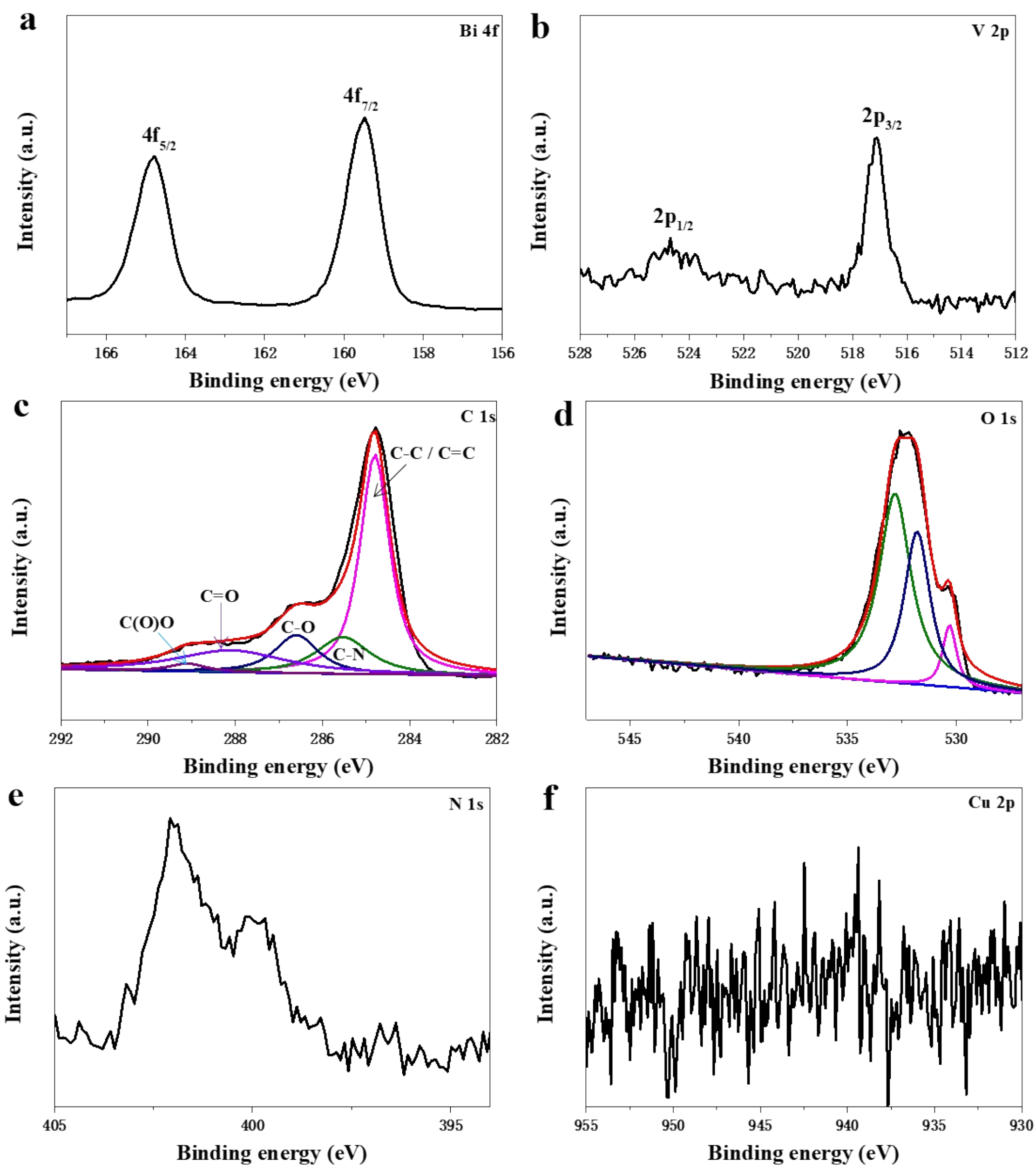

Figure S10. XPS spectra of the CuTCPP/GO/$BiVO_4$ photoanode after reaction: a) Bi 4f, b) V 2p, c) C 1s, d) O 1s, e) N 1s, and f) Cu 2p;

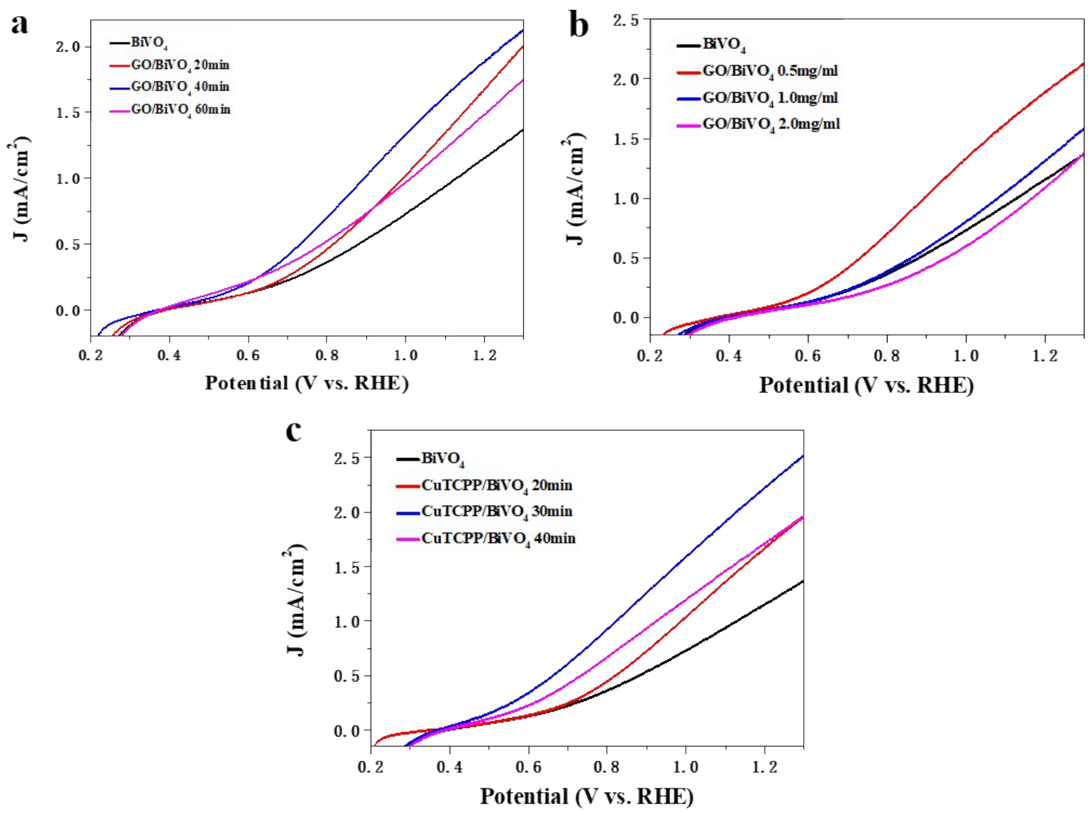

Figure S11. The LSV curves of (a) $BiVO_4$ photoanodes were treated different time by 0.5 mg/mL GO dispersion solution, (b) $BiVO_4$ photoanodes were treated different concentration of GO dispersion solution, and (c) $BiVO_4$ photoanodes were treated different time with CuTCPP dispersion solution.

As shown in Figure S11a, it indicates that $BiVO_4$ was treated by 0.5 mg mL^{-1} GO dispersion solution with 40 min, which the photocurrent density achieves about 1.96 mA cm^{-2} at 1.23 V vs. RHE. $BiVO_4$ photoanode was treated by CuTCPP dispersion solution with 30 min, which the photocurrent density reaches 2.2 mA cm^{-2} at 1.23 V vs. RHE (Figure S11c).

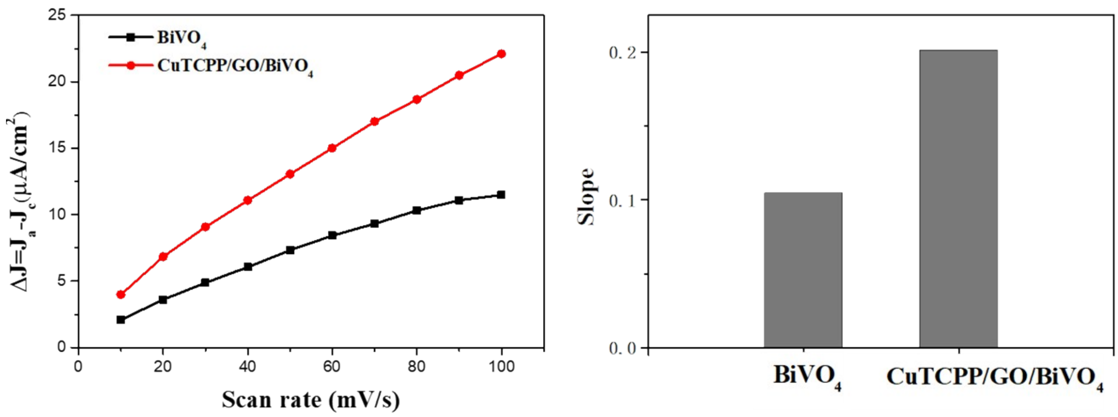

Figure S12. (a) Charging current density differences of bare $BiVO_4$ and CuTCPP/GO/$BiVO_4$ plotted against scan rates. (b) Slopes calculated from the fitting results of bare $BiVO_4$ and CuTCPP/GO/$BiVO_4$.

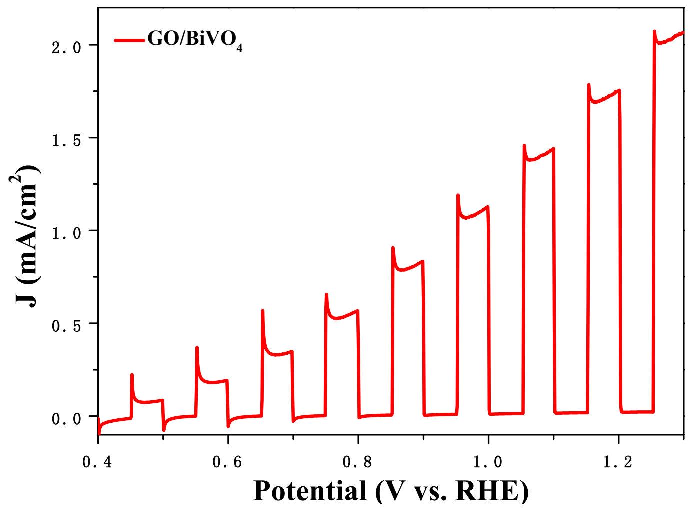

Figure S13. LSV chopping of GO/$BiVO_4$ photoanode.

Evident transient anodic peaks are observed under dark/light, illustrating that photogenerated holes are collected in the GO layer [3,4].

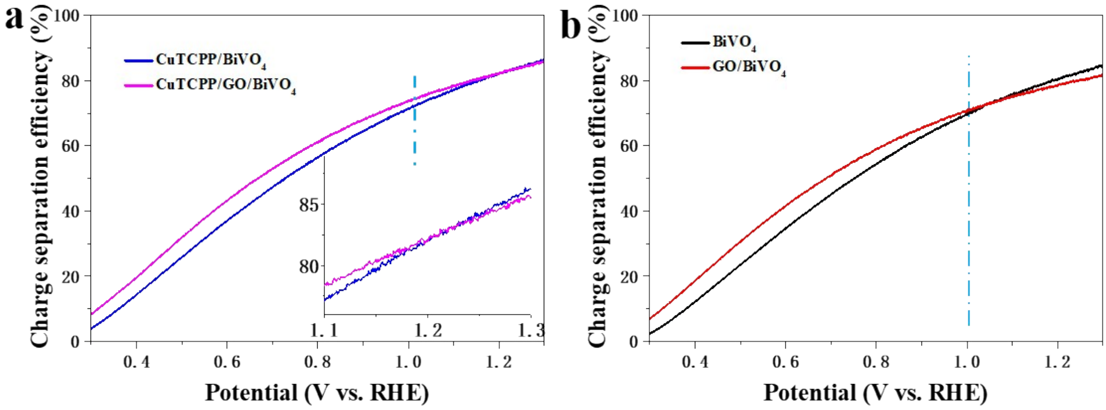

Figure S14. a) Charge separation efficiency of CuTCPP/$BiVO_4$ and CuTCPP/GO/$BiVO_4$, b) Charge separation efficiency of GO/$BiVO_4$ and $BiVO_4$.

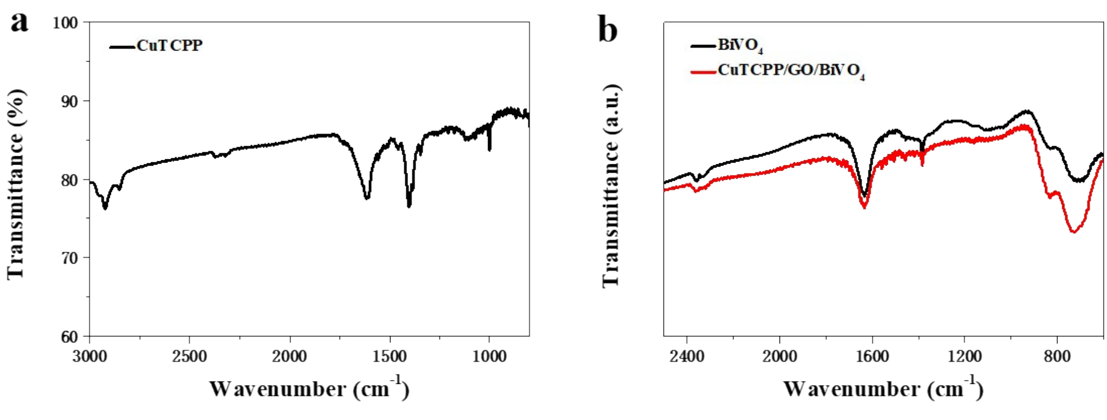

Figure S15. (a) IR spectrum of CuTCPP powder, (b) IR spectroscopy of bare $BiVO_4$ and CuTCPP/GO/$BiVO_4$ electrodes.

Reference

1. Y. Zhang, J. Liu, Y. Zhang and Y. Bi, *Nano Energy*,2018,**51**,504-512.
2. Y. Zhang, Z. Xu, G. Li, X. Huang, W. Hao and Y. Bi, *Angew. Chem., Int. Ed.,* 2019, **58**,14229-14233.
3. M. J. Bröcker, J. M. L. Ho, G. M. Church, D. Söll and P. O'Donoghue, *Angew. Chem., Int. Ed.,* 2014, **53**, 11926-11930.
4. S. Ye, C. Ding, R. Chen, F. Fan, P. Fu, H. Yin, X. Wang, Z. Wang, P. Du and Can. Li, *J. Am. Chem. Soc.,* 2018, **140**, 3250-3256.