

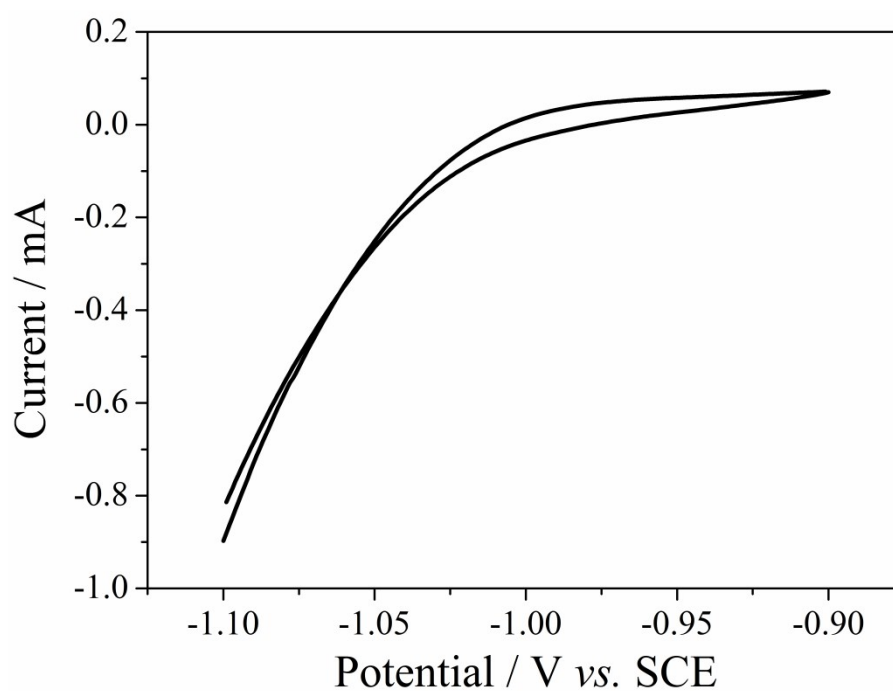
## Supplementary Information

### Etched and Doped Co<sub>9</sub>S<sub>8</sub>/Graphene Hybrid for Oxygen Electrocatalysis

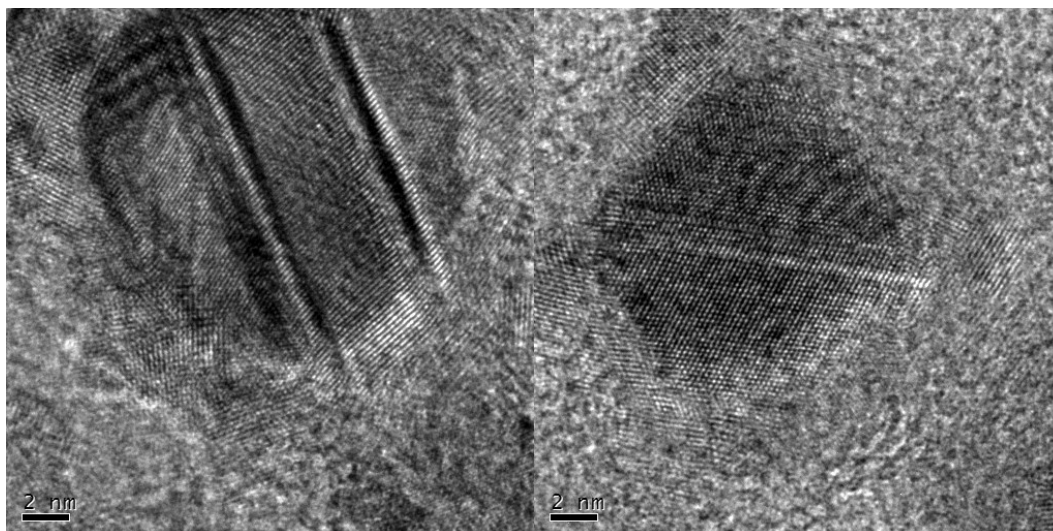
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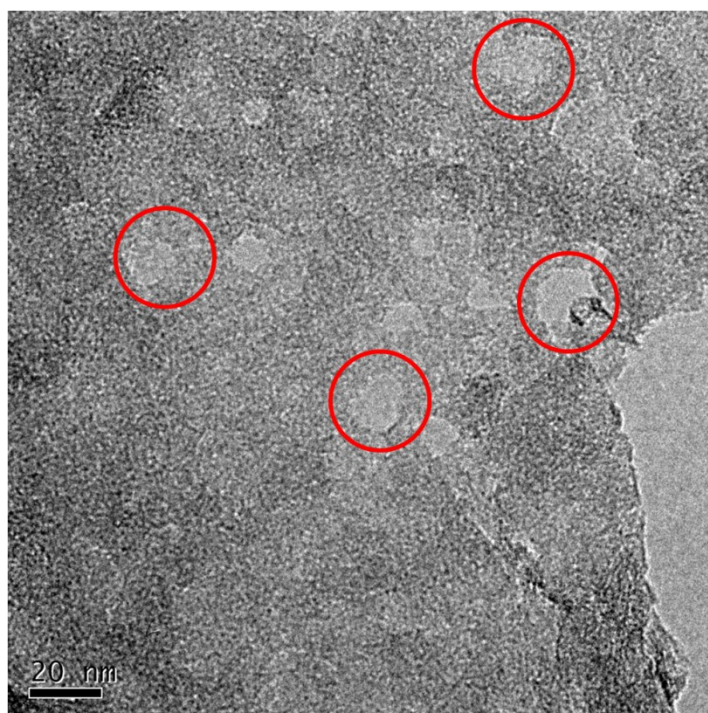
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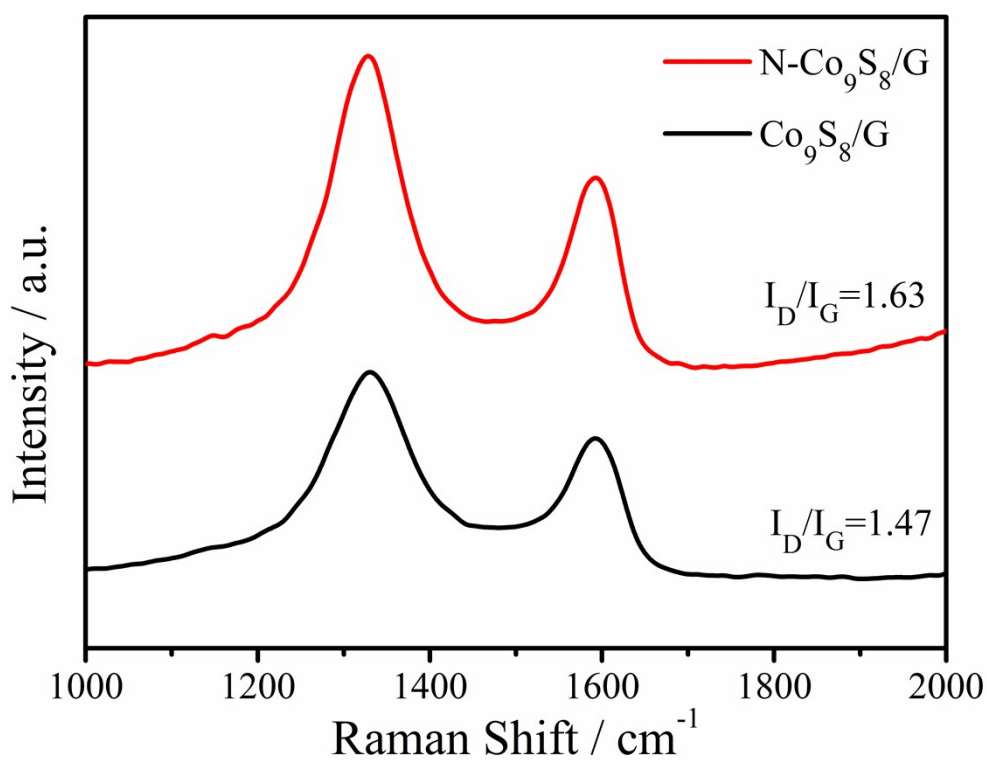
**Figure S1.** Cyclic voltammograms with a scan rate of 1 mV s<sup>-1</sup> in H<sub>2</sub>-saturated 0.1 M KOH aqueous solution for RHE calibration.



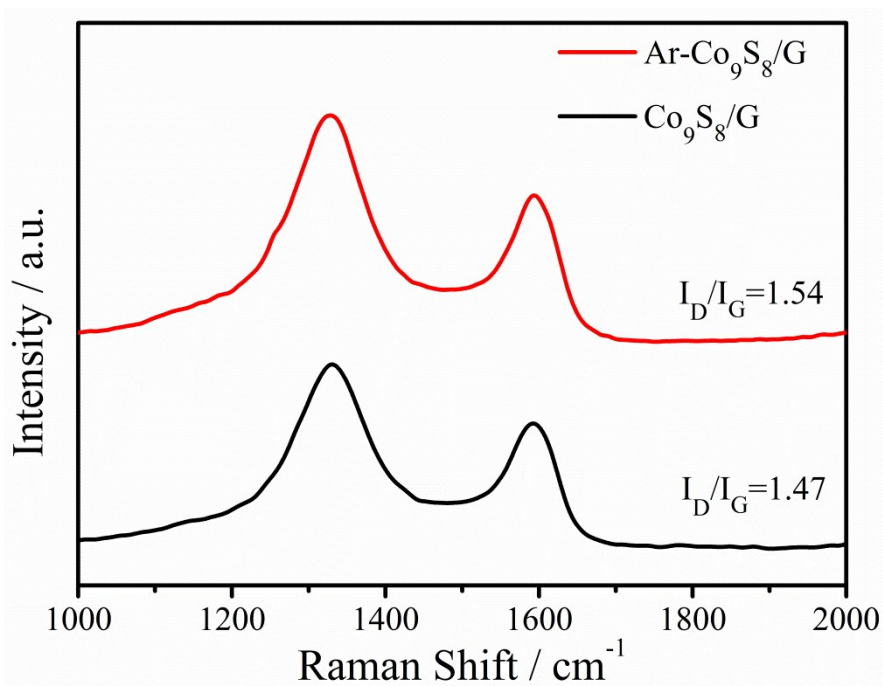
**Figure S2.** HRTEM of Co<sub>9</sub>S<sub>8</sub> nanoparticles from N-Co<sub>9</sub>S<sub>8</sub>/G hybrid electrocatalyst.



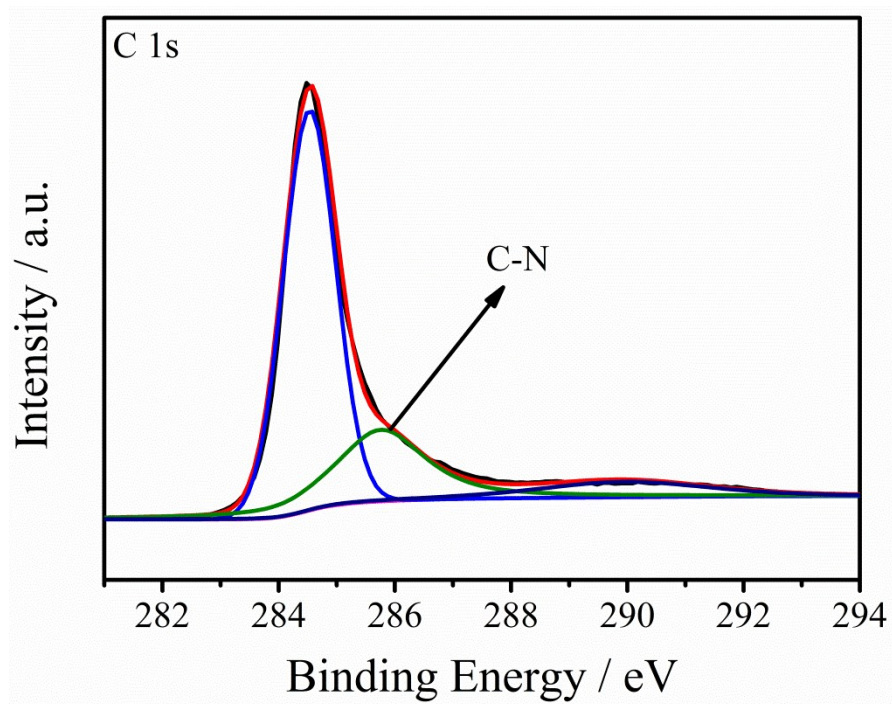
**Figure S3.** TEM image of NG.



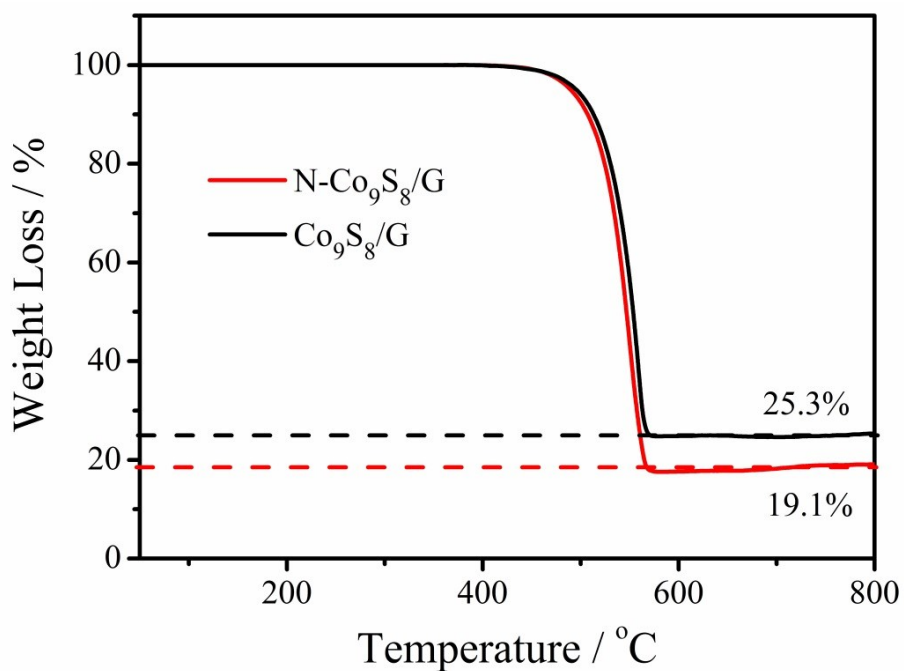
**Figure S4.** Raman spectra of  $\text{Co}_9\text{S}_8/\text{G}$  and N- $\text{Co}_9\text{S}_8/\text{G}$  with a 632 nm laser.



**Figure S5.** Raman spectra of  $\text{Co}_9\text{S}_8/\text{G}$  and Ar- $\text{Co}_9\text{S}_8/\text{G}$

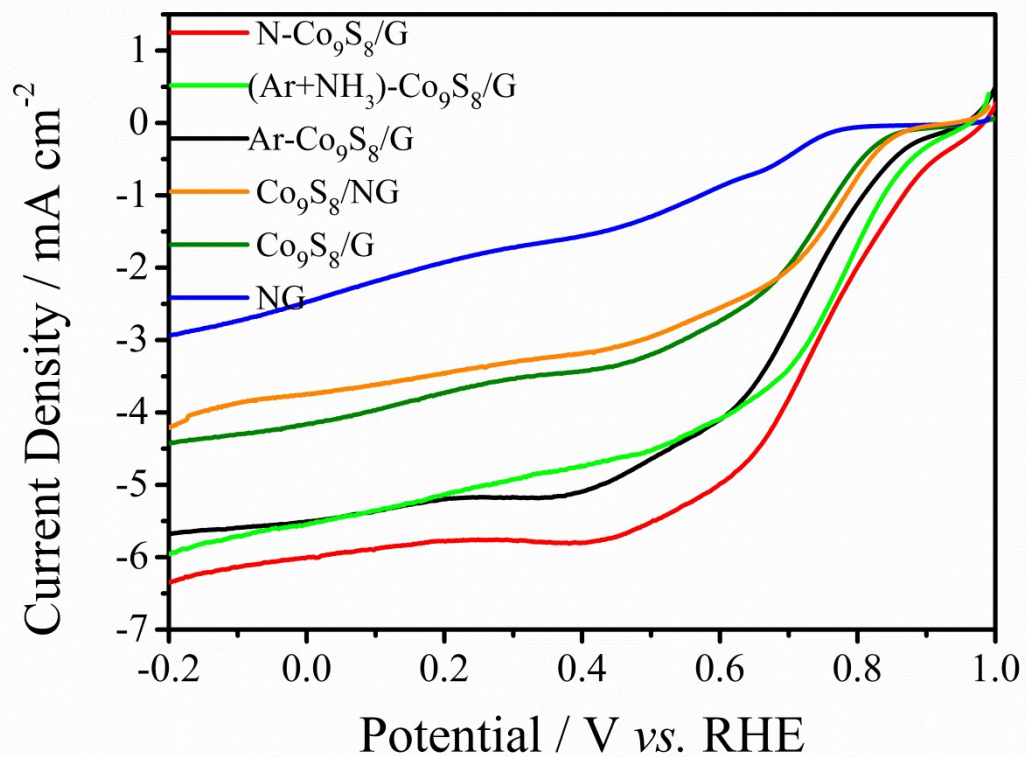


**Figure S6.** High resolution of C 1s XPS peak.

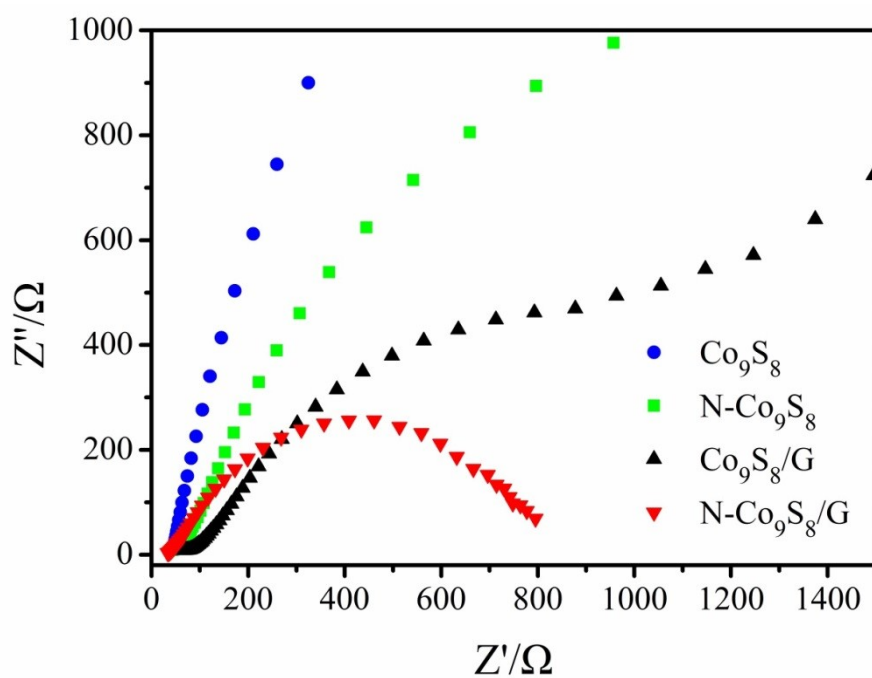


**Figure S7.** TGA curves of N-Co<sub>9</sub>S<sub>8</sub>/G and Co<sub>9</sub>S<sub>8</sub>/G electrocatalysts in air atmosphere from 50 to 800 °C at a heating rate of 10 °C min<sup>-1</sup>.

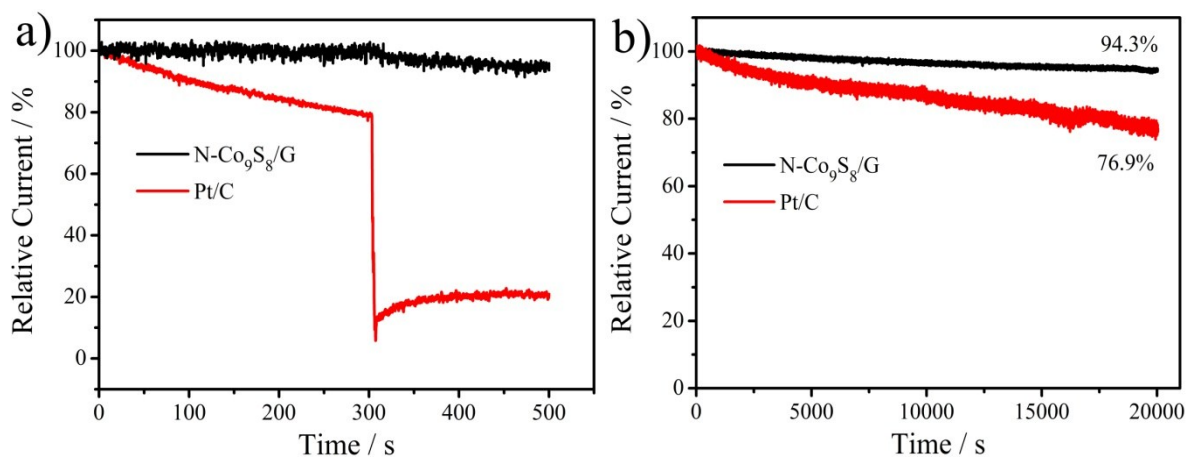




**Figure S8.** Linear sweep voltammetry curves on G, Co<sub>9</sub>S<sub>8</sub>/G, Co<sub>9</sub>S<sub>8</sub>/NG, Ar-Co<sub>9</sub>S<sub>8</sub>/G, (Ar+NH<sub>3</sub>)-Co<sub>9</sub>S<sub>8</sub>/G and N-Co<sub>9</sub>S<sub>8</sub>/G electrodes at rotational speed of 1600 rpm with a scan rate of 10 mV s<sup>-1</sup> in O<sub>2</sub>-saturated 0.1 M KOH aqueous solution.



**Figure S9.** AC impedance spectroscopy of different electrodes at the overpotential of -0.2 V.



**Figure S10.** Chronoamperometric responses for N-Co<sub>9</sub>S<sub>8</sub>/G and Pt/C electrodes on addition of 1.0 M methanol after about 300s (a); Chronoamperometry test in O<sub>2</sub>-saturated 0.1M KOH solution at 0.79 V vs. RHE for N-Co<sub>9</sub>S<sub>8</sub>/G and Pt/C electrodes for 20000 s.