Supplementary Information (SI) for Journal of Materials Chemistry A.
This journal is © The Royal Society of Chemistry 2025

Supplementary Information

Exploring the heterointerface of silver nanoparticle and cobalt oxide nanoring toward oxygen reduction reaction

Fatima Nasim[1], Hira Malik[1], Huilong Dong, and Muhammad Arif Nadeem[1,2]

[1]Catalysis and Nanomaterials Lab 27, Department of Chemistry, Quaid-i-Azam University, Islamabad 45320, Pakistan

[2]Pakistan Academy of Sciences, 3-Constitution Avenue Sector G-5/2, Islamabad, Pakistan.

*Contact details:

M.A.N; manadeem@qau.edu.pk

H. D : hldong@szut.edu.cn; huilong_dong@126.com

Average crystallite size by using Debye-Sherrer equation

The crystallite size of the crystalline materials was estimated from X-ray diffraction patterns using the Debye-Scherrer equation.

$$D = K\lambda / \beta \cos\theta$$

The Scherrer constant (K) was taken as 0.89, and the wavelength (λ) of the X-ray was determined by the X-ray source, which was Cu Kα radiation with a wavelength of 1.5406 Å. The FWHM (β) in radians was measured by determining the diffraction peak width at half of its maximum intensity, and the Bragg angle (θ) was obtained from the XRD pattern by locating the position of the diffraction peak.

Table S1: Crystallite size calculations of the synthesized materials

Materials	Xc	FWHM (β) (degree)	D (nm)	Avg. Size (nm)
Co_3O_4	19.02	0.20203	41.66	**34.2**
	31.21	0.22312	38.63	
	36.75	0.27953	31.29	
	59.37	0.37749	25.31	
Ag/Co_3O_4	19.02	0.24101	34.92	**30.7**
	31.21	0.22634	38.08	
	36.75	0.30368	28.80	
	59.37	0.45363	21.06	
$Ag_{0.9}$-Co_3O_4/NCNS	19.02	0.86593	9.72	**9.5**
	31.21	0.80938	10.65	
	36.75	1.15051	7.60	
	59.37	0.94389	10.12	

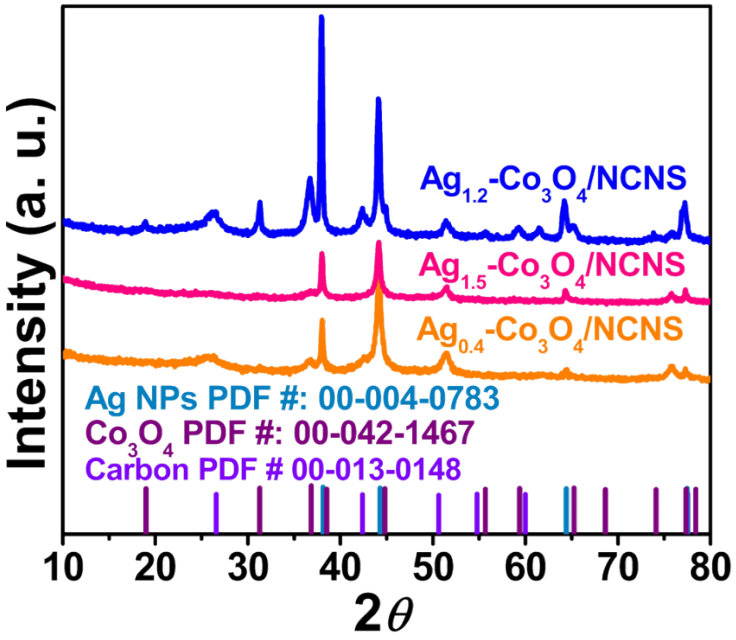

Figure S1: PXRD of all the silver-based catalysts

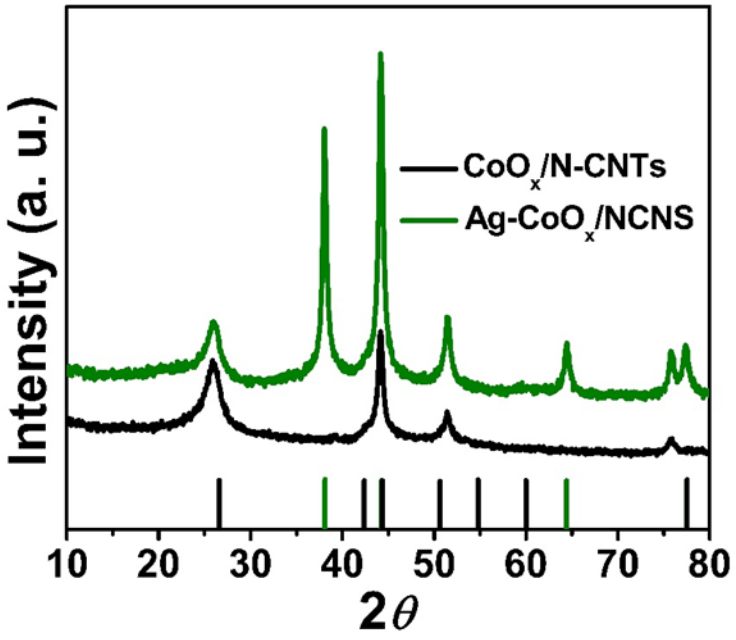

Figure S2: PXRD of CoO_x/N-CNTs and Ag-CoO_x/NCNS

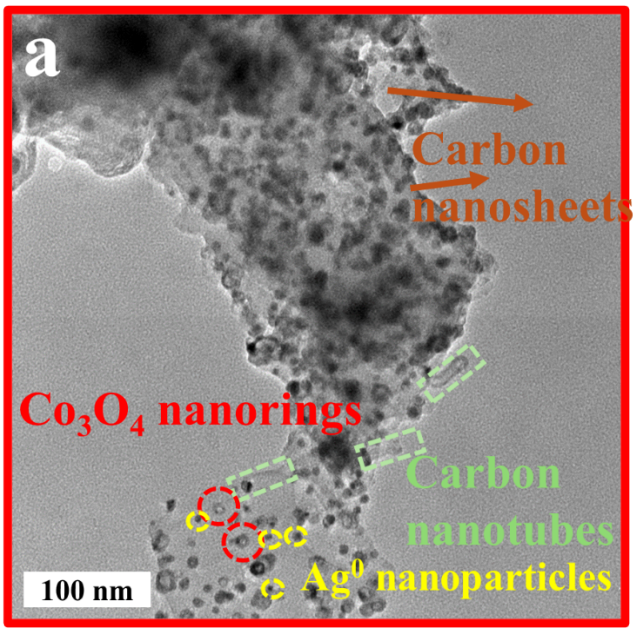

Figure S3: HRTEM analysis of $Ag_{0.9}$-Co_3O_4/NCNS at 100 nm

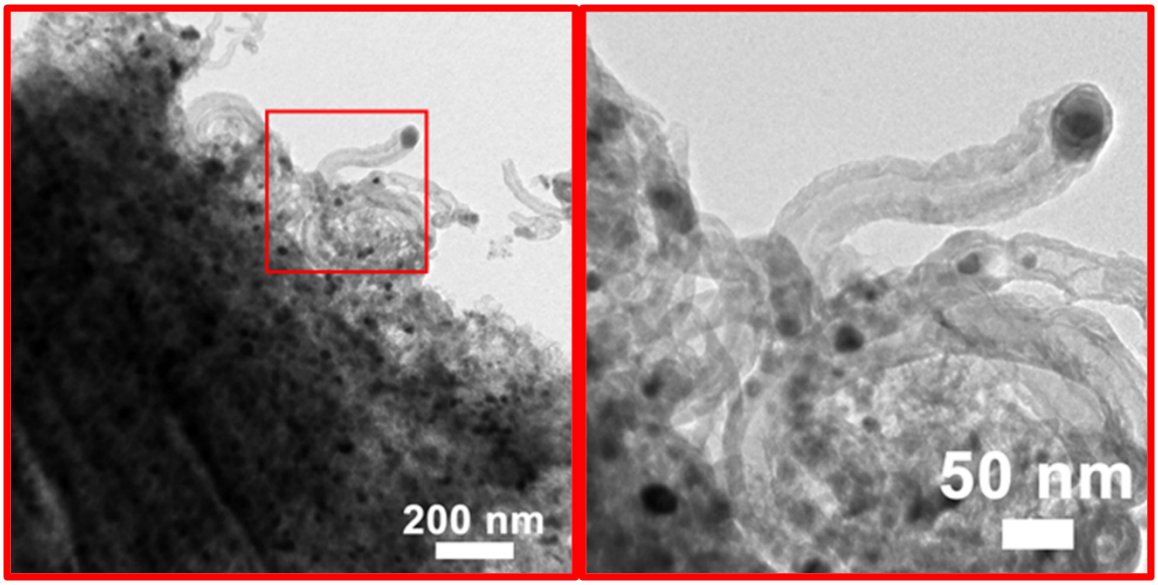

Figure S4: HRTEM of CoO_x/-N-CNTs at different resolutions[1]

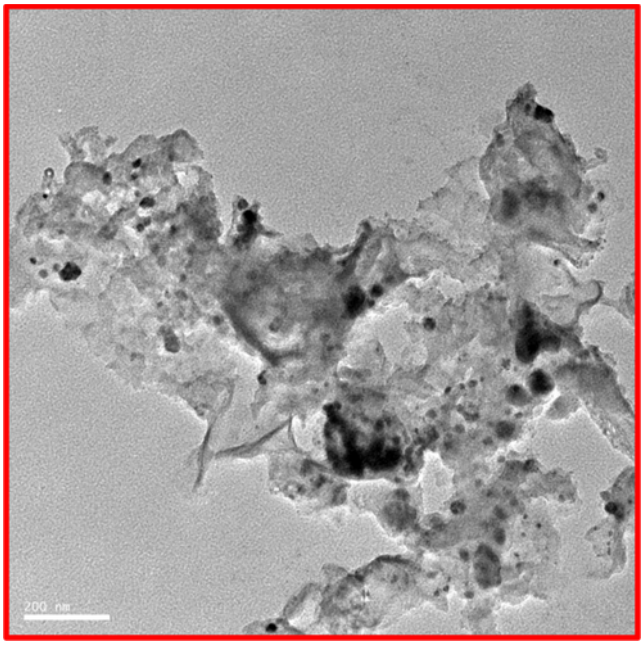

Figure S5: HRTEM of Ag-CoO_x/NCNS at 200 nm

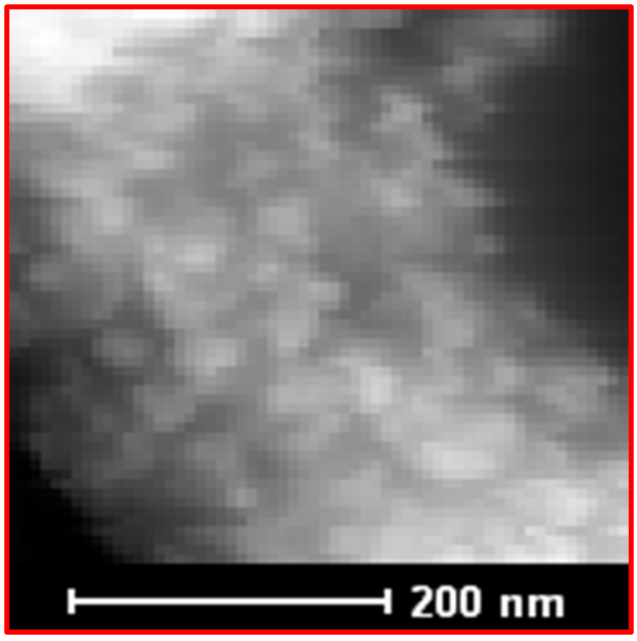

Figure S6: HAADF-STEM analysis of $Ag_{0.9}$-CO_3O_4/NCNS

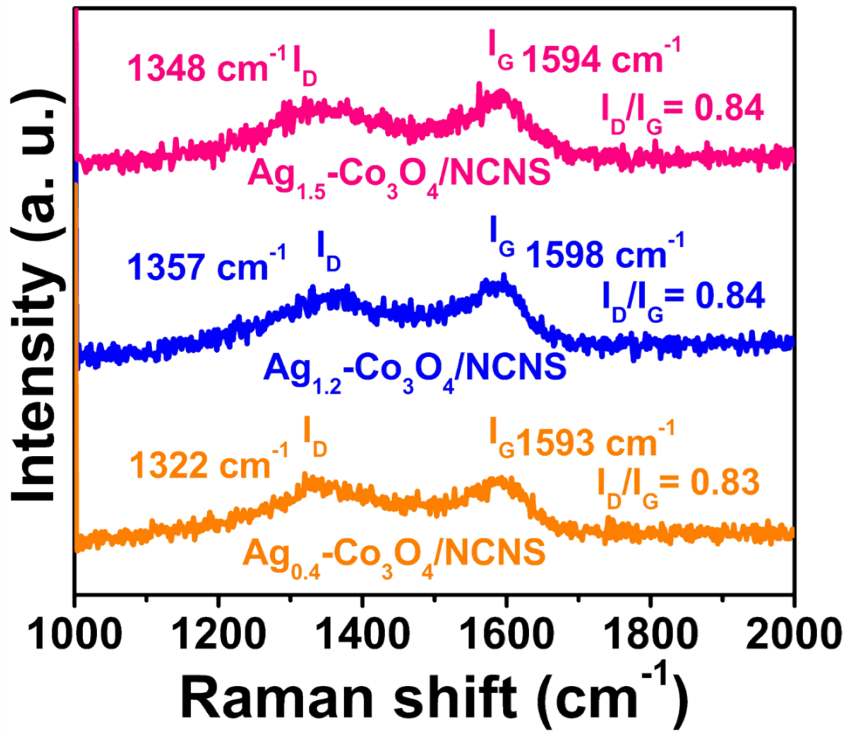

Figure S7: Raman analysis of $Ag_{0.4}$-Co_3O_4/NCNS, $Ag_{1.2}$-Co_3O_4/NCNS, and $Ag_{1.5}$-Co_3O_4/NCNS.

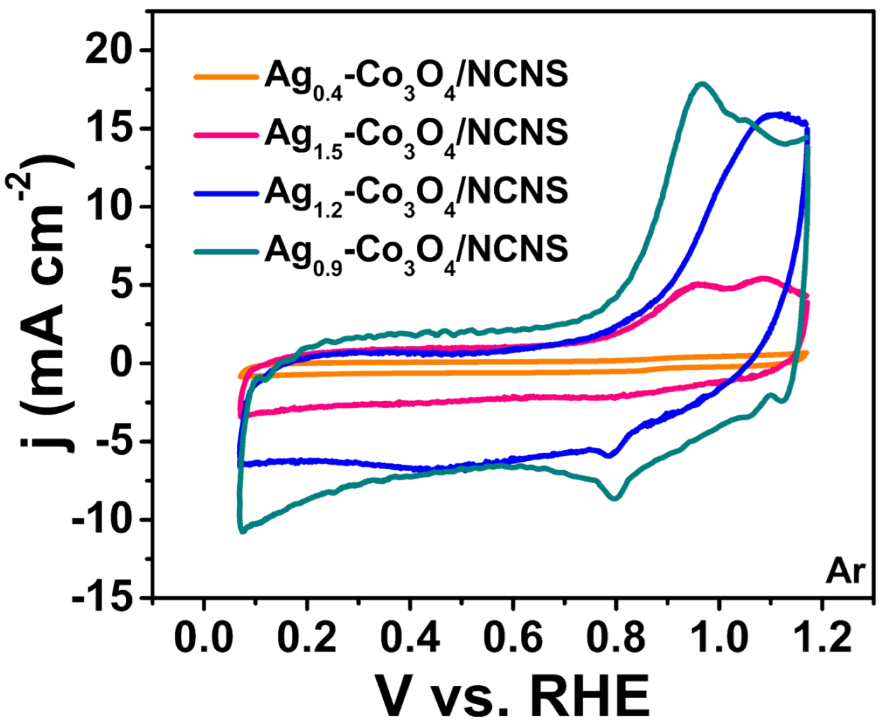

Figure S8: CV cycles of $Ag_{0.4}$-Co_3O_4/NCNS, $Ag_{1.2}$-Co_3O_4/NCNS, and $Ag_{1.5}$-Co_3O_4/NCNS in Ar saturated environment.

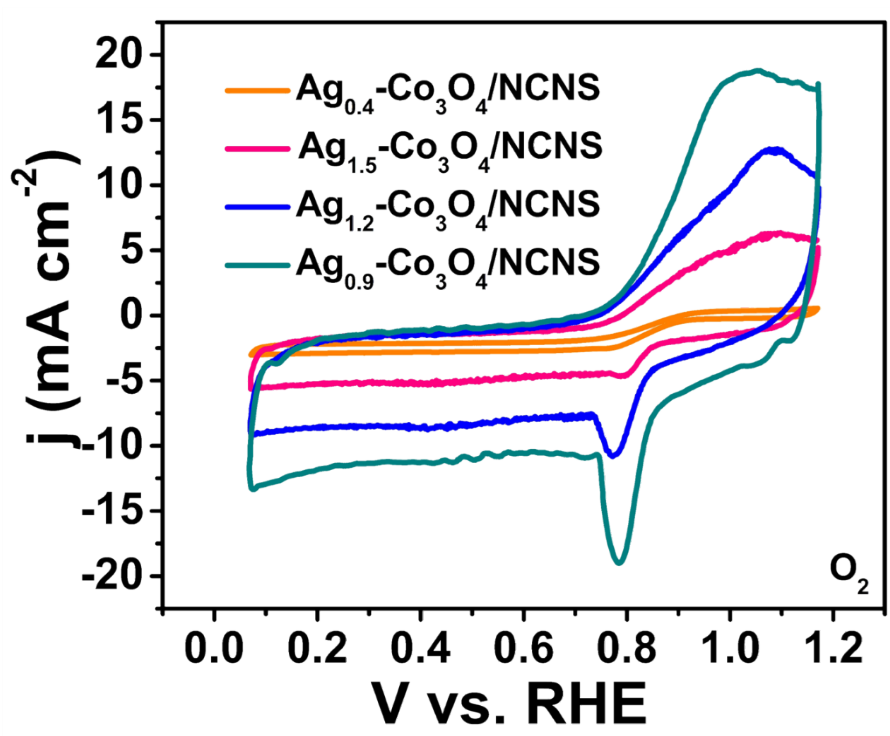

Figure S9: CV cycles of $Ag_{0.4}$-Co_3O_4/NCNS, $Ag_{1.2}$-Co_3O_4/NCNS, and $Ag_{1.5}$-Co_3O_4/NCNS in O_2 saturated environment.

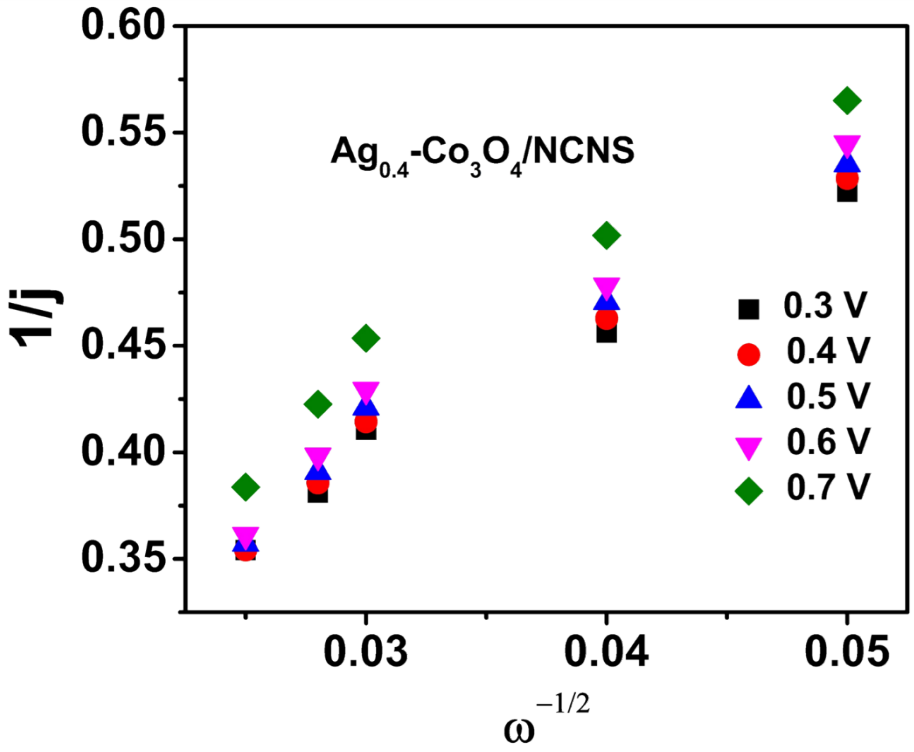

Figure S10: Electron count of $Ag_{0.4}$-Co_3O_4/NCNS.

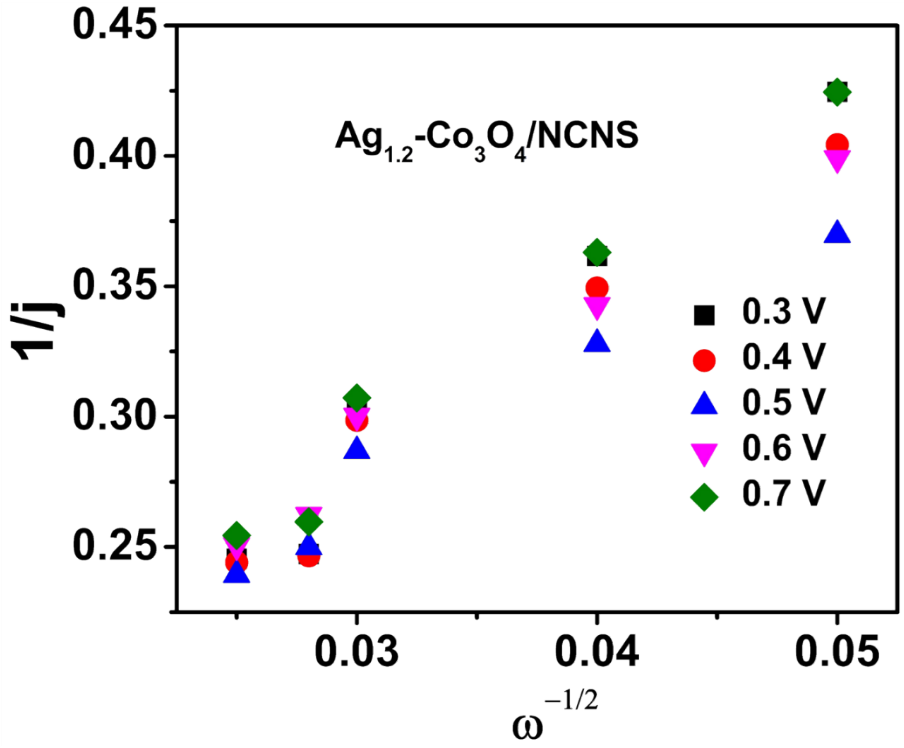

Figure S11: Electron count of $Ag_{1.2}$-Co_3O_4/NCNS.

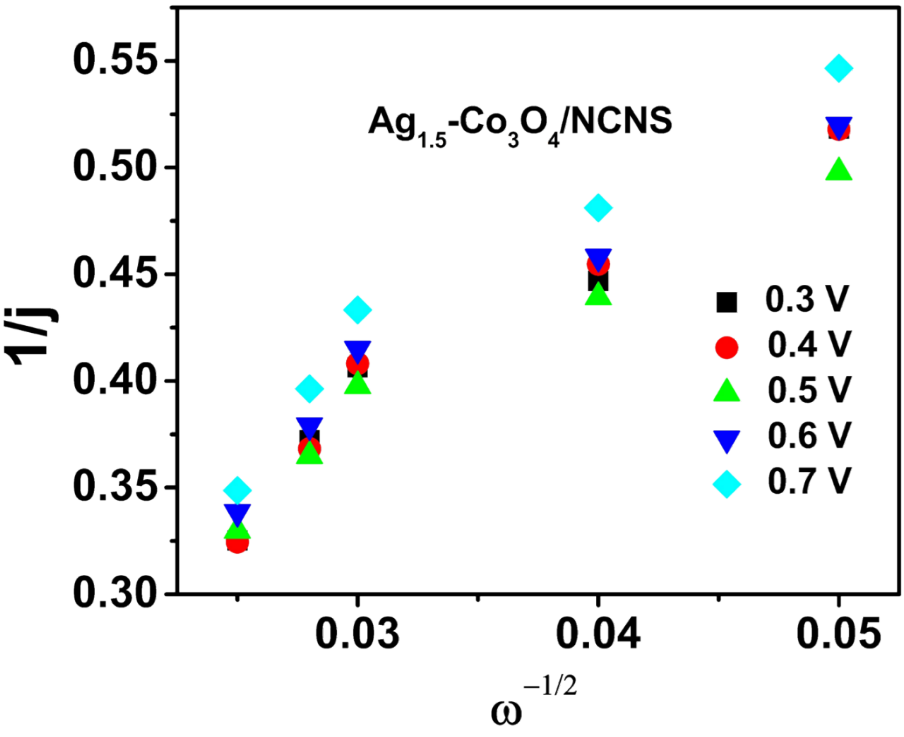

Figure S12: Electron count of $Ag_{1.5}$-Co_3O_4/NCNS.

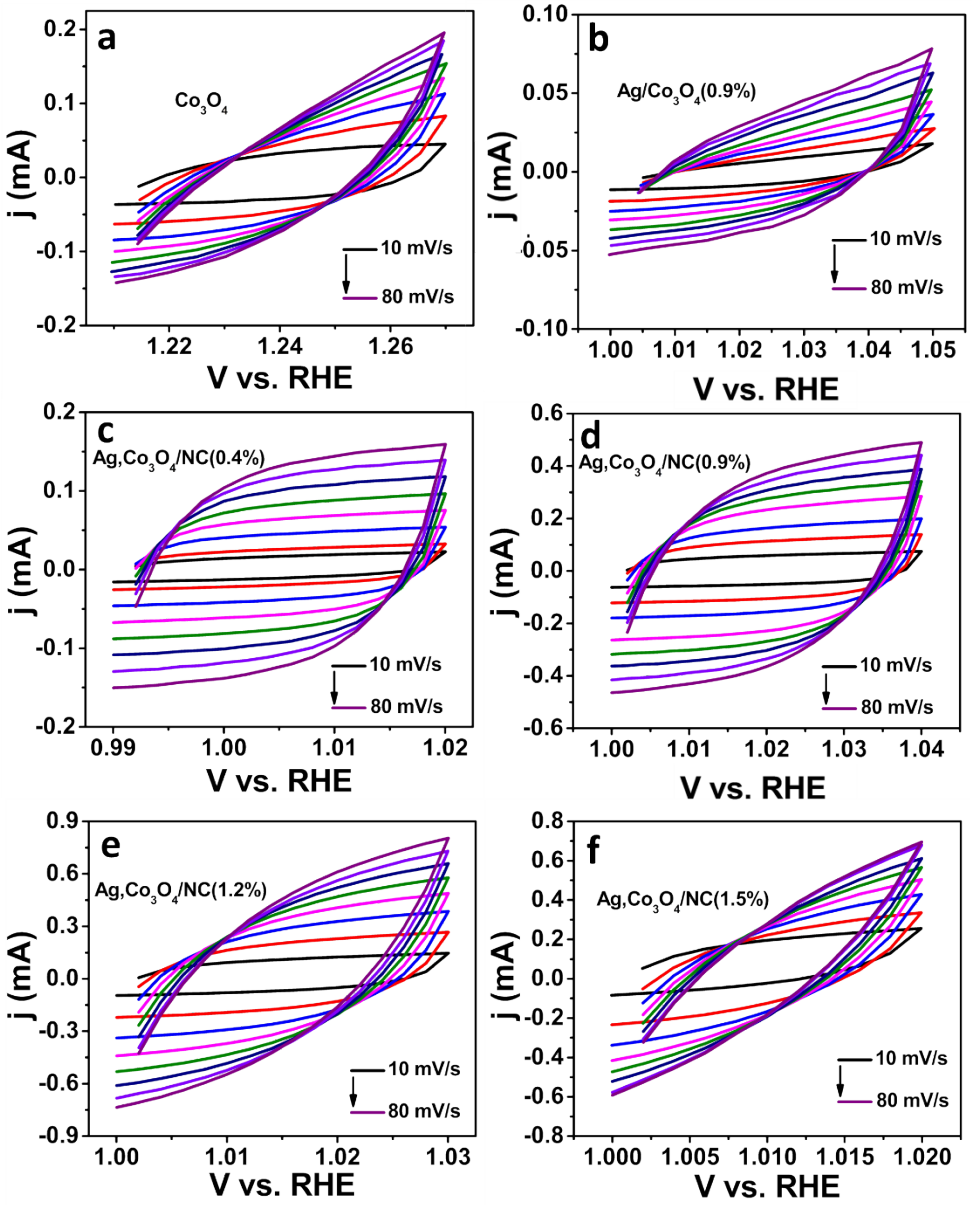

Figure S13: CV curves of all the synthesized materials in the non-faradic region

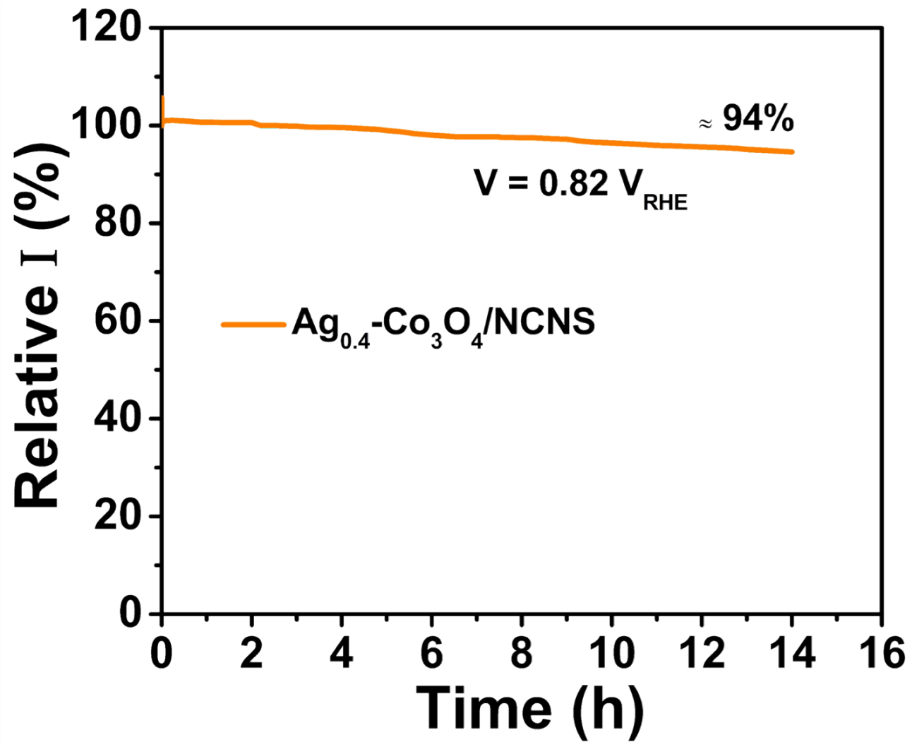

Figure S14: Chronoamperometric analysis of $Ag_{0.4}$-Co_3O_4/NCNS over 14 hrs.

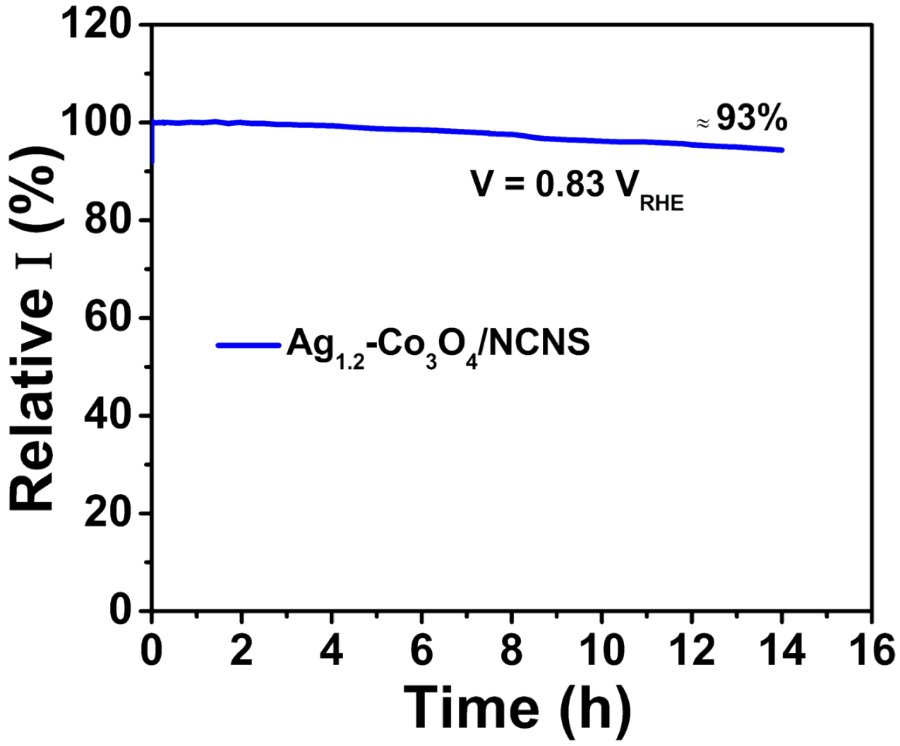

Figure S15: Chronoamperometric analysis of $Ag_{1.2}$-Co_3O_4/NCNS over 14 hrs.

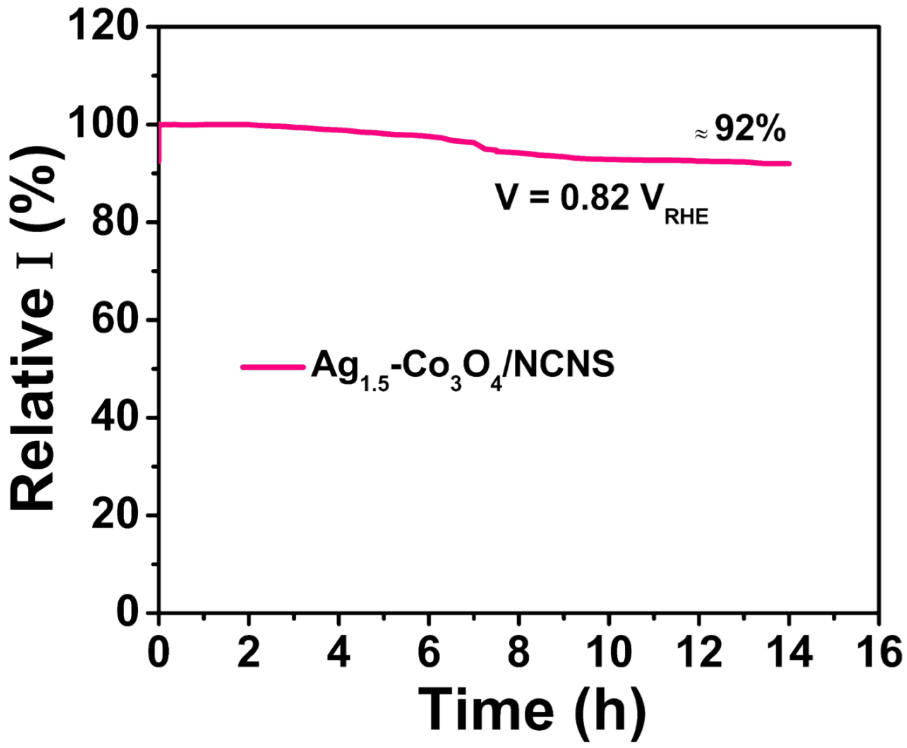

Figure S16: Chronoamperometric analysis of $Ag_{1.5}$-Co_3O_4/NCNS over 14 hrs.

Table S2: ECSA calculations of all the synthesized materials

S.No	Catalyst	C_{dl} (mF)	ECSA (cm^2 mg^{-1})
1	Co_3O_4	0.192	48
2	$Ag_{0.9}/Co_3O_4$	0.113	28
3	$Ag_{0.4}$-Co_3O_4/NCNS	0.54	135
4	$Ag_{0.9}$-Co_3O_4/NCNS	1.47	367
5	$Ag_{1.2}$-Co_3O_4/NCNS	1.96	490
6	$Ag_{1.5}$-Co_3O_4/NCNS	0.918	230

References