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Electrochemical performance of transition metal based CoB_2O_4 (B = Co and Fe) oxides as an electrode material for energy storage devices

Megha Goyal[a], Sahil Verma[b], Jaideep Malik[c], Prakash Giri[d], Rajesh Kumar[e], Anurag Gaur[f,g]*

[a]Centre of Nanotechnology, Indian Institute of Technology Roorkee, Roorkee-247667, India
[b]School of Materials science and Nanotechnology, National Institute of Technology, Kurukshetra-136119, India
[c] Department of Chemistry, Indian Institute of Technology Roorkee, Roorkee-247667, India
[d] Department of Automobile and Mechanical Engineering, Tribhuvan University, Institute of Engineering, Paschimanchal campus, Pokhara-3370, Nepal
[e] University School of Basic and Applied Sciences, Guru Gobind Singh Indraprastha University, New Delhi-110078, India.
[f] Department of Physics, National Institute of Technology Kurukshetra, Kurukshetra-136119, India
[g] Department of Physics, J.C. Bose University of Science & Technology, YMCA, Faridabad-121006, India

* *Corresponding author: anuragdph@gmail.com*

S1

The crystallite size d_{XRD} and the strain (η) of the synthesized Co_3O_4 and $CoFe_2O_4$ are calculated by using Scherrer formula and Williamson-Hall (W-H) plot.

Scherrer formula - $\beta = \beta_{size} + \beta_{strain} = \frac{1}{\cos\theta}\left(\frac{k\lambda}{<dXRD>} + 4\,\eta\,\sin\theta\right)$

Here β is FWHM of the diffraction peaks, k is the Scherrer constant (0.9), λ= wavelength of the incident x-rays, η = strain and θ is the incident x-rays angle.

For crystallite size and strain calculation βcosθ/ kλ versus 4sinθ/ kλ, also known as W-H plot were plotted for both materials and linear curve fitting of the data points were performed to obtain the value of slope (m) and intercept (c). Here intercept (c) provides the strain value, while by the help of slope crystallite size can be calculated by using below formula.

For crystallite size calculation slope (m) = $\frac{k\lambda}{<dXRD>}$

S2

Specific Capacitance/ Capacity at various Scan rates

For the calculation of Specific Capacitance/Capacity below formulas are used:

Specific capacitance (Fg^{-1}) = $\frac{\int I\,dV}{2m * \nu\,(V_2 - V_1)}$

Specific Capacity (Cg^{-1}) = $\frac{\int I\,dV}{2m * \nu}$

Where $\int I\,dV$ represents area under the CV curve, m = mass of deposited active material, ν= scan rate and V_2 and V_1 are maximum and minimum value of operating potentials.

S3

Deconvolution of total capacity at different scan rates

$$I(V)= K_1\upsilon+K_2\,\upsilon^{1/2} \quad (1)$$

Here I(V) is the total current by capacitive and diffusion process at a particular scan rate, K_1 and K_2 are scan rate independent constants and υ is representing the scan rate. $K_1\upsilon$ represents the current contribution by capacitive process, while $K_2\,\upsilon^{1/2}$ represents the current contribution by diffusion process. Equation (1) can also be written as

$$I(V)/\,\upsilon^{1/2}= K_1\,\upsilon^{1/2}+k_2 \quad (2)$$

So, by calculating the value of K_1 and K_2, we can quantify the total current or capacity, separately in to capacitive current or capacitive capacity (C_{outer}) and diffusion current or diffusion capacity (C_{inner}).

S4

Specific Capacitance/ Capacity at various Current densities

For the calculation of total discharge specific capacitance and capacity below formula are used

Specific capacitance (Fg^{-1}) = $\frac{I\,\Delta t}{m\,\Delta V}$

Specific capacity (Cg^{-1}) = $\frac{I\,\Delta t}{m}$

Where I = Current density, Δt = total discharge time, ΔV = potential range and m = mass of deposited active material.

Fig. S1

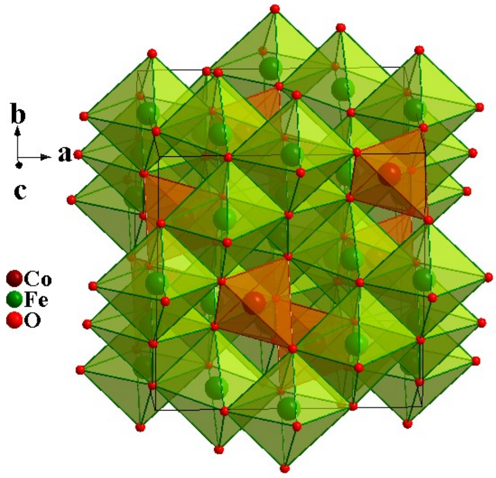

Fig. S1 Crystal structure of $CoFe_2O_4$.

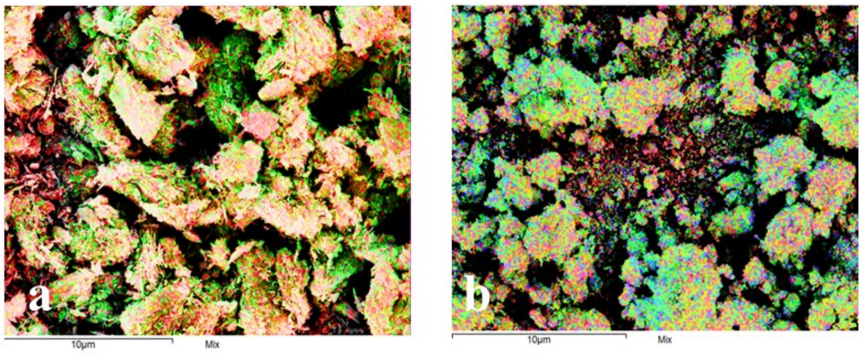

Fig. S2 FESEM Elemental mapping overlap of all elements (a) Co_3O_4 (b) $CoFe_2O_4$

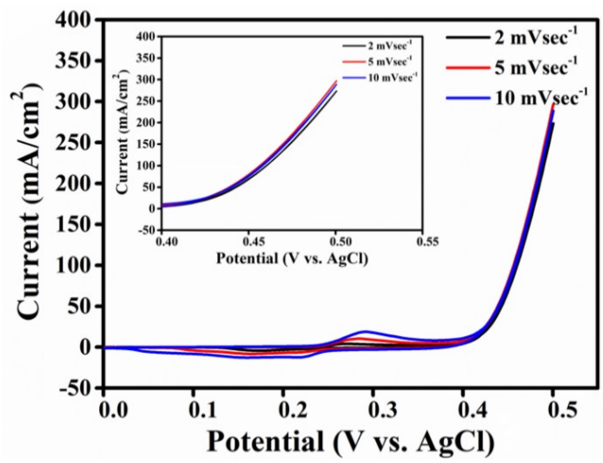

Fig. S3 CV analysis of $CoFe_2O_4$ at potential range of 0 to 0.5 V.

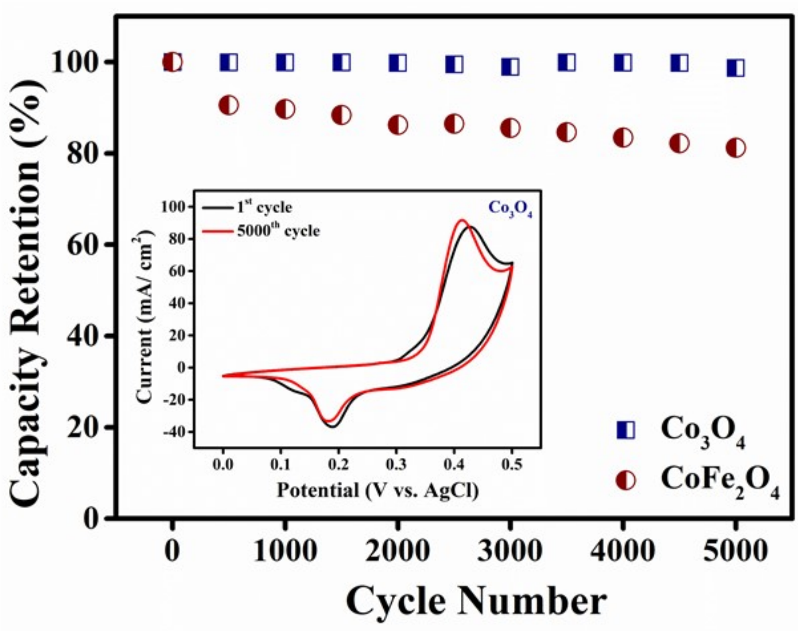

Fig. S4 CV cycling data over 5000 cycles at 100 mVsec^{-1} scan rat**e.**

Table.S1 Specific Capacitance/ Capacity at different scan rates ranges from 2mVsec^{-1} to 50 mVsec^{-1} for Co_3O_4 and $CoFe_2O_4$.

Specific capacitance/ Capacity at different scan rates		
Scan rate (mVsec^{-1})	Specific Capacitance (Fg^{-1})/Capacity (Cg^{-1})	
	Co_3O_4	$CoFe_2O_4$
2	1039 Fg^{-1} (415 Cg^{-1})	527 Fg^{-1} (169 Cg^{-1})
5	938 Fg^{-1} (375 Cg-1)	482 Fg^{-1} (154 Cg^{-1})
10	723 Fg^{-1} (289 Cg^{-1})	472 Fg^{-1} (151 Cg^{-1})
30	470 Fg^{-1} (188 Cg^{-1})	428 Fg^{-1} (137 Cg^{-1})
40	393 Fg^{-1} (157 Cg^{-1})	401 Fg^{-1} (128 Cg^{-1})
50	357 Fg^{-1} (143 Cg^{-1})	380 Fg^{-1} (121 Cg^{-1})

Table.S2 Specific Capacitance/ Capacity at different current densities ranges from 0.6 Ag^{-1} to 12.5 Ag^{-1} for Co_3O_4 and $CoFe_2O_4$.

Specific capacitance/ Capacity at different current densities		
Current density (Ag^{-1})	Specific Capacitance (Fg^{-1})/Capacity (Cg^{-1})	
	Co_3O_4	$CoFe_2O_4$
0.6	663 Fg^{-1} (265 Cg^{-1})	526 Fg^{-1} (168 Cg^{-1})
1.2	656 Fg^{-1} (263 Cg-1)	496 Fg^{-1} (159 Cg^{-1})

2.5	615 Fg^{-1} (246 Cg^{-1})	457 Fg^{-1} (146 Cg^{-1})
6.2	406 Fg^{-1} (162 Cg^{-1})	256 Fg^{-1} (82 Cg^{-1})
12.5	232 Fg^{-1} (93 Cg^{-1})	206 Fg^{-1} (66 Cg^{-1})

Table S3 Equivalent circuit fitting Parameters for Co_3O_4 and $CoFe_2O_4$

Element	**Parameter**	**Co_3O_4**	**Estimated Error (±)**	**$CoFe_2O_4$**	**Estimated Error (±)**
R_s	R (Ω)	1.2	0.03	1.6	0.01
R_{ct}	R (Ω)	45	2.28	65	3.41
C	C (mF)	27.8	0.24	21.8	0.12
CPE	Y0 $(m\Omega\ sec)^{-1}$	7.39	0.73	2.75	1.61
Zw	Y0 $(m\Omega\ sec)^{-1/2}$	107	0.26	15.7	0.43

R_s= Solution resistance (electrolyte, separator, and electrodes).

R_{ct} = Charge transfer resistance.

C= Double layer capacitance.

CPE= Constant Phase Element.

Z_W: Warburg impedance due to diffusional effects.