Electronic Supplementary Material (ESI) for New Journal of Chemistry.

Supplementary information

Porous $CeNiO_3$ with enhanced electrochemical performance and prolonged cycle life (> 50000 cycles) via lemon-assisted sol-gel auto combustion method.

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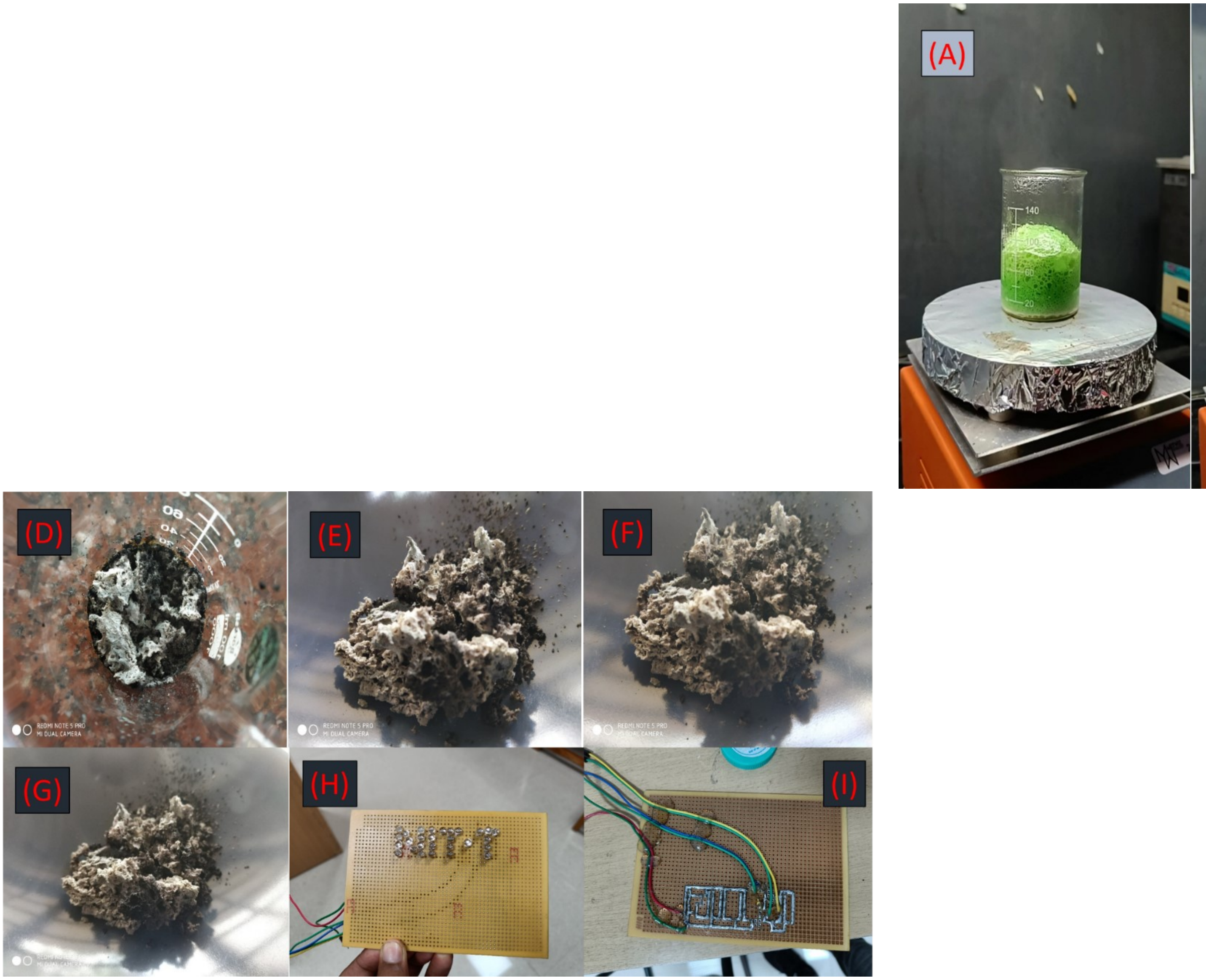


Fig. S1. (A-C) Photograph of bubbling and auto combustion during synthesis, (D-G) fully combusted samples, and (H-I) an array of LEDs arranged in a way to display “NITT” on to a PCB.

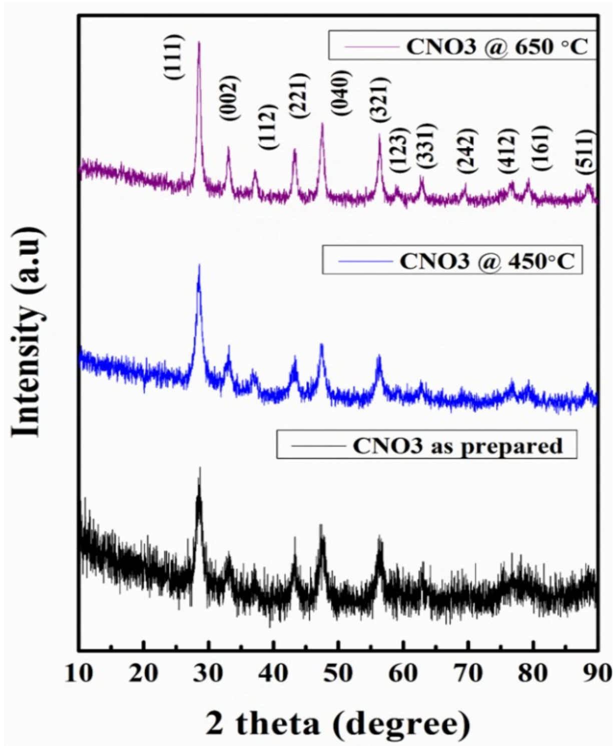


Fig. S2. XRD patterns of as prepared sample, sample annealed at 450 ℃, and 650℃ of CNO3 material.

Table S1. Resistance value, surface area, specific capacity and cyclic stability of CNO electrodes in three-electrode system.

Sample	Surface area	Pore volume	Maximum Specific capacity		Rs	Rct	Cyclic stability
	m^2g^{-1}		CV ($2mVs^{-1}$)	GCD ($1\ Ag^{-1}$)	Ω	Ω	%
CNO1	17.00	2.421	239.12	242.54	1.0962	1.4436	99.48
CNO2	38.57	3.559	531.63	589.33	0.6551	0.9549	100.79
CNO3	56.58	3.586	598.51	605	0.4718	0.8702	102.69
CNO4	44.26	3.964	516.56	591.25	0.7410	0.7218	100.81

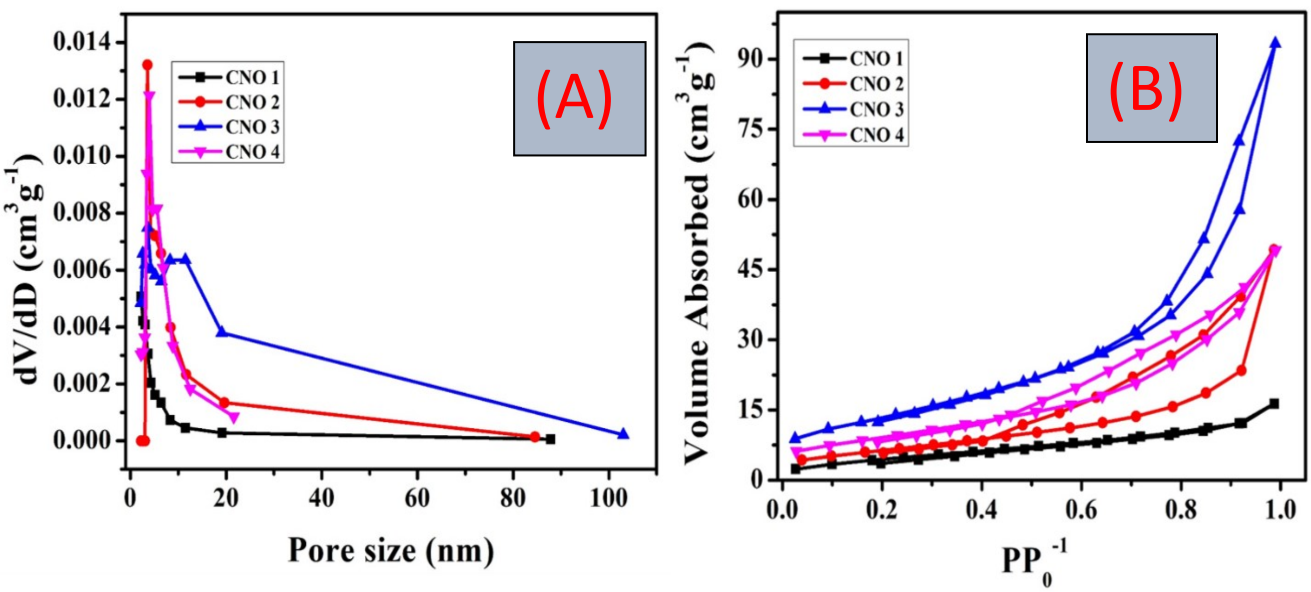


Fig. S3. (A) N_2 adsorption-desorption isotherms, and (B) BJH pore size distributions of CNO1,CNO2,CNO3, and CNO4.

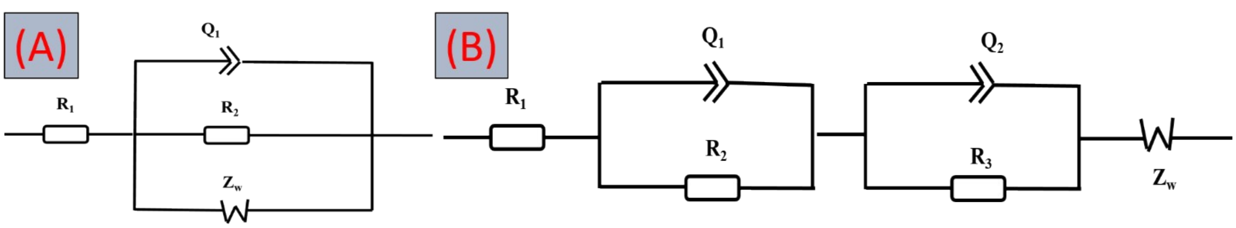


Fig.S4. Equivalent fitted circuit of (A) CNO3 electrode in 3 electrode system (B) symmetric cell

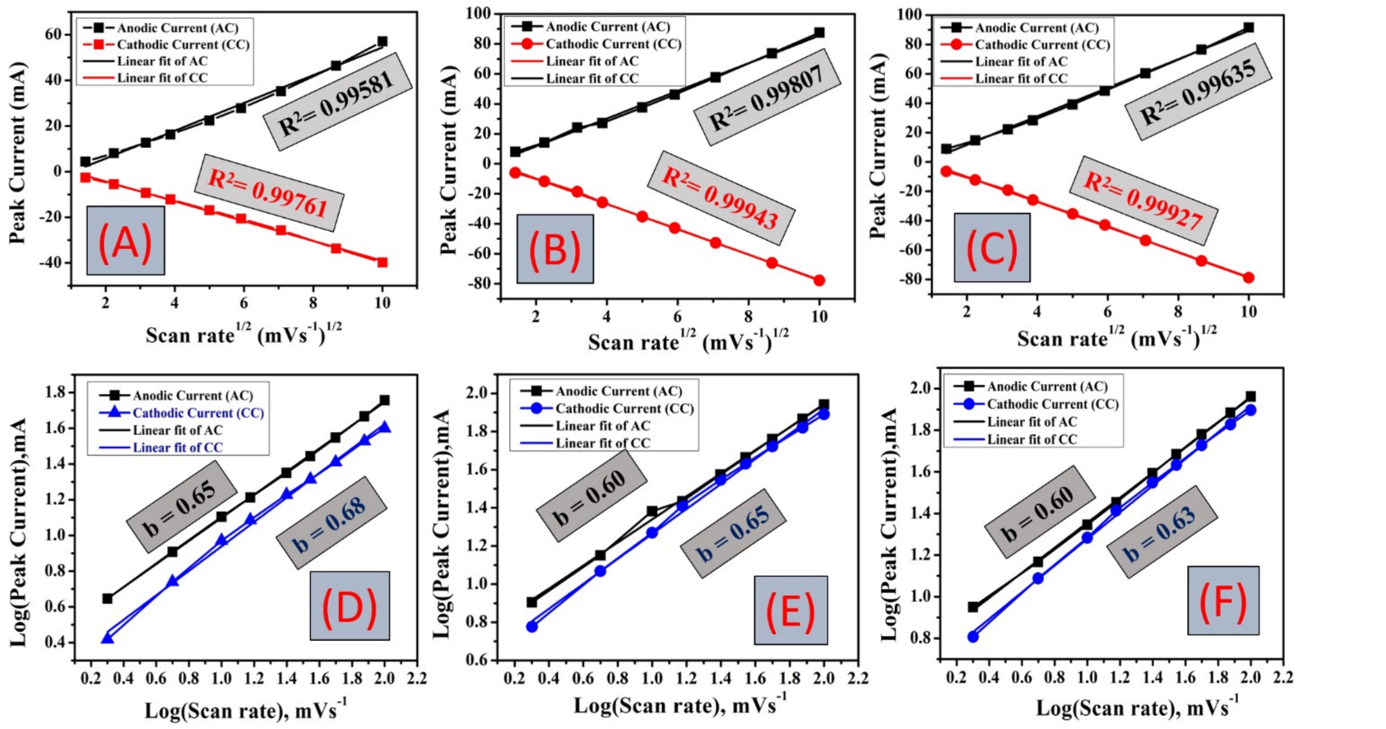
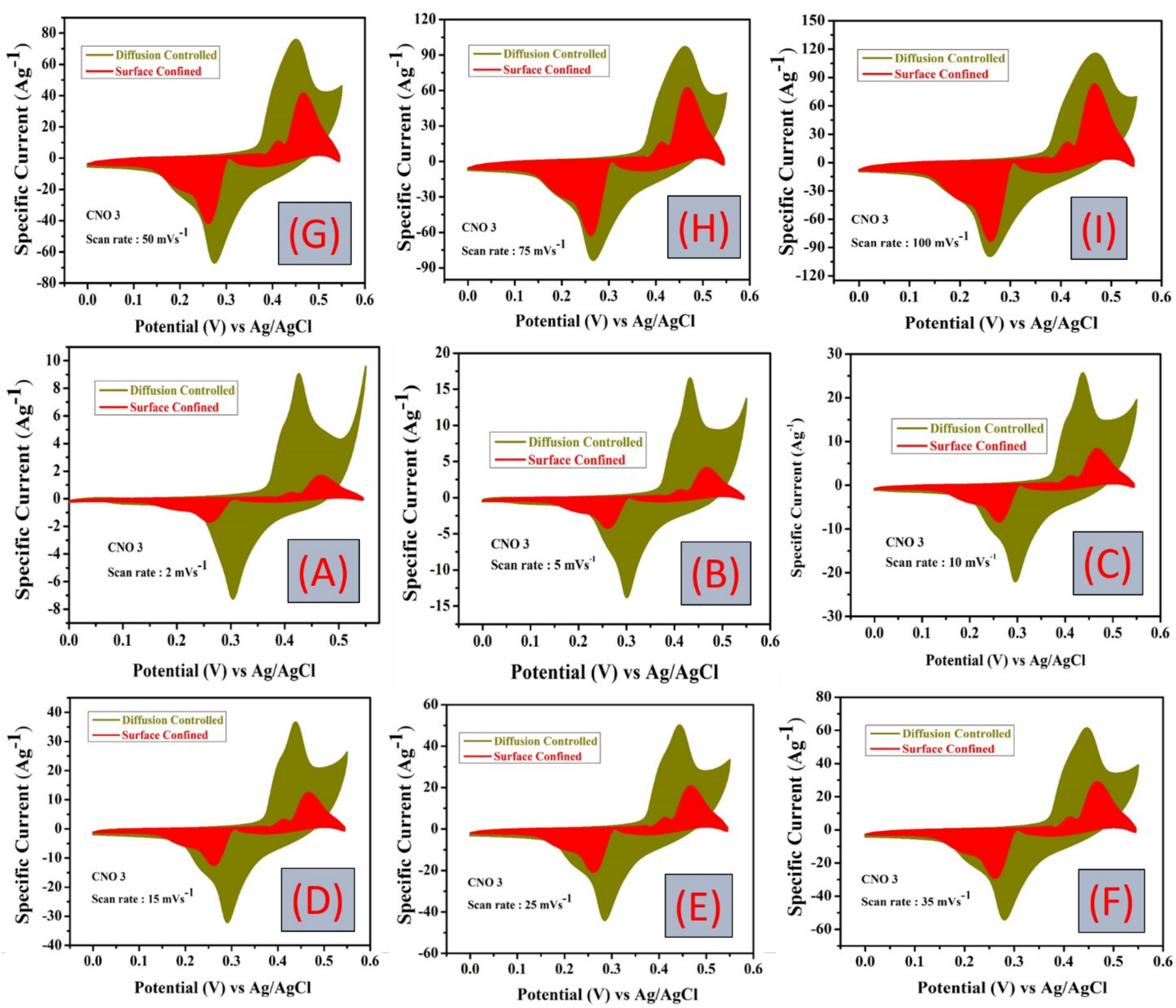


Fig. S5. (A-C) The variation of cathodic/anodic peak currents for the CNO1, CNO2, and CNO4 electrodes as a function of the square root of scan rates; (D-E) The relationship between $log(i_p)\ and\ log(\nu)$ for the CNO1, CNO2, and CNO4 electrodes.


Diffusion Controlled
Surface Confined
CNO 3
Scan rate : 50 mVs^{-1}
(G)
Scan rate : 75 mVs^{-1}
(H)
Scan rate : 100 mVs^{-1}
(I)
Scan rate : 2 mVs^{-1}
(A)
Scan rate : 5 mVs^{-1}
(B)
Scan rate : 10 mVs^{-1}
(C)
Scan rate : 15 mVs^{-1}
(D)
Scan rate : 25 mVs^{-1}
(E)
Scan rate : 35 mVs^{-1}
(F)
Specific Current (Ag^{-1})
Potential (V) vs Ag/AgCl

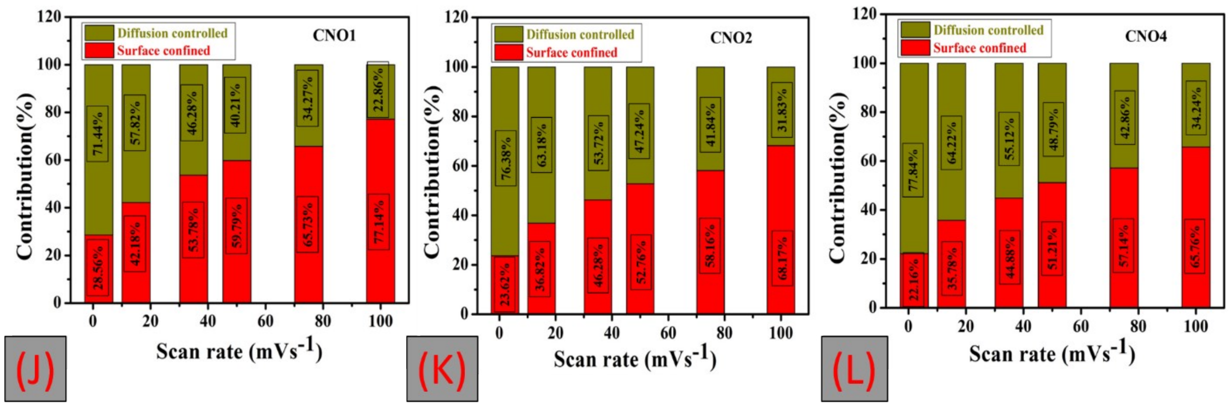


Fig. S6. (A-I) Surface-confined (red region) and diffusion-controlled (green region) contribution to charge storage of CNO3 electrode at different scan rates from 2-100 mVs^{-1}, (J-L) Surface-confined (green region) and diffusion-controlled (red region) contribution to charge storage of the CNO1, CNO2, and CNO4 electrodes at different scan rates.

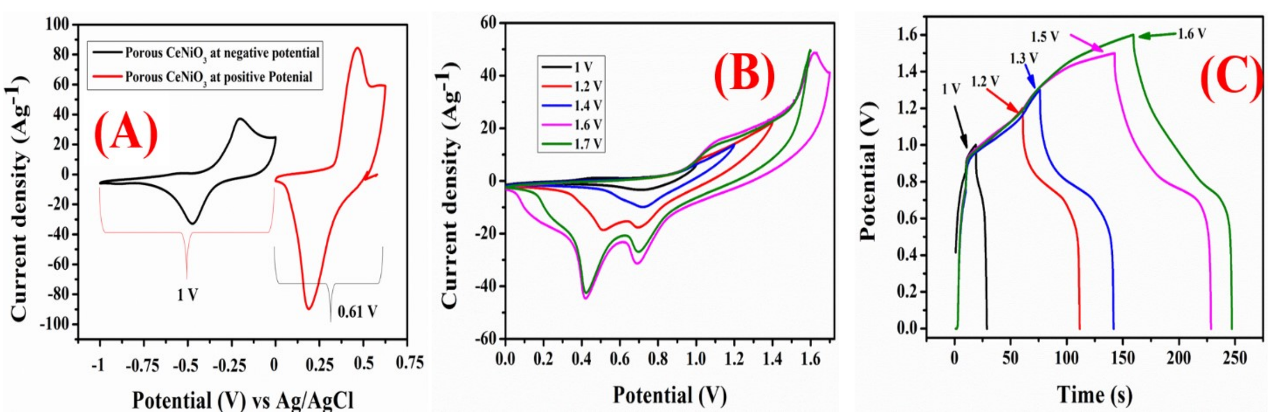


Fig. S7. (A) The operating potential window of CNO3 electrode in negative and positive potential at a scan rate of 70 mVs^{-1} (B) CV at different potential at a scan rate of 150 mVs^{-1} (C) GCD at different potential at a current density of 2.5 Ag^{-1}.

Table S2. Electrochemical performances of different perovskite oxides

Sl. No.	Electrode material	Synthesis Method	Electrolyte	Specific capacity/ capacitance	Surface area	Scan rate/Current density	Energy density	Power density	Cyclic stability	Reference
1	$SrTiO_3$	Sol-gel	3 M KOH	590 Fg^{-1}	50.4 m^2g^{-1}	5 mVs^{-1}	27.8 Wh kg^{-1}	303.3 W kg^{-1}	99% retention after 5000 GCD cycles at 5 Ag^{-1}	[1]
2	$SrCoO_3$	EDTA-citric acid method	6 M KOH	572 Fg^{-1}	1.53 m^2g^{-1}	1 Ag^{-1}	27.5 Wh kg^{-1}	750 W kg^{-1}	Reached to maximum capacitance in 3500 cycles,	[2]

									retains 87.4% after 5000 GCD cycles at 1 Ag^{-1}	
3	$LaMnO_3$	Chemical precipitation method	0.5 M Na_2SO_4	520 Fg^{-1}	18 m^2g^{-1}	1 Ag^{-1}	52.5 Wh kg^{-1}	1000 W kg^{-1}	Retains 117% of its initial capacitance after 7500 cycles at 10 Ag^{-1}	[3]
4	$LaMnO_3$ (Porous)	Sol-gel combustion method	0.5 M Na_2SO_4	580 Fg^{-1}		1 Ag^{-1}	43.55 Wh kg^{-1}	770.5 W kg^{-1}	Retains 135% of its initial capacitance 10 Ag^{-1}	[4]

5	$LaMnO_{3-d}$	Reverse-phase hydrolysis	6 M KOH	609.8 Fg^{-1}	10.6 m^2g^{-1}	2 mVs^{-1}	220.4 Wh kg^{-1}	61.2 W kg^{-1}		[5]
6	$LaNiO_3$ (2D sheets)	Sol-gel	6 M KOH	139.2 mAh g^{-1}	181.2 m^2g^{-1}	1 Ag^{-1}	65.84 Wh kg^{-1}	1800 W kg^{-1}	92.39% retention after 10,000 CV cycles at 150 mVs^{-1}	[6]
7	$LaCoO_3$	Urea combustion	6 M KOH	706.9 Fg^{-1}		1 Ag^{-1}	47.64 Wh kg^{-1}	804.4 W kg^{-1}	96% retention after 4000 GCD cycles at 5 A g^{-1}	[7]
8	$LaFeO_3$	MOF derived using template	1 M Na_2SO_4	241.3 Fg^{-1}	41 m^2g^{-1}	1Ag-1	34 Wh kg^{-1}	900 W kg^{-1}	92.2% retention after 5000 GCD cycles	[8]

									at 10 A g^{-1}	
9	$CeNiO_3$	Co-precipitation	3 M KOH	399 Cg^{-1}	24.83 m^2g^{-1}	1 Ag-1	27 Wh kg^{-1}	826 W kg^{-1}	Capacity retention of 92% for 5000 cycles at current density of 10 Ag^{-1}	[9]
10	$CeNiO_3$	Sol-gel auto combustion	3 M KOH	605 Cg^{-1}	56.58 m^2g^{-1}	1 Ag-1	43.45 Wh kg-1	800 W kg-1	114.21 % initial capacity retention after 50000 cycles at a current density 25	**This Work**

									Ag^{-1}	

Coin cell fabricated

The laboratory prototype supercapattery device in the form of a CR-2032 type coin cell was constructed using porous CeNiO3 (CNO3) as positve and negative electrode, and Whatmannn filter paper (150 mm) as the seperator. The supercapattery performance was carried out in 3M KOH.

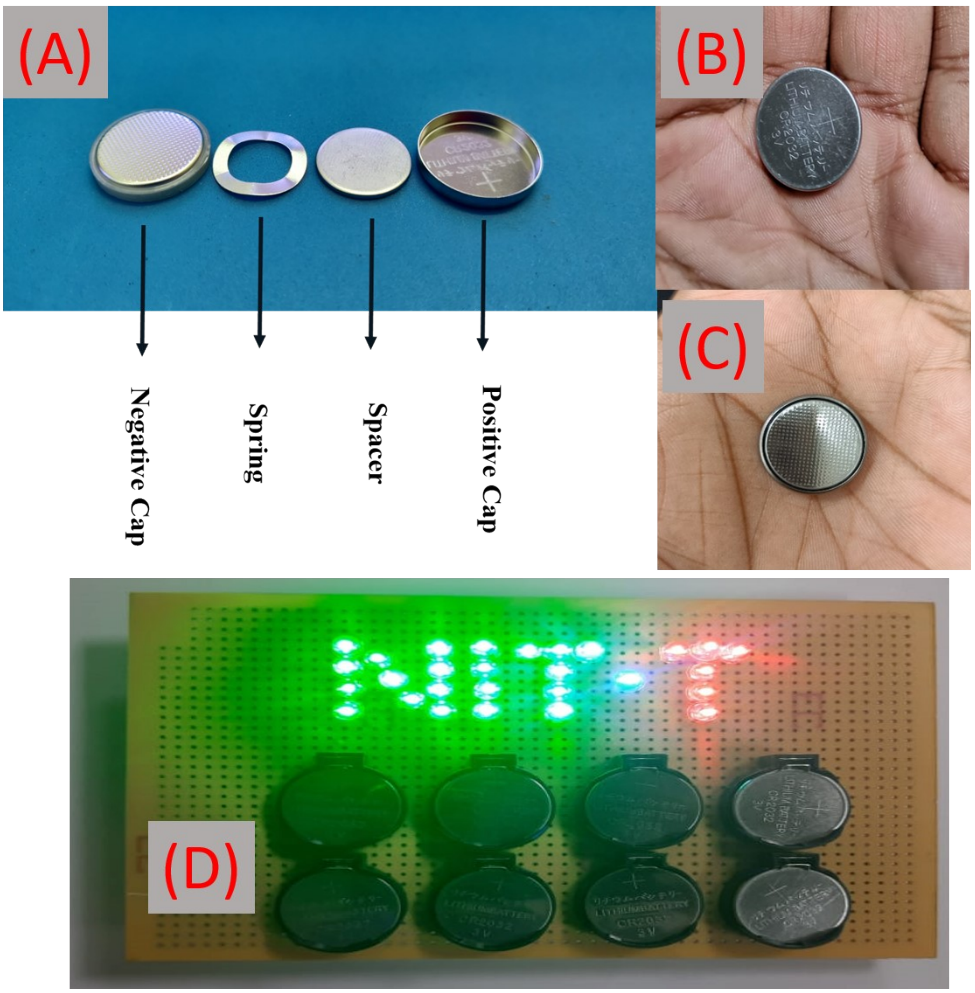


Fig.S8. (A) Components of coin cell (B&C) fabricated coin cell (D) illuminating "NITT" using eight (4 for green, 2 for blue and 2 for red) symmetric cell.

References:

1 A. K. Tomar, G. Singh and R. K. Sharma, *J. Power Sources*, 2019, **426**, 223–232.

2 Y. Liu, J. Dinh, M. O. Tade and Z. Shao, *ACS Appl. Mater. Interfaces*, 2016, **8**, 23774–23783.

3 P. M. Shafi, N. Joseph, A. Thirumurugan and A. C. Bose, *Chem. Eng. J.*, 2018, **338**, 147–156.

4 P. M. Shafi, A. C. Bose and A. Vinu, *ChemElectroChem*, 2018, **5**, 3723–3730.

5 J. T. Mefford, W. G. Hardin, S. Dai, K. P. Johnston and K. J. Stevenson, *Nat. Mater.*, 2014, **13**, 726–732.

6 Z. Li, W. Zhang, H. Wang and B. Yang, *Electrochim. Acta*, 2017, **258**, 561–570.

7 G. Guo, K. Ouyang, J. Yu, Y. Liu, S. Feng and M. Wei, *ACS Appl. Energy Mater.*, 2020, **3**, 300–308.

8 Y. Zhang, J. Ding, W. Xu, M. Wang, R. Shao, Y. Sun and B. Lin, *Chem. Eng. J.*, 2020, **386**, 124030.

9 M. P. Harikrishnan, A. J. C. Mary and A. C. Bose, *Electrochim. Acta*, 2020, **362**, 137095.