Supporting information

Experimental section

Materials

Material	Formula	Quantity	Source	Purity grade
Copper nitrate trihydrate	$(Cu(NO_3)_2.3H_2O)$	1.46 g	Sigma Aldrich	98.9 %
Cobalt nitrate hexahydrate	$(Co(NO_3)_2.6H_2O)$	3.53 g	Sigma Aldrich	98.9 %
Ethylene glycol	$C_2H_6O_2$	5 mL	MERCK	99.5 %
Ethanol	C_2H_5OH	30 mL	Sigma Aldrich	99.9 %
Urea	$(NH_2)_2CO$	2.18 g	Honywell	99.5 %
Ammonium fluoride	NH_4F	0.97 g	Duksan Reagents	99.0 %
Dimethylformamide	C_3H_7NO	15 mL	Honywell	99.8 %
Hydrochloric acid	HCl	37 mL	MERCK	97 %

We have taken 5 g of CCO to prepare the following three composites, each of 200 mg; the measured mass of CNTs is given below:

CCO with 5% CNTs = 0.010 g

CCO with 10% CNTs = 0.020 g

CCO with 15% CNTs = 0.030 g

Active mass area (1.5×1 cm^2)

Electrochemical characterizations setup

A 3-electrode setup of the Corrtest Electrochemical and Corrosion Studio (version, 6.4) was utilized to evaluate the EC performance. For the reference electrode (RE) and CE, an Ag/AgCl electrode and a platinum wire were used, respectively, and the WE was made from the synthesized material and submerged in an electrolyte solution containing 1 M KOH. A 2-electrode setup, comprising CCO/CNTs as the positive electrode and AC as the negative electrode, was used for GITT analysis.

Results and discussion

Galvanostatic charge-discharge analysis

The left side of the figure shows the experimental setup used for GCD measurements, which was based on a 3-electrode configuration. First, all electrodes (WE, RE, and CE) were immersed in a 1 M KOH electrolyte, and the experimental parameters were then defined. After that, the experiment was performed for all optimized I_m, and the corresponding GCD curves were obtained. On the right side of the figure, a magnified view of the EC cell is shown. Before adding CNTs, the transport of electrons and ions was mainly diffusive, which offered resistance and limited the number of electrons reaching the CE. However, after incorporating the CNTs, the transportation of the electrons became nearly ballistic (resistance-free), allowing a large number of electrons to reach the CE and thereby enhancing the EC performance.

Table S1. A comparative analysis of the EC performance of CCO electrodes based on a literature review.

Material	Morphology	Specific capacitance/ Capacity	Energy density	Cyclic stability	Diffusion coefficient	Ref.
CCO@rGO	Nanoparticles	380 C/g	20.6 Wh/kg	98% after 10k cycles	NA	22
CCO	Spherical nanoparticles	764.5 mAh/g	25.5 Wh/kg	95.5% after 2k cycles	NA	30
CCO/MWCNTs	Nanoplates	1054 F/g	NA	NA	NA	31
CCO/CuO	Hexagonal plate-like	892 F/g	NA	94% after 5k cycles	NA	32
CCO/CuO/CNTs	Hierarchical flower-like	1084 F/g	NA	98% after 9k cycles	NA	33
CCO/CuO/rGO	Core-shell nanostructure	NA	37 Wh/kg	83.5% after 4k cycles	NA	52
CCO/MWCNTs	3D microspheres	860 F/g	NA	NA	NA	53
CCO/CNTs	**Semi-spherical and nanorods like**	**1702.01 C/g**	**113.46 Wh/kg**	**99.94% after 4500 cycles**	**3.9×10^{-11} cm^2/s**	**This work**

References

[22] Semerci, F.; & Eşgin, H. Step-wise synthesis of mesoporous $CuCo_2O_4$@reduced graphene oxide composites for supercapacitor applications. *Journal of Electroanalytical Chemistry* **2024**, *970*, 118550.

[30] BoopathiRaja, R.; Parthibavarman, M.; & Begum, A. N. Hydrothermal induced novel $CuCo_2O_4$ electrode for high-performance supercapacitor applications. *Vacuum* **2019**, *165*, 96-104.

[31] Bhagwan, J.; & Han, J. I. $CuCo_2O_4$ nanoplates anchored to multiwall carbon nanotubes as an enhanced supercapacitive performance. *Journal of Energy Storage* **2023**, *62*, 106923.

[32] Arulkumar, C.; Gandhi, R.; Alshgari, R. A.; & Vadivel, S. Improved electrochemical performances of $CuCo_2O_4$/CuO-based asymmetric device with ultrahigh capacitance and attractive cycling performance. *Journal of Energy Storage* **2024**, *92*, 112202.

[33] Liu, Y.; Chang, X.; Wang, M.; Guo, H.; Li, W.; & Wang, Y. Hierarchical $CuCo_2O_4$/CuO nanoflowers crosslinked with carbon nanotubes as an advanced electrode for supercapacitors. *Journal of Alloys and Compounds* **2021**, *871*, 159555.

[52] Kamble, G. P.; Rasal, A. S.; Gaikwad, S. B.; Gurav, V. S.; Chang, J. Y.; Kolekar, S. S.; & Ghule, A. V. $CuCo_2O_4$ nanorods coated with CuO nanoneedles for supercapacitor applications. *ACS Applied Nano Materials* **(2021)**, *4*, 12702-12711.

[53] Abbas, W.; Irfan, M.; Babur, M.; Mazhar, M. E.; Ahmad, J.; Rao, K. A.; & Imran, M. Synergistic $CuCo_2O_4$/MWCNT nanocomposites: advanced electrode materials for energy storage and catalysis applications. *Journal of Materials Science: Materials in Engineering* **(2025)**, *20*, 96.