

Supplementary Information

Growth of carbon nanotubes over carbon nanofibers catalyzed by bimetallic alloy nanoparticles as bifunctional electrode for Zn-air batteries

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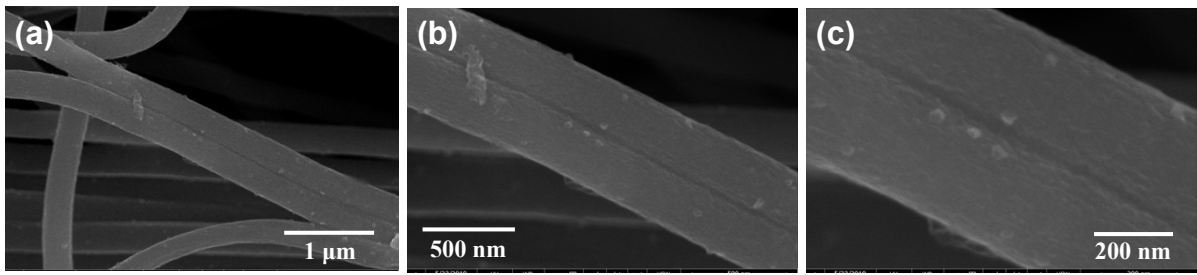


Figure S1 (a - c) SEM images of Mn-CNT@CNF carbonized at 800 °C.

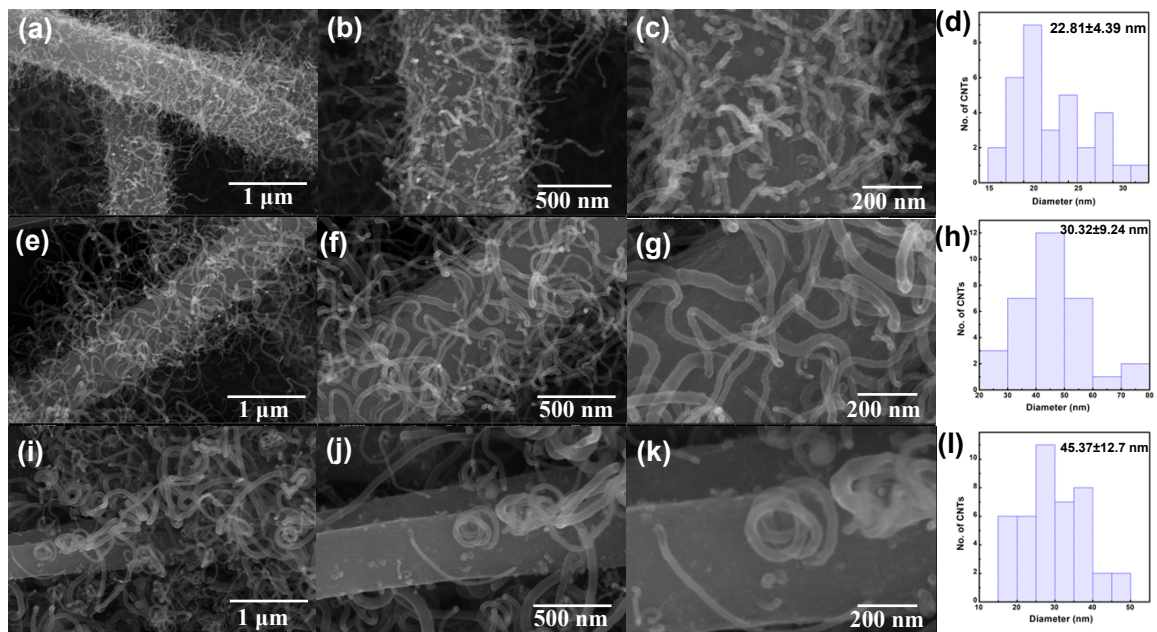


Figure S2 SEM images of (a-c) Fe-CNT@CNF, (e-g) Ni-CNT@CNF, (i-k) Co-CNT@CNF at different magnifications and (d, h, l) corresponding CNT diameter distributions.

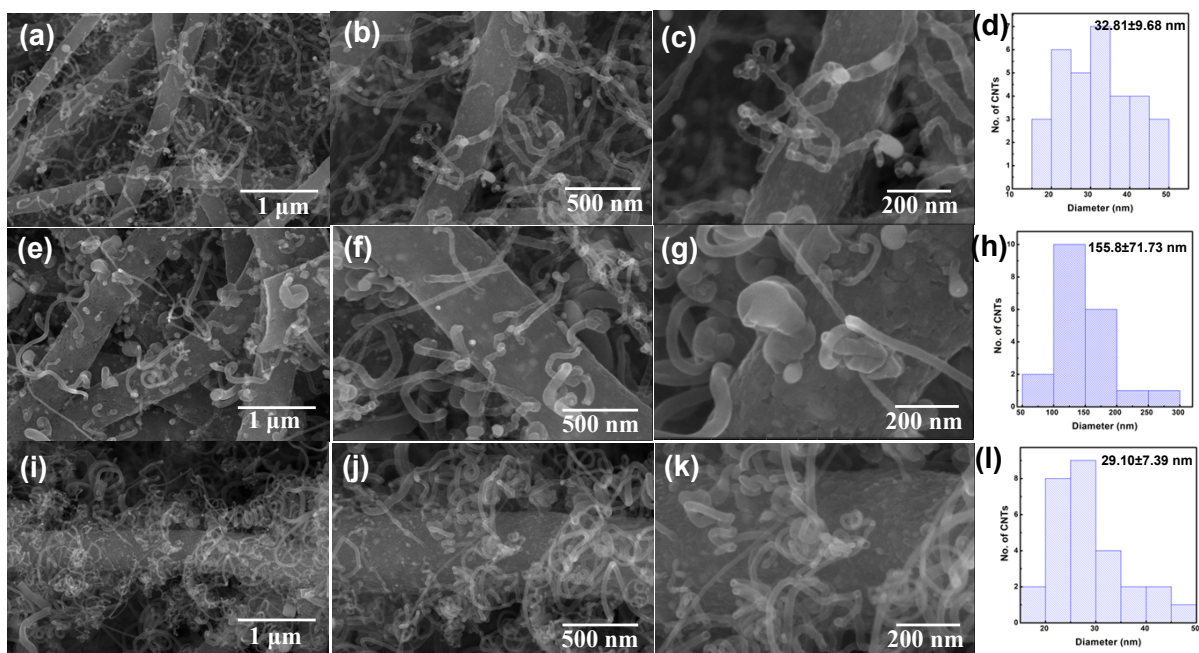


Figure S3 SEM images of (a-c) NiCo-CNT@CNF, (e-g) FeMn-CNT@CNF, (i-k) CoMn-CNT@CNF at different magnifications and (d, h, l) corresponding CNT diameter distributions.

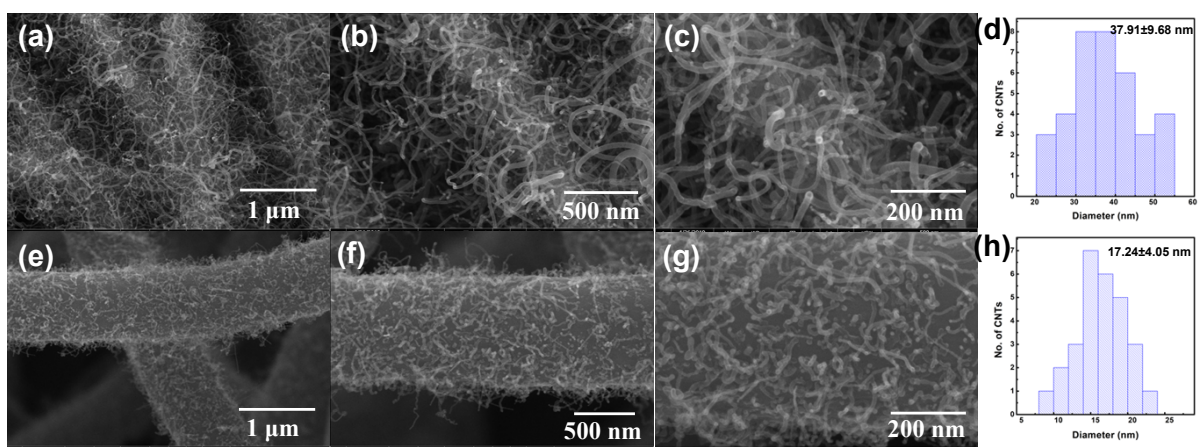


Figure S4 SEM images of (a-c) NiMn-CNT@CNF, (e-g) FeCo-CNT@CNF at different magnifications and (d & h) corresponding CNT diameter distributions.

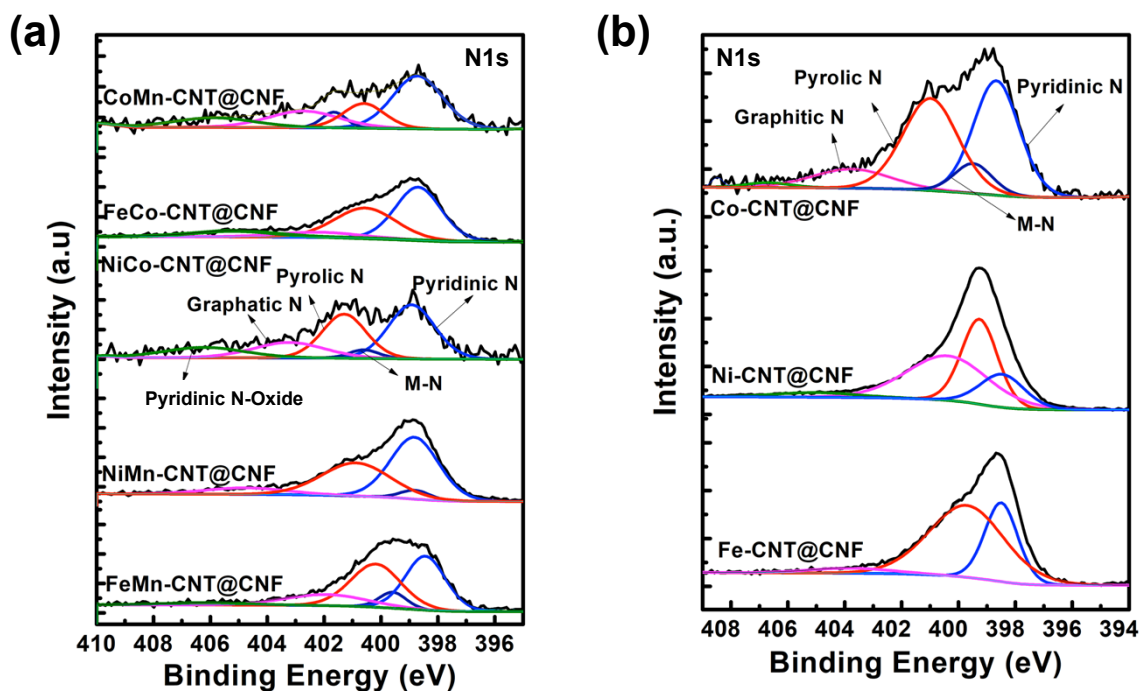


Figure S5 High resolution N 1s XPS spectra comparison of different (a) MM'-CNT@CNF and (b) M-CNT@CNF electrocatalysts.

Table S1 Comparison of different type of N doped in the prepared MM'-CNT@CNF and M-CNT@CNF electrocatalysts.

Sr. No	Sample	Pyridinic N (%)	Pyrolic N (%)	M-N (%)	Graphitic N (%)	Pyridinic N-Oxide (%)
1	FeNi-CNT@CNF	43.45	11.34	11.34	17.00	2.70
2	FeCo-CNT@CNF	46.74	35.74		8.14	9.39
3	FeMn-CNT@CNF	35.67	35.73	4.13	14.86	
4	NiMn-CNT@CNF	48.17	36.69	4.23	8.53	3.11
5	CoMn-CNT@CNF	44.06	16.94	6.39	19.70	2.96
6	NiCo-CNT@CNF	37.69	29.25	3.85	16.62	12.59
7	Ni-CNT@CNF	17.18	42.66		35.86	4.40
8	Co-CNT@CNF	39.44	38.14	8.56	11.17	0.86
9	Fe-CNT@CNF	30.96	64.21		4.83	

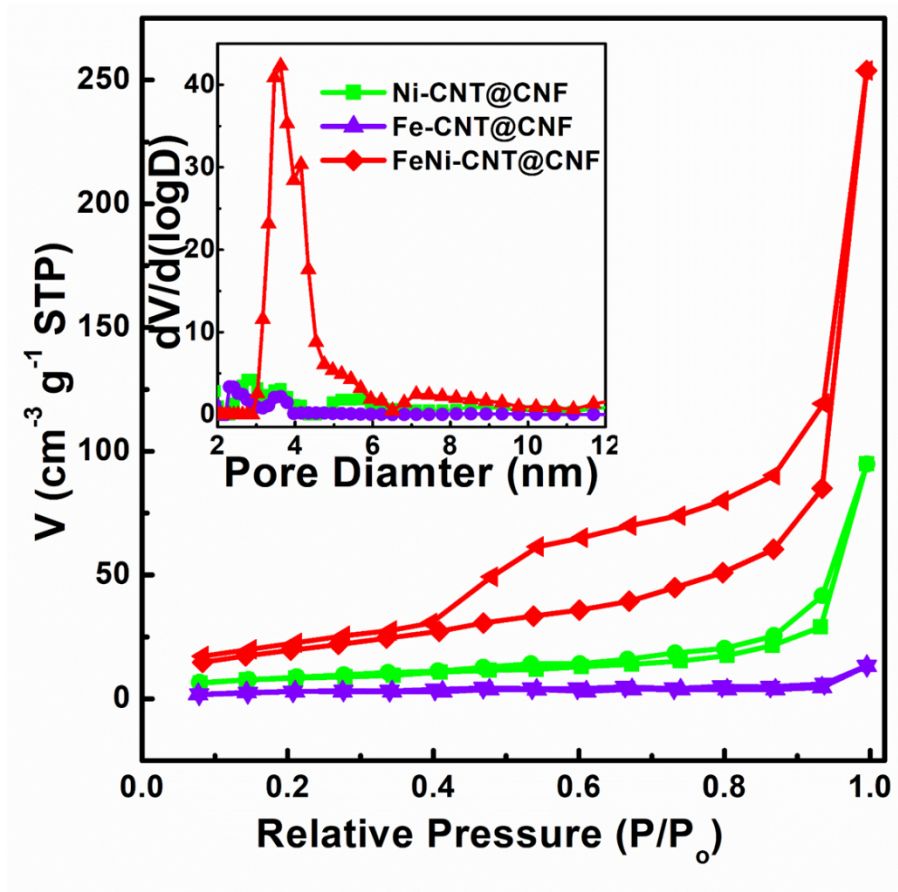


Figure S 6 Nitrogen adsorption-desorption isotherms for Fe, Ni, and FeNi encapsulated CNT@CNF nanocatalysts (inset represents the pore size distribution).

Table S 2 BET surface area and average pore size for Fe, Ni, and FeNi containing CNT@CNF nanocatalysts.

Sample	Surface Area ($\text{m}^2 \text{g}^{-1}$)	Average Pore Size (nm)
Ni-CNT@CNF	21.610	2.897
Fe-CNT@CNF	6.340	2.419
FeNi-CNT@CNF	60.275	3.627

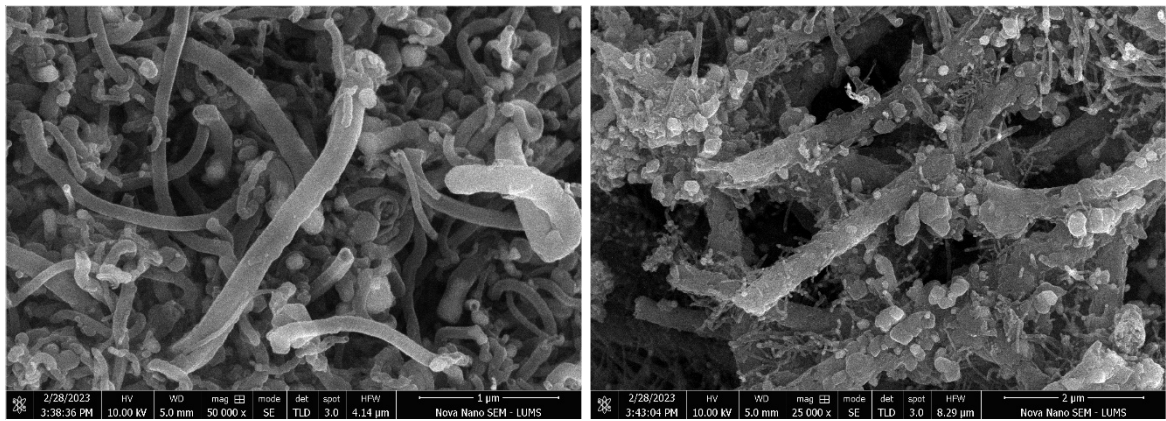


Figure S 7 SEM images of the cycled FeNi-CNT@CNF catalyst.