Supplementary Information (SI)

➢ XRD

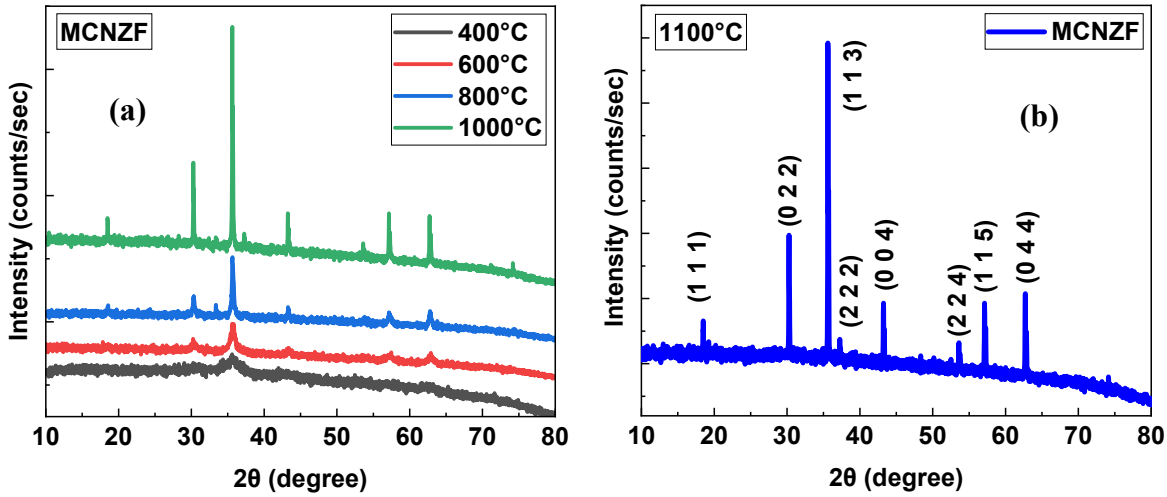


Figure S1 (a) XRD of MCNZF calcined at various temperatures (b) XRD of MCNZF calcined at 1100°C

➢ Table S1: Rietveld Refinement Parameters

Crystal Structure	**Cubic**
Space group	**F d -3 m**
Cell Parameters	
a=b=c	**8.4086**
α= β= ϒ	**90**
Volume(A°^{3})	**594.5168**
Density(g/cm^3)	**26.229**
Site Occupation	
O1	**1**
FE1	**1**
FE2	**1**
MN1	**0.4**
CO1	**1**
NI1	**1**
ZN1	**0.4**
Agreement Factors	
R_p	**37**
R_{wp}	**21.2**
R_e	**19.1**
Chi^2	**1.232**

➢ **Presence of residual carbon**

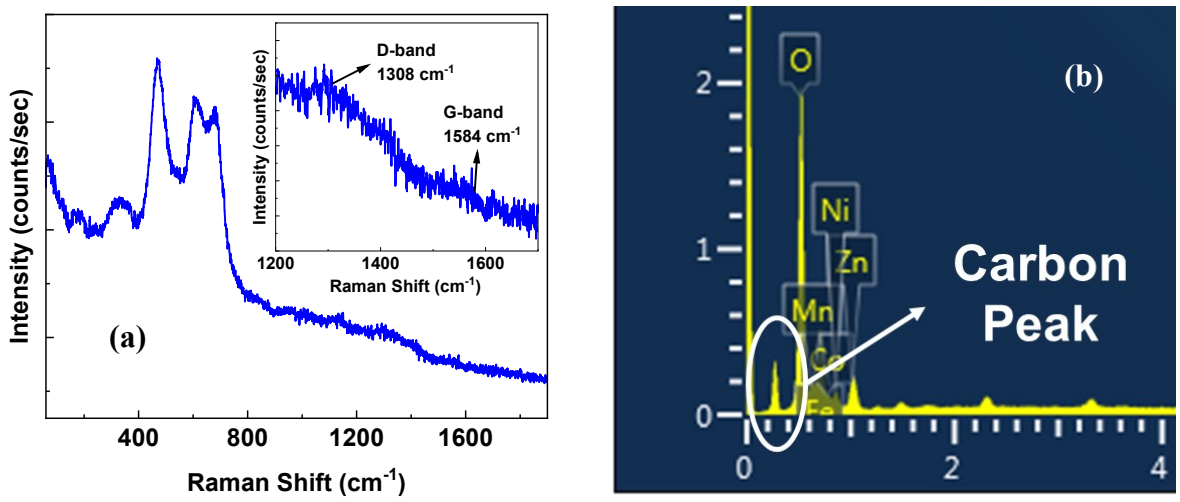


Figure S2 (a) Raman spectroscopy with carbon residue (b) EDX mapping with carbon residue peak

➢ **UV-Visible spectroscopy**

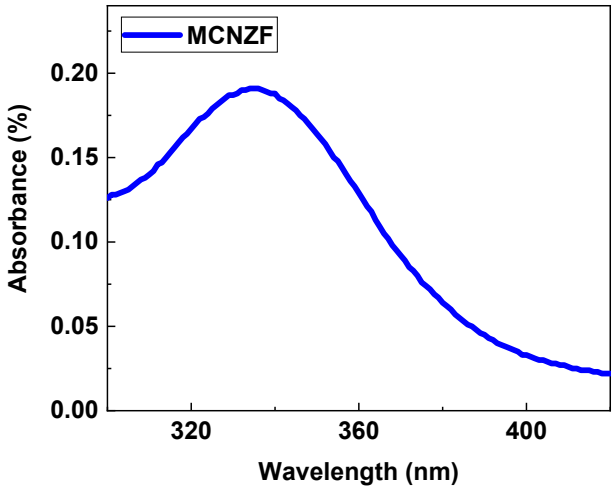


Figure S3. UV of MCNZF

➢ **FESEM Images at various magnifications**

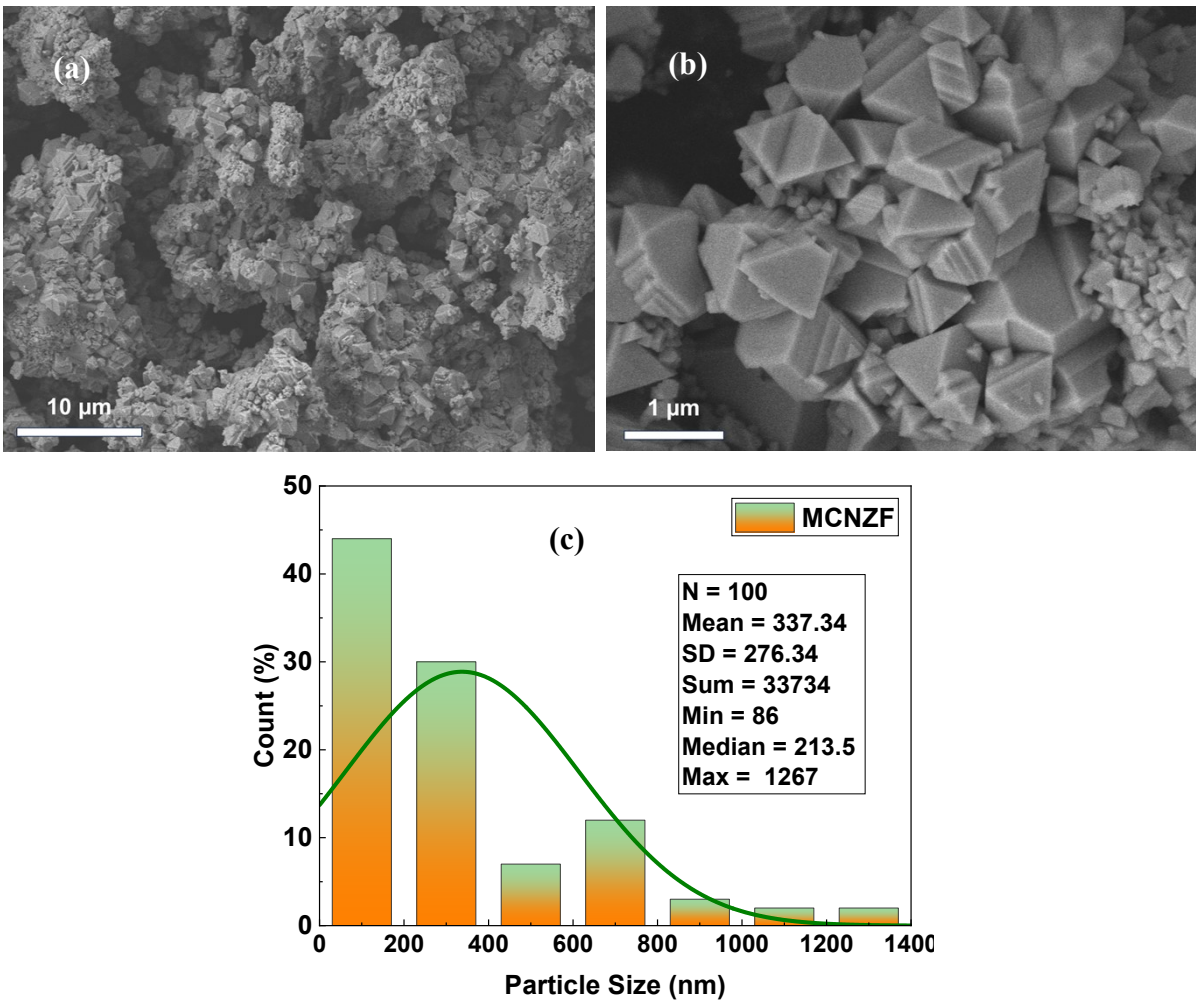
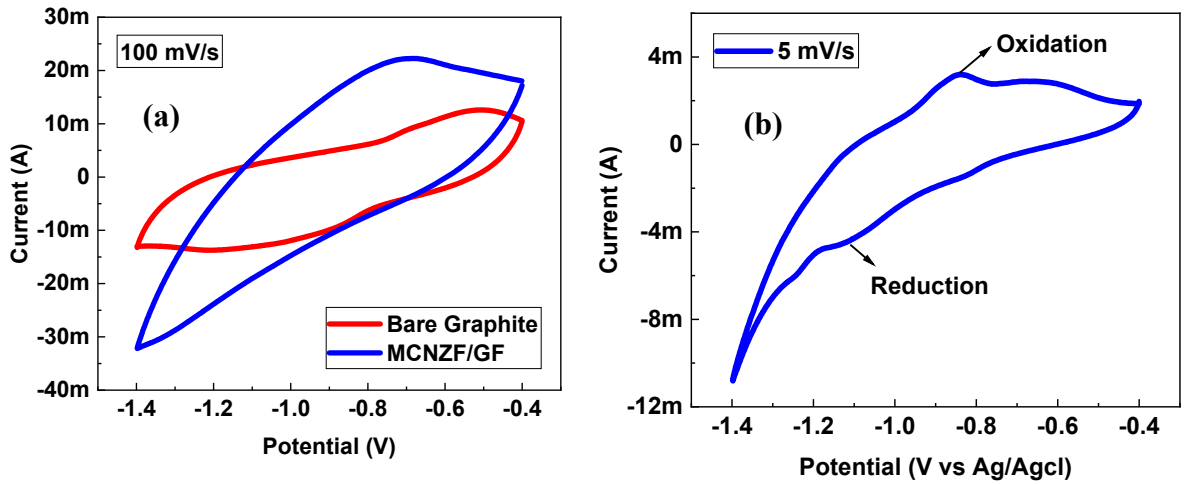


Figure S4 (a) FESEM image at 10 µm (b) FESEM image at 1 µm (c) Particle size distribution

➢ **Electrochemical Analysis**



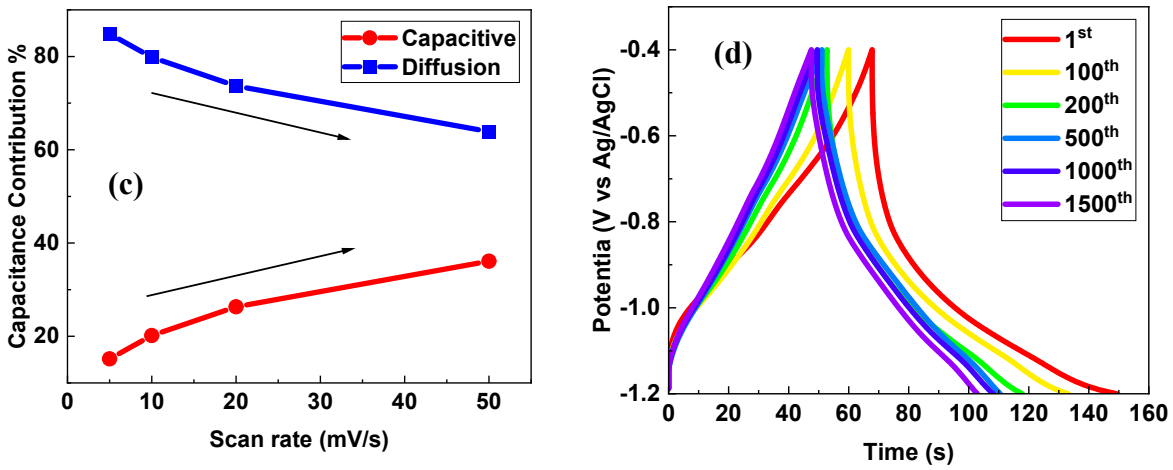


Figure S5 (a) CV of Bare Graphite and MCNZF/GF at 100 mV/s (b) CV of MCNZF/GF at 5 mV/s (c) Variation of capacitance contribution (%) w.r.t scan rate (d) GCD of various cycles number

➢ EIS Analysis

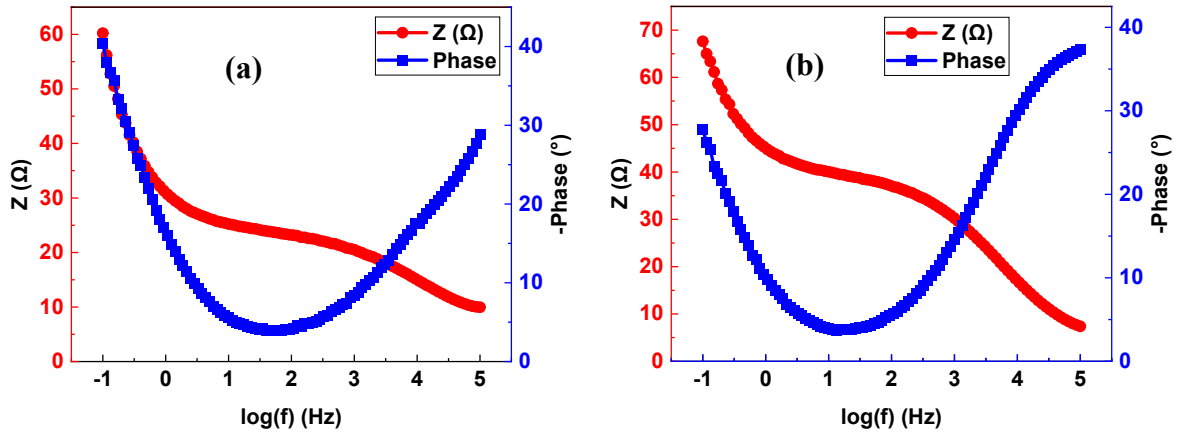


Figure S6 (a) Bode plot of MCNZF/GF before GCD (b) Bode plot of MCNZF/GF after GCD

➢ Table S2: EIS Parameters

Parameters	Before GCD	After GCD
R_0 (Ω)	1.0653E-13	1.0817
R_1 (Ω)	24.906	38.748
R_2 (Ω)	1.869E09	4.895E09
CPE_1 (Mho*s^N)	0.030729	0.035141
N_1	0.66703	0.63303
CPE_2 (Mho*s^N)	0.00025064	9.376E-05
N_2	0.43255	0.55142

- **Formulae used:**
  - Tauc's relation correlates the absorption coefficient (α) and the incident photon energy (hν). The equation is:

$$(\alpha h\nu)^n = A(h\nu - E_G) \qquad (E1)$$

Where, A is a constant, E_G is the optical band gap, and n depends on the type of electronic transition (n = 1/2 for indirect and n = 2 for direct transitions).

- The Specific capacitance (C_{sp}), for three electrode system was calculated from GCD studies from the following equations.

$$C_{sp} = \frac{I \times \Delta t}{m \times \Delta V} \qquad (E2)$$

Where, *I* represent the response of current (A), *m* denotes the mass of the active electrode material (g), *Δt* represents the discharge time (s), *ΔV* represents the potential window (V).

- The capacitance retention (%) reflects the ability of a material to preserve its specific capacitance (C_{sp}) during repeated charge-discharge cycling. Capacitance retention was calculated using the formula:

$$\text{Capacitance retention (\%)} = \left(\frac{C_f}{C_i}\right) \times 100 \qquad (E3)$$

Where, C_f is the capacitance measured after a specified number of cycles. C_i is the initial capacitance measured at the beginning of the experiment.

- Energy density (E) was measured from GCD in the two-electrode system.

$$E = \frac{I}{2 \times 3.6} \Delta C_{sp} (\Delta V)^2 \qquad (E4)$$

- Power density (P) was measured from GCD in the two-electrode system.

$$P = \frac{E \times 3600}{\Delta t} \qquad (E5)$$

Where, *I* denote the current (A) response, *m* denotes the active electrode material mass (g), *Δt* denotes the discharging time (s), *ΔV* denotes the potential window (V), Energy density (E) units are Wh/kg and units of power density (P) in W/kg.