# Concisely constructing S, F Co-modified MnO Nanoparticles Attached to S, N Co-Doped Carbon Skeleton as a High-Rate Performance Anode Material

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**Electrochemical measurements**

The electrochemical performance of the samples was tested using CR2025-type coin cell. The test electrodes were prepared by mixing the samples, carbon black, and binder (polyvinylidene fluoride (PVDF)) at a weight ratio of 7:2:1 in N-methyl-2-pyrrolidinone (NMP). The resulting slurries were coated onto a copper foil and then dried under vacuum at 80 $^{o}$C for 12 h. Coin cells were assembled in an argon-filled glovebox ($H_2O$ and $O_2$ < 0.1 ppm) using lithium foil as the counter and reference electrode, a polymer separator (Celgard 2500), and 1 M $LiPF_6$ in EC:DMC:DEC (1:1:1 in volume) as the electrolyte. The cells were tested using a LANHE Battery Test System in the potential range between 0.01 and 3 V at room temperature. Cyclic voltammetry (CV) was measured using an electrochemical workstation (CHI660C). Electrochemical impedance spectra (EIS) were characterized by the same instrument over a frequency range of 100 kHz to 0.01 Hz.
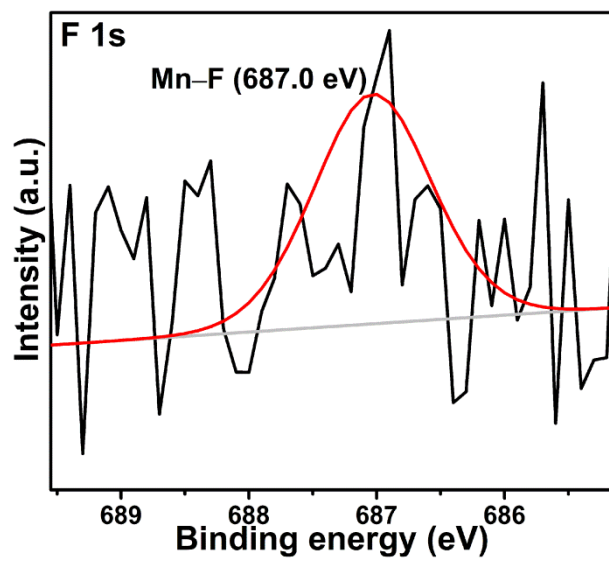
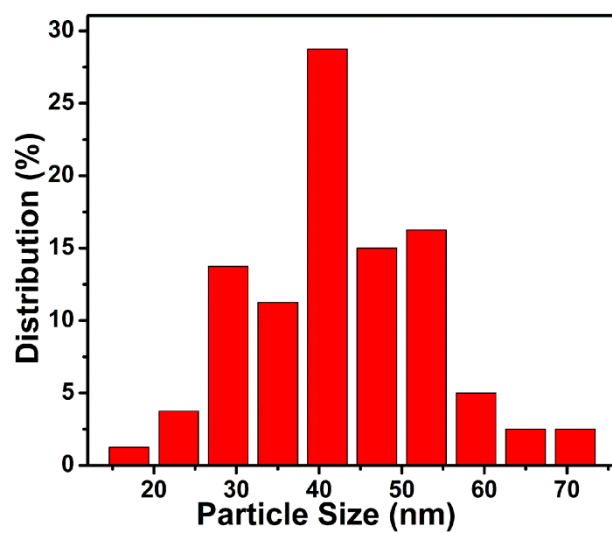**Figure S1** XPS spectrum of the F 1s region for SF-MnO/SNC composite.

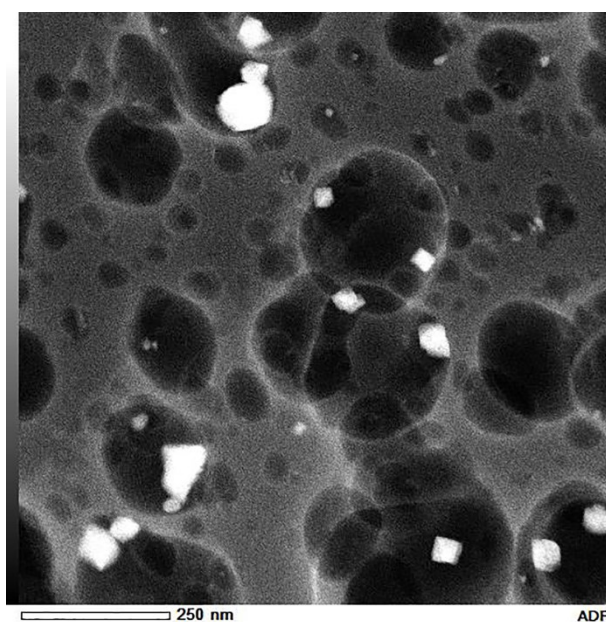**Figure S2** Nanoparticle size distribution diagram for SF-MnO/SNC composite.

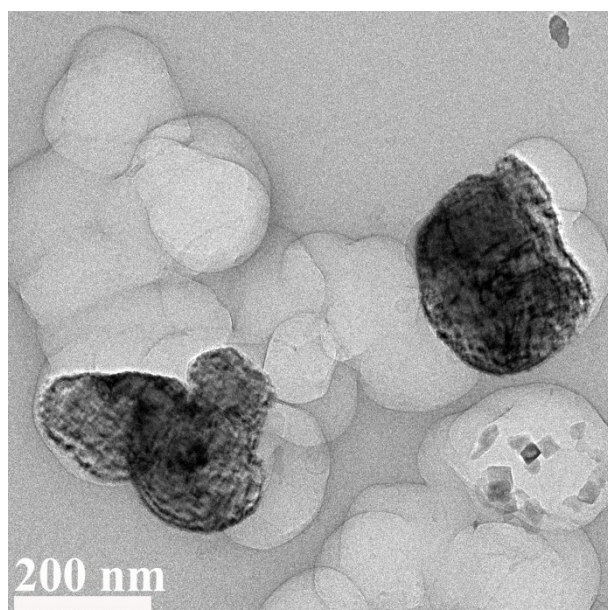**Figure S3** HAADF image of the elemental mapping for SF-MnO/SNC composite.

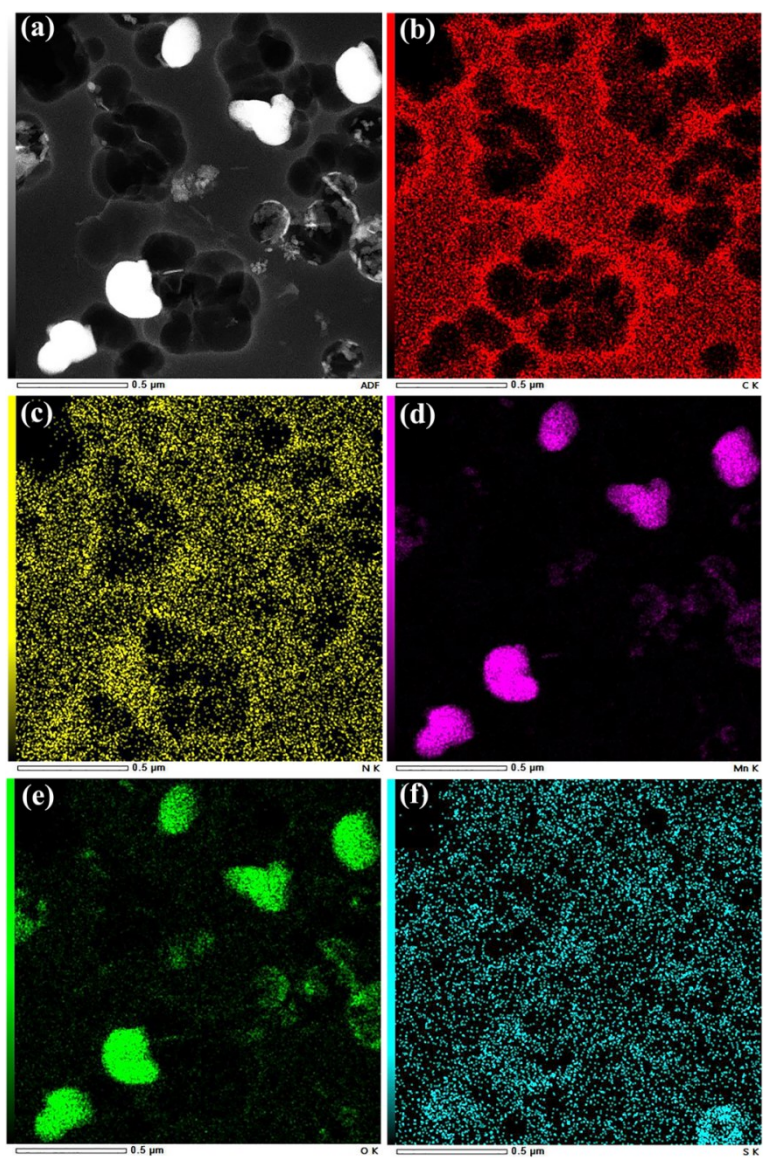**Figure S4** TEM image of S-MnO/SNC composite.

**Figure S5** HAADF image of the elemental mapping (a) and EDS maps of elemental C (b), N (c), Mn (d), O (e) and S (f) for S-MnO/SNC composite.
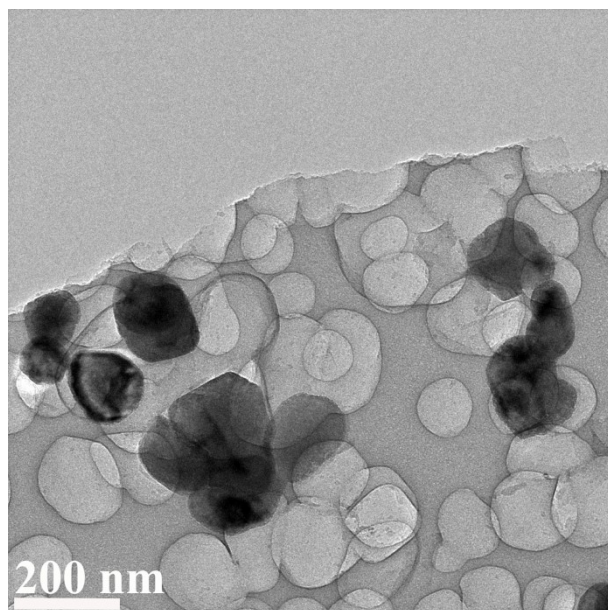
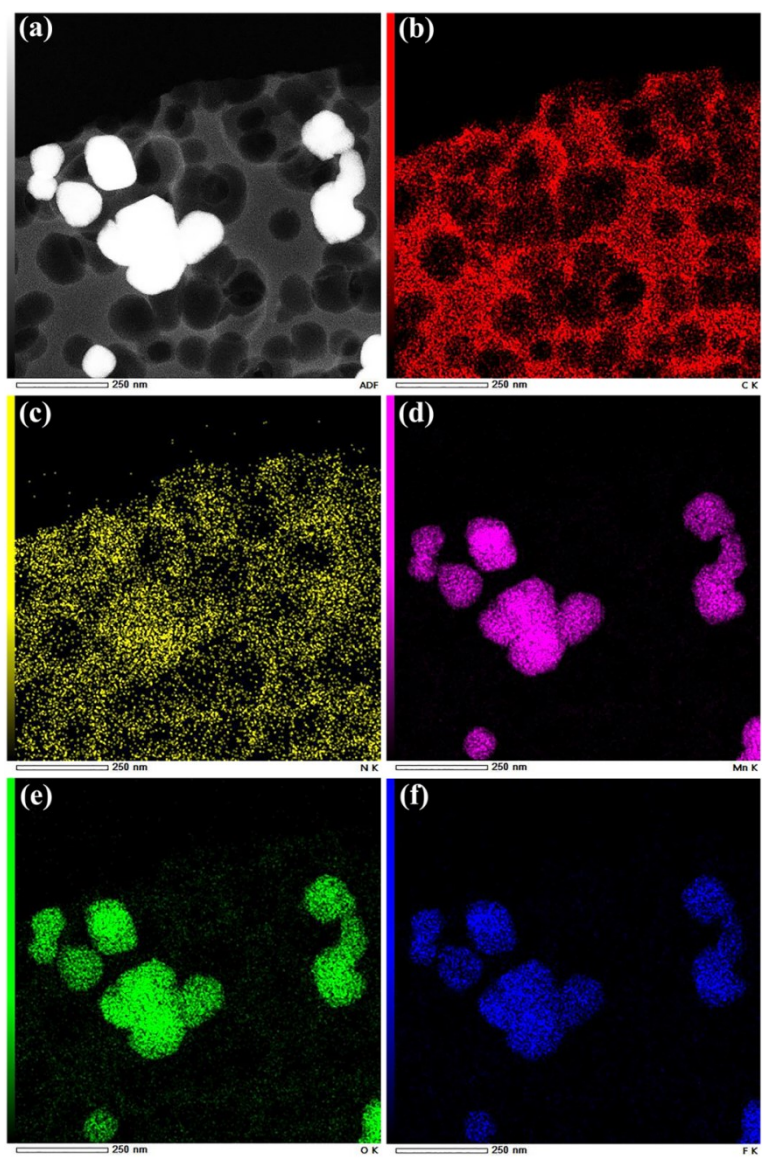**Figure S6** TEM image of F-MnO/NC composite.

**Figure S7** HAADF image of the elemental mapping (a) and EDS maps of elemental C (b), N (c), Mn (d), O (e) and F (f) for F-MnO/NC composite.
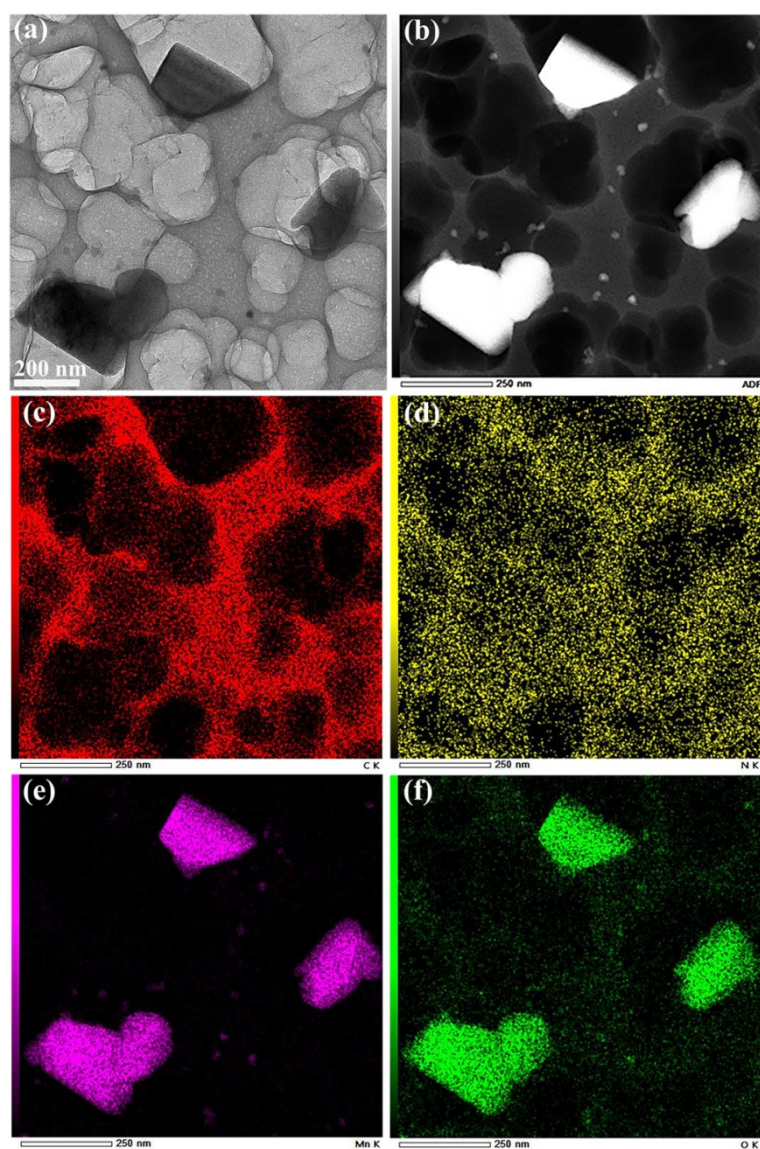
**Figure S8** TEM image (a), HAADF image of the elemental mapping (b) and EDS maps of elemental C (c), N (d), Mn (e) and O (f) for MnO/NC composite.
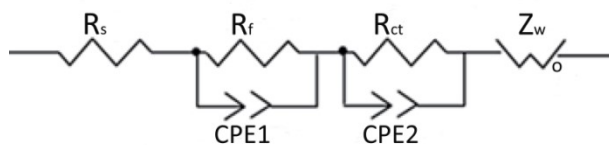
**Figure S9** Equivalent circuit.

**Table S1** EIS parameters for the SF-MnO/SNC, S-MnO/SNC, F-MnO/NC, and MnO/NC electrodes derived through the fitting of experimental data to an equivalent circuit model.

| Sample | Cycle number | $R_s$/Ohm | $R_f$/Ohm | $R_{ct}$/Ohm |
|--------|--------------|-----------|-----------|--------------|
| SF-MnO/SNC | after five cycles | 5 | 27 | 35 |
| S-MnO/SNC | after five cycles | 9 | 41 | 54 |
| F-MnO/NC | after five cycles | 5 | 36 | 51 |
| MnO/NC | after five cycles | 5 | 62 | 70 |