Electronic Supplementary Information (ESI)

Effect of Mn_3O_4 Nanoparticle Composition and Distribution on Graphene as a Potential Hybrid Anode Material for Lithium-Ion Batteries

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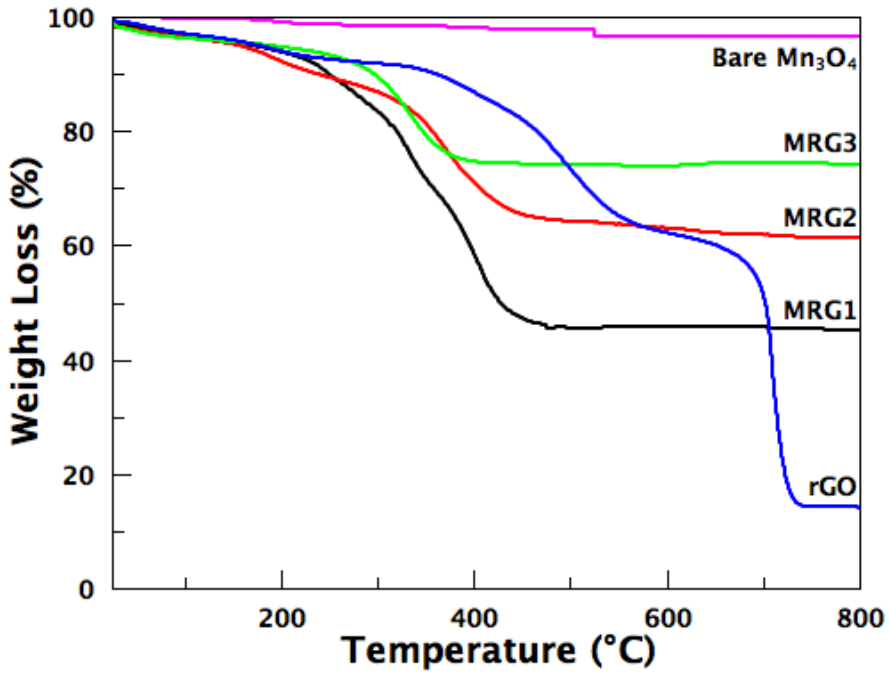

Figure S1 TGA curves of MRG1, MRG2, MRG3 and rGO.

Table S1 Inter-particle distance analysis of sample MRG1, MRG2 and MRG3.

Diameter of particles (nm)	Volume of one particle (nm^3)	Area of one particle (nm^2)	BET Surface Area (g/m^2)	Total area of rGO (nm^2)	Thickness of nanosheet (nm)
30	14.137×10^3	2.83×10^{18}	108.7081	12.05×10^{18}	3.6

Sample	Mass percent of particles (%)	Mass of particles (g)	Number of particles	Total volume of particles (nm^3)	Total area of particles (nm^2)	Inter-particle distance (nm)
MRG1	36%	0.046	6.72×10^{14}	11.62×10^{18}	1.9	**67**
MRG2	54%	0.069	10.08×10^{14}	23.46×10^{18}	2.85	**55**
MRG3	72%	0.092	13.45×10^{14}	35.19×10^{18}	15.21	**47**

Inter-particle distance calculation:

The mass of Mn3O4 nanoparticles (m_{NP}) for each hybrid material (m_H) is calculated using weight loss data (w%)of rGO and hybrid materials from TGA curves.

$$m_{NP} = m_H \times w\%$$

Then, the total volume of the nanoparticles (V_{TNP}) for each hybrid materials is calculated from mass-density correlation.

$$V_{TNP} = \frac{m_{NP}}{\rho_{NP}}$$

The volume of a single nanoparticle (V_{SNP}) regarded as spherical and 30nm of the average diameter (R) was obtained from sphere volume formula.

$$V_{SNP} = \frac{4}{3}\pi(R/2)^2$$

Ultimately, the number of the nanoparticles (N_{NP}) for each hybrid materials is attained from the proportion of the total volume of the nanoparticles and volume of a single one.

$$N_{NP} = \frac{V_{TNP}}{V_{SNP}}$$

Besides, rGO's surface area (A_G) is measured by BET. In order to calculate per nanoparticle how much surface area has on rGO, the surface area of the rGO is proportioned to the total number of the nanoparticles in a hybrid material. Then, the result is taken the square root to suppose that all nanoparticles are aligned on 1D layer and divided by 2 to eliminate one surface of nanosheets. Finally, the inter-particle distance (d_{ip}) as shown in Table S1 is calculated for each hybrid materials.

$$d_{ip} = \frac{\sqrt{A_G/N_{NP}}}{2}$$

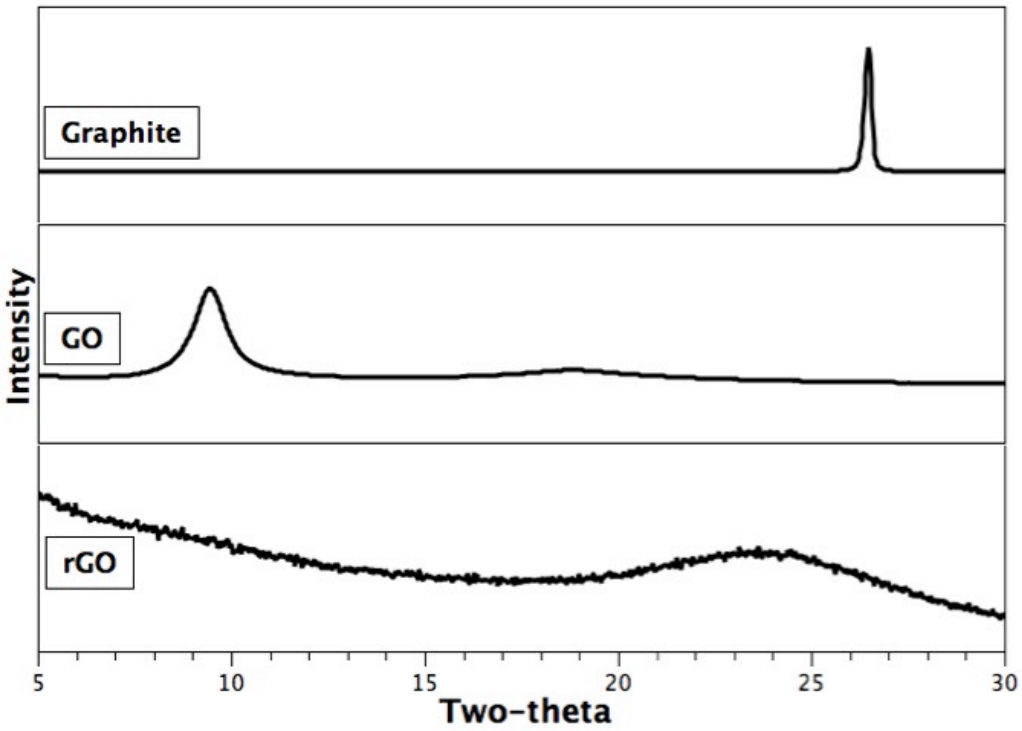

Figure S2. XRD patterns of the samples graphite, GO, and rGO.

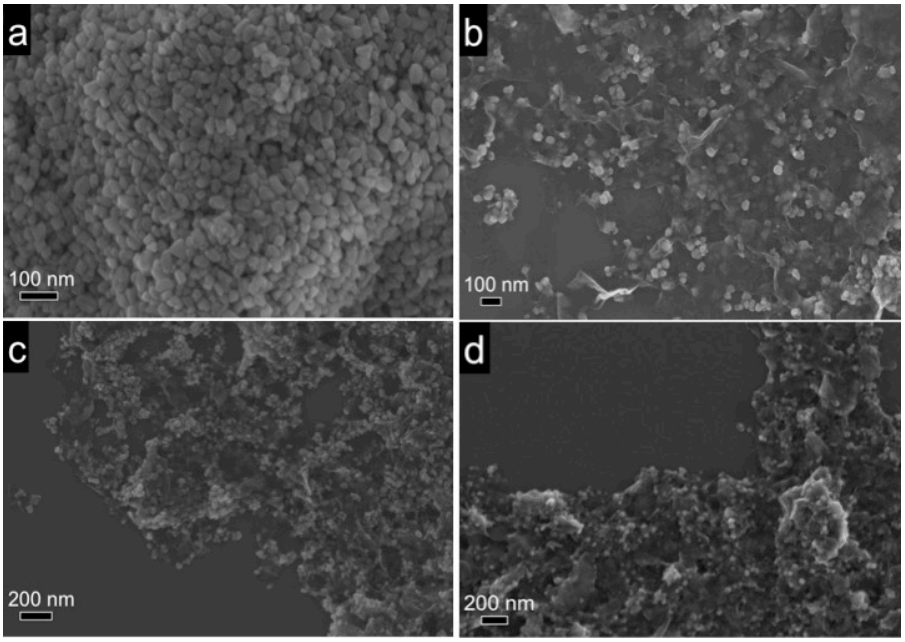

Figure S3. SEM images of the samples (a) bare Mn_3O_4, (b) MRG1, (c) MRG2 and (d) MRG3 hybrid materials.

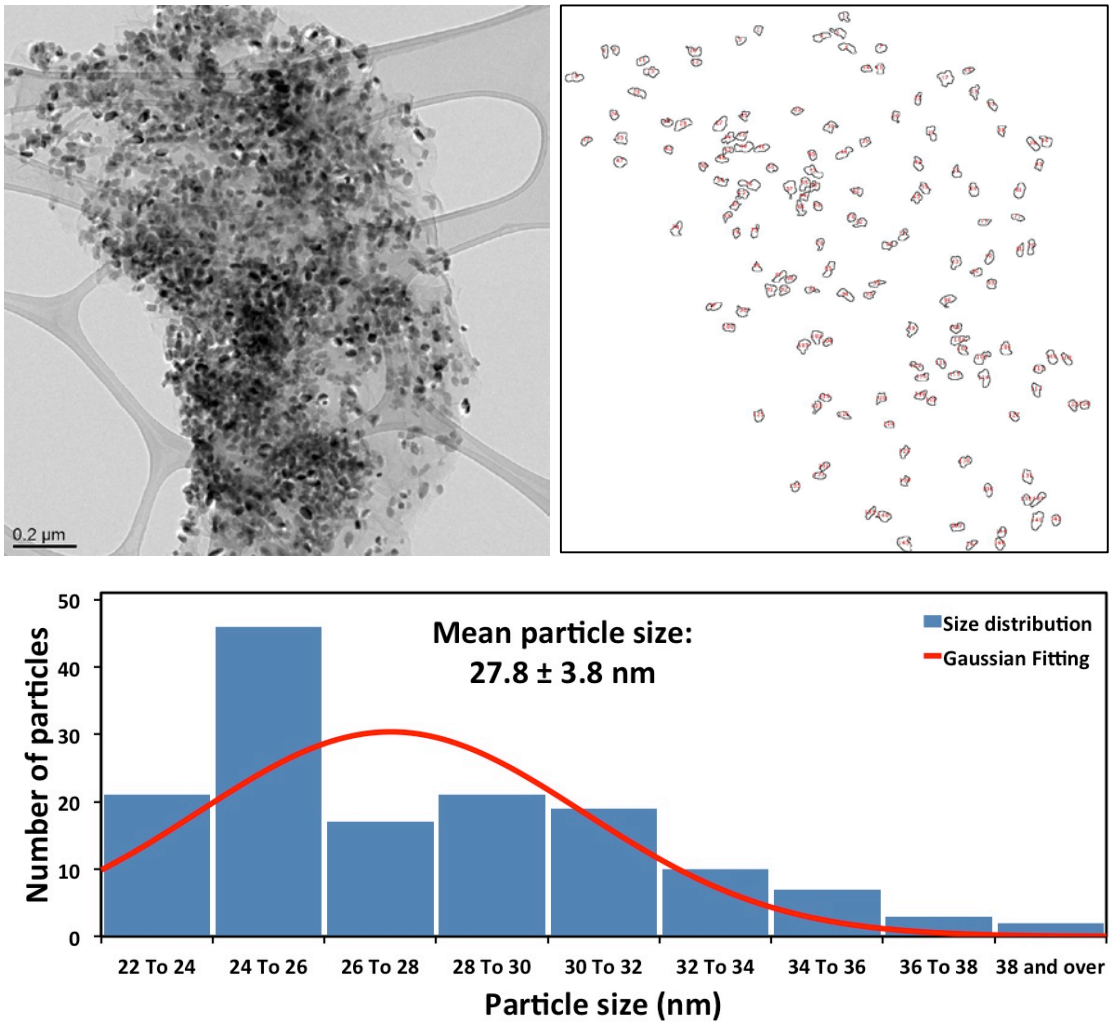

Figure S4. The particles of MRG2 sample and the particle size distribution histogram. From the TEM image, about 150 nanoparticles were considered by ImageJ software to obtain the histogram.

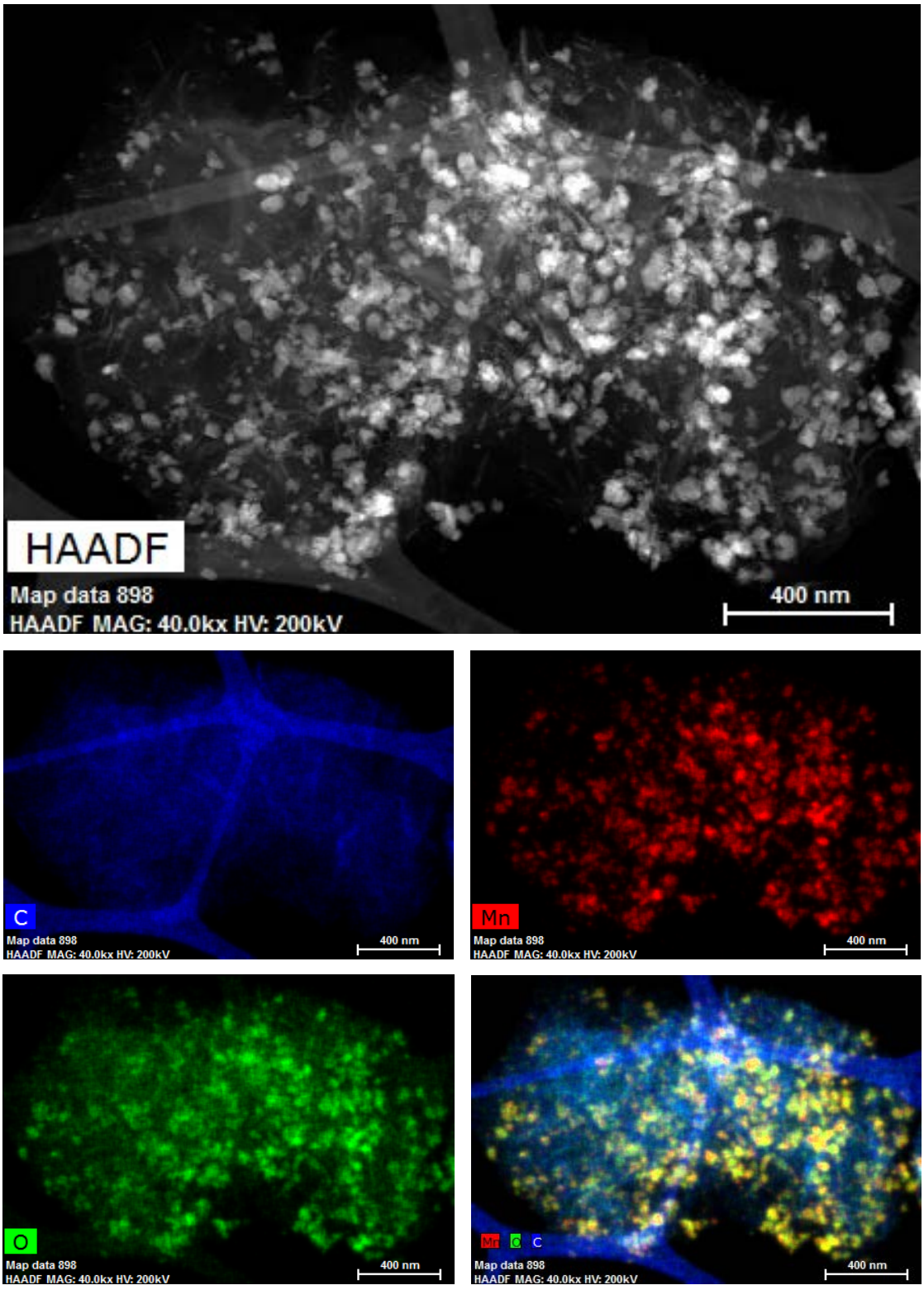

Figure S5. HAADF-STEM image of MRG2 sample and corresponding EDX elemental mapping images.