Supplementary information

Egg whites-derived carbon/magnetic nanoparticles/water-soluble graphene oxide composite with homogeneous structure as an excellent electromagnetic wave absorber

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SI-1: The synthesis of Co$_{0.2}$Fe$_{2.8}$O$_4$ nanoparticles

H$_2$O (300 ml), FeCl$_3$·6H$_2$O (1.9867 g, 7.35 mmol), FeCl$_2$·4H$_2$O (0.5845 g, 2.94 mmol), CoCl$_2$·6H$_2$O (0.1749 g, 0.74 mmol) were added to a 500 mL three-necked flask. With the protection of Ar, the solution was rapidly heated to 70 °C with a mechanical stirring (1000 rpm). Subsequently, NH$_3$·H$_2$O (13.5 mmol) was added to the mixed solution to adjust the pH to 10. And then it reacts at 70 °C for an hour, the products were collected by magnet and washed several times with deionized water and ethanol to remove impurities. The product is dried by a freeze dryer and stored in a cool place under vacuum and sealed conditions. Subsequently, the morphology of Co$_{0.2}$Fe$_{2.8}$O$_4$ nanoparticles was investigated by TEM as shown in Fig S1. Through observation, the Co$_{0.2}$Fe$_{2.8}$O$_4$ nanoparticles is spherical and have an average diameter about of 50 nm.

Fig. S1. The TEM image of the synthesized Co$_{0.2}$Fe$_{2.8}$O$_4$. 
**SI-2: Preparation of coaxial rings of paraffin matrix materials**

First, a certain amount of EWC/MNPs/WSGO was put into a mortar, ground into powder, and bagged for storage. Then weigh 0.1 g EWC/MNPs/WSGO and 0.1 g paraffin, add them into the mortar and grind them vigorously to make them evenly mixed. Then the mixture was poured into a standard mold and compacted with a bench vice to obtain a coaxial ring with an outer diameter of 7.0 mm, an inner diameter of 3.04 mm, and a thickness of 2.0 mm.

**Fig. S2.** The coaxial ring of materials with paraffin matrix for measurement of electromagnetic parameters and EMW absorption performances.
Fig. S3. The EDS elemental data for EWC/MNPs/WSGO-1.0.
SI-3: Thermogravimetric Analysis (TGA)

TGA was performed to further explore the content of metal nanoparticles in the composite absorbers, in air atmosphere, when the temperature rises to 450 °C, the sample mass increases. This is because Fe and Co react with oxygen to form metal oxides under high-temperature conditions, increasing sample’s mass. When the temperature is higher than 450 °C, the carbon components in the sample begin to decompose. When the temperature is up to 750 °C, the carbon components are completely decomposed, and the remaining components are only metal oxides. According to equation 1, the weight percentages of metal for EWC/MNPs/WSGO-0.0, EWC/MNPs/WSGO-0.5, EWC/MNPs/WSGO-1.0, EWC/MNPs/WSGO-2.0, EWC/MNPs/WSGO-4.0 were calculated as 15.90, 14.49, 12.18, 11.16 and 9.86 wt%, respectively.

\[ C_{(\text{wt}\%)} = \left( \frac{m_r}{m_i} \right) \ast 2 \ast \frac{A_M}{M_{M_3O_4}} \]  

(1)

where \( C_{(\text{wt}\%)} \) is the content of metal, \( m_r \) is the remaining weight, \( m_i \) is the initial weight of the sample, \( A_M \) is the atomic weight of the metal, and \( M_{M_3O_4} \) is the molecular weight of \( M_3O_4 \). In the case of EWC/MNPs/WSGO-0.0, EWC/MNPs/WSGO-0.5, EWC/MNPs/WSGO-1.0, EWC/MNPs/WSGO-2.0, EWC/MNPs/WSGO-4.0, the average atomic weight of the Fe/Co alloy and the average molecular weight of the corresponding oxides are calculated based on the initial Fe/Co molar ratios of the preparation process for EWC/MNPs/WSGO and used in equation 1.
**Fig. S4.** TGA curves of EWC/MNPs/WSGO-0.0, EWC/MNPs/WSGO-0.5, EWC/MNPs/WSGO-1.0, EWC/MNPs/WSGO-2.0, and EWC/MNPs/WSGO-4.0 composites in air.
Fig. S5. Cole–Cole plot of EWC/MNPs/WSGO-0.0 (a), EWC/MNPs/WSGO-0.5 (b), EWC/MNPs/WSGO-1.0 (c), EWC/MNPs/WSGO-2.0 (d), and EWC/MNPs/WSGO-4.0 (e).
Fig. S6. the value of the eddy current ($C_0$, $\mu''(\mu')^{-2}f^{-1}$) of EWC/MNPs/WSGO-0.0 (a), EWC/MNPs/WSGO-0.5 (b), EWC/MNPs/WSGO-1.0 (c), EWC/MNPs/WSGO-2.0 (d), and EWC/MNPs/WSGO-4.0 (e).
Fig. S7. (a) The RL-Frequency curves of EWC/MNPs/WSGO-1.0 in 2–18 GHz with the absorber content of 50 wt% ; (b) Relationship between simulation thickness and peak frequency of EWC/MNPs/WSGO-1.0.