

Supporting information for

Bio-gel Derived Nickel/Carbon Nanocomposites with Enhanced Microwave Absorption

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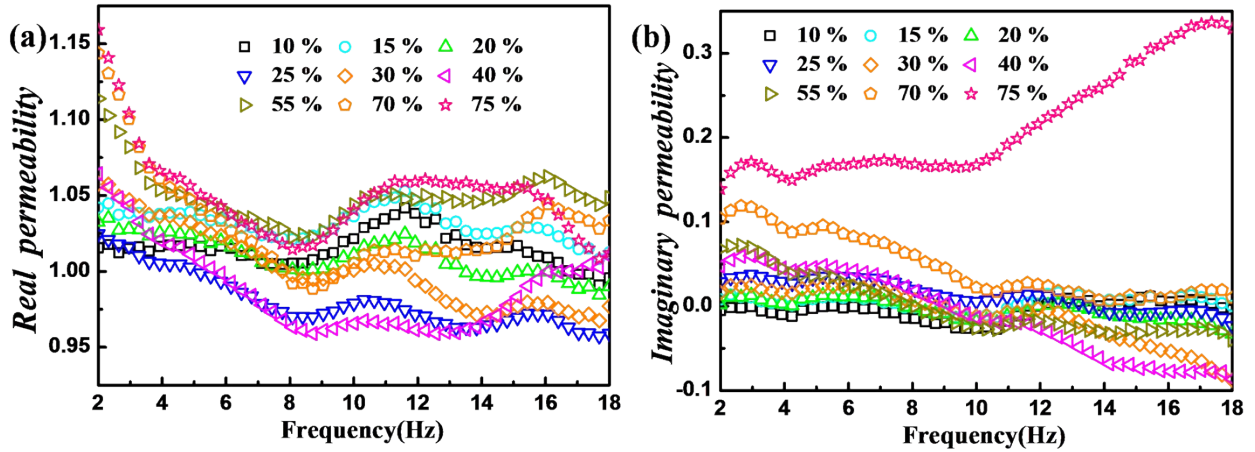


Fig. S1. Real permeability (a) and imaginary permeability (b) of paraffin composites with different Ni/C content in 2-18 GHz region.

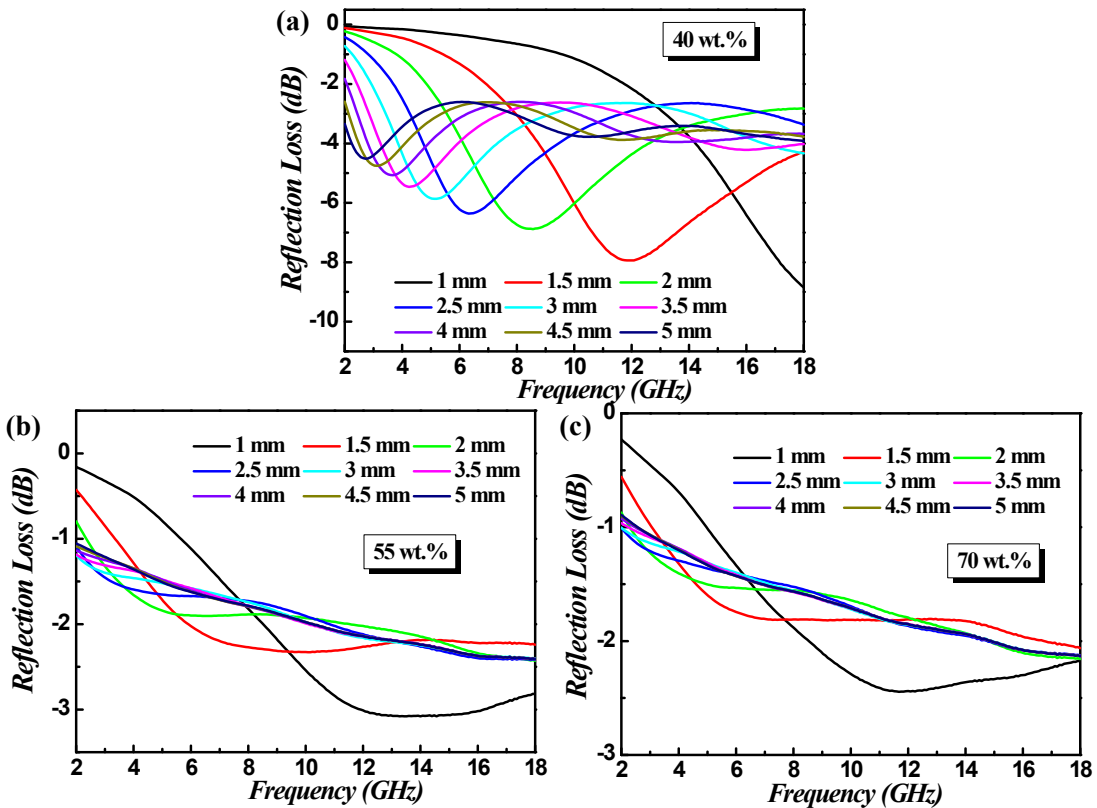


Fig. S2. Frequency dependence of RL curves for paraffin composites with (a) 40, (b) 55 and 70 wt% Ni/C powder at certain thicknesses.

Fig. S2 shows the frequency dependence of RL curves for paraffin composites with 40, 55 and 70 wt% Ni/C powders at certain thicknesses. It is observed that the absolute values of RL are all smaller than 10, indicating bad microwave absorption property. It is worth noting that the RL property of composites with 55 % Ni/C is worse than that of the composites with 40 % Ni/C, while the RL property of composites with 70 % Ni/C is the worst in the three samples. When the Ni/C content is high, the resulting high permittivity results in poor impedance matching. Besides, the high Ni/C content could also lead to high conductivity with the formation of percolating network, which further leads to the reflection of electromagnetic wave at the surface of paraffin composites.

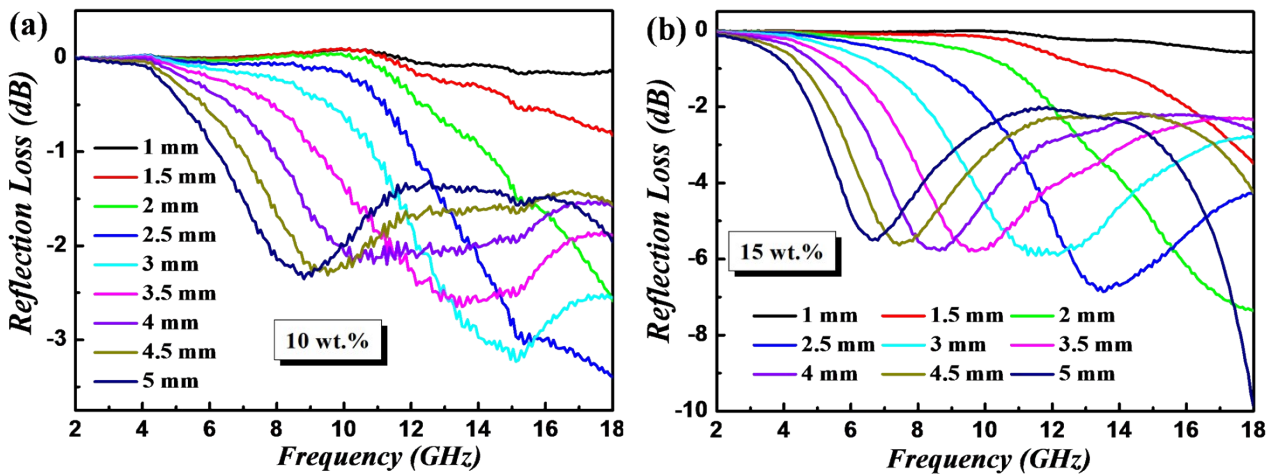


Fig. S3. Frequency dependence of RL curves for paraffin composites with (a) 10 wt% and (b) 15 wt% Ni/C powder at certain thicknesses.

Fig. S3 shows the frequency dependence of RL curves for paraffin composites with 10 and 15 wt% Ni/C powders at certain thicknesses. The absolute value of RL is usually bigger than 10 for most microwave absorption materials. Therefore, the microwave absorption property is bad for the paraffin composites with 10 and 15 wt% Ni/C content. The reason for bad absorption property is that the Ni/C content is too low and dielectric loss is not high enough to completely absorb the electromagnetic waves inside the composites.

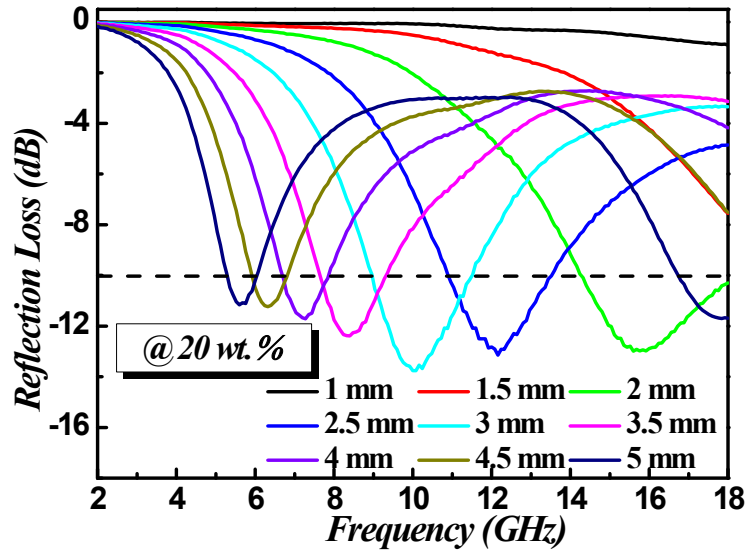


Fig. S4. Frequency dependence of RL curves for paraffin composites with 20 wt% Ni/C powder at certain thicknesses.

Fig. S4 shows the frequency dependence of RL curves for paraffin composites with 20 wt% Ni/C powder at certain thicknesses. As we all know, the RL values of -10 dB correspond to 90% attenuation of the incident EM wave. The absolute value of minimum RL value for the paraffin composite with 20 wt% Ni/C powder decreases with increasing the thickness, and the absorption bandwidth also decreases with increasing the thickness. At the thickness of 2.0 mm, the minimum RL value is 12.99 dB, and the maximum absorption bandwidth is 3.68 GHz for RL= -10 dB. However, the absorption property of composites with 20 wt% Ni/C powders is not good enough compared with the composites with 25 and 30 wt% Ni/C powders due to its small absorption, narrow bandwidth and high thickness (in **Fig. 7**).

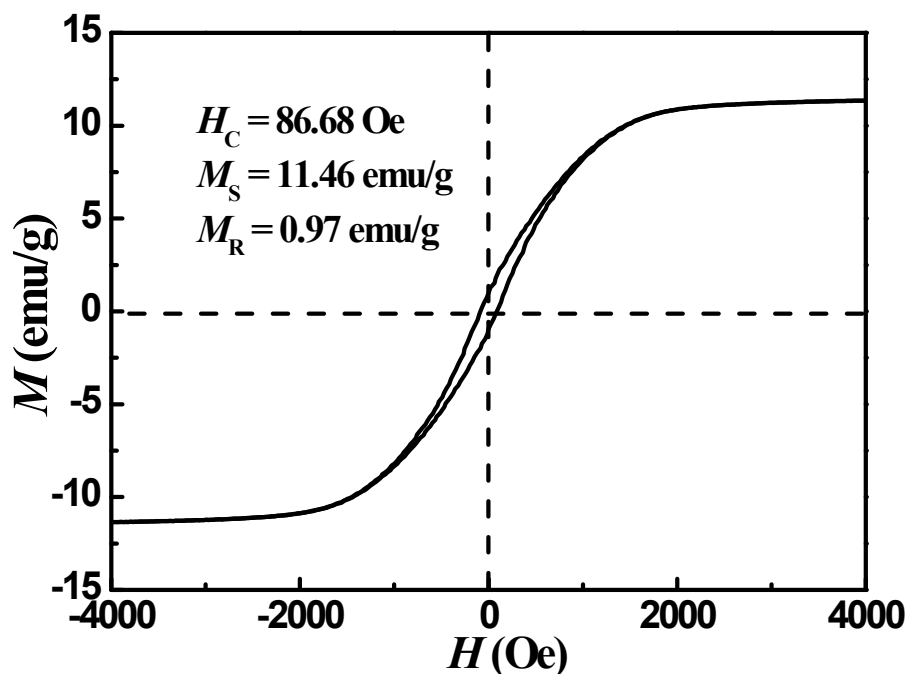


Fig. S5. Hysteresis loop of Ni/C nanocomposites at room temperature.

The hysteresis loop of Ni/C nanocomposites at room temperature is shown in Fig. S5. The saturation magnetization (M_s) of Ni/C nanocomposites is 11.46 emu/g, much smaller than that of bulk nickel (ca. 55 emu/g),¹⁻² which is mainly attributed to the low Ni content. Besides, the destruction of magnetic domain at near-surface region and magnetically dead oxidation layer on the surface of Ni nanoparticle also lead to the decrease of M_s .³ The remnant magnetization (M_R) and coercivity of Ni/C nanocomposites are 0.97 emu/g and 86.68 Oe, respectively. The low coercivity of Ni/C nanocomposites (nickel bulk: ca. 100 Oe) can be attributed to the size effect in nanoscaled magnetic materials.¹⁻²

Reference

1. J. Hwang, V. Dravid, M. Teng, J. Host, B. Elliott, D. Johnson, T. Mason, *J. Mater. Res.* **1997**, 12 (4), 1076-1082.
2. M. Ning, H. Zhu, Y. Jia, H. Niu, M. Wu, Q. Chen, *J. Mater. Sci.* **2005**, 40 (16), 4411-4413.
3. Z. Zhang, H. Wang, C. Qin, S. Chen, X. Ji, K. Sun, M. Chen, R. Fan, X. Han, *Mater. Design* **2016**, 89, 543-548.