Microwave properties of segregated composites with polyethylene and Fe_{20} Ni_{80} -decorated graphite nanoplatelets

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•Aim

The aim of this work is to define the influence of metal decoration of graphite nanoplatelets nanocarbon on the electrical conductivity and shielding properties of segregated composite materials (SCM) GNPFe$_{20}$Ni$_{80}$-UHMPE

•Object

Polymer matrixes: ultra-high molecular weight polyethylene (UHMPE)

Fillers: GNPs and Fe$_{20}$Ni$_{80}$-decorated GNPs

•Electrical properties

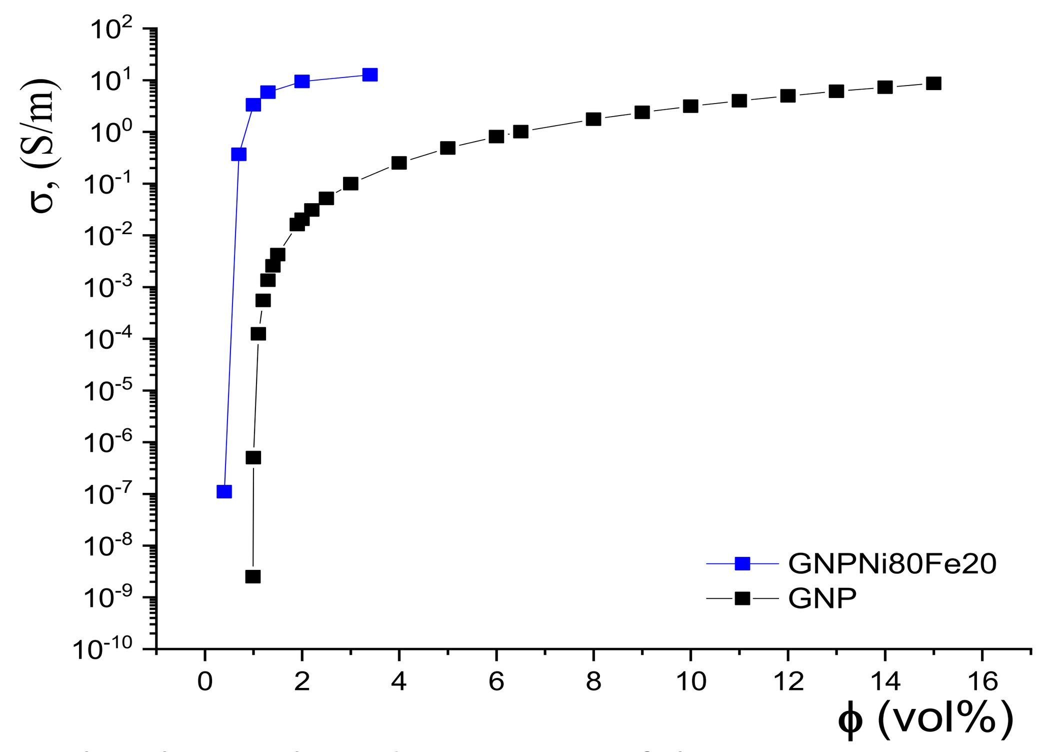

Fig. 1. The electrical conductivity σ_{DC} of the composites GNPs/PE, GNPs-FeNi/PE

SCM GNP-FeNi-UHMPE has lower percolation threshold than GNP-UHMPE (ϕ~0,95 vol.%) for GNPs/PE, and 0,45% for GNPs-FeNi/PE

•Method of preparation

Mechanical mixing of PE and GNP powders in homogenizer ULTRA TURRAX tube drive, hot pressing at 120 °C during 10 min at 110 MPa with subsequent cooling down to the room temperature

The thickness of the samples is 1 mm

•Research method

The DC electrical conductivity was measured using a two-contact scheme. Microscopic studies of composite samples were performed by using optical microscope ("Mikmed-1" with ETREK PCM-510 attachment). The EMI shielding properties of the composites were tested in a frequency range of 26-37 GHz at room temperature using P2-65 device

•Morphological study

Scanning electron microscopy

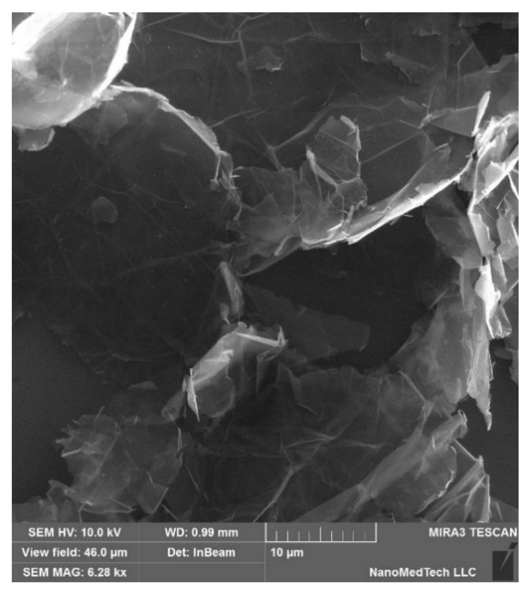

Fig. 2. SEM image of the source GNP

Fig. 3. SEM image GNPNiFe

Optical microscopy

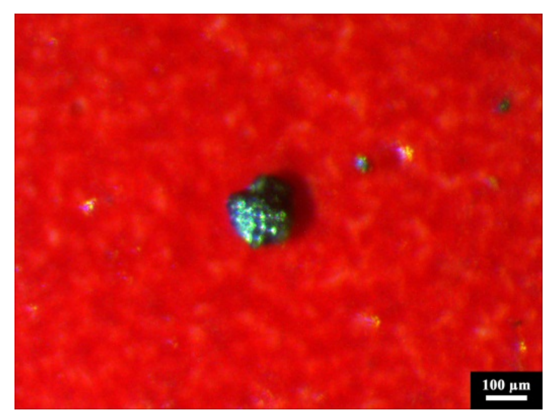

Fig. 4. Polyethylene covered with GNPNiFe

Optical microscopy

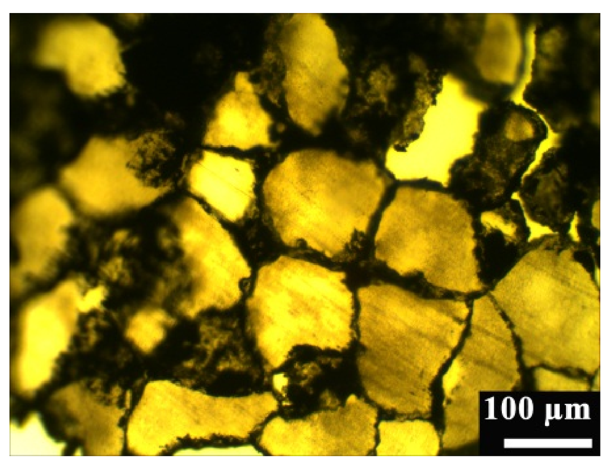

Fig. 5. SCM GNP/UHMPE

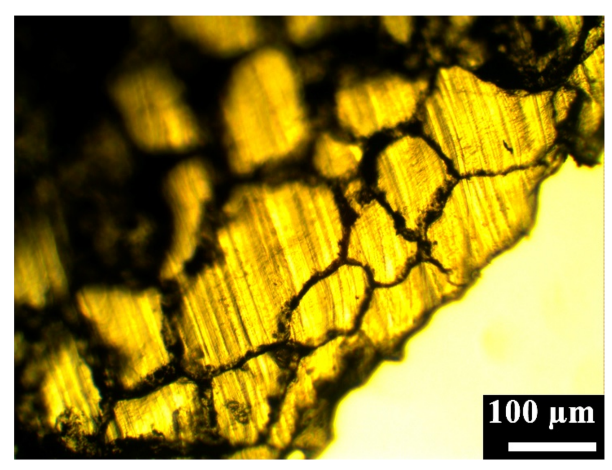

Fig. 6. SCM GNP-NiFe/UHMPE

•Electromagnetic shielding properties

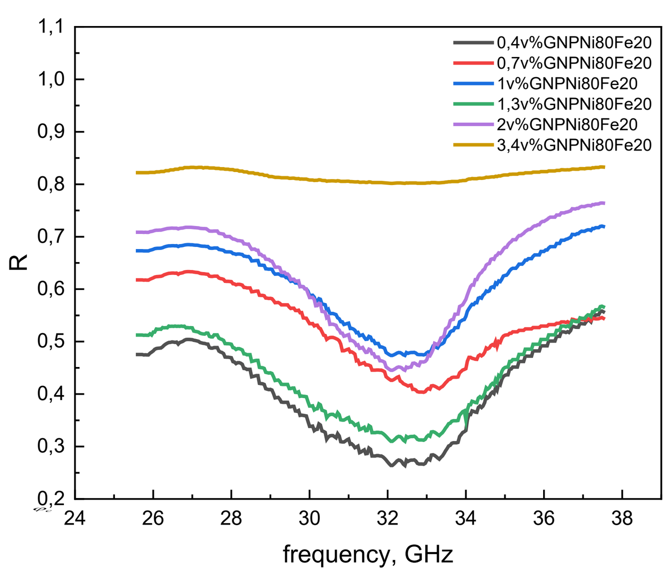

Fig. 7. The frequency dependences of the reflection of SCM

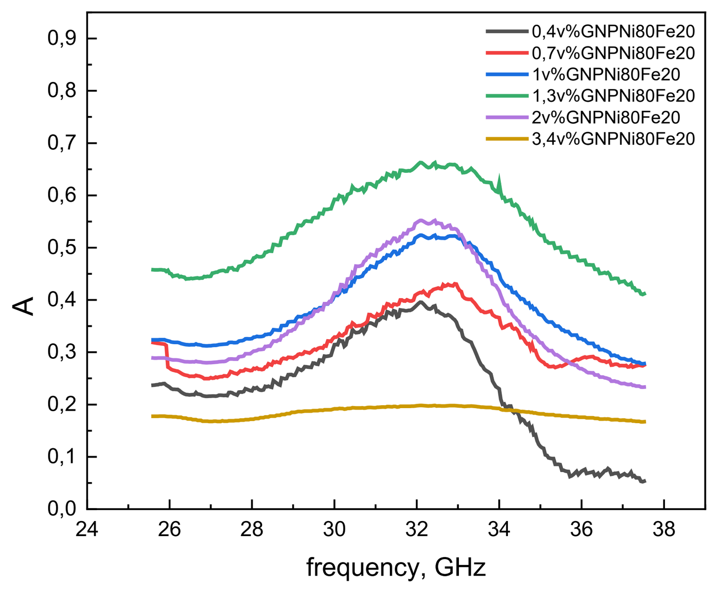

Fig. 8. The frequency dependences of the absorption of SCM

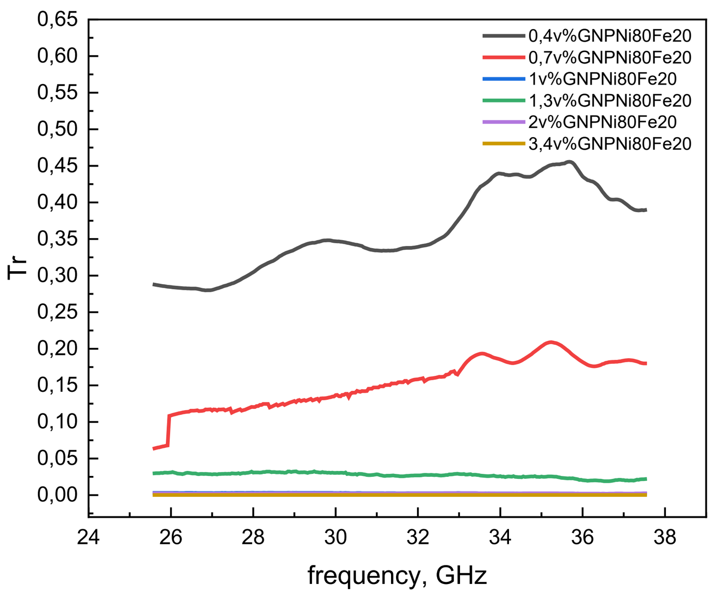

Fig. 9. The frequency dependences of the transmittance of SCM

$$T = |S_{21}|^2 \qquad R = |S_{11}|^2$$

$$A = 1 - |S_{11}|^2 - |S_{21}|^2$$

$$A_{eff} = \frac{A}{1-R}$$

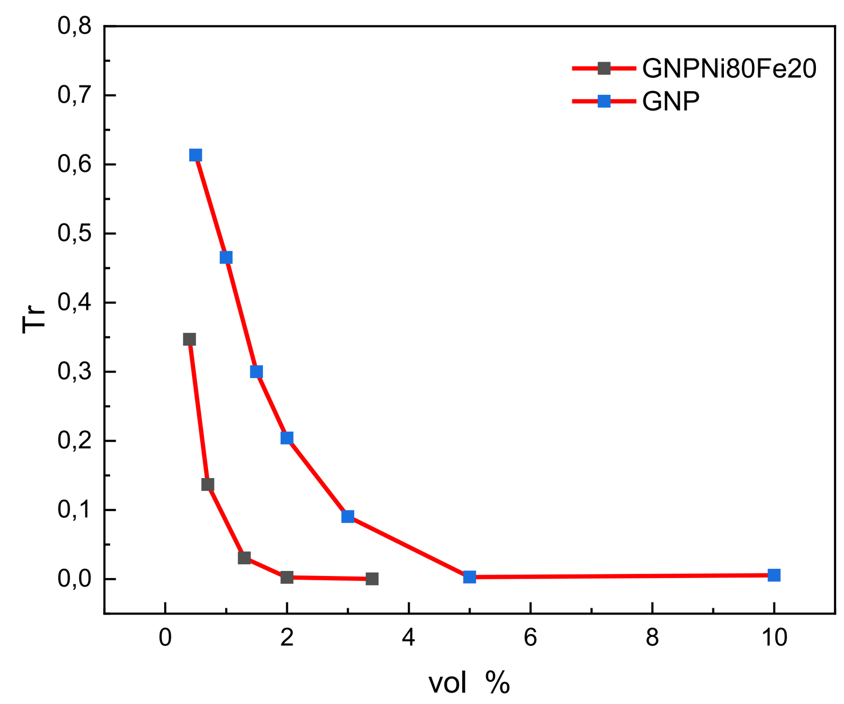

Fig. 10. The concentration dependence of the transmittance of SCM

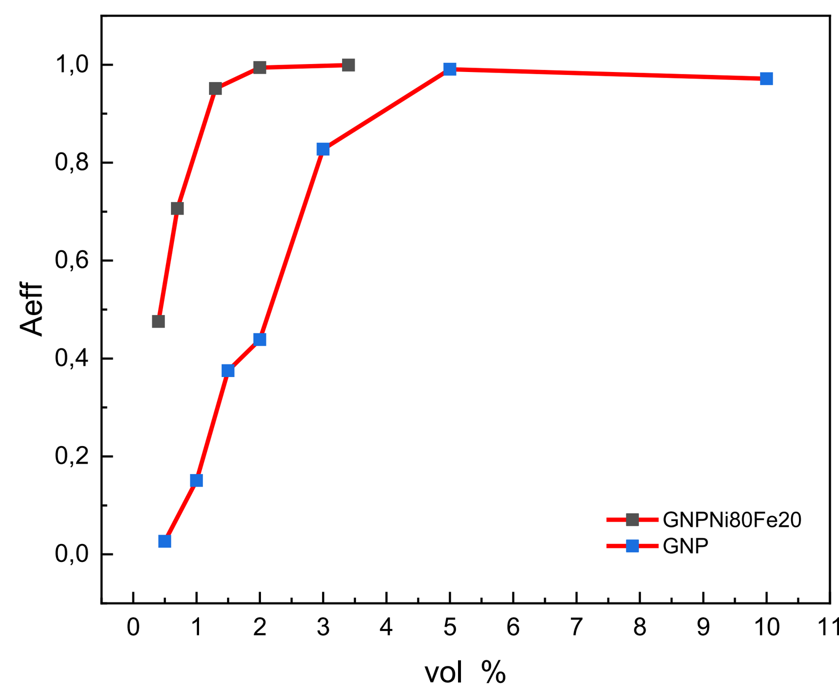

Fig. 11. The concentration dependence of the A_{eff} of SCM

•Conclusion

The frequency dependences of the reflection have a minimum in the vicinity of the frequency of 32.5 GHz, which disappears with increasing filler concentration up to 3.4 vol.%. The concentration dependence of the transmittance has a sharp decreasing character, resembling the percolation behavior for both SCM with and without metal decoration. This increase in shielding properties with increasing filler concentration is due to the predominant absorption mechanism. The results of the study of the concentration dependence of the effective absorption coefficient confirm this. It is shown that the presence of metal decoration on a carbon filler significantly increases the absorbing properties of CM, so SCM GNP-NiFe has 95% absorption only at 2 vol% of the filler content.

Segregated composites with GNP and GNP decorated with metal Fe$_{20}$Ni$_{8}$ were manufactured and their structure, morphology, electrical and shielding properties are investigated. The influence of metal decoration is determined In Fe$_{20}$Ni$_{80}$-decorated GNPs the metal component is in the form of granules and is fairly evenly distributed over the surface of the GNPs plates. It is shown that the presence of a metal component leads to a shift of the percolation threshold of electrical conductivity and to a significant increase in the value of electrical conductivity, as well as to a significant increase in the electromagnetic shielding characteristics of the CM due to increased absorption level.