Microwave absorbing performances of hybrid composites based on nanocarbon and magnetic nanoparticles with negative permeability

Ludmila Matzui, Oleksii Syvolozhskyi, Ludmila Vovchenko, Olena S.Yakovenko , Oleg Turkov, Olena Ischenko , Anna Vakaliuk, Victor Oliynyk, Volodymyr Zagorodnii

Kyiv National Shevchenko University, Physical department, Volodymyrska Str., 64, Kyiv 01033, Ukraine

Structure

SEM

X-ray

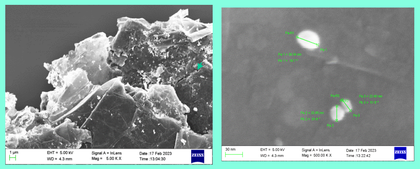


Fig.1: SEM images of GNPs decorated by Fe_3O_4 a different magnification A

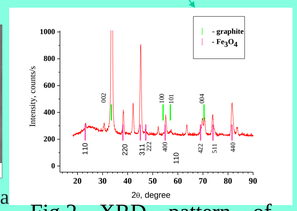


Fig.2 XRD pattern of GNPs decorated by Fe_3O_4

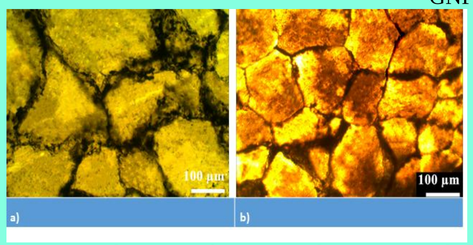


Fig.3 Optical images of GNPs conductive network formation in segregated 0.5 vol% GNPs/UHMPE (a) and 0.5vol%GNPs-Fe_3O_4)/ UHMPE (b) composites

AIM

The aim of this work was to to study the electrodynamic characteristics of segregated polymer composites based on ultra-high-molecular-weight polyethylene (UHMWPE)) filed with hybrid filler – **nanocarbon and magnetic nanoparticles in** *the frequency ranges* 40 – 60 GHz as a function of the content of electroconductive filler particles

Electrodynamic parameters

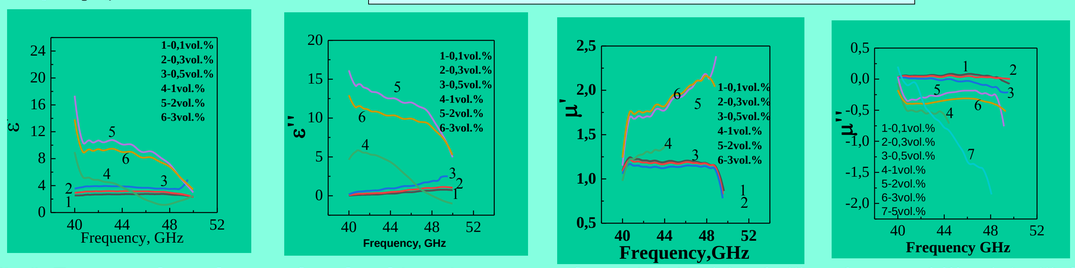


Fig.8. Frequncy dependences of real and imaginary parts of permittivity (ε'and ε'') and permeability (μ',μ'') for SCMs (GNPs/ Fe_3O_4)/UHMWPE

$$\varepsilon'' = \varepsilon_p'' + \varepsilon_p'' = (\varepsilon_s - \varepsilon_\infty)\frac{\omega\tau}{1+\omega\tau} + \frac{\sigma}{\varepsilon_0\omega}$$

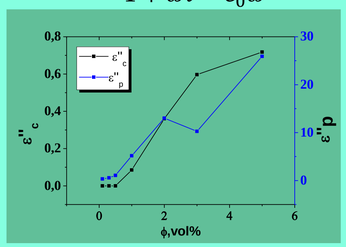


Fig.9. Loading dependences of ε'$_c$, and ε'$_3$ for SCMs (GNPs/ e_3O_4)/UHMWPE

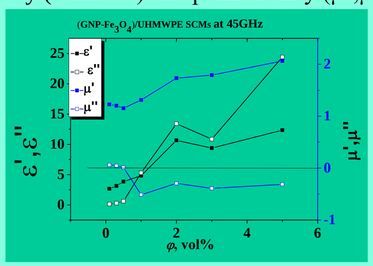


Fig.109. Loading dependences of ε', ε'', μ' and μ'' for SCMs (GNPs/ e_3O_4)/UHMWPE

$$C = \mu''(\mu')^{-2} \quad f^{-1} = 2\pi\mu_0\sigma d^2$$

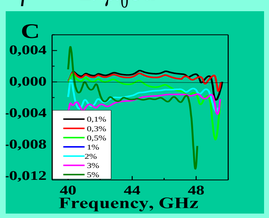


Fig11.. Loading dependences of C for SCMs (GNPs/ e_3O_4)/UHMWPE

Conductivity

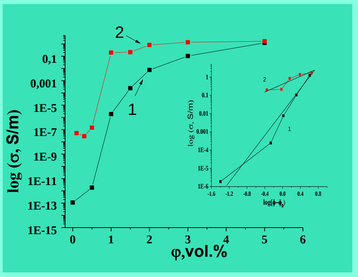


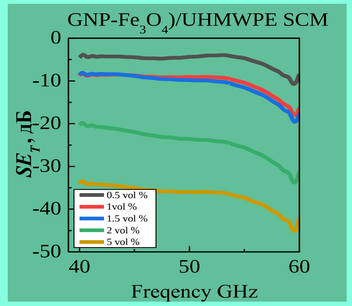
Fig4. Concentration dependences of conductivity for the SCMs GNPs/ UHMPE (1) and GNPs Fe_3O_4/ UHMPE (2)

Table. 1 Parameters of *percolation threshold* φ_c *,critical exponent t, adjustable parameter* σ_0 *for the studied composites*

Composite	φ_c, vol.%	t	σ_0, S/m
SCMs GNPs/UHMWPE	0.97	2.78	9.78
SCMs (GNPs/ Fe_3O_4)/UHMWPE	0.56	1.63	4.25

Increase filler content → increase conductivity
increase imaginary parts of permeability
increase imaginary part of permittivity

Microwave properties



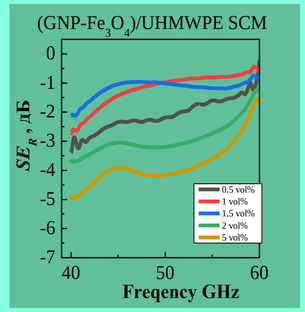


Fig.5.Freqrncy dependences of SE_T (a) and SE_A(b) for SMC (GNPs/ Fe_3O_4)/UHMWPE

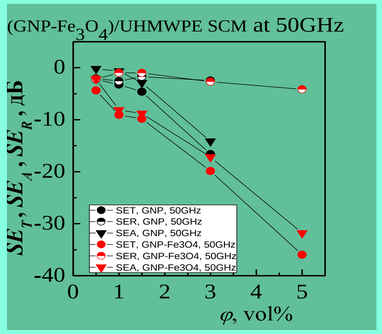


Fig65. Loading dependences of shielding efficiency SE_T, reflection SE_R and absorption SE_A for segregated SCMs GNPs/ UHMPE and GNPs/Fe_3O4/ UHMPE

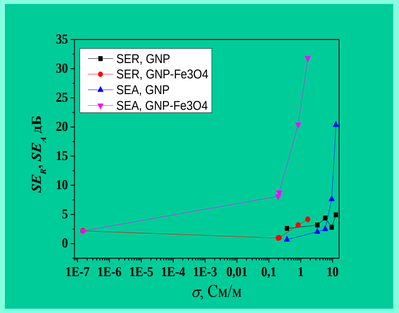
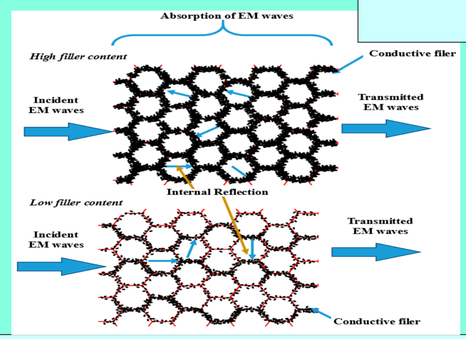


Fig.7. Relationship between conductivity σ_{DC} and SE_A, SE_R of SCMs (GNPs-Fe_3O_4)/UHMPE at the frequency at 50 GHz.

Model



Conclusions

-The segregated polyethylene-based composites with hybrid filler GNPs decorated by Fe_3O_4 nanoparticles have been developed and their structure , morphology , electrical and shielding properties have been investigated.

-It was revealed an essential increase of the shielding characteristics **of SCMs GNPs/Fe_3O_4/ UHMPE** in compare with SCMs GNPs/ UHMPE. SE_A values are much higher than the SE_R values and the difference between SE_A and SE_R values is increased with increased fillers that indicates in a absorption dominant mechanism of EMR interaction in a of segregated composites due multiple reflections and the scattering of incident EMR, and consequently enhances the electromagnetic absorption ability due to the synergistic effect between Fe_3O_4 nanoparticles and GNPs.

-The negative permeability have been revealed in investigated composite and its dependences filler content and frequency of EMR have been investigated.