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Table 1. Magnetic properties, electrical conductivity, shielding effectiveness and thermal stability of γ-Fe_2O_3 NP, RF and PANI/RF composites

Sample name	Ms value (emu/g)	Electrical conductivity (S/cm)	Thickness (mm)	Shielding effectiveness (dB)	IDT (°C)	RF content (wt %)	
						With respect to monomer	Calculated from residual wt at 900°C
PRF10	--	21.49	2.5±0.08	25.95	237	0.0	0.0
PRF11	2.47	28.62	2.5±0.10	39.71	273	50.0	20.17506
PRF12	5.42	39.78	2.5±0.07	40.90	281	66.7	43.15903
PRF13	7.03	53.83	2.5±0.05	51.59	291	75.0	60.55326

Initial decomposition temperature (IDT) (2 °C) where degradation reactions first started

Reflection loss have been calculated from experimental S parameter (S_{11}) using "Agilent E83628 PNA Vector Network Analyser". Measurement have been performed according to Belaabed et. al. (B. Belaabed, J. L. Wojkiewicz, S. Lamouri, N. El Kamchi and T. Lasri, *Journal of Alloys and Compounds*, 2012, **527**, 137-144.) Experimentally, the electromagnetic wave absorbing samples are prepared by compressing powder samples in the form of rectangular pellets of dimension 22.8×10 mm² with a thickness of ~2mm. The wave guide is fitted with the sample backed by a metal short as shown in Fig X1.

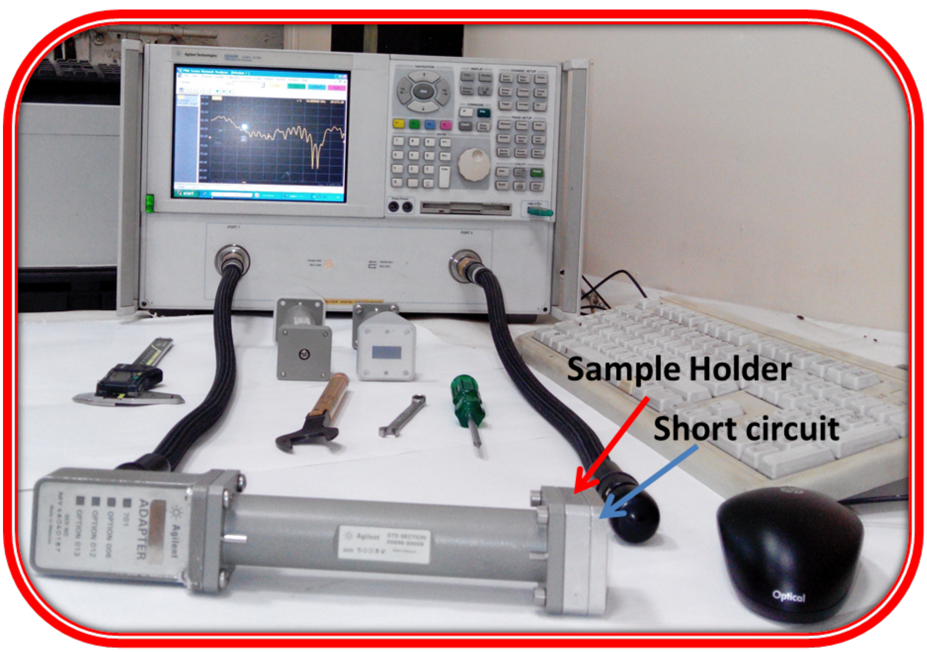

Fig. X1. Reflection loss (RL) measurements using Agilent E8362B Vector Network Analyzer with single port microwave setup for scattering parameters measurements (S_{11}), Sample is placed inside the sample holder backed by a metal short.

According to the transmission line theory, microwave absorbing performance of a shield attributed to many factors, such as complex permittivity, complex permeability, thickness of shield, specific surface area, electrical conductivity and the frequency wave. The % absorption efficiency of the shield is associated to the amount of the charge and its degree of the dispersion.

Theoretically, the microwave reflection loss RL (dB) is calculated from the relative permeability and permittivity at the given frequency and absorber thickness. The reflection loss of any absorber can be expressed as [60–62]:

R_L (dB) = 20 log|(Z_{in} –Z_0)/(Z_{in} + Z_0)|,

where Z_0 =μ_0/ε_0 =377 Ω is the characteristic impedance of free space, and Z_{in} is the input impedance of materials interface

$$Z_{in} = Z_o\sqrt{\mu/\varepsilon}\tanh\left[j(2\pi fd/c)\sqrt{\mu/\varepsilon}\right]$$

is a function of six characteristic parameters, viz. μ', μ'', ε', ε'' f (frequency), and d (the sample thickness)) and c is the velocity of light.

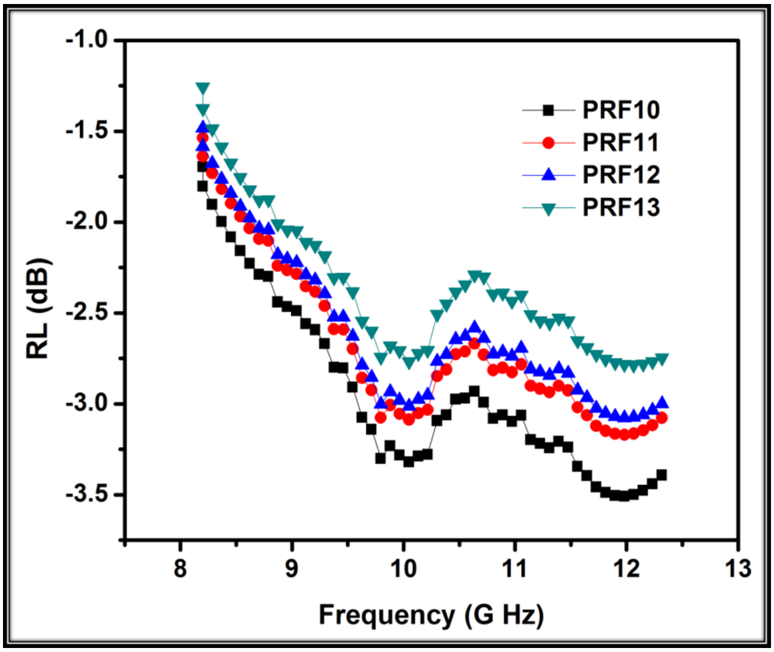

Fig. X2. The reflection loss of PANI-rGO/iron oxide hybrid composites as a function of frequency at different filler's amount:

The wave absorption property can be deduced from the measurement of the reflection loss RL (S_{11}) given by the network analyzer:

RL = 20 log (S_{11})

The minimal reflection of microwave energy can be attributed to the dip in RL. Fig. X2 presents the reflection loss of PANI composites.

As shown in figure, all of composites indicate a value of ~ 2.5 to 3.25 (-dB) reflection loss at the indicated frequency. These results obviously demonstrate that the intensity and the frequency of the microwave energy absorption for the composite also depend on the rGO and iron oxide content in the polyaniline. Thus, microwave absorption properties of composite are improved by the dielectric and magnetic losses.