

Characteristic Observation of Mechanical and EMI Shielding Property of ABS

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ABSTRACT: The growth in the application of electromagnetic devices across a broad spectrum of military, industrial, commercial and consumer sector has created a new form of pollution known as noise or Radio Frequency Interference (RFI) or Electromagnetic Radiation or Electro Magnetic Interference (EMI) that can cause interference or malfunctioning of equipment. Therefore there is a great need for the effective shielding of components from its adverse effect.

In this topic we will be discussing about an engineering plastic such as ABS (Acrylonitrile butadiene styrene) which is reinforced with chopped carbon fibers of 3mm length, electrolessly coated with Carbon Ferrite (CuFe₂O₄) Nano crystals to obtain good mechanical and electrical properties. Carbon Fibers were characterized by XRDA (X-Ray Diffraction Analysis) and SEM (scanning electron microscope).

KEYWORDS: Carbon Fibers, ABS (Acrylonitrile butadiene styrene), Copper Ferrite, Nano crystals, electro less plating.

I. INTRODUCTION

EMI shielding refers to the reflection and absorption of electromagnetic waves by a material that can shield the transmission of waves from sources. The shielding process can be divided into three mechanisms, including reflection, absorption, and multiple reflections. Magnetic metals have been extensively researched and are commonly utilized for electromagnetic wave shielding materials. However, metal-based materials have disadvantages such as corrosion, heaviness, and manufacturing challenges. For these reasons, EMI shielding materials having a low density, the ability to weaken EMI, and ease of manufacture are very important. Recently, carbon materials have been recognized as an appropriate alternative for EMI shielding materials compared to ordinary ferrite and magnetic metals, since carbon materials provide good performance such as high strength, good electrical properties, and light weight. Among carbon materials, carbon fibers (CFs) are suitable EMI shielding material that can absorb electromagnetic waves and withstand loads. However, carbon materials used for shielding electromagnetic waves have the shortcoming of poor magnetic properties, which restricts their further advancement in terms of shielding performance. Therefore, hybrid materials containing carbon materials and metal particles with dielectric polarization, magnetic loss performance, and interface interactions have potential as high-performance shielding materials. Among a number of methods investigated, electroless plating would be a favorable method because its process is simple and cost effective, in particular when metals are used as the magnetic components and CFs as the core. It is well accepted that a reasonable combination of core and shell materials is crucial for improved EMI shielding efficiency since the match between magnetic and dielectric components determines the final attenuation to EMI. Therefore, it can be expected that CFs plated with alloy particles will show excellent electromagnetic interference shielding efficiency. In this work, CuFe₂O₄/CFs composites was coated and reinforced in ABS polymer to study its mechanical and EMI Shielding properties. The electromagnetic interference shielding effectiveness of CuFe₂O₄/CF's ABS composites was investigated in the 500 MHz –1.5 GHz frequency range and good shielding effectiveness of the composites was obtained.]

II. LITERATURE SURVEY

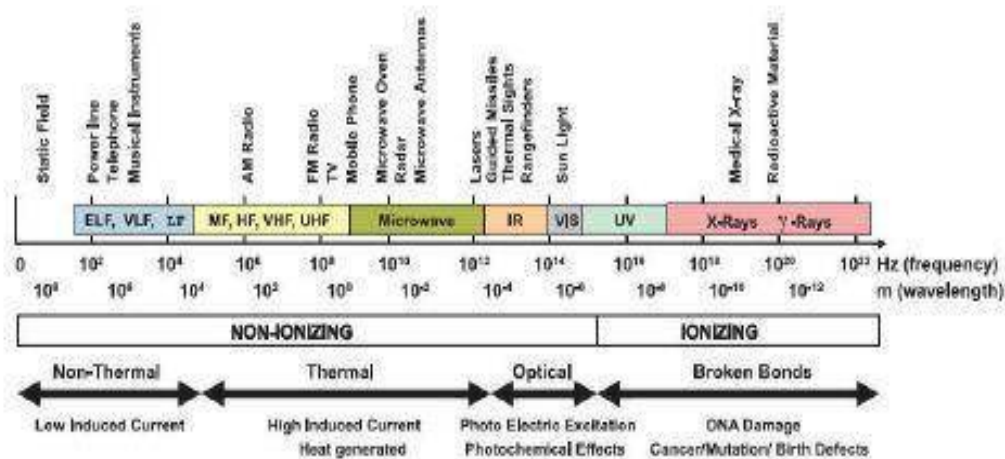


Fig. 1 Graphical representation of the spectrum of electromagnetic

The above figure is a graphical representation of the spectrum of electromagnetic waves and their applications. In recent years, electromagnetic (EM) waves in the 1-10 GHz range are broadly used in wireless communication tools and local area networks. In the future, the usable range of EM waves will tend to shift further to higher frequency regions with the development of information technology as well as electronic devices. As a consequence, the seriousness of problems such as EMI of electronic devices and health issues are ever rising.

When an EM field is passed through an object, there are three phenomena that determine how the field strength is lost as it interacts with the object: absorption attenuation, attenuation due to reflection, and attenuation due to successive internal reflections (usually neglected) as shown in Figure 1. As the wave impinges the surface of the object, it forces charges in the object to oscillate

at the same frequency of the incident wave. This forced oscillating charge behaves as an antenna and results in reflection. The entire signal is not reradiated in the direction of the incident wave, resulting in measured signal loss. The field is emitted in many directions in a pattern associated with a signal charge oscillating antenna, and hence the field is scattered. As the charge is forced to vibrate in the medium, energy is lost in the form of heat. This mode of signal loss is known as attenuation due to absorption.

Thus, EM shields function on the basis of the above mentioned two major EM mechanisms: reflection from a conducting surface, and absorption in a conductive volume. An EM wave striking a metallic surface encounters both types of loss. Part of the wave is reflected, while the remainder is transmitted and attenuated as it passes through the media. The combined effect of these losses (reflection and absorption) determines the effectiveness of the shield.

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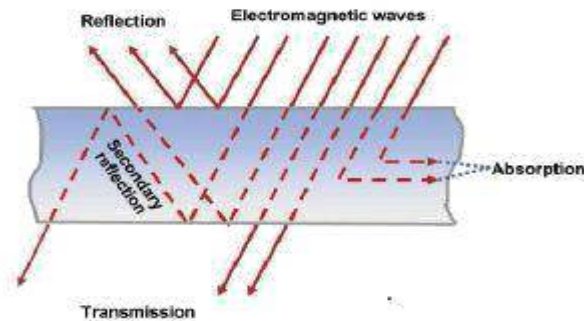


Fig. 2

Reflections from an EM shield results when the impedance of the wave in free space is different from the impedance of the EM wave in the barrier. This phenomenon is independent of the barrier thickness and is a function of the materials conductivity, magnetic permeability, and frequency. An EM wave consists of an electric component and a magnetic component perpendicular to each other and propagates at right angles to the plane containing the two components. As the wave impedance is different for magnetic fields (low impedance) and electric fields (high impedance), the barrier reflection follows a different characteristic for each wave type. Electrically conductive materials such as metals reflect EM fields to prevent them from escaping or penetrating the shield.

Absorption in an EM shield, transforms EM energy into thermal energy. EM shields made of EM absorbers attenuate undesirable EM waves and substantially solve EMI. The absorption loss does not depend on the wave impedance of the impinging field, and thus it is not directly related to near-or far-field conditions of the system. The shield's effectiveness varies with frequency, shield geometry, positioning within the shield, type of field being attenuated, directions of incidence, and polarization. In general, the materials used for absorbing EM waves can be classified into two

groups: (1) materials with high dielectric constant, such as BaTiO₃, carbon particles, and (2) materials with high permeability, such as Fe₃O₄, ferrite materials. Materials with high dielectric constant absorb the electric energy and convert it into thermal energy, while materials with high permeability convert the magnetic energy into thermal energy. EM absorbers could be applied in many fields besides EMI suppression i.e. radar camouflage and stealth technology, microwave noise control, microwave antenna patterning, microwave curing and heating, and finite resistance paths.

III. METHODOLOGY

The work flow of this project work is as follows,

1. Procurement of materials
2. Electro less coating of CuFe₂O₄ on Carbon Fibers
3. Melting of ABS
4. Preparation of Samples
5. Testing of prepared samples

IV. EXPERIMENTAL DETAILS

Electroless-Coating. The chopped carbon fibers were coated with copper ferrite using electro less method.

The sensitizing treatment was carried out in 200mL of solution containing 10g of tin (II) chloride (SnCl₂) and 2mL of hydrochloric acid for 15-30 mins. Then the sensitized carbon fibers were rinsed in distilled water. Then it was transferred to activating 200ml solution containing 0.5g of Silver Nitrate and 2ml of hydrochloric acid and stirred for 15-30 mins. The activated carbon fibers are rinsed in distilled water. And was transferred to the bath containing 5g of Cupric Sulphate and 5g of Ferrous Sulphate dissolved in sulphuric acid along with distilled water. 5g of Sodium Citrate, 5g of NaOH pellets and 5ml of hydaxine was added and mixed using mechanical stirrer and allowed for a day. The coated carbon fibers were drained, rinsed and was subjected for characterization. (Refer Fig. 1)

Preparation of the sample. For the preparation of sample, weighed amount of ABS (Acrylonitrile Butadiene Styrene) is melted in Acetone. Once the ABS was fully molten then weighed amount of coated carbon fibers are added to it, mechanically stirred and poured to the die of (100mm X 100mm) depth 1.5mm and kept in for about 30-40 mins. Then the die is taken out and cooled down, the prepared sample was kept in hot air oven to separate it from the dye. (Refer Fig. 2 & 3)

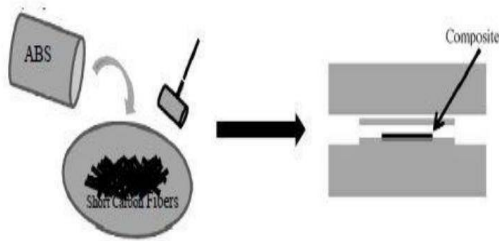


Fig. 3

Sl. No.	Percentage	ABS	Carbon fibers
1	0	13g	0g
2	5	12.35g	0.65g
3	10	11.7g	1.3g
4	15	11.05g	1.95g
5	20	10.4g	2.6g

Table 1



Fig. 4



Fig. 5

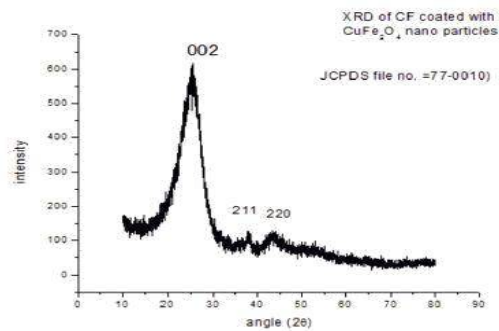
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V. RESULTS AND DISCUSSION

X-Ray Diffraction Analysis. The graph obtained from the analysis of the software matches with the JCPDS file No. 77-0010.



Graph 1

SEM Analysis. The two images of different spots shows that CuFe_2O_4 was coated with high adherence at some spots of the fiber surface it is coating was broken. This may be due to pH effect during the coating process or may be due to mechanical agitation.

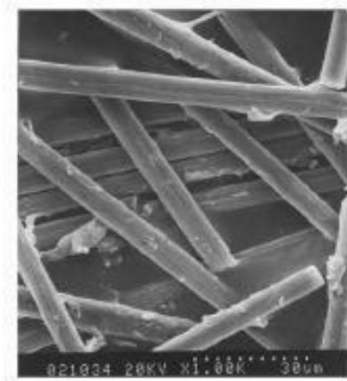


Fig 6

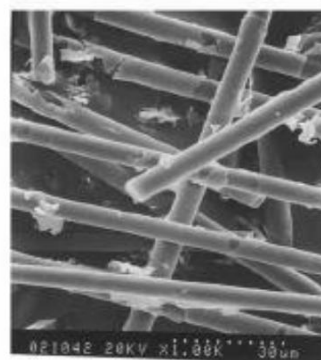


Fig 7

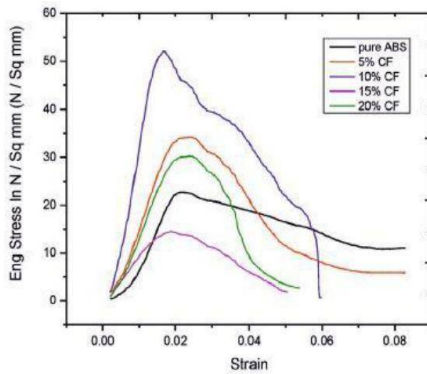
EMI Shielding Effectiveness

Frequency(Hz)	Pure ABS	5%	10%	15%	20%	Uncoated
2 x10 ⁸	0.805	24.663	22.807	27.783	36.7	25.78
4 x10 ⁸	0.5868	24	24.685	29.72	37.8	23.17
5 x10 ⁸	0.4149	24.34	25.563	31.31	38.485	22.3
7 x10 ⁸	0.1341	25.05	27.012	33.34	39.73	20.85
1 x10 ⁹	0.3196	23.85	26.317	31.35	39.23	19.54
1.2 x10 ⁹	0.1406	23.54	26.705	31.72	39.68	20.4
1.4 x10 ⁹	0.0529	24.8	28.32	34.12	41.55	20.26
1.5 x10 ⁹	0.0698	24.91	28.535	34.78	41.913	20.28

Table 2

Mechanical Properties

Tensile Test was conducted on the specimen in Tensometer, the specimen was cut into strips of width around 12mm and the load was applied.

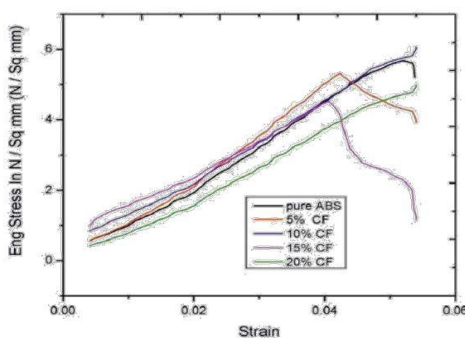


Graph 2

Sl. No.	Filler	compressive yield strength (Mpa)	compressive modulus (Gpa)
1	0%	22.7	2.245
2	5%	34.3	2.393
3	10%	52	3.56
4	15%	14.4	2.53
5	20%	30.2	2.256

Table 3

Compression test also was conducted on the specimen similarly like the tensile test, and the results were obtained.



Graph 3

Sl. No.	Filler	Tensile Strength (Mpa)	Elongation @ Yield/Break (%)	Tensile Modulus (Mpa)
1	0%	5.7	5.4	81.5
2	5%	5.3	3.9	146.7
3	10%	8.5	3.8	239.9
4	15%	4.5	3.6	178.8
5	20%	6.9	4.7	153

Table 4

Applications:

Electromagnetic Shielding can be used in:

- > **Aerospace aviation:** In protection of highly advanced avionic equipment's.
- > **Anti-terrorism:** Encryption of relevant secret codes related to national security.
- > **Communication:** Safeguarding highly sensitive digital signal processing and microwave operating band.
- > **Defence:** To protect equipment related to military, navy or air force.
- > **Information Technology:** Protect users from radioactive effects of computers and peripherals.
- > **Medical:** Prevents interference of electromagnetic waves given out by medical devices especially during critical operations.
- > **Transport:** For improved performances of automotive electronics luxury devices, vehicle tracking system and detection surveillance systems, electric cars etc.

VI. CONCLUSION

The overall material reveals that the material which we have developed was a good engineering composite plastic and we suggest it for light weight engineering applications which will withstand high mechanical, thermal and EMI Shielding properties

REFERENCES

1. S. Ezhil Vannan, Experimental Investigations on Electroless Deposition of Copper on Basalt Fibers, June 2015.
2. Mordiguine, M. Interference Control in Computer and Microprocessors Based Equipments; Don White Consultant Inc: Virginia, 1984.
3. Violette, J. L. N.; White, D. R. J.; Violette, M. F. Electromagnetic Compatibility Handbook; Van Nostrand Reinhold Company: New York, 1987.
4. Jang, J. O.; Park, J. W. U.S. Pat 6,355,707 B1 (2002).
5. Miller, H. K. Mater Eval 1997, 55, 994.
6. Sienkiewicz, Z. Power Eng J 1998, 12, 131.
7. Tech. Trends III—International Reports on Emerging Technologies—EMI Shielding, Conductive Plastics and Elastomers; Innovation: S.A. Paris, 1987; p 128.
8. Trivedi, D. C. In Handbook of Organic Conductive Molecules and Polymers; Nalwa, H. S., Ed.; Wiley: New York, 1997; Vol. 2, p 505–572.
9. Wang, Y. Y.; Jing, X. Polym Adv Technol 2005, 16, 344.
10. Chen, C.; Lee, K. C.; Lin, J. H.; Koch, M. J Mat Process Technol 2007, 192–193, 549.
11. Bigg, D. M.; Bradbury, E. J. In Conducting Polymers; Seymour, R. B., Ed.; Plenum press: New York, 1981; p 23.
12. Niranjanappa, A. C.; Biliya, R.; Trivedi, D. C. Seminar on State of the Art in EMI—EMC and Future Trends; India, 1996.