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# Electromagnetic Interference Shielding of MWCNT/ Mu-Metal/Polyvinylidene Fluoride Nanocomposite

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***Abstract: Electromagnetic Interference (EMI) Shielding material containing a blend of multi walled carbon nano tube (MWCNT) and mumetal has been prepared and their electromagnetic shielding capabilities were characterised through XRD, SEM, EDAX, etc. The shielding effectiveness (SE) was measured using vector network analyser in X-band frequency range (8-12 GHz).***

**Keywords: Carbon nanotube, Mumetal, EMI Shielding, Composite**

## 1. Introduction

Electromagnetic Interference (EMI) is a well-known problem in commercial and scientific electromagnetic instruments, antenna systems and military electronic devices; there is a critical need for developing effective and practical EMI shielding materials and their potential applications. The Electro Magnetic Radiations (EMR) from one device may interfere with other devices causing severe problems [i]. These EMR waves are not only interfering with the normal functioning of the electronic equipment but also harmful to human health. EMI can lead to data loss, picture quality degradation on monitors and other problems with PC. It can jam sensitive equipment, burn out electric circuits and even explosions also. EMI shielding refers to the blocking of electromagnetic radiation so that the radiation cannot pass through the shield. Light weight EMI shielding is needed to protect the workspace and environment from radiation coming from computers and telecommunication equipment as well as to protect sensitive circuits [ii]. The EMI shielding effectiveness (SE) of a composite depends on many factors such as the conductivity of the intrinsic fillers, dielectric constant, aspect ratio etc., [iii]. Materials with lower surface electrical resistivity have higher SE. Depending upon the SE at different frequency ranges, the materials can be used for the encapsulation of different microelectronic devices, computer housings, switches, connector gaskets etc., [iv].

Metal coated or metal plated polymers are the most widely used materials for EMI shielding [v]. The present work deals with the preparation of MWCNT/mu-metal/Polyvinylidene fluoride (PVdF) nano composites for effective EMI shielding. Due to their multifunctional properties, CNT / mu-metal / polymer composites are mainly used for shielding applications. Highly conducting MWCNTs enhances the conductivity of the composites and thereby improving the SE by reflecting the EM radiations. The drawback of increasing the % of CNT would reduce the mechanical properties of the composites like strength, ductility etc. However, it is difficult to achieve the maximum enhancement of physical properties through CNTs without homogeneous dispersion and strong interfacial adhesion between CNTs and polymer matrix [vi]. Magnetically permeable mu-metal acts as magnetic filler, it is effective for the attenuation of electromagnetic radiation by absorption. The EMI shielding effectiveness (SE) of a material is defined as the ratio between the incoming power (*P*i) and outgoing power (*P*o) of an electromagnetic wave [vii].

## 2. Material and Methodology

### 2.1 Synthesis of mu metal alloy:

Mu-metal is an alloy of Nickel, Iron, Copper and Chromium with very high magnetic permeability. The composition of mu-metal is 77 wt % of nickel, 6 wt % of iron, and 5 wt % of copper and 2 wt % of chromium. Ni (3.87299 g), Fe (0.76566 g), Cu (0.27225 g) and Cr (0.0891g) were weighed with particle sizes of + 200 mesh, 5 μ, + 325 meshes, ≤ 325 mesh respectively. It is then grinded using mortar and pestle. The grinded powders were milled in a high energy planetary ball mill with ball to powder ratio as 10:1 at the rotation speed of 200 rpm. In order to minimize oxidation, the entire operation was performed in an argon atmosphere. After 12 hours of milling, the fine powders of mu-metal alloy has been collected and stored in vacuum.

### 2.2 Synthesis of MWCNT / mu-metal / PVdF composites:

**T**he MWCNT / mu metal / PVdF composite were fabricated in N-N, Dimethyl formamide (DMF) as a solvent. 30 mg of f-MWCNT was dispersed in 40 ml of DMF and sonicated for 30 minutes. 30 mg of mu metal was dispersed in 30 ml of DMF and sonicated for 30 minutes separately. Polyvinyliedene fluoride (PVdF) solution was obtained by dissolving 940 mg of PVdF in 40 ml of DMF. All the three solutions were mixed well and again sonicated for 1 hour. After that, the suspension was agitated well in the mixer at 3000 rpm for 6-7 hours. Finally, it is transferred into the petri-dish and kept in oven at 100˚C overnight. Based on this procedure, different compositions of the composites were prepared. Various composites prepared are represented as **A :** 3 wt % f-MWCNT and 3 wt % mu metal, **B :** 3 wt % f-MWCNT and 10 wt % mu metal, **C :** 3 wt % f-MWCNT and 15 wt % mu metal, **D :** 7 wt % f-MWCNT and 15 wt % mu metal, **E:** 7 wt % f- MWCNT and 30 wt % mu metal

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## 3. Results and discussion

### 3.1 Characterization of the mu metal using XRD:

The XRD patterns were recorded for the mu-metal mixture (before milling) and mu- metal alloy (after milling). Fig. (1 a) represents the XRD pattern of mumetal mixture and fig. (1 b) represents the mu-metal alloy.

From fig.(1a), it is observed that the individual peaks for nickel (Ni), iron (Fe), copper (Cu) and chromium (Cr) are found.

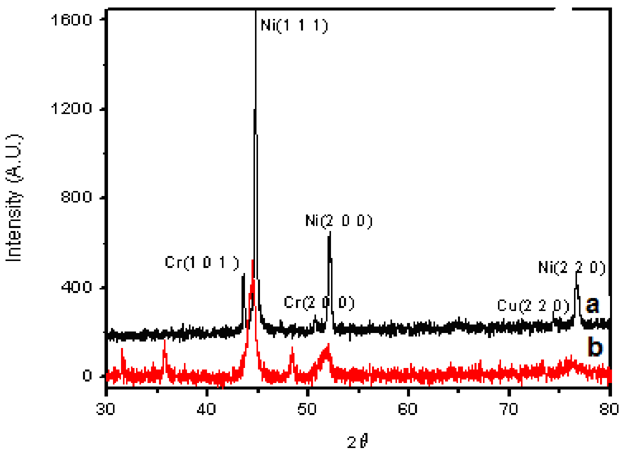
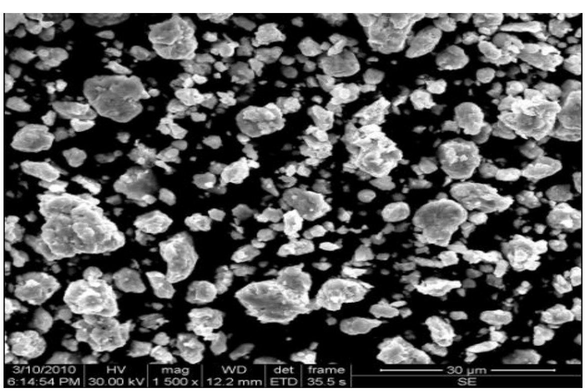



Fig. 1 XRD patterns of mu- metal (a) before and (b) after milling

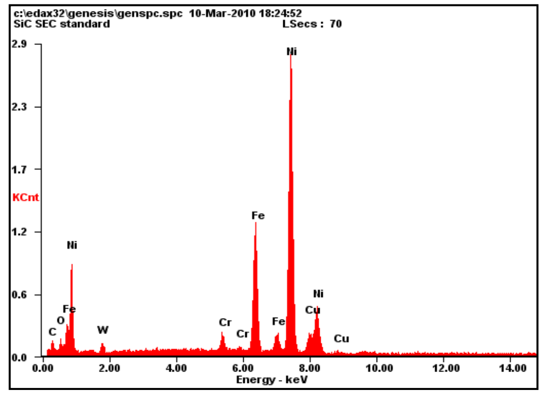
From fig.(1b), it is clear that the individual characteristic peaks for the pure elements are disappeared and a new peak with line broadening effect confirms the formation of mumetal alloy in nano form [viii].

### 3.2 Characterization of mu metal using SEM with EDAX:

Figure (2, a) presents the SEM image of the mu metal alloy. It is observed that the diameter of the particle size reduces and it is in spherical shape. This spherical shape is resulted from continuous refinement of particle size with increase in milling time. The particle size distribution is also narrower [viii]. From the EDAX (figure 2, b) spectrum, the composition of the alloy is determined. It is found that the alloy contains Ni - 62.46 wt %, Fe - 16.57 wt %, Cu - 5.46 wt % and Cr - 1.90 wt % respectively. The results of EDAX are well consistent with the analysis by XRD patterns.




**(a)**




**(b)**

Fig. 2 a, SEM image of the mu- metal

b, EDAX spectrum of mu- metal

### 3.3 EMI Shielding Effectiveness (SE) Characteristics:

Fig (4) represents the EMI shielding effectiveness (SE) of various composites (A to E) over the frequency range of 8-12 GHz consisting of various amounts of magnetic and conductive filler.

From the graph, the SE of the composites have been calculated for **A** to **E** and found that 8.38 dB, 9.62 dB, 8.5 dB, 15.9 dB and 17.2 dB respectively. The composite **B** has higher SE when compared with **A**. This is because of increase in magnetic filler content. Since the mumetal is highly permeable, it attenuates the radiation by absorption. The composite **C** has lower SE value than the composite **B.** Even though it possess higher % of mumetal, the SE value gets reduced. Such higher % of mumetal suppresses the conducting nature of the composite. The higher SE of the composites **D** and **E** is due to increase in magnetic filler as well as conducting filler. It is found that the presence of chlorine in polymer wastes has enhanced their capability to absorb the low energies [ix]. Due to their unique geometry and the chirality, carbon nano tubes were supposed to have unique electrical and optical properties that could be used in nano electronics [x].

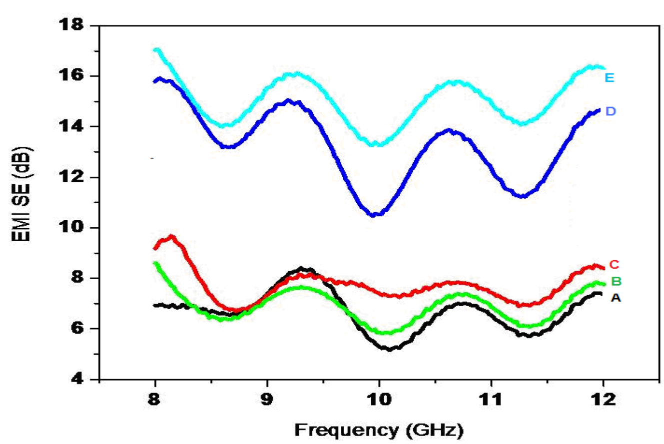



Fig. 4 EMI shielding effectiveness of various composites **A** to **E**

## Conclusion

EMI shielding material mu metal has been synthesized by ball milling. The structural features has been established through XRD, SEM, EDAX etc., and the SE of the prepared composites was measured using vector network analyser. It is concluded that the highly conducting composite with higher % of mu-metal possess high SE.

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