

# An Experimental Analysis of EMI Shielding Effectiveness using Multi layered Metal Meshed Reinforced Sustainable Foam

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**Abstract**— Organic foams are fabricated using a general mixing process incorporated with fine grid metal mesh inside it. The physical and chemical properties and the electromagnetic shielding effectiveness of these foams are investigated. The FTIR results indicate the presence of different organic functional groups. The sample with copper mesh was found to have the best EMI shielding effectiveness followed by brass, iron, and steel meshed samples. The average return loss in dB for a single-layered sample with copper mesh was found to be around 28.715 dB and the average shielding effectiveness was found to be around 29.006 dB in the range of 8-12 GHz. The multilayered mesh samples showed better results than single-layered samples.

**Keywords**—Organic Foam, Electromagnetic Interference (EMI) Shielding, Frequency, Fine Metal mesh

## I. INTRODUCTION

The increasing complexity of electronic devices or systems in the form of higher packing density for quick response has resulted in electromagnetic interference [1]. Electromagnetic interference (EMI) or Radiofrequency interference is the noise that is resulted due to unwanted radiated signals caused by a wide range of electronic devices. The problem of EMI becomes prominent with the increase in the complexity of electronic devices or systems which has a high packing density for a quick response. Thus, it not only affects the performance of the device but also causes its degradation [2]. So, it becomes important to research on the performance features of the potential EMI shielding materials [3-5].

The material chosen must not have any unfavorable impact on the performance of the equipment. It should not trade off the efficiency of the equipment with the EMI shielding or hinder any of its workings. So other properties of the material such as flexibility, mechanical and thermal stability must be decent enough to give it a real industrial application and not just theoretical concept [6, [11].

Considering all the factors reinforced organic foams are believed to serve the purpose. They are lightweight, flexible and eco-friendly. Four samples are synthesized with organic foam as the base and different metal meshes (Steel, Iron, Copper, Brass) as the reinforcement. Various techniques are used to obtain the properties of the samples and a Shielding Effectiveness test setup is used for testing the EMI shielding capability of the material. A comparative study has been carried out to contrast with different samples.

## II. EXPERIMENTL PROCEDURE

### A. Fabrication of Meshed Foam

Samples are prepared with single, double and triple layers of Steel, Iron, Copper, and Brass mesh reinforced in flexible foam. First of all, some identical wooden molds are created with five sides closed and one side open. The open side is mounted with a fixture for holding the mesh of grid size 1mm in the middle of the mold. The walls of the mold are waxed to facilitate the easy removal of the foam after preparation. After fixing the metal mesh on the fixture, a mixture of isocyanides and polyol of ratio 2:3 is put into the mold and the reaction is allowed to take place. The reaction is exothermic and carbon dioxide gas is released as a byproduct. In the multi-layered meshed foams, the distance between the adjacent meshes is 3mm.



Fig. 1. Specimen Mould



Fig. 2. Al tray with wax on surface



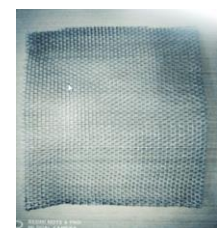
(a) Brass Mesh



(b) Copper Mesh



(c) Steel Mesh



(d) Iron Mesh

Fig. 3. Different Metal Meshes

**B. EMI shielding test Setup**

The electromagnetic interference (EMI) shielding effectiveness is measured by using an experimental setup consisting of a transmitter transmitting radiation of 8 GHz - 12 GHz and a receiver. A spectrum analyzer is used to generate a plot of the Shielding Effectiveness (SE) of the sample being tested. In this setup, the transmitter and the receiver are placed 30 cm apart excluding sample thickness and the sample is placed in between as shown in the photograph. The plot is obtained on the analyzer for the frequency range of 8GHz – 12GHz.

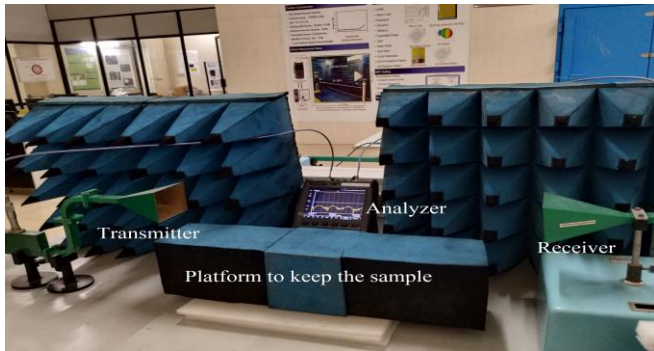


Fig. 4. Experimental Setup



Fig. 5. Setup for meshed sample

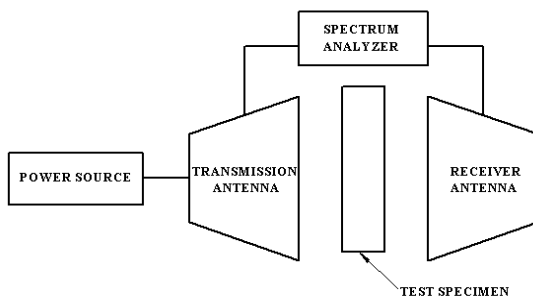


Fig. 6. Schematic Diagram of Setup

**III. FORMULA**

The theoretical quantification of EMI shielding effectiveness as express in the literature [7-10] are as follows:

**Transmission coefficient, (T) =  $|S_{21}|^2$ ;**

$S_{21}$  = Spectrum Parameter of different PU Foams or also called the return loss

**Shielding Effectiveness (SE)<sub>total</sub> =  $10 \cdot \log(1/T)$  [dB]**

**IV. RESULTS AND DISCUSSION**

**A. FTIR Test**

According to the plot obtained from the Fourier Transformation Infrared (FTIR) Spectrum, we have verified the functional groups present in the different foams. The plots obtained is shown below.

- Flexible Foam: In the below graph, we can observe the broadening of the peaks in the range near  $3500\text{cm}^{-1}$  which confirms the presence of -OH functional group. The stretching of the peaks near the range of  $3000\text{cm}^{-1}$  confirms the presence of -C-H groups. The absorption in the range of  $2165\text{-}2110\text{ cm}^{-1}$  shows the presence of cyanide group.

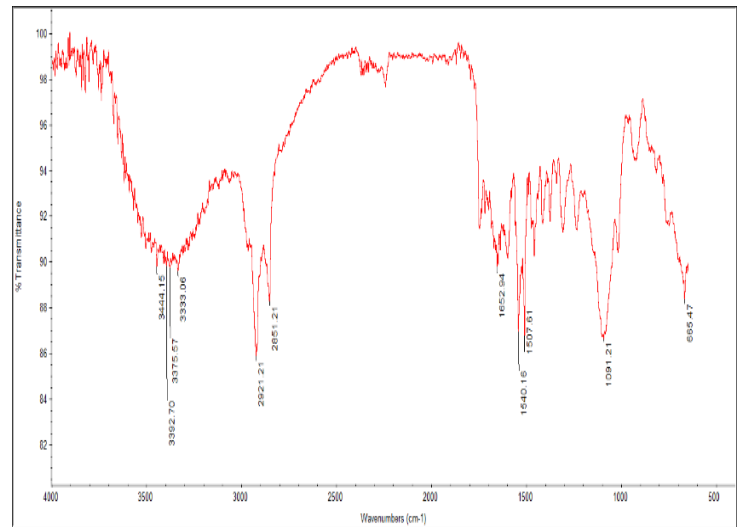


Fig. 7. Flexible Organic Foam (FTIR)

**B. EMI Shielding Performance Test**

The result of the EMI Shielding performance test was obtained in the form of a graph as shown in figures 8, 9, 10, 11 and 12. The results have been summarized in Table 1.

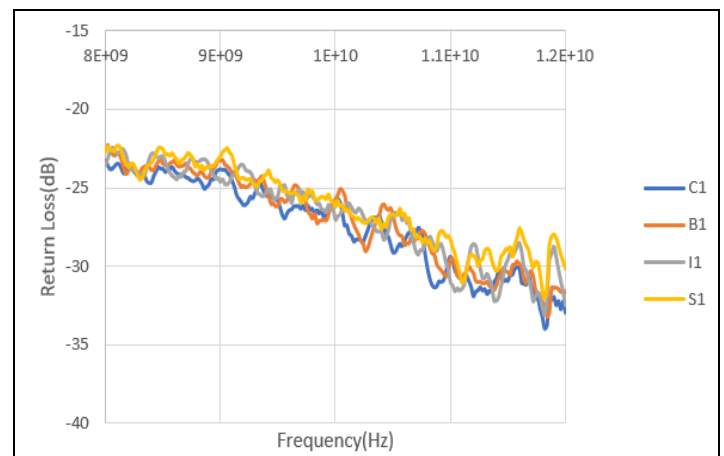


Fig 8. Comparison of Shielding Effectiveness(SE) of different metal meshes in the Organic Foam

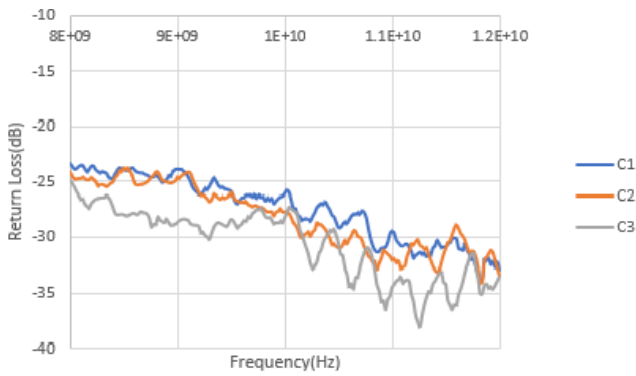


Fig 9. Comparison of Shielding Effectiveness(SE) of single, double and triple layer of copper mesh in the Organic Foam

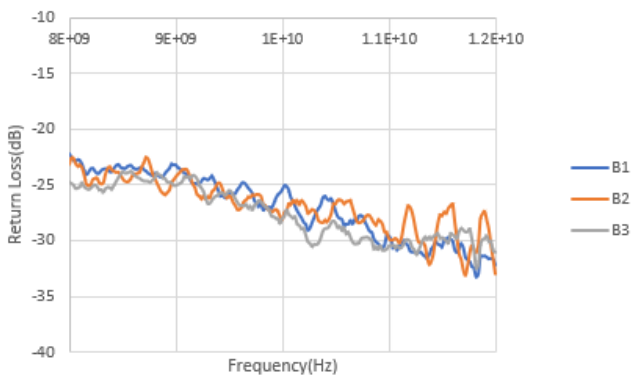


Fig 10. Comparison of Shielding Effectiveness(SE) of single, double and triple layer of brass mesh in the Organic Foam

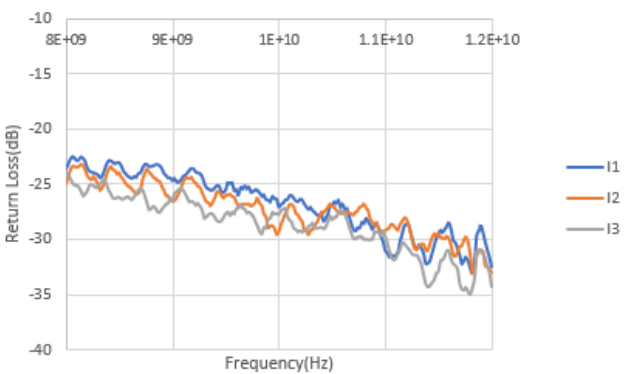


Fig 11. Comparison of Shielding Effectiveness(SE) of single, double and triple layer of Iron mesh in the Organic Foam

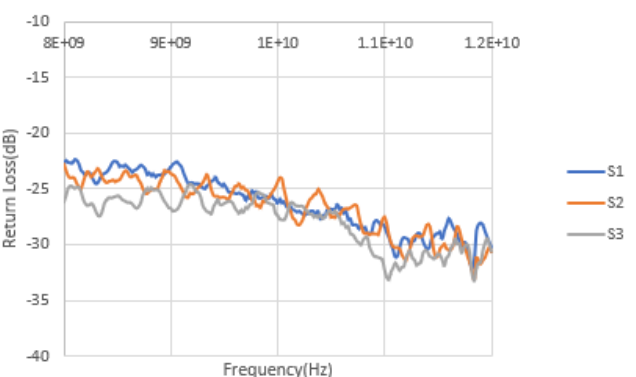


Fig 12. Comparison of Shielding Effectiveness(SE) of single, double and triple layer of Steel mesh in the Organic Foam

Table 1: Shielding Performance Test Quantification

Sample	Frequency Range GHz	Return Loss (dB)	(SE) <sub>total</sub> (dB)
C1	8-12	(-34.106) – (-23.325)	(-30.657) – (-27.356)
B1	8-12	(-33.258) – (-22.242)	(-30.438) – (-26.943)
I1	8-12	(-33.102) – (-22.491)	(-30.397) – (-27.040)
S1	8-12	(-32.064) – (-22.337)	(-30.120) – (-26.980)
C2	8-12	(-34.563) – (23.775)	(-30.772) – (-27.522)
B2	8-12	(-33.232) – (-22.501)	(-30.411) – (-27.044)
I2	8-12	(-33.069) – (-23.215)	(-30.388) – (-27.315)
S2	8-12	(-32.996) – (-22.814)	(-30.369) – (-27.164)
C3	8-12	(-38.098) – (-24.810)	(-31.618) – (-27.893)
B3	8-12	(-33.532) – (-23.830)	(-30.509) – (-27.542)
I3	8-12	(-34.432) – (-23.828)	(-30.483) – (-27.542)
S3	8-12	(-33.292) – (-24.567)	(-30.446) – (-27.807)

The negative value of shielding effectiveness merely represents the loss of EM wave power concerning the incident EM wave. The comparison should be made based on the absolute value of the shielding effectiveness. According to the graphs obtained from the EMI shielding effectiveness experiment, the foam with the copper mesh was found to have the maximum shielding effectiveness followed by brass, iron and steel sample.

The single layered samples have little less Shielding Effectiveness in comparison to multilayered samples. And among all, the samples with copper mesh have better SE followed by brass, Iron and steel which is around 32 dBs.

### V. CONCLUSIONS

The physical and chemical properties of the samples are found, and the shielding effectiveness is characterized using the EMI shielding test.

- The sample with copper mesh was found to have the maximum shielding effectiveness followed by the sample with brass, iron and steel meshes.
- Multilayered samples have little more shielding effectiveness than single layered samples.
- The machinability of the shielding material is improved because of the meshes. Now it is easy to shape the shielding material into different shapes and retain the same.
- Thus, we can derive from our investigation that in the frequency range of 8 GHz- 12 GHz the flexible foam with different meshes can be actively used to



provide effective shielding for satellite communication body parts covering radio navigation and data transfer and operations.

- As brass alloy has better (SE), in comparison to pure metals such as iron and steel so this research work opens the gate for further investigation

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#### NOMENCLATURE

*C1: PU foam sample with single layer of copper mesh*

*C2: PU foam sample with double layer of copper mesh*

*C3: PU foam sample with triple layer of copper mesh*

*B1: PU foam sample with single layer of Brass mesh*

*B2: PU foam sample with double layer of Brass mesh*

*B3: PU foam sample with triple layer of Brass mesh*

*I1: PU foam sample with single layer of Iron mesh*

*I2: PU foam sample with double layer of Iron mesh*

*I3: PU foam sample with triple layer of Iron mesh*

*S1: PU foam sample with single layer of Steel mesh*

*S2: PU foam sample with double layer of Steel mesh*

*S3: PU foam sample with triple layer of Steel mesh*

*SE: Shielding Effectiveness*

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