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Variation Of Electrical Characteristics Of EMI Shielding Materials Coated with Ceramic Microspheres

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Abstract-This paper deals with the work done for finding suitable EMI shielding materials to avoid EMI problems in Electrical and Electronics applications. It is well known that all the electronic devices emit electromagnetic rays during their operations. In order to have a smooth functioning of these devices Electromagnetic Interference (EMI) shielding materials are being made use of. Microspheres are one of the many valuable components obtained from coal combustion process. They are inert, light weight, hollow spheres of alumino silicates filled with gas having low density. They possess excellent thermal insulation properties. Microspheres when coated with silver, provides significant Radio Frequency attenuation(reduction of RF interference).The electrical properties like surface resistivity, volume resistivity, capacitance and dissipation factor of EMI shielding materials of Polycarbonate (PC) and Acrylonitrile Butadiene Styrene(ABS) have been evaluated before and after coating with these silver coated microspheres.

Evolution and advancement in the field of EMI shielding materials, has led to the development of the number of composite materials. The study is a part of ongoing development work at MTD, CPRI Bangalore.

I. Introduction

EMI (Electromagnetic Interference) is the disruption of operation of an electronic device when it is under the vicinity of an electromagnetic field (EM field) in the radio frequency (RF) spectrum that is caused by another electronic device.

EMI consists of any unwanted, spurious, conducted or radiated signals of electrical origin that can cause degradation in equipment performance. Because of these problems, all components must comply with some specifications to ensure electromagnetic compatibility (EMC). All electronic devices give off electromagnetic emissions. Unfortunately these emissions from one device can interfere with other devices, causing potential problems. Inference can lead to data loss, picture quality degradation on monitors, and other problems with PC, or problems with other devices such as television sets and radios. These are generally categorized as electromagnetic interference or EMI problems.

A. Sources and Receptors of EMI

An EMI device can be any device that transmits, distributes, processes or utilizes any form of electrical energy where some aspects of its operation generates conducted or radiated signals that can cause equipment performance degradation.

Again the effect of EMI from one equipment can be felt within the equipment or between the two different equipments which is termed as Intrasystem and Intersystem interference.

Based on different sources and receptors of EMI such as Natural sources, man made sources, Broadband, narrowband, coherent broadband signals, conducted EMI, Radiated EMI and Restricted radiating devices, they are classified as Emitters and Susceptors as given below: -

The term "Emitters" is used to denote source of electromagnetic energy, while the term "Susceptors" is used to denote a device that responds to electromagnetic emissions.

Table1: Classification of Emitters and Susceptors of EMI

Sl No.	Emitters	Susceptors
1	Automobile Ignition Systems	Computers
2	Power Supplies	Televisions
3	Generators	Radios
4	Computers	Mobiles
5	Radar Transmitters	Monitors
6	Fluorescent lamps	RADAR receivers
7	Microwave Relays	Broadcasts
8	Aircrafts	Aircrafts
9	Shipboards	Electronic circuits
10	Land mobiles	Heart pacers
11	Oscilloscopes	Industrial equipments
12	Power Lines	Electronic Gadgets
13	Motors	Oscilloscopes
14	Lightning strokes	Navigation systems
15	RADAR systems	Musical instruments
16	Navigation systems	Climate control systems
17	Communication Systems etc….	Electric Relays etc…

B.Electro Magnetic Interference (EMI) Effect

EMI results from both intersystem and intrasystem problems. As illustrated below:-

Intersystem problem includes:

- Radar interference with aircraft navigation systems.
- Power line interference with telecommunication systems.
- Mobile radios interference with television receivers.
- Power line transient interference to computer systems.
- Aircraft radio interference with shipboard systems.
- Distance FM and TV transmitter interference with nearby FM and TV transmitters.

Intrasystem problem includes:

- Interference from an automotive ignition system to a radio receiver within the car.
- Leakage of radar transmitter energy into the radar receiver.
- Interference caused by magnetic field of the tape drive to low level digital circuits within the computer system.
- Interference caused by digital circuits operating from a common power supply with a low level analog circuit.

Presently metals like copper and aluminum are employed for shielding equipments to avoid EMI effect on them. But due to high cost of metals and increased weight which prohibits them to be used for EMI problems. Other cheaper and light weight materials must be investigated to provide better solution to EMI problems.

II. Ceramic Microspheres

Thermal power generation occupies a pivotal role in the power generation program in India and abroad. Nearly 70% of India's total power generation capacity is thermal power of which coal based generation is nearly 90% presently. Indian coal used in power generation contains high percentage of flyash, up to 45% . Nearly about 70 million tones of flyash is generated annually in India alone. The flyash has tremendous potential to be utilized for different useful applications. Rough estimates of existing utilization are around 10% in the year 1998 of that of total generated as against 3%-5% in the year 1994.

Flyash is the finest of coal ash particles. It is a fine powder formed from the mineral matter in coal, consisting of non-combustible matter in coal plus a small amount of carbon that remains from incomplete combustion. The ceramic particles in flyash have three types of structures. (a) Solid particles called "Precipitators". (b) Hollow particles called "Cenospheres". (c) Hollow particles of large diameter filled with smaller size precipitators and cenospheres called "Plerospheres".

Microspheres also called as Cenospheres are believe to posses better electrical, chemical and thermal properties along with light weight, small size, ultra low density, high particle strength Resistance to acids etc. They are made up of inert silica, iron and alumina. Its size ranging from 1 to 300 microns. They are produced at high temperatures of about 1500-1750 degree Celsius. Colors ranging from white to dark gray. They are easy to handle, not affected by solvents, water, acids or alkalis. Also called as hollow spheres, microspheres and glass beads.

A Silver coated Microspheres.

Silver particles in the form of granules when incorporated to microspheres in powdered form by process of electro less plating gives silver coated microspheres. These particles have high mechanical strength on which it is coated. They even have good reflective property. These properties make it an ideal material for coating applications.

B. Advantages of silver coated microspheres.

The following are the main advantages of cenospheres:-

1. Reduced raw material cost
2. Improved insulation properties
3. Resistance to resin absorption
4. Good reflective properties
5. Improved electrical properties

III Polycarbonate and ABS

A. Polycarbonates (PC)

Polycarbonates are a particular group of thermoplastics polymers. They can be easily worked, moulded and thermoformed. Their interesting features like temperature resistance, impact resistance and optical properties position them between commodity plastics and engineering plastics. The following are the applications of Polycarbonates.

- Lightning lenses, sunglass/eyeglass lenses and safety glasses.
- Compact discs, DVD's
- Drinking bottles.
- Electronic gadgets
- Advertisement applications

B.Acrylonitrile Butadiene Styrene (ABS)

It is copolymer made by polymerizing styrene and acrylonitrile in the presence of polybutadiene. It consists of 15%-35% acrylonitrile, 5% -30% butadiene and 40%-60% styrene. They are light, rigid, tough molded products used in applications such as piping, musical instruments, protective head gears etc. They also posse's good electrical properties that are fairly constants over a wide range of frequencies. They are resistant to oils, alcohols, acids and alkalis.

IV Experimentation

A.Silver coated cenospheres (SSC)

Different types are coatings are used to coat a plastic based substrate; the most reliable means of coating is from silver coating. The following procedure is adapted to produce silver coated cenospheres.

Five grams of microspheres was used as raw material. Microspheres were synthesized in 20% Tin chloride (Sncl2) solution for 5 minutes. After rinsing with distilled water, the powder was activated in 2% silver nitrate solution (AgNo3) for 5 minutes. The treated microspheres was immersed in the reducing agent solution containing polyglycol, ethanol and glucose and stirred for 10 minutes.

AgNo3 and Ammonia were used for silver plating bath preparation. Silver solution was prepared by dissolving the AgNo3 (3.3 grams) in 180 ml of distilled water with addition of several drops of ammonia, then 0.6 grams of NaOH was added to the solution, finally several drops of ammonia were added until Ag(NH3)+ solution became transparent again.

The mixture of cenosphere and reducing agent solution was immersed in the silver solution and stirred for 30 minutes at room temperature. After drying, the silver coated microsphere powder was obtained.

B. Procedure for coating

Substrate is first prepared by cleaning its surface and making it rough. Then coating mixture is prepared by blending silver coated microspheres with polyurethane resin in the ratio of 1:4 and coated on PC and ABS sheets. Then they were let to dry for 24 hours in sunlight.

C. observations and Tabular Columns

The electrical properties such as Volume resistivity, surface resistivity, capacitance and Dissipation factor have been evaluated on the PC and ABS materials with and without applying SSC on the substrate and its effects have been studied.

Table2: Observed values of Volume and surface resistivity.

Sl. No	Material-surface	Thickness before coating (mm)	Thickness after coating (mm)	Volume resistivity before coating (Ω m)	Volume resistivity after coating (Ω m)	Surface resistivity before coating (Ω/m^2)	Surface resistivity after coating (Ω/m^2)
1	ABS-smooth	2.15	3.15	1.47*10^{16}	1.66*10^{16}	0.55*10^{16}	1.36*10^{16}
2	ABS-manually rough	2.15	3.20	1.18*10^{17}	8.35*10^{14}	4.36*10^{14}	0.63*10^{9}
3	ABS-naturally rough	2.1	2.70	1.26*10^{17}	1.07*10^{17}	0.83*10^{16}	0.74*10^{14}
4	ABS-natural rough (opaque)	2.1	2.72	3.64*10^{15}	2.27*10^{16}	0.24*10^{16}	2.84*10^{15}
5	PC-smooth	3.16	3.60	0.68*10^{16}	1.45*10^{130}	2.87*10^{15}	3.10*10^{12}
6	PC-manually rough	3.16	3.60	5.54*10^{16}	1.01*10^{17}	2.02*10^{15}	1.94*10^{16}
7	PC-manually rough (opaque)	3.18	4.10	1.42*10^{17}	4.04*10^{16}	0.3*10^{17}	1.08*10^{16}
8	PC-natural rough	3.18	3.27	1.35*10^{15}	0.81*10^{18}	2.76*10^{15}	0.84*10^{9}

V.Conclusion

Based on readings given in table 2 and table 3, it has been found that Polycarbonate with smooth texture and ABS manually rough, samples of plastic materials have shown considerable decrease in the surface resistivity, volume resistivity and Dissipation factor. Also there is an improvement in the Capacitance values. So this work reveals the importance of flyash based Microspheres when coated with silver nitrate leading to the investigation of two new and important shielding materials with improved Electrical characteristics which canavoid both internal and external Electromagnetic Interference problems in various Engineering applications.

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Table3: Observed values of Capacitance and Dissipation factor.

Sl. No	Material-surface	Thickness before coating (mm)	Thickness after coating (mm)	Capacitance before coating (Pf)	Capacitance after coating (Pf)	Dissipation factor, (Tan Delta)	Dissipation factor, (Tan Delta)
1	ABS-smooth	2.15	3.15	5.182	4.23	0.02345	0.2555
2	ABS-manually rough	2.15	3.20	5.733	18.65	0.02156	0.0078
3	ABS-naturally rough	2.1	2.70	5.961	4.301	0.01948	0.0742
4	ABS-natural rough (opaque)	2.1	2.72	5.843	5.191	0.02026	0.06250
5	PC-smooth	3.16	3.60	4.371	13.818	0.03314	0.00977
6	PC-manually rough	3.16	3.60	3.617	3.241	0.04003	0.11299
7	PC-manually rough (opaque)	3.18	4.10	4.208	12.47	0.03013	0.0475
8	PC-natural rough	3.18	3.27	4.582	15.05	0.02670	0.01027