A Review on Recent Development of Effective Shield for Wireless Radiation

EMI Radiation Shield

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Abstract: As we know that, the mobile phone makes an important place in human life. But along with the benefits, mobile phones are also quite harmful. The electromagnetic radiations (EMR) of the mobile phone can disturb the biological process of the human body and cause brain tumour and cancer like harmful diseases. These EM radiations do greater bodily damage to under 14-year-old children because the brain tissue of children can have absorbed two times more EMR than adults because of their thinner skull that is relatively smaller than adults. In this paper we reviewed about the impact of the EMR, SAR measurement, its effect that how much value of SAR is harmful to human and a shield that is made up of different materials. We studied the composite material, carbon composite material, a conductive and textile material with their shielding effectiveness (SE) and radiation reduction value.

Keywords: EMR, SAR, Composite, Carbon Composite, Conductive, and Textile Materials

1. Introduction

Now mobile phones have become a crucial part of life all over the world. Nowadays technically mobile phones have an ability of not only making and receiving calls, but can be used as multitasking such as storing data, taking pictures, and can even use a walkie-talkie. The rising of the cellular phone has raised the anxiety about the possible interaction between the electromagnetic fields (EMF) radiation and the biological effects on the human body especially the brain. These concerns have prompted a large volume of research in the recent past. However, most of the previous reviews are engaged to find out the negative impact caused by cell phones.[1]

New studies suggest that mobile phone is suspected to have huge amount of harmful radiation that might double the risk of developing cancer on the side of head where we used to pick the phone, increase brain activity, can damage the nerve around the ears and more importantly it can damage the blood-brain barrier (BBB). Also, new researches show that biological effects are possible without any warming of tissues which is imposed of the current radiation exposure levels.[2]

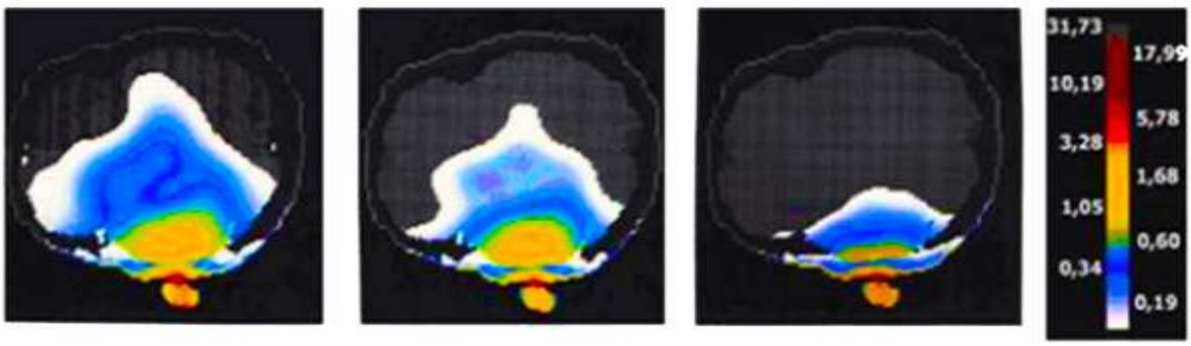
In this we have discussed the Impact on Human about the various modern area of EM Radiation:

1.1 Effect of EMR on body

When electromagnetic waves pass through our body an electrical current is induced inside our body. Naturally, electrical impulses are used by our body for thinking, conveying sensory information, controlling heartbeats and for muscular movements. For the precise functioning of a body, a chemical process which takes place in our cell, tissue, organs, and blood depends on an electrical charge that is present in the body. So as a conclusion of it, when an external EMF is interfaced with our body then it may disturb many of the biological processes that may increase in temperature of body tissues and cause brain tumor or cancer which is one of the most visible impacts of such radiations.[3]

1.2 Biological Impact of EMR on Human

Mobile phones are suspected to have a huge amount of radiation that is very harmful to human as well as animal also. So that an electromagnetic shield is developed as a safety for human beings to minimize the risk of the electromagnetic radiation. we need electromagnetic shielding for reducing electromagnetic fields. A research by Defender Shield reports that 5-year-old child absorbs more radiation than adults. This research was completed by examining the skull of a 5-year-old child, 10-year-old child, and adult as shown in fig 3.1. As a result of it, 5-year-old and a 10-year-old child were much radiated than that of an adult's brain. So there is a need for electromagnetic shielding to reduce the bad effect of mobile phone radiation that harms the biological process in the human body. [4]



(a) 5-year old (b) 10-year-old (c) Adult (d) SAR Scale

Fig 3.1 Skull model of three different person[4]

1.3 Effect of EMR on Children

Children and unborn babies are much effected by EMF radiation than adults. They do face a greater bodily damage because multiple types of research have shown that the brain tissue of children can absorb two times more MWR than adults. Children's skull is thinner and relatively smaller than adults, that is why the rate of MWR absorption is higher in children. Also, new study has reported that bone marrow of children is ten times more absorbent of MWR than that of adults.[4]

1.4 Specific Absorption Rate (SAR) Measurement

The limit of exposure use as a unit of measurement is known as SAR. A rate in which how much energy is absorbed by the human body exposed to radio and electromagnetic frequency. SAR is power absorbed by the mass of tissue and its unit in watts per kilogram (W/kg). SAR is usually measured either over the whole body (10g of tissues) or over a small volume (1 g of tissue). A regulatory threshold SAR value for mobile phone device has accessed by every country. 1.6 W/kg units for 1g of tissue and 2.0 W/kg units for 10 g of tissues are being the regulatory unit in India. In India, no mobile company can able to exceed this fix regulatory unit.

SAR for electromagnetic energy can be calculated from the electric field within the tissue as:

$$\mathrm{SAR} = \frac{1}{V}\int_{\text{sample}} \frac{\sigma(\mathbf{r})|\mathbf{E}(\mathbf{r})|^2}{\rho(\mathbf{r})} d\mathbf{r}$$

Where,

σ is the sample electrical conductivity

E is the RMS electric field

ρ is the sample density

V is the volume of the sample[5]

1.5 Table Harmful Impact of SAR on Human

SAR	Reported Biological Effects	Year	References
0.000021- .0021 W/Kg	It can change in the cycle of the cell at 960 MHz GSM cell phone.	1997	Kwee, (Sage)
0.0004 W/Kg	It can cause a change in the Blood-Brain Barrier (BBB) at 915 MHz GSM cell phone.	1997	Salford (Sage)
0.0008 W/Kg	It can increase the DNA Strand Breaks.	2009	Kesari and Behari, (Levitt/Lai)
0.0004-0.008 W/Kg	It can cause leakage in Blood Brain Barrier (BBB) at 915 MHz GSM cell phone.	1997	Persson, (Sage)
0.001 W/Kg	It affects the cell growth rate and damages the DNA.	2000	de Pomerai, (Sage)
0.0027 W/Kg	It can cause a behavioural change in human after 5 hours of mobile exposure.	1994	Navakatikian, (Sage)
0.0037 W/Kg	It may change the repair mechanisms of DNA.	2009	Belyaev et al, (Levitt/Lai)
0.005 W/Kg	It can increase calcium flux in human cells.	1989	Dutta et al, (Levitt/Lai)
0.0024 W/Kg to 0.024 W/Kg	It can damage the DNA and DNA repair mechanisms. Also, the low intensities digital cell phone can cause DNA effect in the human cell.	1998	Phillips, (Sage)
0.0317 W/Kg	It can decrease in eating and drinking and cause abdominal stomach problems	1900	Ray & Behari, (Sage)
0.3-0.44 W/Kg	More use of cell phone change the cognitive thinking and mental task related to memory retrieval.	2000	Krause et al, (Sage)
0.005 to 0.05 W/Kg	It can increase calcium flux	1989	Dutta et al, (Sage)
0.121 W/Kg	It can cause a significant decrease in arterial blood pressure (hypertension).	1999	Lu et al, (Sage)
0.14 W/Kg	It can harm the immune response at 100 µW/cm2	1996	Elekes, (Sage)
0.26 W/Kg	It can cause harmful effects to the eye.	1992	Kues, (Sage)

0.58 - 0.75 W/Kg	Increase in brain tumour at 836 MHz TDMA Digital cell phone.	1996	Adey, (Sage)
0.6 and 1.2 W/Kg	Increase in DNA single and double strand breaks from RF exposure (2450 MHz)	1996	Lai & Singh, (Sage)
2 - 3 W/Kg	It can cause skin cancer and breast tumours.	1982	Szmigielski, (Sage)

1.6 Following are some reports that prove the current problems of bad Impact of EMR on human health:

1) The WHO reported on cell phone radiation and concluded that EMF can increase the risk of brain cancer. They also concluded that long-term and short-term cell phone exposure can damage the brain activities. [6]

2) Neuroscientist Dr. Johannson, a professor at Karolinksa Institute in Stockholm, Sweden confirms the danger of electromagnetic radiation. their studies have shown that EMF has a measurable effect not psychosomatic. [7]

3) To prove the bad effect of electromagnetic radiation, an interesting work was done by the Environmental Health Trust with a team in Brazil to calculate the rate of cell phone radiation absorption in the brain. A model has developed that show radiation absorbed by a man and a 3-year-old girl as shown in fig 3.2. The result was analysed after both have 6 minutes' conversation on a cell phone that 3-year-old girl's brain was more affected by EMF and have relatively greater absorption rate in tissues than adult's brain. (The red/orange area represent the areas of radiation).[8]

Fig 3.2 shows the radiation absorbed by adult's and child's brain. [8]

1.7 Table shows the SAR value in Branded/ Non-Branded:

Sr.No.	Mobile Phone	Model	SAR (W/kg)	Frequency (Hz/MHz/GHz)	Observed SAR (W/kg)	References
1	Samsung J2 Pro 16	SM-J2-10F	0.780	1024	0.170	This work calculated from the phone
2	I phone 5	MF 35 2HNA	1.18	1134	0.189	This work calculated from the phone
3	Motorola	Moto E (2G)	0.16	1161	0.1935	This work calculated from a phone
4	Samsung J7	SM A710 F	0.296	1251	0.2085	This work calculated from a phone
5	i-Pad	MP2F2HNA	1.19	1612	0.268	This work calculated from a phone

6	Samsung Galaxy Tab 2	GT-P3100	0.831	1228	0.2046	This work calculated from the phone
7	Intex	Yuvi+	0.902	874	0.145	This work calculated from a phone

2. Types of Shielding

In this paper, we have discussed the different type of shield material with their Shielding Effectiveness and Radiation/SAR reduction.

Table 2.1 shows the different type of material of shield and Radiation Reduction (%age) and SE(dB) of material with frequency range

Sr. No.	Material of shielding	Type of Material	Radiation Reduction (%age) and SE(dB) of material with frequency range	Year	References
1	Thermoplastic composite with conductive Nano fillers	Composite	44.8% at 15-300MHz	2018	[9]
2	BF/EG composite	Composite	52.4 dB at 8-12 GHz	2018	[10]
3	Polyurethane composite foam	Composite	65.6 dB	2018	[11]
4	MXenes and their polymer composite	Composite	92 dB	2016	[40]
5	Polyvinyl alcohol (PVA) and Natural rubber latex (NRL)	Composite	95%	2018	[13]
6	Flexible spongy CNT interconnected with CNT skeletons with 1.8mm of thickness	Carbon Composite	46.3 dB	2018	[14]
7	CNT/CFRP composite	Carbon composite	62-74 dB at 8.2-12 GHz	2018	[15]
8	Composite of graphene copper ferrite and polyaniline (PANI)	Carbon composite	30.27772 dB	2018	[32]
9	Carbonized melamine foam (CMf) with Au nanoparticle, graphene(G), Fe304(IO) and Poly (dimethyl silocone) (PDMS) thickness of 2mm	Carbon composite	30.5 dB at 8.2-12.4 GHz	2018	[17]
10	Carbon composite foam impregnation of phenolic resin censophere loading (0-40%) into polyurethane (PU) foam substrate	Carbon composite	-25.2 to -48.6 dB in 8.2-12.4GHz	2018	[18]
11	Flexible and anticorrosive silver nanowire with carbon hybrid sponge (Ag@C)	Carbon Composite	70.1 dB at 8.2 - 18 GHz	2018	[19]
12	Polystyrene with thermoplastic properties and CNT with polymer	Carbon Composite	-27.5 to -39.9 dB at 12.4-18 GHz	2017	[31]
13	Carbon fiber reinforced polyacrylamide/ wood fibercomposite with 150nn diameter	Carbon Composite	41.03 dB	2018	[20]
14	Multilayer textile set like woven fabrics made of cotton and hybrid yarn with 3 layers of set	Textile	56dB	2018	[21]
15	Silver coated polyamide (Ag/PA66), woven fabrics with 0.04/cm2 density	Textile	1200 dB at 0.015- 3 GHz	2018	[22]
16	Alloy sheets with a duplex Mg-9Li alloy and laminated form of 24-1 interface strips fabricated by accumulative roll bonding (ARB) upto 4 cycle	Conductive	56-73 dB at 1350 MHz	2018	[23]
17	Mg-XZn and Mg-XSn alloy	Conductive	13 dB at 1200 MHz	2018	[24]
18	Conductive composite sheet with styrene acrylonitrile (SAN) copolymer and graphite (Gr) properties	Conductive	10-1Ghz	2018	[37]

19	Woven cotton fabric modified with polyvinyle alcohol (PVA) coated with copper (Cu), titanium and stainless steel (SS)	Conductive	-30dB	2018	[26]
20	Mg, alloy with mechanical properties	Conductive	500-6GHz 7-13 GHz	2018	[27]
21	Hydrophilic MXenes material with thickness of 2.5mm of film	Composite	70dB	2017	[29]
22	Poly (o-toluidine/ red mud) composite	Composite	8.9dB at 8.2 to 12.4 GHz	2017	[30]
23	Carbon Nanotube/ Ground tire rubber composite	Carbon Composite	93% 66.9dB	2017	[33]
24	Flexible rubber composite with low filler content of Nano size conducting carbon loading 1-15% wt with 2.8mm of thickness	Carbon Composite	-40dB at 8 to 18 GHz	2017	[35]
25	Woven fabric containing cotton metal fiber yarn	Textile	4 to 14 GHz	2017	[36]
26	Dopant concentration and nature of dopant (SLS, SDBS, LiSiPA, NDSA)	Composite	126dB at 8.2 to 12.4 GHz	2016	[39]
27	b- Naphthalene sulphoic acid (b-NS) doped polyaniline (PANI) composite with different carbon filler i.e. MWCNT, CF and reduced graphene oxide (rGO)	Composite	37 dB of MWCNT 31 dB of CF 39 dB of rGo at 8-12 GHz	2016	[41]
28	Polymer Composite filled with metal particles with thickness of 2.8mm	Composite	Raised upto 87dB	2016	[42]
29	Barrium ferrite with reduced graphene oxide BaFe12O19@rGO) Nano composite with 3mm of thickness	Carbon Composite	32 dB 99% at 12.4 to 18 GHz	2015	[44]
30	Laminated structure of sulphur doped reduced graphene oxide (SrGo) with small thickness 140 micrometer	Carbon Composite	33.2 dB at 100MHz	2015	[45]
31	Fabricated composite sheets of poly (o-asidine) carbon fiber (PoACF) with 4mm of thickness	Carbon Composite	32.57 dB at 8.2 to 12.4 GHz	2015	[46]
32	Nano magnetic structure with 3-5 micrometer thickness	Conductive	20 dB at 6.78 MHz	2015	[48]
33	Conductive filler composite and conductive fabrics	Textile	80dB at 18MHz	2014	[50]
34	Metalized textile fabric nonwoven, knitted fabrics and coated textile with conductive polymers	Textile	100dB	2013	[51]
35	Metals, conductive plastic and conductive polymer. Other metal like metalized plastic and conductive carbon graphene comopsites. Synthetic metals like PAn and PPY.	Conductive	40-50 dB at 10 KHz to 1 GHz	2009	[53]
36	RF shield with metal like nickel, zinc, spinel ferrite sheet.	Conductive	54% at 2.4 GHz	2009	[54]
37	Multiwalled CNT/ polymer composite	Carbon Composite	Exp= 36.4dB Theory= 30.9dB at 12.4 GHz	2009	[52]
38	Nano Structured polyaniline (PANI) and polyaniline clay Nano composite (PANICN) with ethylene vinyle acetate (EVA)	Composite	40-80 dB at 8GHz	2008	[55]
39	Silicone rubber with loading of HCI-doped polyaniline (PAN-HCI)	Composite	1-19.3 dB at 3 to 1500 MHz	2005	[56]
40	Reduced large area graphene oxide (rLGO) with 1592 micro square area	Carbon Composite	20dB at 1GHZ	2005	[47]
41	Carbon material with composite material, colloidal graphite and flexible graphite	Carbon Composite	Raised upto 87 dB	2000	[57]
42	Wood ceramic made up of waste material	Carbon Composite	30dB at 100 MHz 43dB at 300MHz	1997	[58]

Table 2.2 shows the different type of material of shield and SAR Reduction in 1g and 10g od tissues

Sr. No.	Material of shielding	Type of Material	SAR Reduction (W/Kg) in 1g or 10 g of tissues	Year	References
1	Dipole antenna made up of copper aluminium, zinc ferrite, silver and nickel with dimensions of 0.1mm, 0.2mm and 0.3mm	Antenna type with conductive material	88% of SAR reduction of both 1g and 10g of tissues	2015	[59]
2	Triangular metamaterial After deploying	Metamaterial	1.0923 SAR for 1 g of tissue with 45.44% reduction in initial SAR. 0.692 SAR for 10 g of tissues 1.09 2 SAR for 1 g of tissue	2012	[60]
3	Simple metamaterial After deploying	Metamaterial	53.94% SAR reduction in 10 g of tissues, 1.16079 SAR for 1g of tissue 0.737 SAR for 10g of tissues	2010	[61]
4	Ferrite material and metamaterial After deploying	Metamaterial	For ferrite material, SAR reduction is 47.68% For metamaterial, SAR reduction is 42.12%. 0.676 SAR for 1g of tissues 0.737 SAR for 10g of tissues	2009	[62]
5	Ferrite material	Metamaterial	57.75% reduction of SAR in 10g of tisuues	2009	[63]

3. LITERATURE REVIEW

3.1 COMPOSITE MATERIAL

In **2018**, **Yilmaz et al.,** observed thermoplastic composites doped with conductive nanofillers effect of vapor-grown carbon nanofibers with various amounts in polyvinylidene fluoride matrix for the analyses of the mechanical, electrical and electromagnetic shielding properties in which vapor-grown carbon nanofibers were utilized at various weight ratios (1 wt.%, 3 wt.%, 5 wt.%, and 8 wt.%) as conductive and reinforcing materials and in result overall increments of 16%, 37.5%, and 56% were achieved and total reduction of 44.8% was observed in the frequency range of 15–3000 MHz. Another research in **2018 Gairola et al.,** presented BF/EG composite and found microwave absorption characteristic in the frequency range 8–12 GHz. With shielding effectiveness of obtained 52.4 dB. Shielding effectiveness of 65.6dB obtainted by composite foam shown by **Ghosh et al.,** in **2018**. Herein, author adopted 'dip coating and drying' method to prepare high surface area conductive black (Ketjen-600JD) loaded polyurethane (PU) composite foam.

In **2018**, **Singh et al.,** reviewed about the lightweight porous material for Electro-magnetic interference and replaced conducting material based shields by conducting polymer based shields and focused on understanding the ideas related to porous high EMI shielding composite material with lower density value. Author found porosity is to be effective in providing higher shielding effectiveness at low filler volume fraction because of, concentrating the filler in solid polymers. A new research was studied on polyvinyl alcohol (PVA) and natural rubber latex (NRL) by **Ghosh et al.,** in **2018** in which polymer blends were not only physically mixed but also covalently interwoven by means of interpenetrating polymeric network (IPN) approach and tested the coated fabric was tested. In result coated fabric showed high electrical attributes and long-term cyclic deformation study shows ~95% retention of EM performance due to the flexible network structure.

Another research has shown that a layer of super hydrophobic coating having good electromagnetic shielding. In **2017 Xing et al.,** worked on super hydrophobic coating and their analysis revealed that the microscale particles were uniformly distributed on the wood surface and the main component of the coating is metallic copper that showed super hydrophobic coppered wood has excellent electromagnetic shielding. **Liu et al.,** reported hydrophobic MXene materials in 2017 and enhanced EMI-shielding effectiveness of ≈70 dB is achieved. In **2017**, the poly (o- toluidine)/ red mud composite used by **Gairola et al.,** to show its electromagnetic shielding properties. Author used red mud as filler material. 50% of red mud in polymer matrix resulted in shielding effectiveness of 8.9 dB in 8.2 to 12.4 GHZ frequency range.

In **2016**, Another research described the effect of reaction conditions by **Gahlout et al.,** dopant concentration and nature of dopant (sodium lauryl sulphate [SLS], sodium dodecyl benzene sulphate [SDBS], lithiosulphoisophthalic acid [LiSiPA] and naphthalene disulphuric acid [NDSA]) on the conductivity and electromagnetic shielding properties of polypyrrole (PPy) showed the Polypyrrole synthesized using optimized conditions and SLS as dopant electromagnetic shielding effectiveness of _126 dB in the X-band [8.2-12.4 GHz]. **Shahzad et al.,** demonstrate the potential of several MXenes and their polymer composites for EMI shielding in **2016** and showed A 45-micrometer-thick Ti3C2Tx film exhibited EMI shielding effectiveness of 92 decibels (>50 decibels for a 2.5-micrometer film). Same research in **2016** by **Mishra et al**., b-Naphthalene sulphonic acid (b-NSA) doped polyaniline (PANI) composites having different carbon fillers such as MWCNTs, carbon fiber (CF), reduced graphene oxide(rGO) for electromagnetic shielding and calculate shielding effectiveness using S-parameters obtained from the Vector Network Analyzer (VNA) in 8.2 to 12.4 GHz frequency range for PANI composites along with MWCNT, CF, rGO was 37, 31 and 39 dB respectively. **Los et al.,** in **2016** reviewed about the polymer composite that was filled with metal particle with sample thickness is 2.8mm and conclude shielding effectiveness of different composite material were 26dB, 42dB, 19dB, 23dB, 58dB, 32dB, and 87dB.

In **2008** Electromagnetic interference shielding composite materials were developed from the conductive blends of nanostructured polyaniline (PANI) and polyaniline-clay nanocomposite (PANICN) with ethylene vinyl acetate (EVA) as host matrix by **Sudha et al.,** in which conductive films containing PANICNs has 15% loading that showed shielding effectiveness of 40–80 dB at 8 GHz.

In **2005 Yuping et al**., mainly aimed at electrical conductivity and EMI shielding effectiveness (SE) of the conducting composites made from silicone rubber (SR) with different loading levels of HCl-doped polyaniline (PAN-HCl) in the low frequency range from 3 to 1500 MHz that calculated SE of the composites are from 16 to 19.3 dB at 100 mass ratio loading of the PAN-HCl.

3.2 CARBON COMPOSITE MATERIAL

In **2018 Dongwei Lu et al**., used flexible spongy CNTs consisting of self-assembled, interconnected CNT skeletons, with a density of 10.0 mg/cm3, for EMI shielding film with thickness of 1.8 mm. After composited with PDMS by directly infiltrating method, the CNT/PDMS film still exhibits excellent EMI SE (46.3 dB) at the thickness of 2.0 mm, while the CNT loading content is less than 1.0 wt%. **Shen Gong**, **et al**., In **2018** the effect of carbon nanotubes (CNTs) on the electromagnetic interference shielding of carbon fiber reinforced polymer (CFRP) composites was investigated. The shear strength of CNT was below 3.0 g/m2. Then, the electromagnetic interference shielding effectiveness (EMI SE) of CNT/CFRP composites loadings over the X-band frequency range (8.2–12.4 GHz) and EMI SE of CNT/CFRP composites increased by approximately 20%, from 62 dB to 74 dB and from 45 dB to 53 dB, respectively, by adding 2.5 g/m2. In **2018 Nazir et al.,** focused on the shielding materials based on composites of carbon nanotubes and graphene and found that the composites based on these carbon fillers were more effective due to unique properties for electromagnetic shielding.

In **2018 Sun et al.,** developed a specifically engineered variant of carbonized melamine foam (cMF) by carrying systematic structural modifications with Au nanoparticles, graphene (G), Fe3O4 (IO) and poly(dimethyl siloxane) (PDMS) to construct a lightweight and flexible cMF composite. So author calculated EMI shielding effectiveness (SE) of cMF-Au-G-IO/PDMS film with a thickness of 2 mm as 30.5 dB in X band (8.2-12.4 GHz) and SE is further raised up to 52.5 dB when the film thickness is increased to 10 mm. Here, author used lightweight carbon composite foam with multifunctional properties that were developed by impregnation of phenolic resin and cenospheres with loading of 0-40% weight into polyurethane (PU) foam substrate by **Kumar et al.,** in **2018** and converted impregnated foams were converted into carbon cenosphere composite foams via heat treatment at 1000ºC. EMI shieling of carbon cenosphere composite foam was measured in X-band frequency region (8.2-12.4 GHz) using waveguide method and total shielding effectiveness (SE) of carbon foam was increased from -25.2 to -48.6 dB by the loading of 30 wt. % cenosphere. A lightweight, flexible, and anticorrosive silver nanowire wrapped carbon hybrid sponge (Ag@C) is used by **Wan et al.,** in **2018** which is fabricated and employed as ultrahigh efficiency EMI shielding material and provide an EMI shielding effectiveness of around 70.1 dB in the frequency range of 8.2–18 GHz. In **2018**, **Dang et al.,** author used carbon fiber reinforced polyacrylamide/wood fiber composite boards for electromagnetic interference shielding. Author arrange CF with an average diameter of 150nn which is distributed on wood fiber then encased by polyacrylamide. The carbon fiber/ polyacrylamide/ wood fiber (CPW) composite exhibits EMI Shielding effectiveness of 41.03dB.

New study was reviewed in **2017** by **Kausar et al.,** about the polystyrene that have thermoplastic properties and discussed about structure and properties of carbon nanotube (CNT) and polymer for making electromagnetic shielding. CNT is consider as filler for polymers. The shielding effectiveness of -27.5 to -39.2 dB was obtained in the Ku-band (12.4-18.0 GHz). In **2017 Dakshayini et al.,** used shielding materials used for electromagnetic interference (EMI) are composites of graphene, copper ferrite and poly aniline (PANI) and found electromagnetic measurements were done by using a coaxial cable connected to a network analyzer to obtain the shielding effectiveness (SE), so that mixed in a ratio 1:1 gives the SE of 30.2772 dB. **Jia et al.,** designed a carbon nanotube (CNT)/GTR composite with typical segregated structure in **2017** with CNTs selectively localized at the boundaries of GTR domains that containing only 5.0 wt% CNT and exhibits conductivity of 109.3 S/m and an EMI shielding effectiveness (SE) of 66.9 dB. The CNT/GTR composite shows excellent flexibility and stability with 93% retention of EMI SE even after repeatedly bending to the radius of 2.0 mm for 5000 times. Another research by **Li-Chuan Jia et al.,** in **2017** was presented on network stabilized carbon nanotube/natural rubber composite that showed high EMI shielding and concluded that long-term cycling tests in all deformation modes show >80% retention of EMI shielding. In **2017 Jani et al.,** studied on broadband microwave absorption and electromagnetic shielding effectiveness in 2017 of flexible rubber composites with low filler content of nanosize conducting carbon over 8–18 GHz frequency and found rubber based composites are prepared by loading of 1–15 wt% nanosize conducting Carbon Black (CB) in silicone rubber matrix. The electromagnetic Shielding Effectiveness (SE) of silicone rubber composites with concentration of 15wt% of CB shows −40 dB SE over the broad frequency range 8–18 GHz at thickness 2.8mm.

In **2015**, A study on barium ferrite decorated reduced graphene oxide (BaFe12O19@RGO) nanocomposite reviewed by **Verma et al.,** in which, it was synthesized by a high energy ball milling technique and its electromagnetic properties were investigated in the frequency range of 12.4–18 GHz (Ku band). So multiple scattering and the effective anisotropy energy leading to a high electromagnetic interference shielding effectiveness of 32 dB (B99.9% attenuation) at a critical thickness of 3 mm. **Shahzad et al.,** demonstrated a laminated structure of sulfur-doped reduced graphene oxide (SrGO) in **2015** that was designed by significant potential for electromagnetic interference shielding application in which SrGO was prepared through the reaction between graphene oxide and hydrogen disulfide (H2S) gas at elevated temperatures. As a result of it 119% larger EMI SE (33.2 dB at 100 MHz) with a very small thickness of 140 μm than the undoped graphene. In **2015 Kumar et al.,** presented a work to fabricate processible composite sheets of poly (o-anisidine)-carbon fiber (PoACF) by a facile in 2015 to find their use in electromagnetic interference (EMI) shielding in X-band (8.2-12.4 GHz). So maximum shielding effectiveness of 32.57 dB at 4 mm thickness. Another research in**2015 Kumar et al.,** fabricated reduced large-area graphene oxide (rLGO) with maximum surface area of 1592 μm2 through a cost-effective chemical reduction process at low temperature. The efficient electromagnetic interference (EMI) shielding effectiveness of ~ 20 dB at 1 GHz.

In **2009 Saleh et al.,** The electromagnetic interference (EMI) shielding mechanisms of multi-walled carbon nanotube (MWCNT)/polymer composites were analyzed experimentally and theoretically. By the experimental analysis the shielding effectiveness (SE) of MWCNT/polypropylene (PP) composite plates made in three different thicknesses and at four different concentrations were studied. The overall EMI SE decreased by multiple reflection within MWCNT internal and external surface. The EMI SE of MWCNT/PP composites of experimental and theoretical study was 36.4 dB and 30.9dB respectively in the frequency range of 12.4 GHz.

Chung has concentrated on electromagnetic shielding effectiveness of carbon material in **2001** and include composite material, colloidal graphite and flexible graphite and concludes the shielding effectiveness for different material are 26dbB, 42dB, 19dB, 23dB, 5dB, 58dB, 32dB and 87dB.

In **1997 Shibata et al.,** has showed the electromagnetic properties of wood ceramic made up of waste material and found wood ceramic are new carbon material which made up of woody material with phenol resin and then thermos formed in a vacuum furnace and these been shown to have electromagnetic shielding properties. The result should that the wood ceramic made up of waste material had an electric shielding effectiveness of 30dB for 100MHZ and 40 to 43dB for 300MHZ.

3.3 TEXTILE MATERIAL

In 2018, **Marciniak et al.,** discovered the multilayer textile sets like woven fabrics which is made up of cotton and hybrid yarn for electromagnetic shielding. Author used 3mm thickness of a copper coil that is pitched on hybrid yarn and verify the effect of number of layers of fabrics on shielding effectiveness. After concluding, the shielding effectiveness is 56dB by applying three layer of fabrics. A high-performance silver coated polyamide (Ag/PA66) nonwoven fabrics with a density of only 0.04 g/cm3 have been developed using staple fibers of 19 (3.3 dtex) and 27 (6.7 dtex) μm diameter by **Ozen et al.,** in **2018** in which nonwoven fabrics with an Ag loading of 12-18 wt% had electromagnetic shielding effectiveness of over 1200 dB/(g/cm3) in the 0.015-3 GHz range. The needle-punched Ag/PA66 nonwoven fabrics which has low density of the order of 0.04 g/cm2, exhibited EMSE values of nearly 69-80 dB.

In **2017**, **Liang et al.,** calculate the method of shielding effectiveness for woven fabric containing metal fiber yarns and explain the calculation formula of shielding effectiveness for the fabric through the transfer matrix of the electromagnetic field and theoretical value by using the theoretical formula and the measured value tested by the shielding chamber method. Author calculated the result of theoretical value and the measured value in a frequency range from 4 to 14 GHz and shows that the theoretical calculation model is simple, highly precise, and is valuable for the design and development of fabric containing metal fiber yarns.

Another research in **2016** on conductive polymer based electro-conductive textile composite for EMI shielding was reviewed by **Maity et al.,** and discussed about its preparation development and characteristic. Author modified ordinary textile material in the form of electro-conductive composite and also explored various metallic and non-metallic electro-conductive textiles and calculated different SE of conductive textiles. The highest shielding effectiveness is counted as 75-80dB in testing frequency of 100KHz to 1GHz of metallic fabrics.

In **2014, Bhattacharjee** also used different types of shielding. Author used some shielding fabrics like bamboo fiber with silver, pure 100% surgical stainless steel knitted into shielding fabric, a multi metallized fabric made up of polyester, nickel, copper and nickel copper alloy mixed, thin silver, coated copper wire spun with cotton or polyester yarn were used for making the electromagnetic shielding.

Another research has studied on textile material by **Maity et al.,** in **2013** showed the shielding effectiveness is raised to 100dB by using different method of shielding like metalizing of textile fabric, non-woven, knitted fabrics and coated textile with conductive polymer. Other commercial products like natural shielding, conductive acrylic and polyethylene with hot melt adhesives are used.

3.4 CONDUCTIVE MATERIAL

In **2018**, **Jian et al.,** designed some alloys sheets for electromagnetic radiation in which designed a duplex Mg-9Li alloy with laminated form of 24-1 interfaces of strips that is fabricated by accumulative roll bonding (ARB) up to 4 cycles at ambient temperature and after testing shielding effectiveness (SE) of the sheets was 56dB to 73dB at 1350MHz with the increasing of phase interlayers interface through ARB process. **Gao et al.,** used Mg-XZc and Mg-XSn alloys which is prepared under different rolling and heating treatments to reviewed about the electromagnetic shielding properties in **2018**. As a result, when Mg5Sn alloy subjected to 16h of solution treatment at 480 degrees Celsius and 60h of artificial aging at 17 degrees Celsius, the maximum increment in shielding effectiveness is 13dB at 1200 MHz. The recent development of advanced conductive coating technologies and their application in antistatic reviewed by **Kelvin et al.,** in **2018** in which different type of conventional textiles, conductive textile for electromagnetic shielding. Author discussed in paper the material for shielding should have high electric conductivity and magnetic permeability Metals, alloys, and carbonaceous materials are common components in conductive composite materials used as conductive fillers for electromagnetic shielding.

In **2018 Jiang et al.,** used the samples of the woven cotton fabric are first modified with a continuous polyvinyl alcohol (PVA) thin film by using the padding method and then coated with copper (Cu), titanium and stainless steel (SS) respectively, by using a magnetron sputtering system for analysing electromagnetic interference shielding properties in 2018. Author notified that metal coated PVA/cotton samples show a better performance in electro-conductivity but Cu coated PVA/cotton sample has a higher electromagnetic interference shielding effectiveness of − 30 dB. Another research on conductive material in **2018** by **Pandey et al.,** in which Mg alloys were used which are known for their light weight and excellent mechanical properties. The results of this study indicate that the EMI SE is strongly reliant on the porosity and grain/dendritic boundaries of the material which is from 500 MHz–6 GHz and 7–13 GHz of frequency range.

In **2017**, **Rathi et al.,** used conductive composite sheet for electromagnetic interference shield in near and far region and utilized the dielectric properties of styrene acrylonitrile (SAN) copolymer and graphite (Gr) conducting composite in radio frequency for calculating EMI Shielding. Author calculated the shielding effectiveness in the range of 10 MHz–1 GHz of the SAN–Gr **c**onducting composites with addition of Gr content. For minimizing the effectiveness of EMR **Monzen et al.,** has discussed the tungsten functional paper (TFP) in **2017** that contains 80% of tungsten by weight.

In **2015 Mishra et al.,** presented materials modeling, design, processing, integration and characterization of a new class of nanomagnetic structures for coupling and shielding. This research described vertically aligned magnetic composite structure and modeling, design and fabrication of nanomagnetic structures for ultra-thin EMI shields. The ultra-thin EMI shields showed greater than 20dB attenuation at 6.78 MHz even for 3-5μm shield thickness. A research on dipole antenna in which shield made up of copper, aluminium, zinc ferrite, sliver and nickel by **Rani and Pandey** in **2015** with different dimension that was 0.1mm, 0.2mm and 0.3mm. Author has done two sets of simulation in which set up 1 was not affected in SAR reduction. But in simulation set up 2, the author was successful to reduce the SAR value of phone more than 88% for both 1g or 10g of tissue.

Another studies about the electromagnetic shielding behavior of conductive filler composite and conductive fabrics by **Jaganthesan et al.,** in **2014** in which different metal with alloy and polymer material. Metal coated carbon fiber, metalized cloth of 3m fabrics, shielding tents, coated shielding material like copper, aluminium, steel, nickel and stainless steel, carbon fiber reinforced polymer composite is used for electromagnetic shielding. As a result, shielding effectiveness of shielding tent is 30-50dB and other shielding effectiveness is raised 80dB for the frequency of the 18GHZ.

In **2009 Geetha et al.,** surveyed the shielding materials like metals, conducting plastics and conducting polymers for the control of electromagnetic radiations. The common material used for construction of enclosures for shielding is mumetal, a high permeability alloy of 14% iron, 5% copper, 1.5% chromium and 79.5% nickel. The other metals/materials used as a shield are brass, aluminium, silver, nickel, stainless steel, metalized plastics and conductive carbon/ graphite composites. Shielding material that is made up of metals suffer from heavy weight, corrosion. Therefore, synthetic metals like PAn and PPY are most effective material for EMI Shielding. The EMI SE of PAn and PPY is 40 to 50dB in the frequency range of 10KHz to 1GHz. The SAR reduction by using RF shield reviewed by **Ragha et al.,** in**2009** in which author found the SAR reduction in human head model is achieved by attaching nickel, zinc, spinel ferrite sheet resonating at 2.4 GHZ to mobile phone and used simulation software CST microwave studio to investigate different parameter like size, shape and type. So as a result of it author noticed 54% of reduction is taken out by using RF shield.

3.5 METAMATERIALS

In **2012 Farque et al.,** has worked on triangular metamaterial for electromagnetic absorption reduction at microwave and used time domain method with a lossy Drude model in which triangular metamaterial have to attain 1.0923 watts per kilogram SAR for 1 gram of tissue and which is 45.44% reduction of initial SAR. After deploying metamaterial in phone mode, the SAR value results in 0.692 watts per kilogram for 10gram SAR and 1.092 for 1gram of SAR. Same research in **2010** by **Farque et al.,** on metamaterial for absorption of electromagnetic radiation in human head and used time domain with a lossy Drude model in which author observed the SAR by varying distance between the head model and phone model. As a result of it, metamaterial observed 53.94% of radiation in 10 gram of SAR. SAR value for 1 gram of tissue is 1.16079 watt per kilogram and for 10 gram of tissue, the value is 0.737 watt per kilogram.

Islam et al., in **2009** used ferrite material and metamaterial for the reduction of the SAR in the human head and also used lossy Drude model. By this model, ferrite material has attained a 47.68% reduction in initial SAR value and metamaterial reduces about 42.12%. After deploying SAR value of 10gram of tissue are 0.676 watt per kilogram and 0.737 watts per kilogram for 10 gram of tissue with metamaterial. Hence SAR is reducing by using ferrite material and metamaterial. But same research by **Islam et al.,** in **2009** showed the work on ferrite sheet attachment for SAR reduction in human head and used lossy Drude model and compute the SAR reduction of 57.75% is attainted for 10g of tissues and find that ferrite sheets can reduce the maximum SAR level effect inside of the human head.

Conclusion and Result

In this paper, we concluded that mobile phone EMR is very dangerous for human as well as for animals. Most affected by EMR are children under the age of 14 and studies show that SAR value from 0.000021- to 3 W/Kg is very harmful that can cause brain tumour and cancer like diseases. After studied about shield material we concluded that Flexible rubber composite with low filler content of Nano size conducting carbon (loading 1-15% weight) with 2.8mm of thickness has much shielding effectiveness of 40 dB at the frequency range of 8 to 18 GHz and in antenna material Dipole antenna made up of copper aluminium, zinc ferrite, silver and nickel with dimensions of 0.1mm, 0.2mm and 0.3mm has 88% of SAR reduction of both 1g and 10g of tissues.

Future Direction

After studying the recent and past research on electromagnetic shielding, the future direction for this review is to make an effective anti-radiation shield to minimize the maximum radiation factor in the wireless devices such as mobile phone, to reduce the impact of electromagnetic interference in human being that cause harmful diseases.

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