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Anti Radiation Case from Paper Waste for Smarthphone

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Abstract: *Electromagnetic radiation (Electromagnetic Field, EMF) can be sourced from nature and man-made, such as a smartphone. EMF exposure to humans is increasing with the presence of smartphones. Paper waste that has biodegradable properties has potential as antiradiation. By mixing other additives such as starch, glycerol, and Polyvinyl Acetate (PVAc) can increase the tensile strength of Case Smartphone Antiradiation (CSAR). The anti-radiation properties of CSAR was calculated using dosimeters by comparing the anti-radiation properties of CSAR with other materials (aluminum foil, paper without aluminum foil, and softcase), various conditions (stand-by, dialing, and charging), and different distances/thickness (0 mm, 2 mm, 4 mm, and 6 mm). In charging conditions, EMF is larger than the stand by and dialing conditions. As increasing the thickness of CSAR, EMF exposure is also reduced*

Keywords: *Anti Radiation, Electromagnetic Fields, paper waste*

1. Introduction

Electromagnetic radiation (Electromagne-tic fields: EMF) consists of electromagnetic fields (E-field) and magnetic (H-field), can be sourced from nature and man-made. All populations are exposed to different levels of electromagnetic radiation, the level of exposure will continue to increase along with the development of technology [1]. Smarthphone is one of the modern tele-communication technologies and rapidly evolving into a part of lifestyle. Because of its popularity, world smarthphone production tends to increase from 2015, 2016 and 2017 respectively, i.e. 1,298.3 million units, 1,359.6 million units and 1,457.5 million units and estimated to increase in 2018 to 1,498.3 million units smathphone [2]. Thus, EMF exposure in humans, especially smarthphone users will increase compared with those who do not use smarthphone. This may indicate adverse health effects, although there have not been any successful studies showing the effect of EMF from smartphones on health such as genes, proteins and cancer [3,4]. Obviously EMF can cause a rise in body temperature or often referred to as a thermal effect [5]. However, there is a need for preventive measures to reduce the exposure of EMF from smarthphone, as in this paper that is by making casing smarthphone.

Smartphone casing, additional accecories smarthphone produced commercially (in this paper called softcase) certainly increased along with increased the production of smartphones. However, softcase waste has non-biodegradable properties that will cause environmental pollution. Paper, has potential as a biodegradable, renewable, inexpensive, and is a flexible polymer substrate [6] and has 85-99% of cellulose and 0-15% of lignin [7]. that can be formed and used to replace of softcase. Thus, paper waste can be utilized to the maximum. In this research, will be potential paper research that has been made as antiradiated smarthphone casing (CSAR) EMF from smartphone.

2. Materials and Methods

2.1. Materials

The main ingredients used in this experiment are HVS (*HourVrij Schrijfpapier*) type paper waste, starch flour, polyvinyl acetate (PVAc), glycerol, aluminum foil, water, wax glue, rubber strap, and spray paint. The tools used are screen printing, wood, dosimeter (Version 3120-EN-00), Universal Testing Mechine (ASTM D638) and SEM.

2.2. Research Procedure

2.2.1. CSAR Creation

Paper waste weighed, immersed in water, blended to form suspension, then drained. Drained paper, added with starch content of 25% of the total paper dry weight, 10% glycerol of total starch weight, and PVAc by 10% of the total paper weight. The mixture was heated while stirring at 80 °C for 15 minutes. After that, the dough is poured in a paper-aluminum foil-paper and is made also a casing with no aluminum foil layer (paper). The dough is loaded 50 N for 15 minutes, then removed and dried it under the sun.

2.2.2. Anti-radiation Test

The anti-radiation test was performed by using the dosimeter version 3120-EN-00, by placing dosimeters on the smarthphone with a distance of 0 mm, 2 mm, 4 mm, and 6 mm, with smarthphone: stand by, dialing, and charging conditions and using CSAR with thickness of 2 mm, 4 mm, and 6 mm. Anti-radiation tests are also performed on smarthphone paired softcase, aluminum foil, and paper casing. Each measurement is done in three times.

2.3. Tensile Test (ASTM D638) and SEM Test

The specimens tested were casing dough formed without starch and glycerol, and the dough formed into CSAR. The specimens were measured in length, width, thickness, grip, and gauce, then inputting the measurement data, then inserting the specimen into the tool and finally testing. The result obtained is processed to yield tensile test data, EB and MOE.

For SEM, visualization of sample surface morphology is paper without blend of starch and glycerol, and samples from CSAR. The magnification used is 1000x.

3. Results and Discussions

3.1. TS and SEM of CSAR

In preparing the paper CSAR first mush by using a blender to facilitate the formation of the dough. All of the good mixture is heated with the aim of gelatinization of starch. The purpose of the addition of glycerol is to enhance the elasticity of the starchy starch, so it is not easily brittle. PVAc is one of the adhesives commonly used in paper making, used for the purpose of strengthening the bonds between fibers and preserving the paper, to obtain quality paper, resistant to microorganisms and does not result in stains on dryness[8]. Mixing of these materials can increase the tensile strength of the created CSAR, as can be seen in table 1.

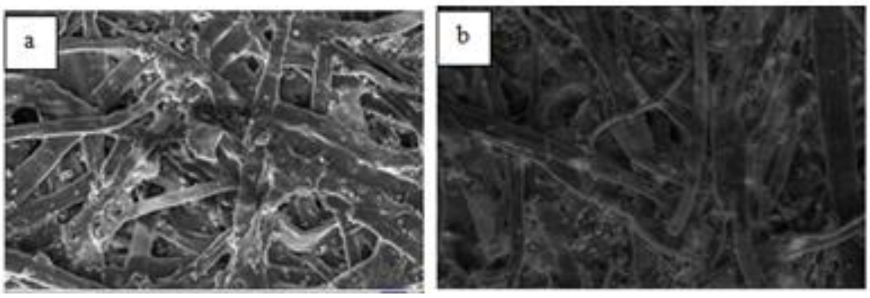
The result of the SEM test also shows the difference of morphological surface of the material made. Paper (Figure 1.a) has many pores and is brighter when compared to CSAR (figure 1.b) which has slightly pore and darker.

Table1. *Tensile strength test results of Smartphone Case Materials*

No	Sample	*Tensile strength* (Kgf/mm^2)	*Elongation* (%)	MOE (Kgf/mm^2)
1	CSAR	0,264	4,053	6,520
		0,176	5,110	3,447
		0,162	2,864	5,652
Average		**0,201**	**4,01**	**5,206**
2	Paper (without starch and glycerol)	0,099	2,115	4,696
		0,147	2,647	5,546
		0,133	2,024	6,573
Average		**0,126**	**2,262**	**5,605**

3.2. Comparison of CSAR to Various Materials

CSAR has been made compared to other materials i.e. paper (without layer of aluminum foil), aluminum foil and softcase. Determination of caseless radiation was used as a control for this experiment. In the picture can be seen that softcase can not absorb radiation at all, either E-field or H-field. Aluminum foil has anti-radiation properties against E-field (figure 2a), but it tends not to hold H-field (figure 2b). However, aluminum foil can not be used as a smartphone case because it is a thin sheet and can spread heat (thermal radiation) around the smartphone caused by EMF.



a) Paper without mixture of starch and glycerol and b) CSAR

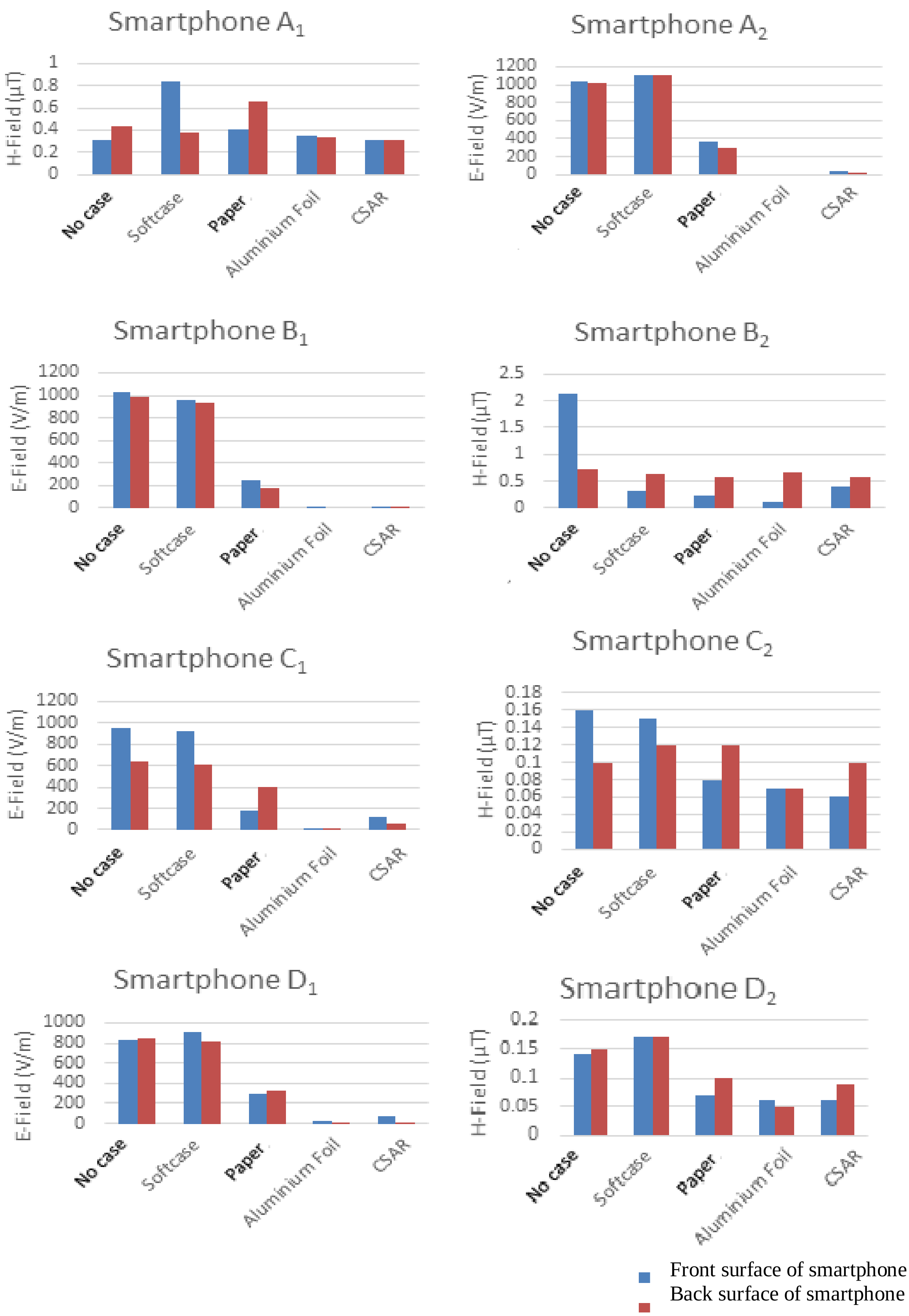


Figure2. *E-field (Smartphone A_1, B_1, C_1, and D_1) and H-field (Smartphone A_2, B_2, C_2, and D_2) exposure from smartphone by using of some materials.*

The paper (without the aluminum foil layer) has the potential to be both E-field and H-field antiradiated, although not as strong as aluminum foil in absorbing E-field radiation, but paper tends to absorb H-field. The paper can also be formed into a case and is a poor conductor of heat.

CSAR, as a paper having an aluminum foil coating has a potent EMF-better antiradiation when compared to paper. This is due to two combinations of antiradiated materials. The aluminum foil layer on CSAR is also expected to spread thermally caused by EMF around the paper layer, allowing the thermals to reach the user's body less.

Table2a. *The effect of CSAR distance / thickness retains radiation in stand by condition*

Smarthphone	distance / thickness (mm)	E-field (V/m)				H-field (µT)			
		Without CSAR		Using CSAR		Without CSAR		Using CSAR	
		Front	Back	Front	Back	Front	Back	Front	Back
A	0	0	0	-	-	0,19	0,17	-	-
	2	0	0	0	0	0,17	0,18	0,16	0,27
	4	0	0	0	0	0,15	0,18	0,15	0,17
	6	0	0	0	0	0,17	0,19	0,18	0,19
B	0	433	63,67	-	-	6,86	0,44	-	-
	2	256,33	4	1	2,33	0,4	0,32	0,27	0,45
	4	78,67	1,67	0,67	0,67	0,28	0,27	0,28	0,28
	6	60,67	0,67	1	0,67	0,28	0,27	0,27	0,33
C	0	0	0	-	-	0,07	0,07	-	-
	2	0	0	0	0	0,07	0,07	0,07	0,07
	4	0	0	0	0	0,07	0,09	0,07	0,09
	6	0	0	0	0	0,07	0,07	0,07	0,07
D	0	37	15	-	-	0,17	0,17	-	-
	2	12,33	3,33	12,33	5	0,18	0,17	0,18	0,18
	4	7	1,33	0	6	0,18	0,17	0,18	0,18
	6	7	0	0	0	0,18	0,19	0,5	0,19

Table2b. *The effect of CSAR distance / thickness retains radiation in dialing condition*

Smarthphone	distance / thickness (mm)	E-field (V/m)				H-field (µT)			
		Without CSAR		Using CSAR		Without CSAR		Using CSAR	
		Front	Back	Front	Back	Front	Back	Front	Back
A	0	0	0	-	-	0,31	0,28	-	-
	2	0	0	0	0	0,28	0,31	0,25	0,27
	4	0	0	0	0	0,25	0,29	0,24	0,27
	6	0	0	0	0	0,25	0,27	0,25	0,26
B	0	766,67	29,00	-	-	5,28	5,39	-	-
	2	268,00	3,67	0,00	6,33	6,53	8,14	1,19	1,56
	4	84,67	2,33	2,33	0,00	7,57	12,60	0,82	1,88
	6	81,33	3,00	1,00	0,00	6,38	7,40	1,17	1,43
C	0	0	0	-	-	0,31	0,28	-	-
	2	0	0	0	0	0,28	0,18	0,29	0,26
	4	0	0	0	0	0,28	0,18	0,26	0,21
	6	0	0	0	0	0,28	0,18	0,29	0,20
D	0	49,00	17,33	-	-	0,18	0,20	-	-
	2	20,00	2,33	1,36	2,67	0,21	0,19	0,28	0,47
	4	8,33	0,00	1,25	1,33	0,16	0,18	0,30	0,35
	6	3,00	0,00	0,00	0,33	0,21	0,20	0,30	0,56

Table2c. *The effect of CSAR distance / thickness retains radiation in charging condition*

Smarthphone	distance / thickness (mm)	E-field (V/m)				H-field (µT)			
		Without CSAR		Using CSAR		Without CSAR		Using CSAR	
		Front	Back	Front	Back	Front	Back	Front	Back
A	0	1040,67	1013,67	-	-	0,31	0,44	-	-
	2	795,00	598,67	35,33	22,67	0,31	0,32	0,31	0,31
	4	751,67	601,00	39,00	12,67	0,29	0,35	0,29	0,27
	6	620,67	551,33	50,33	79,00	0,30	0,30	0,29	0,31
B	0	1025,33	991,33	-	-	2,13	0,72	-	-
	2	901,00	699,33	15,00	6,00	0,47	0,44	0,40	0,56
	4	660,33	579,33	58,00	14,00	0,38	0,39	0,41	0,52
	6	655,33	555,33	25,67	29,33	0,41	0,37	0,29	0,37
C	0	1146,67	746,00	-	-	0,26	0,19	-	-
	2	894,33	609,67	126,33	126,33	0,24	0,17	0,20	0,17
	4	815,67	547,33	157,00	257,67	0,23	0,21	0,17	0,19
	6	721,33	487,33	495,67	357,33	0,21	0,21	0,26	0,19
D	0	1153,33	622,67	-	-	0,35	0,24	-	-
	2	923,00	542,00	173,67	146,67	0,33	0,26	0,23	0,24
	4	821,33	430,00	155,67	107,00	0,29	0,17	0,24	0,25
	6	746,67	408,00	77,00	78,67	0,26	0,24	0,26	0,23

3.3. Effect of Distance/Thickness Difference on CSAR Effectiveness

In table 2a, 2b, and 2c, EMF data are presented on the front and back of the smarthphone, with CSARs having different thicknesses and without CSAR with CSAR thickness spacing, and in standby conditions, communicating (dialing) and charging. It can be seen that in the condition of charging, EMF on smarthphone is very high that reaches 1000an V/m for E-field and 0,30an µT for H-field. This is because in these conditions, electric energy is flowing in the smarthphone. To note that electricity also has EMF, EMF is sourced from human made8. While on dialing (table 2b), H-field is higher that reaches 12.60 µT (smartphone B).

When compared with radiation exposure without CSAR on smatphone of these three conditions, radiation on the front side of the smartphone tends to be larger than the rear of the smartphone. This reason can be known through the comparison of the dosimeter distance to measure EMF smartphones without CSAR, ie because there is a difference of distance closer from the cellphone core of the smartphone on the front side smatphone compared with the back side smatphone.

The Distance differences without CSAR tend to lead to reduced EMF radiation exposure, but not greater when compared to using a smartphone. Thus, it is highly recommended to smartphone users to keep their distance in using smartphones to reduce EMF exposure. However, by using CSAR, EMF exposure has decreased considerably.

In table 2c, it can be seen that there is a tendency to increase E-field with increasing CSAR thickness. This is not regarded as a mistake by the author, but when in charging conditions, there is a flow of electricity that is considered not constant in the smarthphone and may be caused by the program that runs automatically in the smartphone. This possibility can be proved by E-field on stand by and dialing conditions. In this condition, there is a tendency to decrease EMF exposure with increasing CSAR thickness.

Of all the data presented, the charging conditions may be considered quite dangerous because according to Brune et al[9], the E-field in the open only for 100-130 V/m while the E-field charging condition reaches 1000 V/m. Although there is no scientifically acceptable evidence of EMF dangers from smartphone[10], the authors suggest not to use a smartphone while charging conditions. H-field can be considered harmless because, according to Brune et al[9], in the H-field nature of 30 µT (horizontal near equator) and 70 µT (vertical near magnetic poles).

4. Conclusion

Paper waste has potential as an anti-radiation one of them in the form of CSAR. CSAR is biodegradable, that it can reduce the use of non-biodegradable and non-antiradiated soft cases. In charging conditions, EMF is larger than the stand by and dialing conditions. Getting thicker the CSAR, EMF exposure is also getting reduced.

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