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# **The Innovation Breakthrough in Digital and Disruptive Era**

## Effect of the Carbon Source on the Characteristics of Silica-carbon as a Handphone's Case Material

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**Abstract.** Activated carbon is believed to reduce radiation from cell-phone because it has large pores. This study aims to synthesize a silica-carbon composite as a mobile phone casing using activated carbon from bamboo, coconut shells, and coal combined with silicone rubber. The addition of activated carbon is carried out in the range of 10 - 30 g. Activated carbon mixed with silicone rubber and stirred for 3 minutes at 150 rpm. Based on Digital Electromagnetic Radiation, the highest addition of activated carbon (30g) provides a high radiation reduction but has a small tensile strength and a large elongation value. SEM images show that the distribution of activated carbon 10 - 15 g is more homogeneous on the mobile phone casing.

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## 1 Introduction

The development of today's communication technology, such as mobile phones, requires more good communication devices, including various supporting electronic components [1]. These electronic components generally work at high frequencies up to GHz [2]. Radiation exposure is one of the effects of mobile communication devices that users need to be aware of [3]. Radiation is the emission of energy through a material or space through heat, particles, or electromagnetic waves/light (photons) from a radiation sources [4]. Several ways need to be done to overcome the dangers of cell-phone radiation, one of which is using a soft cell-phone casing (mobile phone anti-radiation device) [5]. In today's market, many products are offered to reduce the dangers of cell phone radiation, ranging from anti-radiation stickers for cell-phones to particular cell-phone soft casings for smartphones that have high radiation but use synthetic materials that are not environmentally friendly [6].

Along with the development of communication technology, especially mobile phones, which are increasingly sophisticated, many cheap and environmentally friendly electromagnetic wave absorber materials are needed [7]. The main requirement for a material to be categorized as an electromagnetic wave absorber material is that the material must have a high magnetic and dielectric loss [8]. The lack of studies on reducing radiation on mobile phones is an exciting problem to be developed. This research studies the manufacture of silica carbon cellphone casings to minimize cellphone radiation [9]. The activated carbon components could be used as radiation absorbers. This is generally used in the field of defense and security to make combat equipment so that it is not detected by the enemy while conducting military operations [10]. This is reinforced by Nandang et al. 2016 who state that activated carbon or activated charcoal is a material in the form of amorphous carbon, which consists mainly of free carbon and has good adsorption capacity [5].

Activated carbon is also widely used as a blanching agent (dye remover), gas absorber, metal absorber, and so on [9]. This is because activated carbon has a large surface area which can effectively be used as an adsorbent. Commercial activated carbon is generally in the form of graphite. In contrast, non-commercial activated carbon is usually synthesized from new A4 paper size (210 x 297 mm) and adjust the margins to those shown in Table 1. The final printed area will be 172 x 252 mm.

agricultural waste or biomass, such as peanut shells, rice husks, salary powder, and coconut shells. From several activated carbons, it is known that activated carbon from coconut shells [11] and activated carbon from bamboo [12] have a reasonably high surface area, around 189,630-1900.69 m<sup>2</sup>/g according to SII No.0258 – 79. On the other hand, carbon can also be obtained from commercial materials such as coal [13].

The synthesis of silica-carbon has been widely developed [14] for various applications, mainly as an adsorbent. Several methods have been developed

related to the synthesis of silica-carbon, including the Chemical Vapor Deposition (CVD) method [15] and the sol-gel method [16]. The CVD method is considered less effective because it requires energy and a high operating temperature and is very sensitive to vapor rate. In contrast to CVD, the sol-gel method is quite effective and efficient, considering that it does not require much energy [17]. Based on previous research that nanostructured silica-carbon has been shown to exhibit superior properties (more excellent elasticity and strength) [4].

This research develops the synthesis of carbon silica using the sol-gel method. The carbon we use comes from coconut shell carbon [18], bamboo carbon [19], and coal. The resulting silica-carbon composite will be used as a radiation-reducing cellphone casing by testing the radiation level and tensile strength [20]. On the other hand, silicon rubber, as the primary material for forming silicon carbide, tends to create agglomeration properties in the presence of hydroxyl groups [21]. This is evidenced by using the results of the SEM test. Meanwhile, activated carbon from coconut shell carbon, bamboo carbon, and coal is used as an electromagnetic wave adsorbent. This study also studied variations in the amount of added carbon to determine the best composition in manufacturing radiation-reducing cell phone casings from activated carbon.

## 2 Materials and Methods

Silica-carbon composite were prepared by the sol-gel method and printed on standard cell phone-sized molds.

### 2.1 Materials

Silicone rubber is obtained from the Chemical Store. Coconut shell activated carbon, Japanese bamboo activated carbon, and coal-activated carbon with iodine absorption quality 100 was obtained from Barata Chemical. The casing/molding is made of 17 x 10 cm plate material.

### 2.2 Preparation of Silica-carbon

Each activated carbon was reduced in size with a ball mill and sieved to a height of 100 mesh. Activated carbon was mixed with silicone rubber and stirred for 3 minutes at 150 rpm. The addition of activated carbon was carried out in the range of 10,15,20, 25, and 30 g. After the mixing process, the carbon silica is poured into the mold, leveled to a thickness of about 1.5 mm, and allowed to harden. After that, it was lifted and trimmed [22]

### 2.3 Characterization

SEM image obtained from SU3500 operating under vacuum, SE Image 7nm with resolution at 3 kV, 10 nm BSE image resolution at 5kV.

Physical properties test (stress-strain) with an autograph type Microcomputer Control Universal Testing, as well as a radiation value test using Digital Electromagnetic Radiation. Stress is the force applied to a material, divided by the material's cross-sectional area.  $\sigma = \text{stress (N/m}^2, \text{Pa)}$   $F = \text{force (N)}$   $A_0 = \text{original cross-sectional area (m}^2)$ . Strain is the deformation or displacement of material that results from an applied stress. Tensile strength testing was carried out using samples with the addition of 10, 15, and 20 g of activated carbon. In testing the physical properties, the samples were cut into blocks with a width of 6 mm, a length of 42.125 mm, and a thickness of 2.55 mm. The length increment value is taken every two seconds to obtain data in the form of length increase (L) and force (F). The results is then processed to become stress and strain data.

### 3 RESULT AND DISCUSSION

#### 3.1 Reduction and Level of Radiation

The correlation between the amount of activated carbon to the level of radiation and radiation reduction for the three types of carbon (coal, coconut shell and Japanese bamboo) is shown in Graphic 1. There is a tendency to decrease the level of radiation with the addition of activated carbon. The initial measurement of the radiation value of a cell phone without a casing was 148 J/Kg. For the addition of each active carbon of 10, 15, 20, 25, and 30g the resulting radiation values for coal carbon are 121, 113, 106, 98, and 94 J/Kg respectively, coconut shell activated carbon gives radiation values respectively 117, 110, 101, 92 and 78 J/Kg, while Japanese bamboo activated carbon gave radiation value of 101, 97, 90, 85, and 73 J/Kg respectively. All three types of activated carbon support radiation reduction levels. Activated carbon from Japanese bamboo showed greater radiation reduction compared to activated carbon from coal and coconut shells.

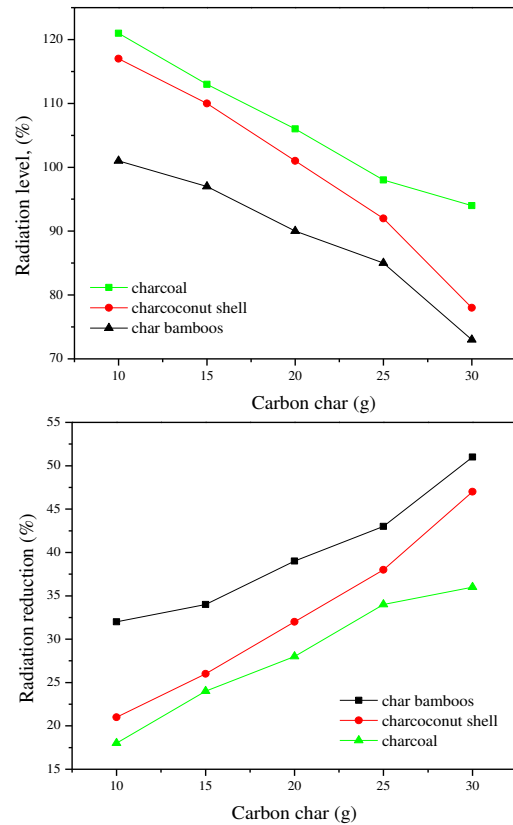
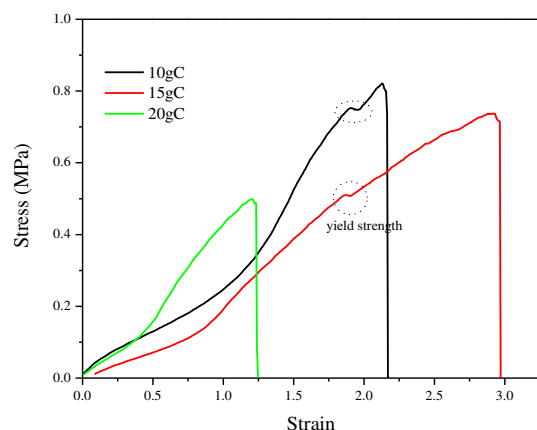


Fig.1. Correlation of the amount of carbon to (a) radiation levels and (b) radiation reduction

#### 3.2 Tensile strength of silica-carbon composite

Based on the stress-strain data (Fig.2), the tensile strength value of the mobile phone casing with the addition of 10, 15, and 20 g of activated carbon was 0.85 MPa, 0.75 Mpa, and 0.5 Mpa, respectively.

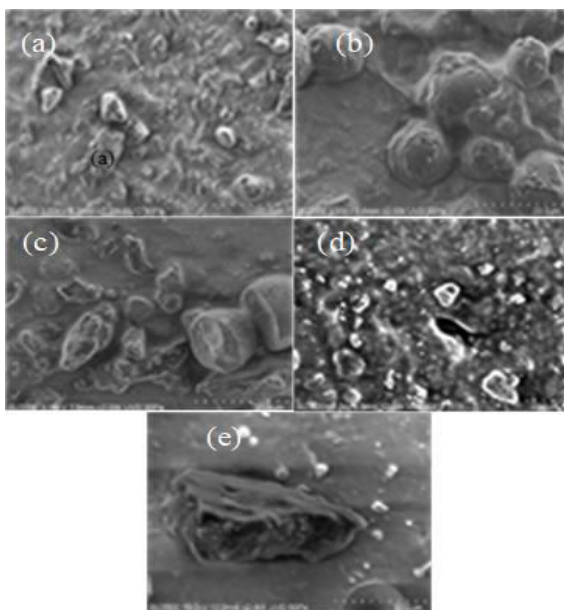
The addition of activated carbon filler to the carbon silica composite affects the elongation at break. The more activated carbon filler added to the carbon silica composite, the elongation at break decreased. This is what Ahmed et al. (2012) reported with  $\text{CaCO}_3$  as a filler added to natural rubber. Natural rubber vulcanization without filler has a higher elongation value at break than vulcanization with additional filler. Fillers can severely affect polymer chains and reduce strain [23].



**Fig.2.** Graph of Stress Vs Strain cellphone casing

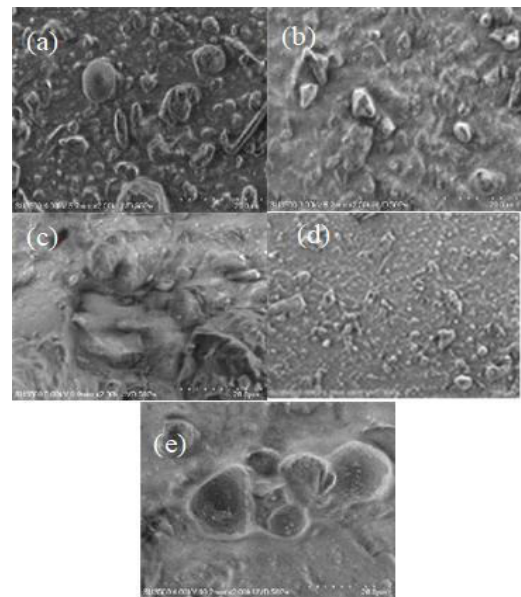
### 3.3 Morphology of silica-carbon composite

SEM image of silica carbon from coal charcoal is shown in Fig.3. The distribution of carbon is pretty even with adding 10 and 15 g of charcoal (Figs. 3a and 3b). However, the more carbon is added, the carbon is not evenly distributed, and there are empty voids. Empty cavities occur because of the tendency of silica rubber to form agglomerations because silica rubber has a hydroxyl group that will try to help hydrogen bond with silica molecules or other chemical materials that are polar, namely activated carbon [20].

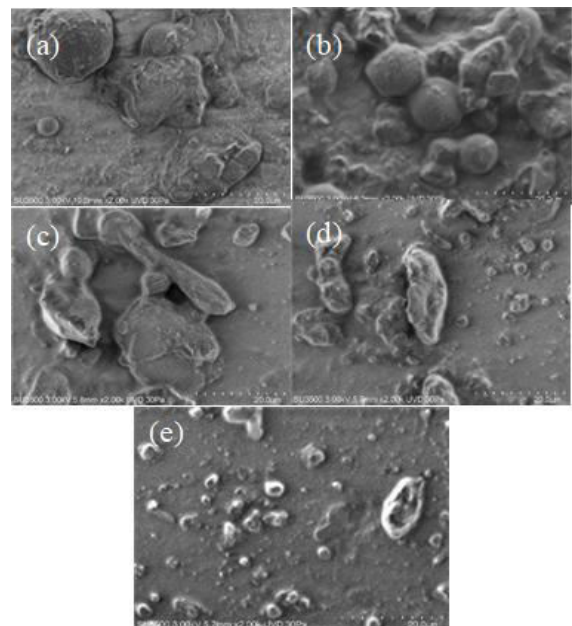


**Fig.3.** Silica-carbon SEM image prepared by coal in amount of (a) 10 g, (b) 15 g, (c) 20 g (d) 25 g, and (e) 30 g

Silica-carbon prepared from bamboo charcoal showed an even distribution by adding 10 and 30 g charcoal (Figs. 3a and 3d). The more carbon added, the rougher the surface. This influences tensile strength as a physical property that a cell-phone casing must possess as a protector and a radiation reducer. The same process also occurs in the formation of silica-carbon which is made from coconut shells charcoal (Figs 5a-5d).



**Fig.4.** Silica-carbon SEM image prepared by bamboo charcoal in amount of (a) 10, (b) 15, (c) 20, (d) 25 and (e) 30 g



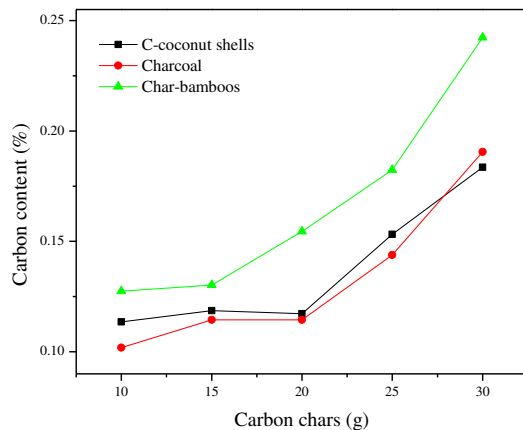
**Fig.5.** Silica-carbon SEM image prepared by coconut shells charcoal of (a) 10, (b) 15, (c) 20, (d) 25, and (e) 30 g.

### 3.4 Silicon (Si) and Carbon (C) content

The denser or even distribution of activated carbon, the greater the tensile strength and vice versa; this is according to what was reported by Novarisa (2017) regarding the morphology of thermoset rubber with palm ash and carbon black filler. The morphology of the carbon silica composite still has many empty cavities due to the tendency of silicon rubber to form agglomerations [24].

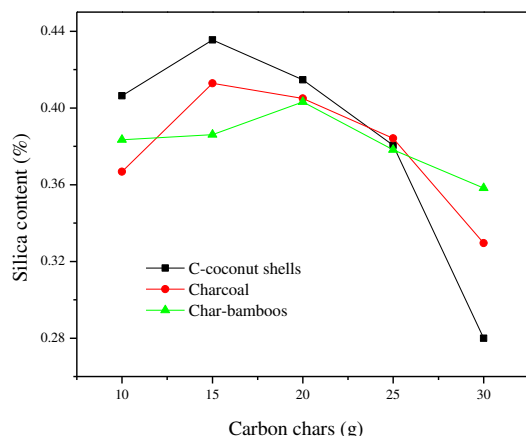
The correlation between the addition of the amount of charcoal to the carbon content of the casing product based on the EDX results is shown in Fig. 6. The tendency for more charcoal, the higher the carbon content. In contrast, the silica content tends to decrease

with the addition of the amount of charcoal (Fig. 7). The highest carbon content in the casing is obtained from coconut shells because the initial composition has a high carbon content [25]. In the casing of coal charcoal, as much as 30 g, the resulting composition of Si 0.358 and C 0.242 showed the highest radiation reduction (51%).



**Fig. 6.** Correlation of the amount of charcoal to the carbon (C) content in the casing product.

The tendency for the more charcoal, the higher the carbon content, which is shown in Graphic 3. In contrast to the silica content, which tends to decrease with the amount of charcoal (Figure 7), this is because the more fillers or fillers are added to the carbon silica, the more carbon fillers will be, while the silica will decrease. Therefore, adding an amount of charcoal as a filler material will increase the carbon content considering that the most significant component in the composition of charcoal, bamboo charcoal, coal charcoal, and coconut shell is element C (carbon). This is the basis of the increase in the C (carbon) content after adding charcoal.



**Fig.7.** Correlation of the amount of charcoal to the content of silica (Si) in the casing product.

The silicon (Si) content decreased and was inversely proportional to the addition of activated charcoal (Graphic 4). This is because the more fillers or fillers are added to the carbon silica, the more carbon fillers will be, while the silica will decrease. Silica will tend to agglomerate to bind with carbon to form cavities. The more the addition of activated

charcoal, the carbon will increase so that the ratio of silica to agglomerate carbon will decrease.

## Conclusions

The study on the characteristics of carbon silica as a radiation-reducing cell phone case has been successfully carried out. The carbon source is an important factor in the formation of carbon-silica composites that are able to reduce cell phone radiation properly. The amount of carbon in silica-carbon composites is proven to be able to increase radiation reduction but is still limited by the tensile strength which is also required in composite materials. Japanese bamboo activated carbon can be recommended well for anti-radiation cell phone casing production materials.

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