High performance of superhydrophobic durian shell-magnetite electromagnetic wave absorber for UHF RFID application

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ABSTRACT – This paper investigates the absorption performance of durian shell-magnetite nanocomposite sheet as electromagnetic wave absorber in ultra high frequency (UHF) radio-frequency identification (RFID) application near metallic environment. A novel and green electromagnetic wave absorber of flexible, light, thin and low cost nanocomposite sheet that can work in high frequency range is invented. RFID encountered a problem to read the information transmitted from tag that attached on metal which may lead to application disturbance. Therefore, magnetic sheet that functioned as electromagnetic (EM) wave absorber is used to solve the problem. In this study, durian shell (*Durio zibethinus* Murray) cellulose fiber was embedded with Fe_3O_4 via lumen loading technique and the surface of nanocomposite sheet was coated with stearic acid hydrophobic formulation. Different UHF RFID reading distances were achieved at different % of degree of loading and different saturated magnetization. SEM micrograph shows that the Fe_3O_4 nanoparticles are existed and well distributed in the durian shell lumens fiber. The microwave absorption properties of the sheets were tested by ultra high radio-frequency identification RFID. The RFID reading distance of the samples increases continually with the increasing of loading degree and magnetization of samples.

1. INTRODUCTION

Radio-frequency identification (RFID) is a technology that use of electromagnetic waves to track, read and capture information stored on a tag attached to an object. A tag can be read from up to several feet away and does not need to be within direct line-of-sight of the reader to be tracked. Compared to bar code technology, RFID gives alignment freedom to customers in detecting goods.

RFID has problem when working near to metallic environment. Metal surfaces reflect energy emitted from RFID readers and create interference for RFID tag antennas, which means the tag is not able to receive power and transmit information. Therefore, magnetic sheet is designed for RFID to absorb the electromagnetic wave. The decay of the electromagnetic signal in RFID system will be effectively reduced by using magnetic interference resistance sheet [1].

Magnetite powders with a higher permeability coefficient could lessen the thickness of the magnetic sheets and enhance the energy harvested by the tags. Greater harvested energy will result in a larger reading range. Besides, magnetic particles are good candidates for different electromagnetic wave and radiation absorption applications due to their broad bandwidth, mild conduction, and low cost [2].

The higher the frequency band the faster the speed of tag reading and also the larger the information storage capacity. This is the reason why UHF RFID has gained popularity in many applications [3].

Thus, in this study, a green magnetic nanocomposite sheet from durian shell pulp was fabricated via lumen loading technique as a wave absorber in RFID application.

2. METHODOLOGY

2.1 Pulping

Before reaching the process of making magnetic nanocomposite sheet, the durian shells chips need to be cooked through soda pulping process to transform the shell chips into pulp. The process was carried out at 170°C of cooking temperature with 21% of alkalinity for 90 minutes. The amount of durian shell chips needed was about 300 g (oven-dried) and the ratio of total cooking liquor to durian shell chips was 10:1 [4].

2.2 Lumen Loading and Superhydrophobic Coating

The process of embedding magnetic particles inside the durian shell fiber and coating with superhydrophobic stearic acid formulation have been discussed in our previous works [5,6].

2.3 Characterization

The percentage of the magnetic particles being loaded and saturated magnetization were also determined according to the procedure mentioned in our previous paper [5]. The RFID reading distance was done by using Omron V720-HS04 UHF RFID machine in near metallic environment. The cross section morphology of the nanocomposite sheets were examined by scanning electron microscopy (SEM) of Zeiss EVO-50 Environmental model.

3. RESULTS AND DISCUSSION

According to Hsu et al., 2010, a magnetic sheet that has higher magnetic particles filling has more magnetic flux and thus more energy was emitted from the analyzer and harvested by the tag. Degree of loading is how much (in percentage) particles being loaded into the fibre. The relationship between the degree of loading (of magnetite) and successful RFID reading distance is illustrated in Figure 1. Figure 1 shows the RFID reading distances were directly proportional with the degree of loading of magnetite as better degree of loading will produce better distance in RFID reading process.

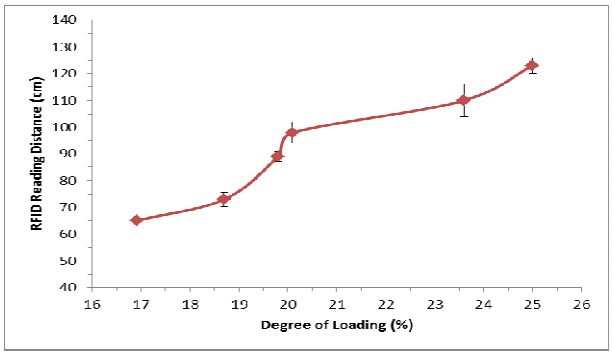

Figure 1 Graph of RFID reading distance in metallic environment versus degree of loading of magnetite

The same goes to the performance of magnetization of the samples. From Figure 2, it shows that when the magnetic saturation values increase, the distance in RFID reading also increases. The higher saturated magnetization properties is really affect the absorption the EM wave as it can gives longer RFID reading distance near or in metallic environment.

Degree of loading had a direct correlation with the magnetic properties. It can be said that as the loading degree increase, the saturated magnetization also increase. Therefore, in order to get better magnetization, control on the degree of loading must be made.

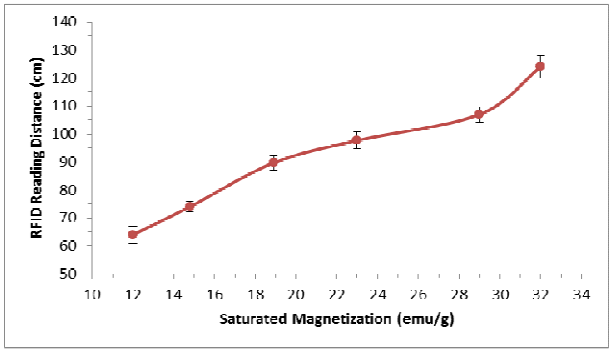

Figure 2 Graph of RFID reading distance in metallic environment versus saturated magnetization

Figure 3 shows the cross section image of the lumen fibres that are fully filled with magnetic particles. These embedded magnetic particles determines the good performance of the magnetic composite sheet as the EM wave absorber. The exterior surfaces of the samples are cleaned from any foreign particles. While the magnetic particles presence inside the lumens, it is important for the outer surface to be cleaned so that it will not interfere with the inter-fiber bonding. This situation will help to maintain the mechanical properties of the magnetic paper while still giving the sheet a significant magnetic properties.

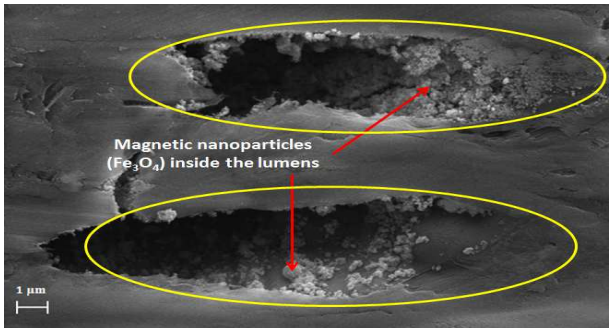

Figure 3 SEM micrograph of magnetite nanoparticles inside the durian shell lumens fibre of the nanocomposite sheet

4. CONCLUSIONS

In conclusion, as the loading degree of the magnetite inside the samples increase, the RFID distance is also increase and as the saturated magnetization increase, the RFID distance is also increases. This new simple method can be used to enhance the performance of RFID antenna tag, which helps to solve the metal interference problem.

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