Dielectric properties of kenaf filled epoxy composites

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Abstract. The dielectric properties of kenaf filled epoxy composites was investigated. Composites was fabricated using kenaf fibres and epoxy resin. The composites was manufactured using a cold press method; the volume fraction of the natural fibres were 7 and 14%. The dielectric test were conducted using Agilent/Keysight E8363B PNA Network Analyser. Result shows that the 14% Kenaf filled epoxy composites successfully decrease the dielectric constant between 12.4 GHz and 16.66 GHz. It shows that the dielectric constant increased with decreased on the fibre loading. Besides that, 14% Kenaf has a higher dissipation loss factor compared to 7% Kenaf filled epoxy composites and reached its peak at 17.89 GHz. In summary, the 14% Kenaf shows a lowest dielectric constant and permeability compared to 7% Kenaf filled epoxy composites.

1. Introduction
Nowadays, the composites formed by natural fibre/polymer has received big attention. Natural fibre/polymer-based composites with a great performance in mechanical properties, reasonable cost and low density had attracted the interest of the researchers [1]–[4]. Dielectric and electromagnetic materials with excellent dielectric and electromagnetic properties are of critical importance in various applications, such as electromagnetic interference (EMI), artificial muscles, drug release and energy storage capacitors [5]–[10]. The dielectric studies of minerals filled epoxy composite point out that the electric regular increased with the increased of filler loading [11]. The find out about of dielectric regular and dielectric loss as a feature of temperature and frequency is one of the most convenient and sensitive techniques of analysing the polymeric structure. Electric properties of pineapple reinforced polyethene composites have been studied by Jayamol et. al. [12]. They discovered that the expansion in the dielectric regular of the composite with fibre loading used to improve orientation and interfacial polarization. The electric properties of sisal fibre strengthened composite showed that the composite has electric powered anisotropic behaviour [13]. In this study, experimental were performed to evaluate the dielectric and electromagnetic properties of kenaf filled epoxy composites under dry condition.
2. Material and Methods

2.1 Materials
The composites consisted of kenaf fibres, and epoxy resin. Kenaf fibres were supplied from local supplier in Malaysia. EpoxAmite 100 series resin was used as a matrix, and mixed with a hardener at a ratio of 3:1.

2.2 Preparation of fillers
The Kenaf fibres was entered inside the grinding machine to produces fillers. Retsch sieve shaker was used to sieve the filler and separate it into various size. Filler size of the kenaf fibres is less than 500 μm.

2.3 Composites fabrication
Composites were fabricated using Kenaf fillers and epoxy resin. The volume fraction of kenaf fillers is 7 and 14%. The composites were manufactured using a cold press method. The fillers weighted by using Hanchen Analytical Balance JJ224BC high precision digital balance scale. The measurement can measure up to 200g and the tolerance is 0.0001g. Epoxy resin and hardener were measured using A&D SK-5001WP Washdown Scale.

2.4 Dielectric and Electromagnetic test
The machine used to test the dielectric and electromagnetic properties of kenaf filled epoxy composites was Agilent/Keysight E8363B PNA Network Analyser and the frequency range used to conduct the experiment was P-band which between 12.4GHz and 18 GHz. In order to test the dielectric and electromagnetic properties of the kenaf fibre filled epoxy composites, the small piece of sample was inserted into the hollow middle holder. The result obtained was in both graphical and numerical form which included real and imaginary part of permittivity and permeability respectively.

3. Results and discussion
Figure 1 shows the effect of the Kenaf fibre loading on the dielectric constant for dry conditions. The 14% Kenaf filled with epoxy composites successfully decrease the dielectric constant between 12.4 GHz and 16.66 GHz. It shows that the dielectric constant increased with decreased on the fibre loading. The decrease in resistivity on the incorporation of fillers may arise from the presence of more polar groups, which facilitate the conducting process [14]. The incorporation of fillers into elastomers, generally decreases the volume resistivity and there is a critical loading of fibre, i.e., percolation threshold, at which the composites change from insulating to conducting material [15].
Figure 1: Dielectric constant of Kenaf filled epoxy composites

Figure 2 shows the effect of Kenaf fibre loading on the dissipation loss factor under dry conditions. According to Figure 2, the Kenaf fibre loading shows insignificant effect on the dissipation loss factor between 12.4 GHz and 17.22 GHz. However, 14% Kenaf has a higher dissipation loss factor compared to 7% Kenaf filled epoxy composites and reached its peak at 17.89 GHz. The peak of \( \tan \delta \) is associated with molecule movement and amount of energy dissipation. In composite material, energy dissipation is dependent on fibre/matrix interaction, a molecule moment in the polymer chain, strength of fibre, fibre breakage and crack propagation in composite material [16].

Figure 2: Dissipation loss factor of Kenaf filled epoxy composites

Figure 3 shows the effect of Kenaf fibre loading on the permeability for dry conditions. Based on the figure, the permeability for 14% Kenaf is the lowest compared to 7% Kenaf filled epoxy composites between 12.4 and 16.77 GHz. Magnetic permeability (\( \mu \)) is the ability of a magnetic material to support magnetic field development. In other words, magnetic permeability is the constant in the proportionality between magnetic induction and magnetic field intensity. The greater the magnetic permeability of the material, the greater the conductivity for magnetic lines of force, and vice versa.
4. Conclusion

In summary, the dielectric properties of kenaf filled epoxy composites was investigated. It shows that the dielectric constant increased with decreased on the fibre loading. The Kenaf fibre loading shows insignificant effect on the dissipation loss factor between 12.4 GHz and 17.22 GHz. However, 14% Kenaf has a higher dissipation loss factor compared to 7% Kenaf filled epoxy composites and reached its peak at 17.89 GHz. 14% Kenaf is the lowest compared to 7% Kenaf filled epoxy composites between 12.4 and 16.77 GHz.

Acknowledgement

This research was financed by the Ministry of Education, Malaysia, through the Fundamental Research Grant Scheme; (Ref: FRGS/1/2018/STG07/UNIMAP/02/1). The authors would also like to acknowledge the School of Mechatronic Engineering, Universiti Malaysia Perlis (UniMAP) for the equipment and technical assistance. The authors are much gratitude to the dedicated staff for the fruitful discussions and input to the project.

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