UNIVERSITI TEKNOLOGI MARA

Leucaena Leucocephala : A New Green Biocomposite Substrates for Wireless Applications

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ABSTRACT

The green biocomposite antenna substrate serves as an alternative material for microwave applications. The mixture between polypropylene as a laminator and sawdust as a filler from Leucaena leucocephala stem tree offered six different substrate compositions which were labelled as PP100, PB9010, PB8020, UPB7030 (untreated), PB7030 (treated), and PB6040. These substrates were fabricated with three types of antenna design that used the single patch, off centre feed array antenna (OCFA), and Balance to unbalance (BALUN) control feed antenna (BCFA) in comparison to the FR4 substrate. In the process of substrate identification, the substrate sensor was developed to recognise the mixture type using light visibility sensor. This circuit was produced to help users identify the substrate even if the substrate information sticker on the substrate was wiped out. The process of fabrication applied the compounding moulded flat pressed method, and this method consisted of hot pressed (melting process) and cold pressed (preservation) machines which followed the American standard test and measurement (ASTM) procedure. Every fabricated material has unique dielectric properties and characteristic which give the big impact in antenna design. The analysis of the biocomposite substrate in terms of dielectric constant (Dk), Loss tangent (Tan δ), thermal properties, electrical strength analysis, and mechanical strength properties was conducted to update the CST antenna simulation software new material database. The measurement of dielectric constant for PP100 (1.9), PB9010 (2.27), PB8020 (2.63), UPB7030 (3.05), PB7030 (3.1), and PB6040 (3.49) indicated that the value increased as the wood filler content increased. This condition occurred since the natural carbon inside the wood filler increased parallel with the increasing of wood filler compositions. Besides dielectric properties, the analysis of thermal properties, and electrical and mechanical strength analyses indicated that the parameter value decayed with the increase of the wood filler content. This situation occurred due to the porosity between the polypropylene and sawdust particle. Since there was no additive to hold the sawdust filler interlocking, the elimination relied only on polypropylene, which was the reason why the composition of polypropylene must exceed the sawdust filler, and decayed the measurement value. The antenna design that used a UPB7030 substrate with three by three OCFA orientation gave a great performance with the gain measured at 7.98 dBi and directivity at 12 dBi. The comparative study on other substrates was performed using the BCFA structure with the measured gain results indicated by PP100 (4.77dBi), PB9010 (4.62dBi), PB8020 (4.0 dBi), PB7030 (0.9dBi), and PB6040 (0.1dBi). The decay of the gain occurred due to the increment of dielectric loss ranging from 0.0053 to 0.0781 from the PP100 to the PB6040 substrate. In this BCFA design analysis, the physical substrate dimension was maintained while the control resonant frequency was only adjusted through the quarter wave radiator and Balun for matching section. The proposed green biocomposite antenna substrate not only gives six different dielectric characteristics but now also serves as a transmitting antenna to cover the dean's meeting room access point (AP) in the Electrical Faculty in Universiti Teknologi MARA (UiTM)

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CHAPTER ONE
INTRODUCTION

1.1 RESEARCH BACKGROUND

Recently, green biocomposite antenna substrate has been offered as a significant research topic among antenna designers. The significance occurs due to the low dielectric property values, high thermal property conduction, low production cost, and light weight, high strength on mechanical and electrical voltage conduction properties, hence making it environmentally friendly for preserving natural resources [1]–[3]. The natural resources like fibre polymers using polypropylene (PP) will introduce a new variation of materials that have good future as an alternative to rare wood-based composite material in many antenna substrate applications as mentioned by Suki and Grozdanov [4], [5]. The variations are exhibited by bonding the saw dust filler from Leucaena leucocephala acting as a cement and PP as a compounder. This bonding gives a high electrical resistance that will produce lower phase delay hence reducing dielectric properties. The natural carbon from the filler exploited by heating process offers multiple variations that can be used for multiple antenna substrate designs with changes on their dielectric properties [6].

As an important parameter for antenna design, dielectric properties that consist of dielectric constant (Dk) and loss tangent (Tan δ) will change the antenna gain, efficiency, directivity, return loss and bandwidth [7]–[9]. The changes occur due to the dielectric property values being influenced by the capacitive effect of the signal propagation inside the biocomposite [10],[11]. Despite this behaviour, the multiple variations of biocomposite substrate with different compositions offer a new topic in searching for the possibilities of adapting natural resources to serve as antenna substrates. There are challenges exhibited by natural filler resources adopted to biocomposite materials relating to arising of anisotropic instances. The anisotropic condition occurs due to the specific orientations of the filler and also the issue of particle size, comparable to polymer network mesh sizes, which are still being debated and need solutions [12], [13]. Adopting biocomposite thickness and filler size is the turning point to solving these issues as highlighted in a study by Derecichei et al. [14].