Performance Characteristics of Unsaturated Polyester Reinforced with High Frequency Microwave Treated Natural Fibre.

Patrick Ehi Imoisili 1* and Tien-Chien Jen 1*

1Mechanical Engineering Department, University of Johannesburg, South Africa.
*Corresponding author: patrickehis2002@yahoo.com, tjen@uj.ac.za

Abstract
Using the most environmentally sustainable agro-waste fibers as reinforcement has opened up a new direction for polymer composite research. Research has recommended that altering of fibre surface by both chemical and physical means, increases the performance characteristic of natural fibre/polymer matrix. In this study, high-frequency microwave irradiation at a frequency of 2.45 GHZ and 550W power was used to treat natural fibre extracted from plantain (Musa paradisiacal) pseudo steam. Microwave modified and untreated plantain fibre was used to fabricate a bio-composite using polyester resin as polymer matrix, by means of hand lay-up and compression moulding technique. Results reveal an increase in mechanical strength of the modified fibre reinforced bio-composites at optimised conditions, thus creating opportunities and consistency to be use in technological and structural applications.

Keywords; Bio-Composite, Microwave, Natural Fibre, Plantain Fibre

1. Introduction
The improved performance of biocomposites in manufacturing and critical applications through the implementation of fibre-based materials has shown considerable potential and has recently become a major concern. Several types of polymer composites reinforced with natural fibre have a broad variety of industrialised applications and thermal stability at elevated temperature [1-4]. Such natural fibre reinforced bio-composites are desirable due to their properties such as low density, strong resistance to corrosion, ease of processing and low expense. These natural fiber reinforced bio-composites are attractive due to their low density, good corrosion resistance, simplicity of processing and affordable prize [3-7]. Natural fibre polymer composites are widely utilized in the car sector, in fields such as overhead panels, boot-lines, door panels, vibration insulation sheets, internal battery cover, exhaust insulation, inner insulation, wheel-box, windshield and roof cover, for example. A, S, C, and E collections of Mercedes Benz, Audi A series. Exploration is in the process of producing synthetic polymers, using reinforcement from the most socially sustainable agro-waste fabrics. Recently, scientists have researched plantain fiber as a viable source of natural fiber for various applications [8-16].

Microwave (MW) are electromagnetic waves that reside in the electromagnetic continuum at between radio and infrared spectrum bands. In fact, their contact with materials is by reflection, transmission or absorption. The mainstream frequencies of microwave are used for networking and sensor uses, whereas 915 MHz, 2.45 GHz, 5.8 GHz and 20.2–21.1 GHz are used for research, medicinal and industrialised purposes [9]. The capability of substance to turn microwave to temperature renders them suitable for the microwave utilization. Orthodox heating strategies comprise heat spread across the exterior rather than within, but microwave radiation is absorbed by the substrate and transformed to heat. [10-14].
Within this context, the application of MW irradiation to natural fibers is of that concern and has been documented by scientists [9, 10, 14]. In this study, high-frequency microwave irradiation at a frequency of 2.45 GHZ and 550W power was used to treat natural fibre extracted from plantain (*Musa paradisiaca*o) pseudo steam. Treated and untreated fibre was used to create a bio-composite incorporating polyester resin as polymer matrix utilizing hand-laying and compression molding techniques. The impact of MW irradiation on the mechanical properties of the fibre reinforced bio-composite was examined.

2. **Materials and methods**

Plantain (*Musa paradisiaca*) Fibre (PF) was obtained after harvest from a farm in south-west Nigeria. Fibre Extraction from the pseudo-stem was performed using water retting method [9,10]. PF treatment with MW radiation was achieved using a Sanyo Electronics (EM 51052) microwave oven at 2.45 GHZ frequency and 550W power for 2 minutes. An Orthophthalic polyester resin and catalyst was used as the composite matrix. The combination was emptied after the resin and the catalyst had been fully blended, the mixture was evenly poured into the mould over the fibres, then squeezed and pressed hard with rollers to eradicate and remove air bubbles. Using a compression-moulding machine, a load was finally placed on it to remove surplus matrix and allow ageing at room temperature (35 ℃) for 24 h. Plantain fibres with 30 mm length and amount ranging from 5, 10, 15, 20, and 25 wt. % were fabricated for both treated and untreated bio-composite.

2.1. **Characterizations**

Tensile property tests were achieved as defined in ASTM Test Method D638. Flexural property tests were accomplished using a 3-point bend testing as define in ASTM Test Method D790. Impact assessment was performed according to ASTM D6110-10 standard. A Leco LM700AT hardness tester was used to access the micro-hardness as specified in ASTM D-2240.

3. **Results and Discussions**

3.1. **Tensile and Flexural Behavior**

The tensile performance of the bio-composite’s samples are shown in Fig 1 & 2, while results for flexural properties are display in Fig 3 & 4. For all test results, it was observed that, as fiber volume increases, a higher tensile and flexural strength were attained. When the weight fraction of fibre increases past the optimal amount, the load is spread to more fibres which are tightly bound to the polymer matrix ensuing an improved tensile and flexural strength.
A further improvement in the weight fraction of the fibre above the optimal value, increases the volume of matrix contained in the material resulting in a decreased wetting of the fibres in the bio-composite. In this scenario, the load on the bio-composite will not be moved from the fibre to the fibre through the matrix. Catastrophic strength losses is known as a consequence of decreased fibre wetting [3, 4, 15]. Microwave treatment of fibre has significantly improve both the tensile and flexural property behaviour of the reinforced bio-composite and It may be attributed to the mild microwave capacity of 550 W which has been able to rearrange and efficiently release the residual tension in the fibre and thereby strengthen the interaction of the fibre matrix bonding in the bio-composite.
3.2. Impact and Hardness Behavior

Impact intensity of the composites, as the resistance posed during application of tension at high-speed are display in Fig. 5. Test results reveals a gradual increase in hardness value as fiber content increases, which can be attributed to the fiber ability to absorbed impact stress. As it was shown in Fig. 5, the rise in impact intensity after microwave radiation was seen as an improvement in fiber quality, which can be due to the enhancement effect of treated plantain fiber on the matrix process.
The hardness properties as shown in Fig 6 is the average hardness measurements of five (5) samples. It should be noted that the microwave treatment of PF bio-composite resulted in a rise of surface hardness. This boost of bio-composite toughness is the result of the stiffening impact of the fiber on the polymer matrix.

4. Conclusions.
High-energy microwave radiation applicability and suitability for modulating plantain fibres and its impact on the mechanical properties of fibres reinforced polyester bio-composite fibres have been studied. The results obtained show that microwave irradiation at a frequency of 2.45 GHZ and 550W power has enhanced the mechanical properties of the plantain fibre reinforced polyester bio-composite as increases in mechanical properties was achieved at
optimised fibre content and treatment parameters, thus creating opportunity and reliability to be use in structural and engineering applications.

Acknowledgement
Authors would like to appreciate funding support from URC of University of Johannesburg, and Prof T. C. Jen would also like to appreciate funding support from NRF of South Africa.

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