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Dynamic Mechanical Analysis and Morphology of Desert Date Particles Reinforced Polymer Composites for Vehicular Dashboard

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ABSTRACT: The major problems of polymer composites are low thermal resistance and high coefficient of thermal expansion; a common problem limiting their applications in area subjected to high temperature such as inner cabin of motor vehicle where the temperature especially on the Dashboard used to reach 72.4 ℃. This phenomenon degrades the material and affect their performances. These challenges are reduced by reinforcing the polymers with proper fibres derived from synthetics and natural source. In recent time, there is shift in interest toward study of organic reinforced composites and their properties are usually explored in depth. Dynamic Mechanical Analysis (DMA) is one of the methods used for the evaluation of reinforced polymers' properties such as storage modulus (E'), loss modulus (E''), tan δ and glass transition temperature (T_g). In this study, an optimized randomly distributed particles of 212 μm (sample B) and 300 μm (sample E) of desert date particles (DDP) were used to reinforce polypropylene (PP) matrix with Maleic Anhydride Grafted polypropylene (MAPP) as modifier using compression molding for Vehicular Dashboard and their thermal properties were determined using DMA. The morphology of the composites was studied using Scanning Electron Microscope (SEM). DMA results revealed that the composite sample B and E has storage modulus (E') of 57.6 °C and 54.1°Cat inflection corresponding to 1037.2 MPa and 1335.2 MPa respectively. Loss modulus (E'') of 126.4 °C and 115.2 °C corresponding to 36 MPa and 58 MPa while the damping coefficient are 0.076 and 0.073 were obtained for sample B and E respectively. This implies that sample B can be used within the temperature range of 50.3 °C to 126.4°C, and for sample E 51.7 °C to 115.2°C conveniently. The microstructural characterization revealed that the micro sized reinforcements were dispersed homogeneously in the matrix of polypropylene with negligible agglomeration of the particulate. From these, it is concluded that sample B is the most suitable for the targeted application.

Key words: Desert Date Particles (DDP), Dynamic Mechanical Analysis, thermal properties, microstructure, scanning electron microscope and vehicular Dashboard.

I. INTRODUCTION

Polymer composites are very popular and in fact the most successful composites material systems with a wide range of applications spanning from electric productions such as printed circuits boards, automobile components, to advanced aerospace structures such as reusable launch vehicles [1].

Polymer matrix are reinforced with different types of fibres at different size and volume fraction for various purposes. They can be tailored for structural application to transmit primary loads and secondary loads often used as under body parts of car such as roof panels, door trims, dashboards etc. low performance fibre reinforced composites contain less than 20% volume fraction [2].

Reinforcement of composites by strong fibrous network permits fabrication of polymer composites which is characterized by high specific strength, stiffness and fracture resistance. Also, good abrasion, impact, corrosion and fatigue resistance; and low cost makes it acceptable economically [3]. Further, they have been found promising in production of automotive parts, building applications and consumer products [4].

The major disadvantages of polymer composite materials are low thermal resistance and high coefficient of thermal expansion; a common problem limiting it applications in area subjected to an elevated temperature. However, these properties can be tremendously improved by reinforcement with optimum amounts of treated organic fibres/particulates thereby making them suitable for various temperature conditions [5]. In addition, to improve the physical and mechanical properties of polymer composite materials at lower production cost, different types of organic fillers are nowadays usedin preference to synthetics fibres[6]**.** The organic fibers and fillers include wood, sisal fiber, rice husk, bamboo, kenaf, etc**.** Theshift in interest towards the study of these green composites is due to their availability, environmental friendliness, light weight, renewability, cheap and ability in enhancing quality of composites [7].

A polymer reinforced with either spherical, cubic, tetragonal or platelet size particles suspended in the matrix is referred to as particulate composite. Various studies revealed that particulate composites are characterized by enhance stiffness, modified thermal properties, increased surface hardness and reduced shrinkage; a reason why they are extensively used in various application[8].

The properties of Polymer composites are greatly affected by change in temperature, as such investigation on the its behavior under heat is paramount. Dynamic Mechanical Analysis(DMA) is an efficient means of exploring the materials' mechanical performance and the investigatingits rheology under varying temperatures, frequency or loading. Also, it provides a means of determination of storage modulus, loss modulus tanδ and glass

performance. Also, [11] reported that the internal vehicle temperature can reach 47 ℃ within 60 minutes, with 80% of the temperature rise occurring in the first 30 minutes. Consequent to these findings, it is imperative to develop alternative composite material that can withstand these conditions. Hence, the aim of this research is to investigate the dynamic mechanical properties and morphology of an Optimized volume fractions of 212 μm and 300 μm DDP, PP and MAPP (19%, 76.8% and 4.2% respectively) polymer composites for vehicular dashboard application.

II. MATERIALS AND METHODS

Materials and Equiptment

The materials used include 212 **μ**m and 300 **μ**m desert date particles as reinforcement, Polpropylene as matrix, Maleic Anhydride Grafted

transition temperature (Tg) [9].Moreover, Dynamic Mechanical Analysis (DMA) is an alternative method for measuring glass transition temperature of materials to the most common one, defferential scanning calorimetry (DSC). It provides the general deflection temperature under load, which is a standard method for evaluating the softening temperature and gives a sensitive profile of viscoelastic property of materials which includes the storage modulus E', which determine load bearing ability of composite [10]; loss modulus E" and tangent of delta (tan d/loss factor) as they change with temperature. The storge and loss modulus of a mterial is known as complex modulus E^* which are dynamic elastic characteristics and are material specific; their magnitude critically depends on the frequency as well as the measuring condition and history of material

On a hot day, vehicles parked under direct sunlight at an ambient temperature of 37 ℃ with window glasses closed build up high temperature inside the cabin. The upsurge in temperature inside the car and especially at dashboard get to72.6 ℃ within thirty minutes[12]. This is solely due to the fact that dashboard and rear compartment are the two locations in the car cabin with the highest heat accumulation as a consequence of larger quantum of radiation. [13]performedexperimental study of the cabin temperature of a parked vehicle under scorching sunlight in Nsukka, Nigeria andreported that maximum cabin air temperatures were recorded at the dashboard and rear compartment reaching a value of 72.4 ℃. These poses serious discomfort and potential ill health to the vehicle occupants when they return to use it. Furthermore, the dashboard and rear compartment's materials undergoes abrupt viscoelastic changes, these, degrade the materials and affect their PP (MAPP) as modifier and Processing oil (Acetone). Optimized volume fractions of desert date particles, PP and MAPP of 19%, 76.8% and 4.2% respectively,were used in fabrication of the composites samples as reported by [14]. While the equiptment are; Dynamic Mechanical Analysis Model DMA 242E and SEM Machine model VP SEM35 VP SUPRA.

Methods

The Dynamic Mechanical Analysis (DMA) of composite samples were carried out in accordance to [15]. The develop composites (plate I) were fixed on vice, and Samples dimension of 40 x 12 x 4.5 mm were cut using hacksaw. The composites samples were mounted between film tension fixtures of the DMA machine. The samples were subjected to an oscillatory stress, temperature slowly scanned; the storge modulus, loss modulus and tan delta continuously measured.

Plate I: DMA Test Samples

III. RESULTSAND DISCUSSION

The results of dynamic mechanical analysis and morphology of the polymer composites reinforced with different desert date particles (300 and 212)at an optimum volume fraction of 19% are discussed with the aid of graphs.

Dynamic mechanical analysis (DMA)

The Dynamic Mechanical Thermal Analysis (DMA) results of composites sample B and E-storage modulus E', loss modulus E'', tan delta and damping coefficient as a function of frequency and temperature are read off from the graph as presented in Figure 1 and 2. The materials were experimentally exposed over a temperature range of 0 °C to 150°C and oscillated at frequency of 2 – 5 Hz and heating rate of 5 K/min to study the viscoelastic properties of the composites produced

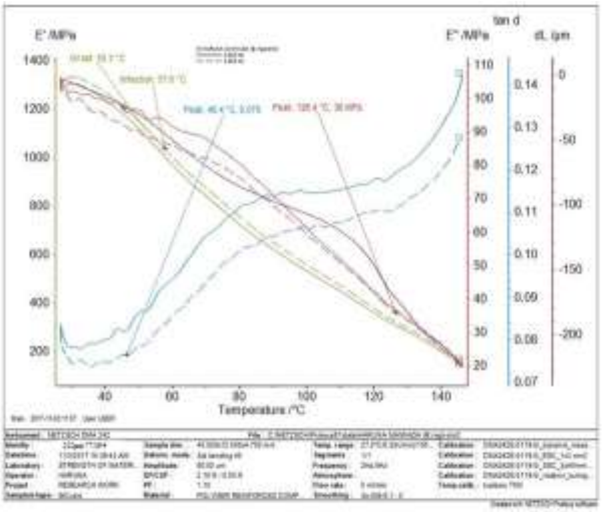

Figure 1: DMA graph of Sample B

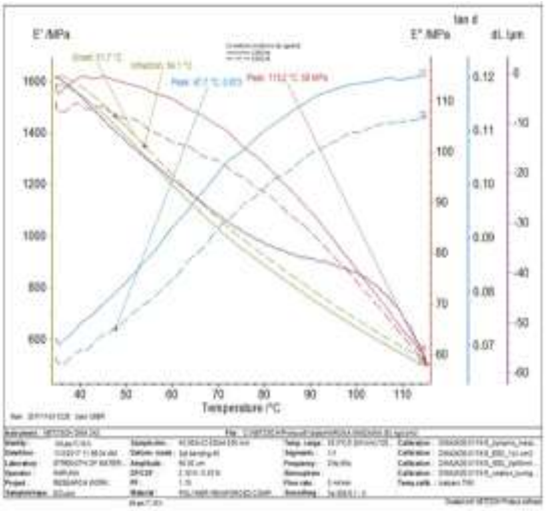

Figure 2: DMA graph of Sample E

Effect of optimized volume fraction of 300 µm and 212 µmdesert dateparticles size and temperature on storage modulus.

The storage modulus E' represent the stiffness of a viscoelastic material and is proportional to the energy stored during loading cycle. It is roughly equal to the elastic modulus for a single, rapid stress at low load and reversable deformation.The storage moduli E' (an in-phase transportation) of the composites as observed in Figure 3 and 4start decreasing with the application of heat within the range of temperature studied.As the heating continued, the materials warm at onset temperatures of 50.3°C and 51.7°C for sample B and E respectively; at these temperatures the dynamics moduli (stiffness) of the composites are

1148 MPa and1409.7 MPa. Further increase of the heat led to localized bonds and side chains movement at inflection points of 57.6°C and 54.1°C corresponding to 1037.2MPa and 1335.2 MPa. The results showed that sample B has higher values of storage modulusthan sample E, with respect to the temperatures, indicating improved dynamic load carrying capacity and enhanced stiffness ofsample B due to better interfacial bonding between the 212 µm size particles of desert date and modifiedPolypropylene. Similar results have been reported by [16]and [17].

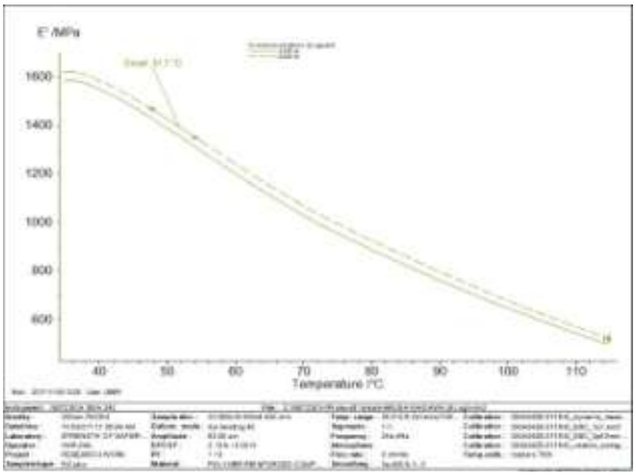

Figure 3:Storage Modulus of sample B

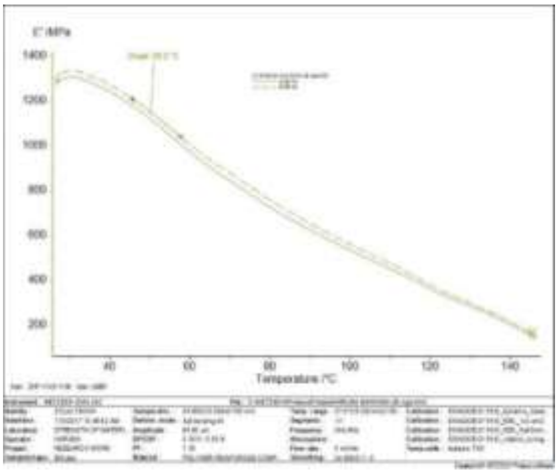

Figure 4: Storage Modulus of sample E

Effect of optimized volume fraction of 300 µm and 212 µmdesert date particles size and temperature on Loss modulus.

The loss modulus determines the viscous properties of material, it is defined as being proportional to the energy dessipated during one loading cycle. It represents energy loss as heat, and is a measure of vibrational energy that has been converted during vibration and that cannot be recovered.The loss moduli E'' (an out-phase transportation) of sample B and E (Figure 5 and 6)at peak are 126.4°C and 115.1°C respectively. At these states the materials gradually lost their stiffness down to 36 MPa and 58 MPa, and internal friction of the materials begun, giving rise to atomic transformation of the structures. It could be observed that the loss modulus of sample Bis lower than sample E, because the composites reinforced with 212 particle sizes loss less heat energy during the cyclic deformation. This is as a consequence of finer particle sizes restricted its relaxation more than the larger particles. This restriction makes sample E more viscous and flexible,making its polymer chains gain enough energy in order to substantially increase their mobility within the polymer matrix and became prone to loss more energy than sample B.Similar result was reported by [18]. These temperatures are referred to as glass transition temperatures Tg of the composites. The glass transition temperature is a key property of polymer composites and this defines the temperature range in which this composite may be exposed. This implies that sample B can be used within the temperature range of 50.3 °C to 126.4°C, and for sample E 51.7 °C to 115.2°C.

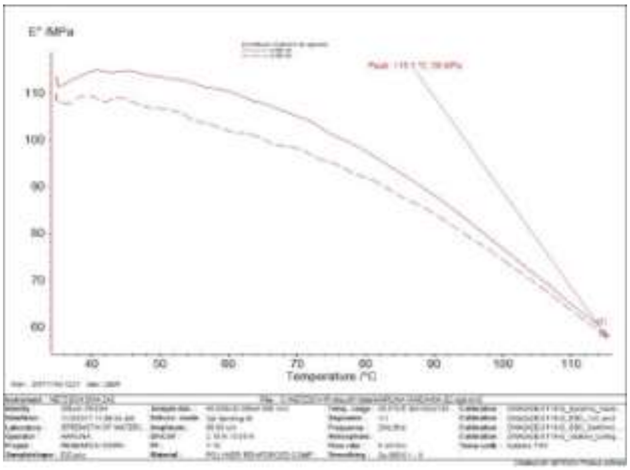

Figure5:Loss Modulus of sample B

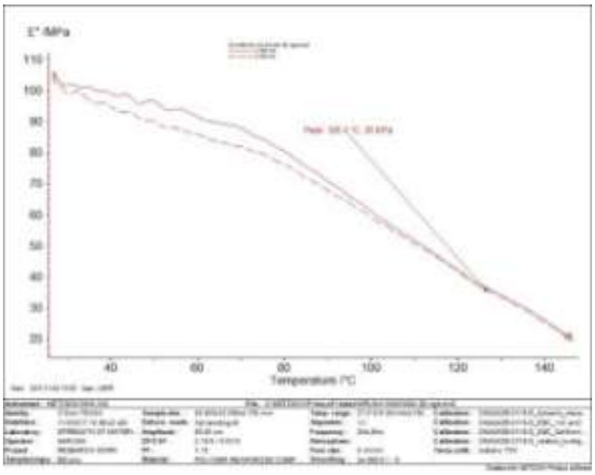

Figure 6: Loss Modulus of sample E

Effect of optimized volume fraction of 300 µm and 212 µm desert date particles size and temperature on Damping Factor.

Tangent delta is defined as ratio between the loss and storage modulus, and represents the relative contribution of the viscous vs. elastic properties of materials.The tangent of the phase angle (Tan delta) of the samples (Figure 7 and 8) increased with the increased of temperatures and were obtained at 46.4°C and 47.7°C for sample B and E respectively. These results indicated that there is good balance between elastic and visco-elastic properties of the composites which determined its impact resistance. Also, the materials can get rid and absorb energy marvelously. These temperatures indicated the damping ability of the materials caused by a change in the microstructure and precipitates. The damping coefficient of the samples were found to be 0.076 and 0.073 for sample B and E respectively; these showed that the composites are of good type because the lower the damping coefficient the better. The results obtained in this study are in line with that reported by [19]. These results indicated that the materials are thermally stable.

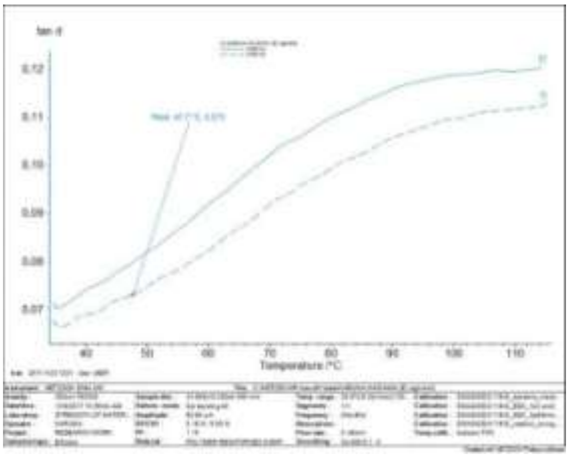

Figure 7: Damping Factors of sample B

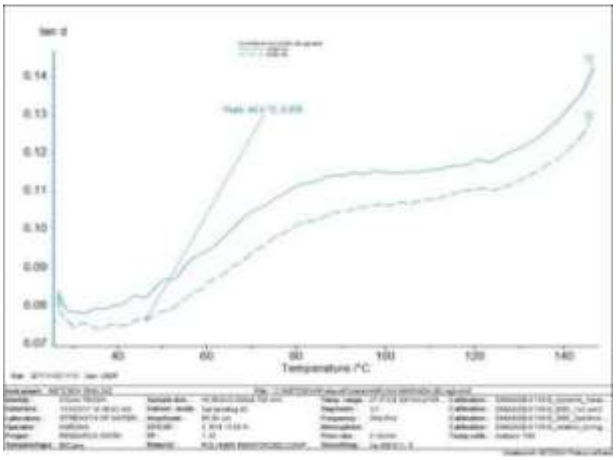

Figure 8: Damping Factors of sample E

Scanning electron microscopy (SEM) analysis

The scanning electron micrograph in Figure 9 and 10 showed the morphology of desert date particles reinforced polypropylene composites with MAPP as compitibilizer. The results revealed that the polypropylene matrix reinforced with 212 **µ**m particles exhibited some little improved properties over that reinforced with 300 **µ**m particles size. This could be attributed to balance embedment of the smaller particles size of the sample that result to a strong and large number of interfacial adhesions; a finding corroborative to that of [20]. Moreover, this cannot be unconnected to the addition of MAPP which prevent phase separation between the particles and matrix and thereby aiding their adhesion[20]. The dispersion of the particles in the matrix are random with negligeble agglomeration of the desert date particles as can be observed in sample B (212 **µ**m) Figure 9, and therefore the void content is at minimal. Consequently, these improved the thermal behaviour of the the composite. The SEM of Sample E (300 **µ**m), Figure 10, showed coarse surface over sample with 212 **µ**m. Both samples exhibit good mechanical properties, a result that is in agreement with that reported by [21].

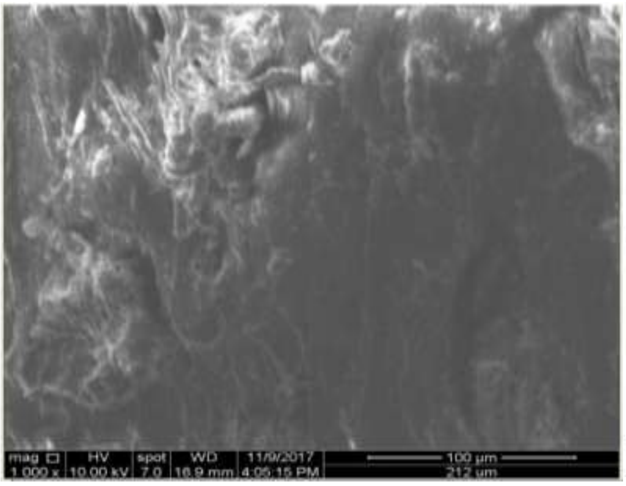

Figure 9: SEM of sample B

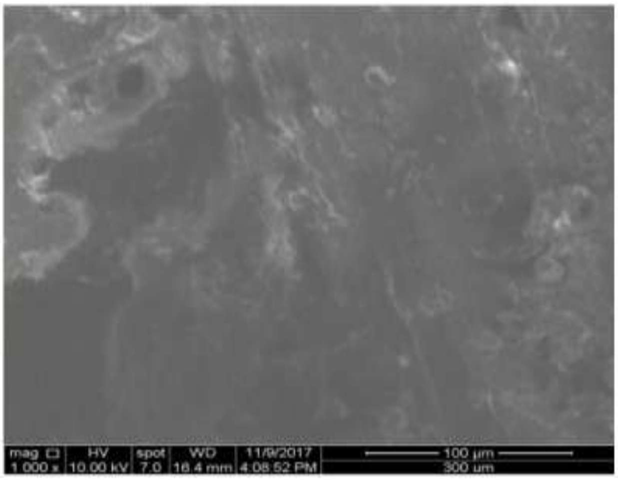

Figure 10: SEM of sample E

IV. CONCLUSION

From the results of the study undertaken, the following conclusions were drawn:

i. The Dynamic Mechanical properties of the developed composites increased with the decrease of particles size, as sample B with 212 **µ**m particles sizes exhibited improved properties over Sample E.

ii. The modified polypropylene matrix reinforced with 212 **µ**m particles showed some little improved properties over that reinforced with 300 **µ**m particles size.Also,the dispersion of the particles in the matrix are random with negligeble agglomeration of the desert date particles as can be observed in both samples and hence the void contents are at minimal.

iii. The viscoelastic properties and morphology of both sampleshave been found appropriate. Although,Sample B is considered most suitable of being used as Vehicular Dashboard material.

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