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Enhanced Thermal and Mechanical Properties of Recycled LDPE Composites Reinforced with *Prosopis africana* Wood Powder

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Abstract: Investigations were conducted into the mechanical, physical, and dynamic properties of recycled low-density polyethylene composites reinforced with *Prosopis africana* (PA). Compression molding equipment and a Two-Roll Mill were used to compound the constituents. Using standard methods, properties such as density, water absorption, tensile strength, elastic modulus, flexural strength, and hardness values were assessed. The materials were additionally put through a dynamic mechanical property test to determine how the inclusion of PA fiber affected the damping parameter, storage modulus, and loss modulus of recycled low-density polyethylene (rLDPE). The kinetic study results revealed that the adsorption process is pseudo second order. The current composite could be an excellent alternative for current industrial scale adsorbents). Maximum flexural strength of 68.8 MPa, stiffness of 2.05 GPa, hardness of 70 Shores, and tensile strength of 58.5 MPa with a 20% weight proportion of reinforcement. In a similar vein, the results of the dynamic mechanical characteristics showed that the greatest load bearing capacity and storage modulus (1.2 GPa) for a composite containing 20% PA fiber were found (compared to 400 MPa of the unreinforced), however, as temperature and frequency increased, a drop in loss modulus was noted. This indicates that incorporation of PA fibre into rLDPE improved its physical, mechanical and dynamic mechanical properties.

1. Introduction

In recent times, there has been an exponential utilization of single-use plastics, such as water bottles and sachets in large volume which contribute significantly to environmental waste (Williams & Rangel-Buitrago, 2022). Recycling these plastics into composites reinforced with natural fibers like *Prosopis africana* can mitigate this issue. This study explores the effects of PA fiber on the thermal and mechanical properties of recycled LDPE composites, aiming to enhance material performance for broader applications. This, coupled with the serious environmental concerns and issues such as sustainability present an opportunity for materials scientists and designers to step up research for materials that are eco-friendly, biodegradable and inexpensive to save the ecosystem. Exploiting waste resources promotes sustainability and lowers the environmental impact of disposing them, while also assisting in the development of low-cost goods (Naveenkumar *et al.*, 2023; Azzaoui *et al.*, 2023). It is projected that the amount of waste plastics in municipal solid garbage is increasing at a pace of two times every decade. This rise is closely linked to the rapid changes in population, urbanization, and developmental activities and lifestyle. Studies show that waste plastics can withstand 450–500 years at room temperature on Earth's surface before degrading (Shinde *et al.*, 2018 and Thirugnanasambantham *et al.*, 2017). Adopting a recycling procedure is one approach to appropriately handle the quantities of plastic garbage that are being disposed of, and recycling also helps to keep the environment cleaner (Osarumwense *et al.*, 2020). Due to the tight regulations controlling their disposal and the mounting environmental concerns brought on by waste plastics, researchers are being encouraged more and more to employ garbage that is readily available locally to create novel and inventive goods (Lendvai *et al.*, 2024).

The thermal characteristics of a polymer composite are quite important, particularly with regard to the production parameters and areas of application. Several similar studies on LDPE composite development have been published. Some of these studies include (Krehula *et al.*, 2024; Jacqueleen *et al.*, 2024 and Bam *et al.*, 2023). When examining the thermal properties of polymers, one of the most crucial techniques is dynamic mechanical analysis (DMA) (Jacob, 2023). Robust research is needed to deliver excellent performance qualities for these ever-expanding wood plastic composites in order to meet end-user application needs (Jacob and Yusuf, 2023). In addition, the need to reduce the overdependence of fossil-based fuels, there is increased interest of researchers to maximize the use of renewable materials like the natural fibres in composite manufacture (Jacob and Mamza, Yusuf *et al.*, 2020). Numerous studies have been published on the reinforcing of commonly used plastics to enhance their morphological, creep, and physical characteristics (Yusuf *et al.*, 2020; Ali *et al.*, 2021 and Jacob *et. al.*, 2022). On the other hand, not much is known about the mechanical and dynamic mechanical characteristics of waste LDPE composites packed with *Prosopis africana*. It has become appropriate to explore how the incorporation of PA fibres into rLDPE could influence its physical, mechanical and dynamic mechanical properties.

2. Methodology

2.1 Sourcing and preparation of Prosopis africana fibre

Plastic wastes from low density polyethylene (with recycling code 2) were collected from the refuse dumps in and around Federal University, Gusau and within the Gusau metropolis. The wastes samples were washed and dried. The *Prosopis africana* log was obtained from Hannu-Tara in Dansadau, Maru Local Government, Zamfara State, Nigeria. Locally, the log is known as Kiriya in Hausa and Ayan in Yoruba. The wood was cut into pieces and then dried in the sun for seven days in order remove any moisture before being ground into a powder. Then it was sieved using a 100 µm mesh in accordance with the work of Jacob and Mamza (2021). In order to reduce the potential surface hindrances and increase the compatibility between hydrophilic wood fibre and hydrophobic polymer matrix, the wood powder was exposed to chemical treatment using sodium hydroxide solution.

2.2 Experiments

Composite Production

Plastic wastes from low density polyethylene and *Prosopis africana* were prepared by compounding and compression molding techniques two roll mill (Model No. 5183, New Jersey, USA). Composite samples were prepared by adding rLDPE while running the roller counterclockwise for 10 min at a temperature of 160°C. Once the pasty matrix was formed, the filler (*Prosopis africana* powder) was carefully manually introduced while rotating the roller at a speed of 500 rpm. The samples' compositions ranged from 10% to 50% PA and rLDPE were varied. After that, the samples were cured for ten minutes using a hydraulic press set to 170 °C and 3 Pa of compression pressure. The obtained samples were machined and chilled before being put through characterization tests (Jacob *et al.*, 2018 and Jacob *et al.*, 2019a).

2.3 Mechanical Property Test

2.3.1 Tensile test

The ASTM D 638 (2014) suggested procedure was used to determine the results of the samples' tensile testing. Following the samples' dumbbell-shaped machining, they were put in the computerized Instron universal tensile testing equipment 3369 model, which assessed the samples' elastic modulus and tensile strength.

2.3.2 Flexural strength

In accordance with ASTM D790 (2015), flexural strength was determined utilizing a universal testing machine and a three-point bending technique. The strain rate was 5 mm/min, and the spans were 40 mm apart. The flexural strength (MPa) was calculated using equation (1): $\sigma = \frac{3Pl}{2bt^2}$

l = specimen span length between supports (mm)
P is the greatest deflection force (N).
b is the specimen's width (mm).
t = specimen thickness (mm)

2.4.3 Hardness test

The relative resistance of a composite's surface to indentation by an indenter of a certain size under a given load is the basis for the hardness test of that material. (Jacob *et al.*, 2018). Durometer Shore A was used to measure the shore hardness values of samples measuring 30 mm by 30 mm by 5 mm. The sample underwent five measurements at various locations, and the average of the results was used to determine the sample's hardness.

2.4.4 Density

Following ASTM D792, 2013, the mass and volume of the sample were measured to determine the density of the composites.

2.5.1 Test for Absorption of Water

The ASTM D570 (2010) technique was followed when conducting the water absorption test. An oven-dried specimen measuring 76 × 25 × 5 mm was used as the test sample, and it was submerged in water at room temperature for a full day. Following a 24-hour immersion period, the specimens were taken out and dried with a lint-free cloth before being weighed again on a Sartorius ED 224S digital analytical scale. The dried weight before ($W_{initial}$) and after weight immersion (W_{final}) were noted. Similar method has been reported by Jacob (2019). The water absorption was determined as follows:

$$W = \frac{W_{final} - W_{initial}}{W_{final}} (\%) \qquad (2)$$

2.6 Thermal Properties

2.6.1 Analysis of Dynamic Mechanical (DMA) Systems

The DMA characterization was conducted on DMA 242 E machine according to ASTM D7028 (2015). Using a personal computer and the proteus software, the test parameters—storage modulus (E'), loss modulus (E"), and tangent of delta (Tan ∂)—were initially set up. The furnace temperature range of 30-110 °C, the dynamic load of 4 N, the frequency range of 1-10 Hz, the sample holder (3-point bending), and the heating rate of 3 K/min were all configured as part of the instrument setup.

3.0 Results and Discussion

3.1 Physical properties

3.1.1 Density

Figure 1 indicates the density profile of unreinforced rLDPE and the composites. A gradual decrease in density of the materials could be observed from the unreinforced (rLDPE) up to 25 % weight of PA filled rLDPE composites. The lowest being 0.99 g/cm^3 at 25 %. This indicates that incorporation of PA fibres into rLDPE decreases its density. The results in this work is at par with the works of other authors (Dan-asabe, 2016; Jacob, 2019).

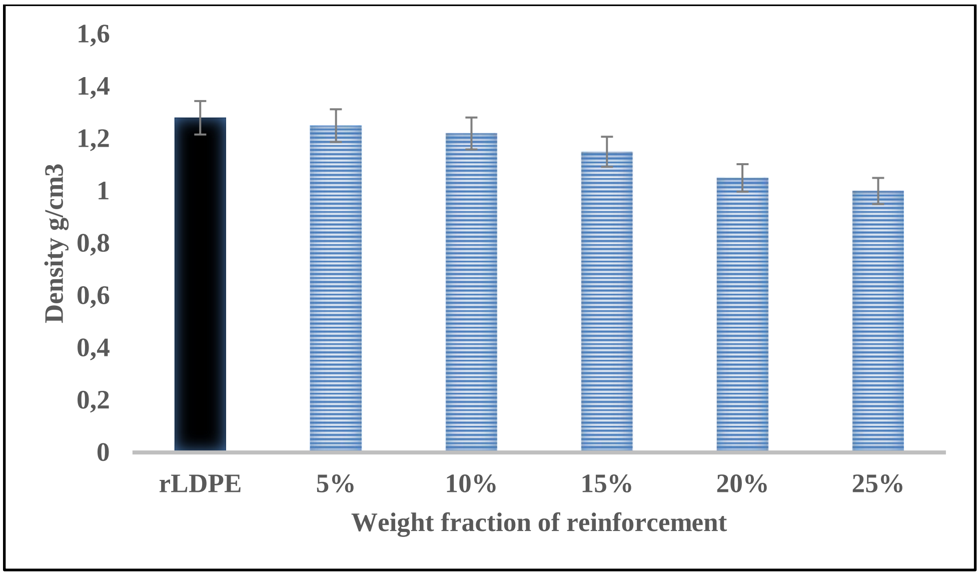


Figure 1: Presents *Prosopis africana* powder's impact on recycled LDPE composites' density

3.1.2 Water absorptions

Figure 2 represents the rate of water absorption of PA filled rLDPE composites after 240 hrs of immersion at ambient temperature. The weight percentage of PA fiber integrated was found to increase with an increase in water absorption, reaching a maximum value of 6.2% at a 25% weight fraction of PA fiber. This is anticipated as the amount of hydrophilic natural fiber in polymer composites raises the absorption of moisture. This outcome is consistent with the research conducted by Jacob and Mamza (2018) who studied into how waste LDPE composites loaded with groundnut shell powder absorbed moisture and that reported by Abisha *et al.* (2023) The linearity of the chart at 0 % (unreinforced rLDPE) indicates that there is minimal or no moisture uptake in the control sample being hydrophobic.

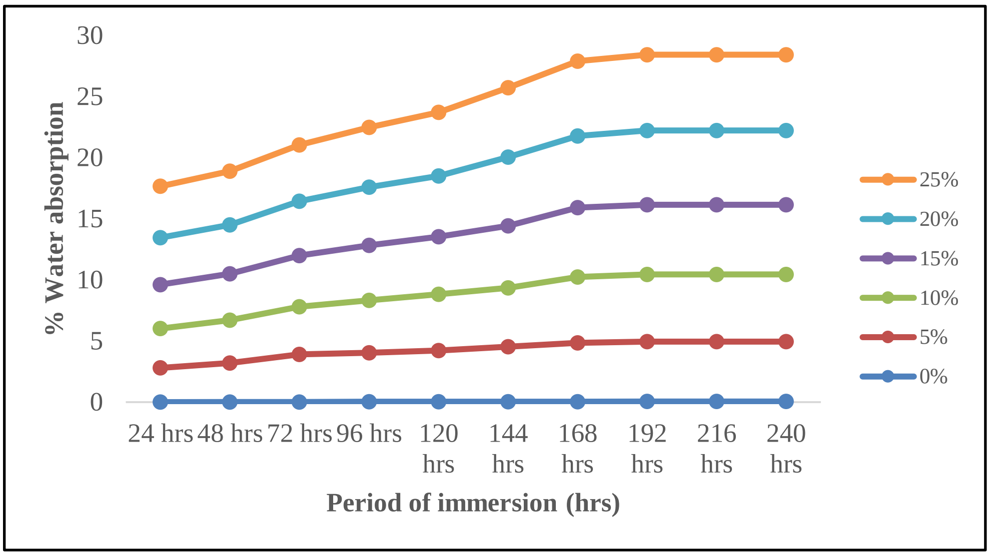


Figure 2: Percentage moisture absorption of PA-rLDPE composites at ambient temperature

3.2 Mechanical Properties

3.2.1 Tensile strength

Fig. 3 shows the tensile strength of PA-rLDPE composites with increasing fraction of the PA fibres. The tensile strength increases from 5 % to 20 % and then a steep decrease at 25 %. The addition of PA fiber significantly increased the tensile strength of rLDPE composites, indicating enhanced mechanical properties. Incorporation of fibre at 20%, the tensile strength reached 58.5 MPa, a notable improvement over unreinforced rLDPE. This enhancement is likely due to improved interfacial bonding between the PA fibers and the polymer matrix. The steep reduction at 25% could be due to weakening of the interfacial attraction of the constituent composition as the fraction of rLDPE is reduced with increasing fibre. Several writers have made similar observations (Jacob et al., 2018; Jacob and Mamza 2021 and Jacqueeleen et al., 2024).

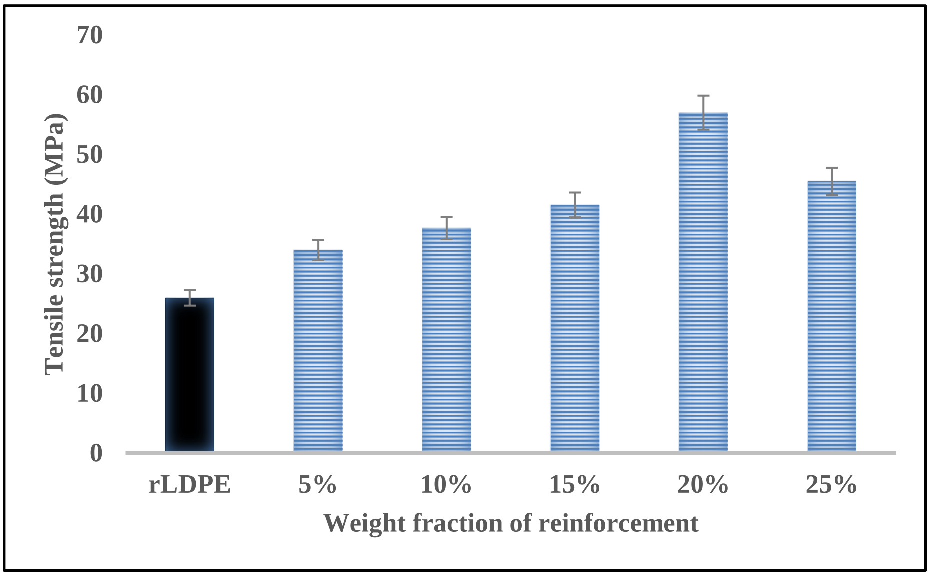


Figure 3: *Prosopis africana* powder's impact on recycled LDPE composites' tensile strength

Figure 4 portrays the PA-LDPE composite's elastic modulus, or stiffness against the weight of the reinforcement. It could be observed that, the trend of stiffness increases with rLDPE weight percentage. The composites' elastic modulus rises from 1.0 GPa (rLDPE) to 2.1 GPa (at 20 % of PA). This could be due to better interaction between rLDPE and the incorporated PA fibre. The storage modulus increased with fiber content, suggesting better energy storage capabilities and stability under dynamic loading. These results are at par with the works of other authors (Khalaf, 2015; Jacob *et al.*, 2019b; Jacob and Mamza, 2021).

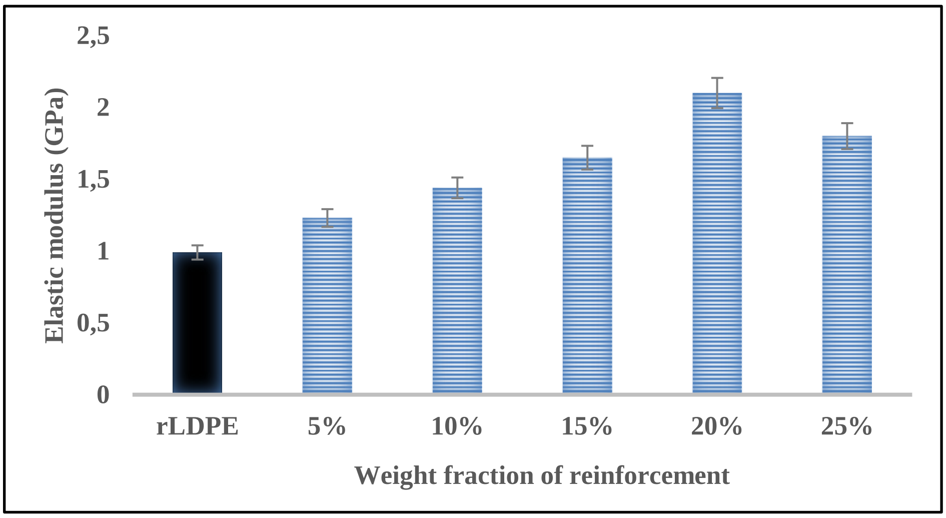


Figure 4: Prosopis africana powder's impact on recycled LDPE composites' elastic modulus

3.2.3 Flexural strength

Figure 5 displays the composites' flexural strength in relation to the weight percentage of PA fibers. With an increase in weight percentage of reinforcement, the flexural strength of *Prosopis africana* powder reinforced rLDPE composites drops, reaching a maximum value of 68 MPa at 20 % wt of reinforcement. This suggests that the rLDPE and PA particles are interacting and transferring stress more effectively. However, it was shown that a further 25 % increase in the weight fraction of reinforcement lowers the flexural strength value because of weak fibre-matrix adhesion (Jacob and Shinggu, 2021).

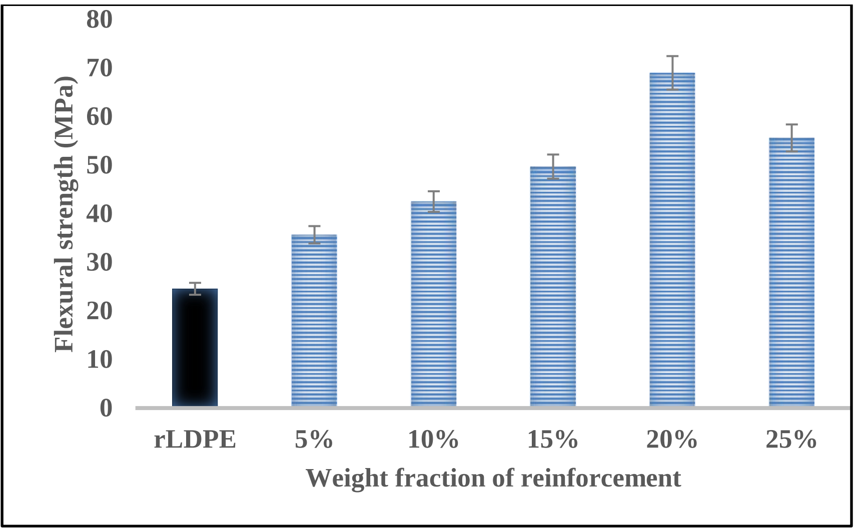


Figure 5: Prosopis africana powder's impact on recycled LDPE composites' flexural strength

According to Jacob *et al.* (2018), the relative resistance of a composite's surface to indentation by an indenter of a certain size under a given load is the basis for the hardness test of the material. The highest hardness value was observed at 20 % weight fraction of reinforcement (68 shores) while the lowest was 25 shores at 5% fibre loading (Figure 6). This could be due to better interfacial attraction between the PA fibre and the polymer matrix. This result is in conformity with the findings authors (Yusuf *et al.*, 2020).

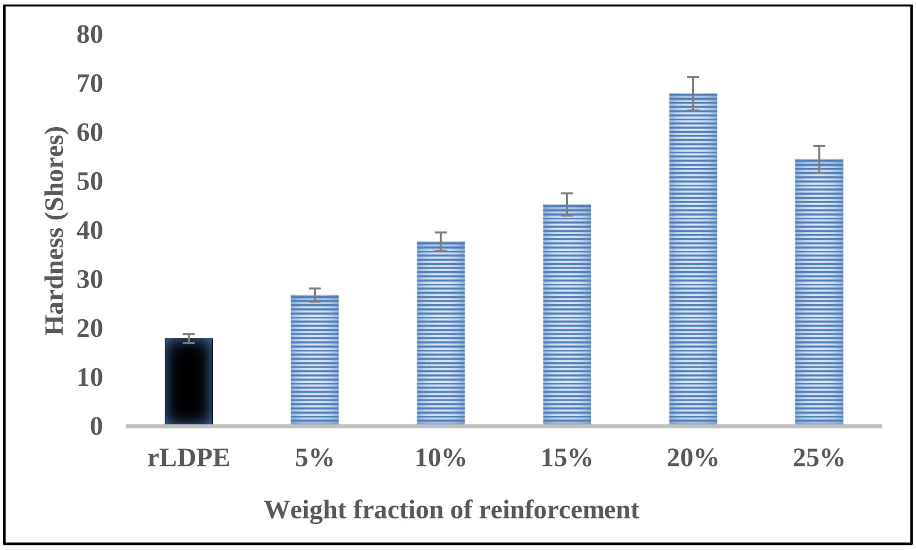
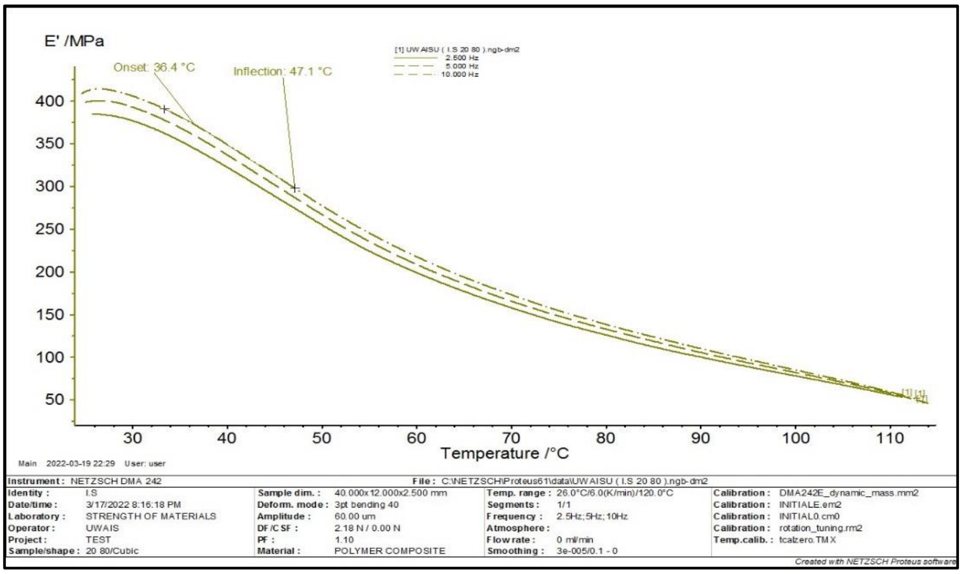


Figure 6: *Prosopis africana* powder's impact on recycled LDPE composites' hardness.

3.3 Thermal Properties

3.3.1 Storage modulus of unreinforced recycled LDPE

Storage modulus describes the stiffness and the energy storage in material (Gupta, 2018; Jacob et al., 2019a; Jacob and Yusuf, 2023). Figure 7 shows the storage modulus of unfilled LDPE (control) at various frequencies of 2, 5, and 10 Hz, respectively. With a maximum stiffness of 0.42 GPa, the curve clearly shows that the material is unstable at temperatures below 40 °C. This outcome is consistent with the research conducted by Jacob *et al* (2019b), who examined the thermo-mechanical characterisation of waste LDPE reinforced with plantain peel particles as composite wall tiles.



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Operator :	UWAIS	**DF/CSF :**	2.18 N / 0.00 N	**Atmosphere :**		**Calibration :**	rotation_tuning.rm2
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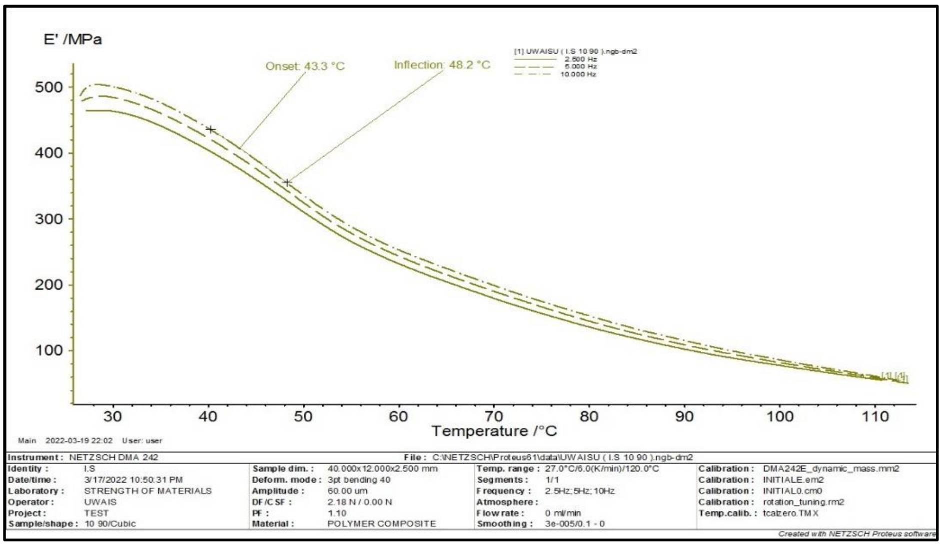
Sample/shape :	20 80/Cubic	**Material :**	POLYMER COMPOSITE	**Smoothing :**	3e-005/0.1 - 0		

Figure 7: Unfilled recycled LDPE storage modulus

3.3.2 Storage modulus of PA reinforced recycled LDPE composites at different compositions

Figure 8, 9 and 10 depict the storage modulus of 15, 20 and 25 % PA reinforced rLDPE composites at 2, 5 and 10 Hz respectively. From these figures, it could be observed that incorporation of PA fibre into recycled HDPE improved the stiffness and energy storage capability of the material. This is because, the maximum stiffness stability of LDPE improved from 0.42 GPa (control) to: 0.50 GPa at 15 % weight of PA (Figure 8); 1.25 GPa at 20 % weight of PA (Figure 9); and 0.34 GPa at 25 % (Figure 10). The robust fiber-matrix interaction of the composites may be the cause of the evident rise in storage modulus from 15% to 20% weight percentage of PA fibers (Jacob *et al.*, 2019a). The sudden drop in stiffness stability to 0.34 GPa at 25 % weight fraction of PA fibre may be the result of a decrease in the constituent composition's interfacial attraction when the weight fraction of PA fiber increases and the percentage of rLDPE decreases (Gupta, 2018; Jacob, 2023). Additionally, the graphs demonstrate that the composites remain stable under dynamic loading as the temperature rises to 43.3 °C before to the point of inflection at 48.2 ℃ (Figure 8); 57.6 ℃ (Figure 9) and 51.8 ℃ (Figure 10) which are taken as the glass transition temperatures for the composites with 15, 20 and 25 % weight of PA fibre respectively. This indicates the suitability of these materials up 50 ℃ (Palanivel *et al.*, 2017; Jacob *et al.*, 2019b; Yusuf *et al.*, 2020; Jacob andYusuf, 2023).



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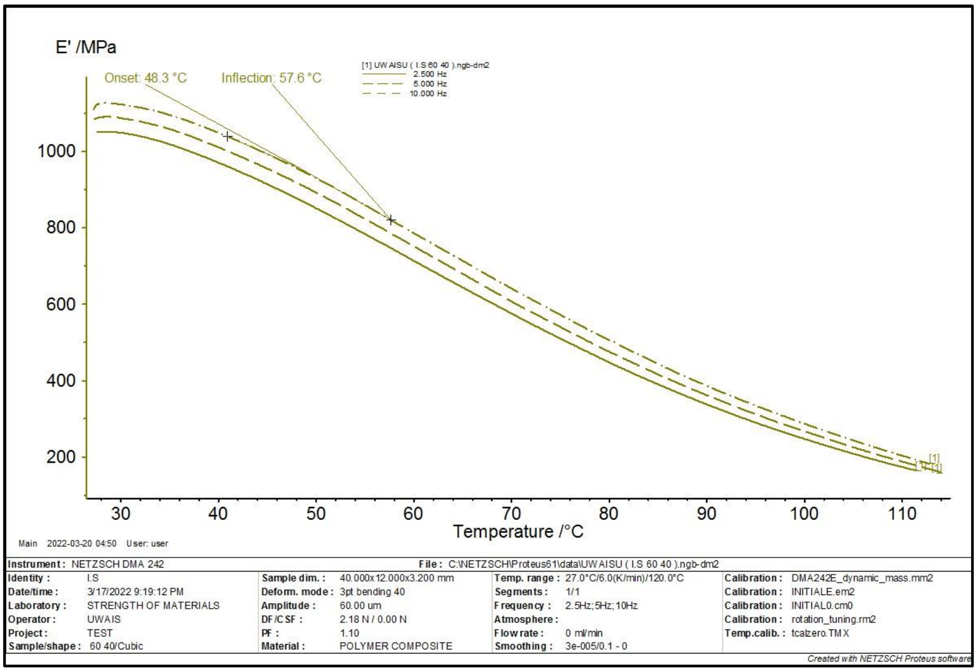
Sample/shape :	10 90/Cubic	**Material :**	POLYMER COMPOSITE	**Smoothing :**	3e-005/0.1 - 0		

Figure 8: Storage modulus of 15 % *Prosopis africana* powder filled recycled LDPE composites.



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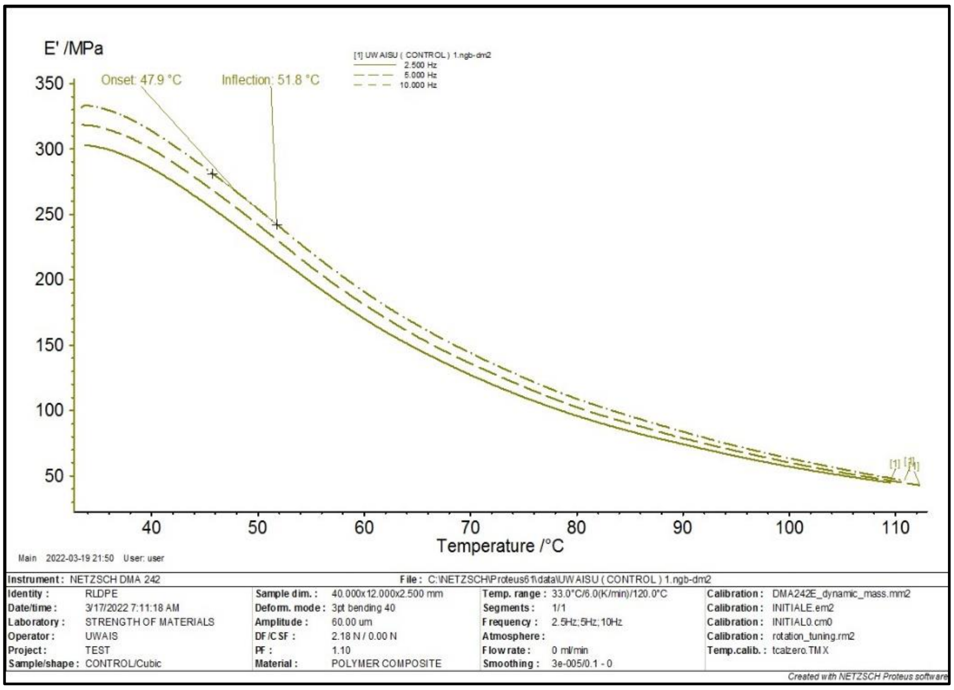
Project :	TEST	**PF :**	1.10	**Flow rate :**	0 ml/min	**Temp.calib. :**	tcalzero.TMX
Sample/shape :	60 40/Cubic	**Material :**	POLYMER COMPOSITE	**Smoothing :**	3e-005/0.1 - 0		

Figure 9: Storage modulus of 20 % *Prosopis africana* powder filled recycled LDPE composites



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Project :	TEST	**PF :**	1.10	**Flow rate :**	0 ml/min	**Temp.calib. :**	tcalzero.TMX
Sample/shape :	CONTROL/Cubic	**Material :**	POLYMER COMPOSITE	**Smoothing :**	3e-005/0.1 - 0		

Figure 10: Storage modulus of 25 % *Prosopis africana* powder filled recycled LDPE composites

3.3.3 Loss modulus of PA reinforced recycled LDPE composites at different compositions

The loss modulus is the quantity of energy that materials release as heat during a single sinusoidal load cycle (Jacob *et al.*, 2019a; Shen et al., 2019; Shaikh *et al.*, 2023). The variation of loss modulus with temperature and frequency at different weight fraction of reinforcement are shown in figures 11-14. From these figures, the energy dissipation of the unreinforced recycled LDPE (110 MPa) is higher than all the composites: 45 MPa at 15 %; 38 MPa at 20 % and 48 MPa at 25 % weight of PA respectively. This suggests that adding PA fibers to the rLDPE matrix improves the material's thermal stability by slowing down the material's energy dissipation (Jacob *et al.*, 2018; Jacob *et al.*, 2019; Shaikh *et al.*, 2023; Jacob, 2023).

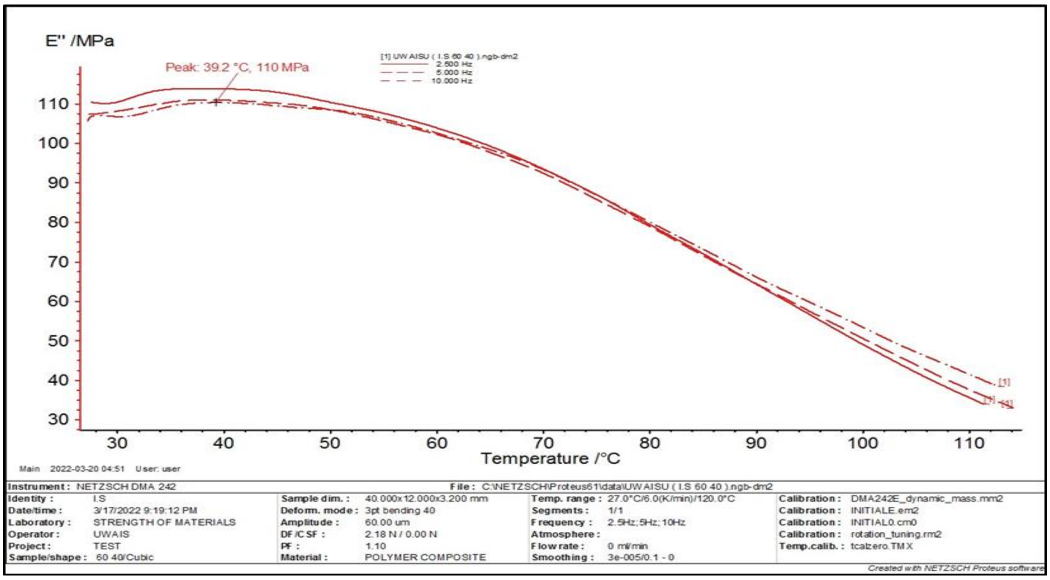

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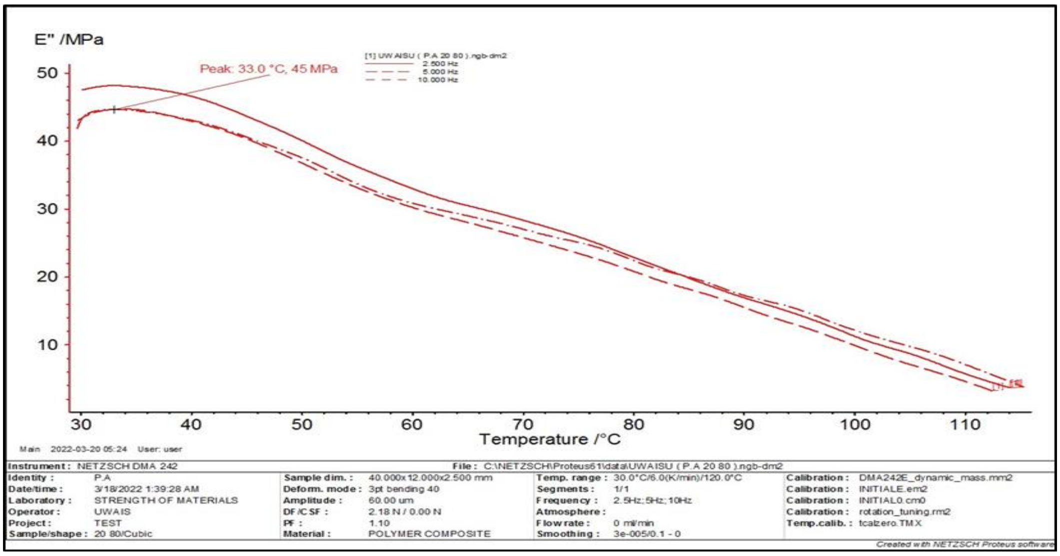
Figure 11: Loss modulus of unreinforced LDPE at 2, 5 and 10 Hz.



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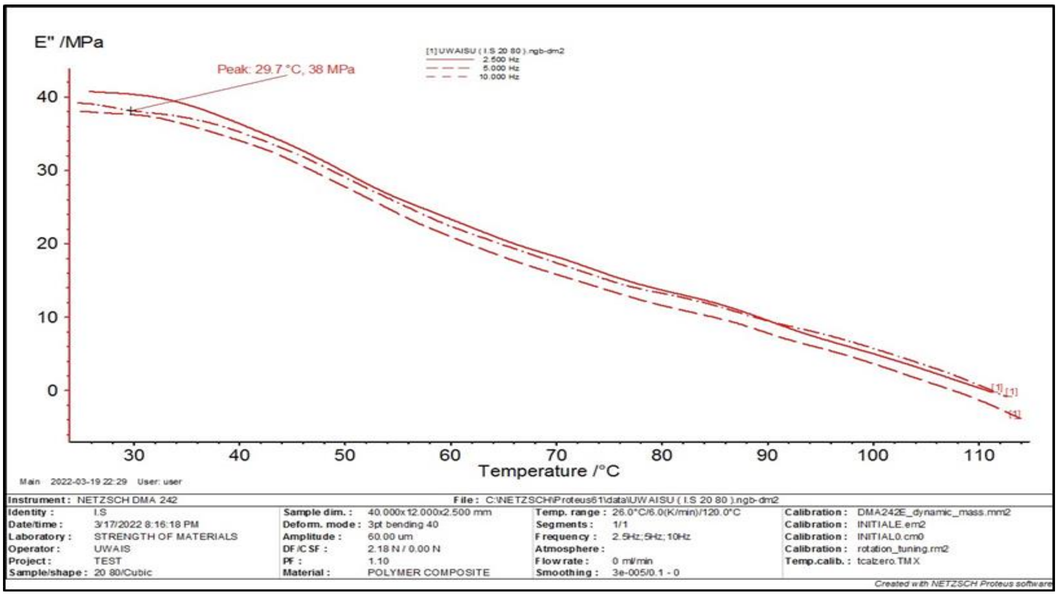
Sample/shape :	20 80/Cubic	Material :	POLYMER COMPOSITE	Smoothing :	3e-005/0.1 - 0		

Figure 12: Loss modulus of 15 % PA reinforced recycled HDPE composites at 2, 5 and 10 Hz.



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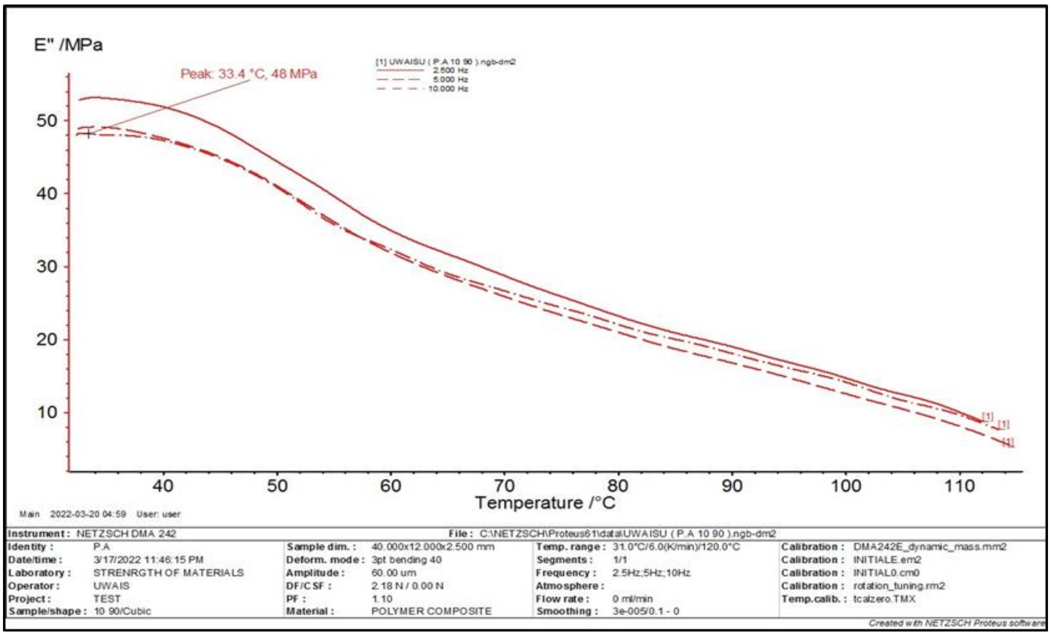
Sample/shape :	20 80/Cubic	Material :	POLYMER COMPOSITE	Smoothing :	3e-005/0.1 - 0		

Figure 13: Loss modulus of 20 % PA reinforced recycled LDPE composites at 2, 5 and 10 Hz.



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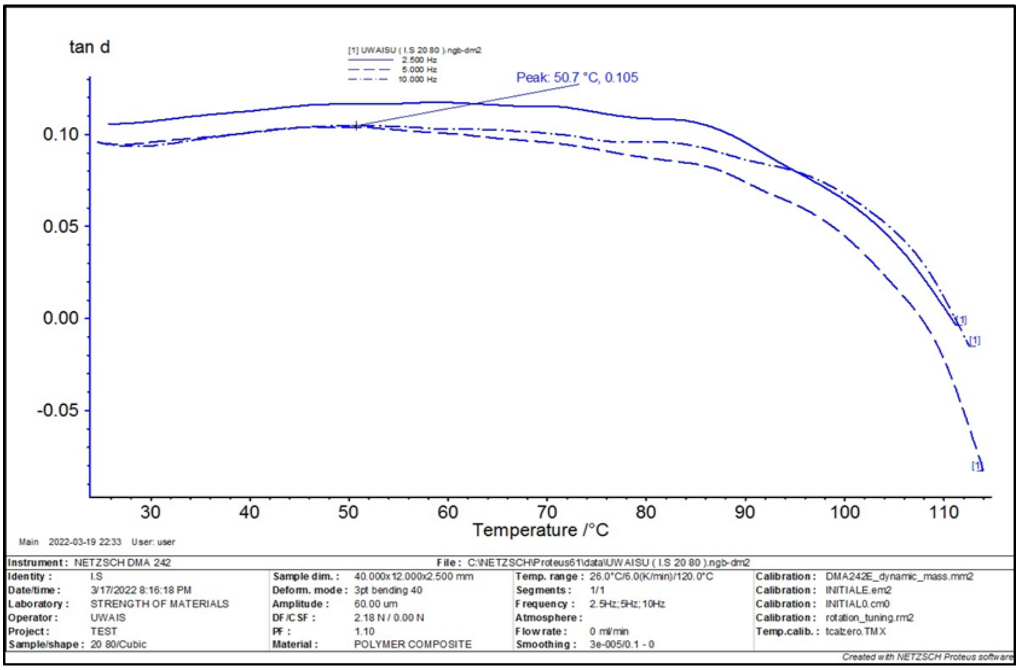
Identity: P.A
Date/time: 3/17/2022 11:46:15 PM
Laboratory: STRENRGTH OF MATERIALS
Operator: UWAIS
Project: TEST
Sample/shape: 10 90/Cubic
Sample dim.: 40.000x12.000x2.500 mm
Deform. mode: 3pt bending 40
Amplitude: 60.00 um
DF/CSF: 2.18 N / 0.00 N
PF: 1.10
Material: POLYMER COMPOSITE
Temp. range: 31.0°C/6.0(K/min)/120.0°C
Segments: 1/1
Frequency: 2.5Hz;5Hz;10Hz
Atmosphere:
Flow rate: 0 ml/min
Smoothing: 3e-005/0.1 - 0
Calibration: DMA242E_dynamic_mass.mm2
Calibration: INITIALE.em2
Calibration: INITIAL0.cm0
Calibration: rotation_tuning.rm2
Temp.calib.: tcalzero.TMX

Figure 14: Loss modulus of 25 % PA reinforced recycled LDPE composites at 2, 5 and 10 Hz.

3.3.4 Damping parameter of PA reinforced recycled LDPE composites at different compositions.

The ratio of loss modulus to storage modulus is known as damping (Tan delta). It is also called loss factor and is often expressed as a dimensionless number (Gupta, 2018; Jacob *et al*., 2019a; Rajesh *et al*., 2021). Figure 15 shows the damping parameter of unfilled rLDPE while Figures 16-18 show the damping parameter of the PA filled composites at 15, 20 and 25 % respectively. These figures clearly show that when the weight percentage of reinforcement increases from 15% to 25%, the composites' damping reduces. This suggests that of all the composites, the sample with 20% weight of PA has the best capacity to support loads. Better interfacial contact between the rLDPE and the PA fibers may be the cause of this. Other authors have reported similar experiences with damping decreasing with weight percentage of reinforcement (Rana *et al*., 2018; Gupta, 2018 and Jacob *et al*., 2019a).



Instrument: NETZSCH DMA 242
File: C:\NETZSCH\Proteus61\data\UWAISU (I.S 20 80).ngb-dm2
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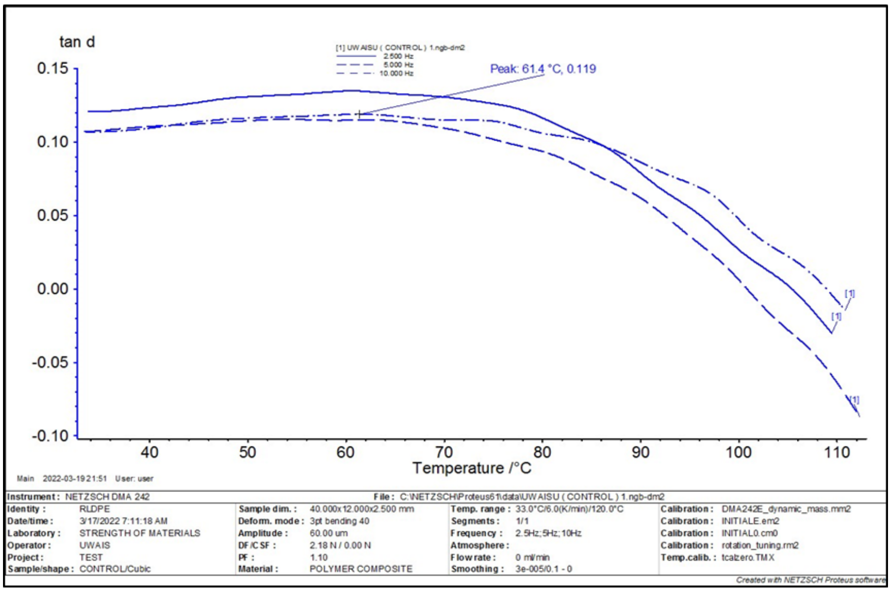
Laboratory: STRENGTH OF MATERIALS
Operator: UWAIS
Project: TEST
Sample/shape: 20 80/Cubic
Sample dim.: 40.000x12.000x2.500 mm
Deform. mode: 3pt bending 40
Amplitude: 60.00 um
DF/CSF: 2.18 N / 0.00 N
PF: 1.10
Material: POLYMER COMPOSITE
Temp. range: 26.0°C/6.0(K/min)/120.0°C
Segments: 1/1
Frequency: 2.5Hz;5Hz;10Hz
Atmosphere:
Flow rate: 0 ml/min
Smoothing: 3e-005/0.1 - 0
Calibration: DMA242E_dynamic_mass.mm2
Calibration: INITIALE.em2
Calibration: INITIAL0.cm0
Calibration: rotation_tuning.rm2
Temp.calib.: tcalzero.TMX

Figure 15: Damping parameter of unreinforced HDPE at 2, 5 and 10 Hz.



Instrument: NETZSCH DMA 242 File: C:\NETZSCH\Proteus61\data\UWAISU (CONTROL) 1.ngb-dm2

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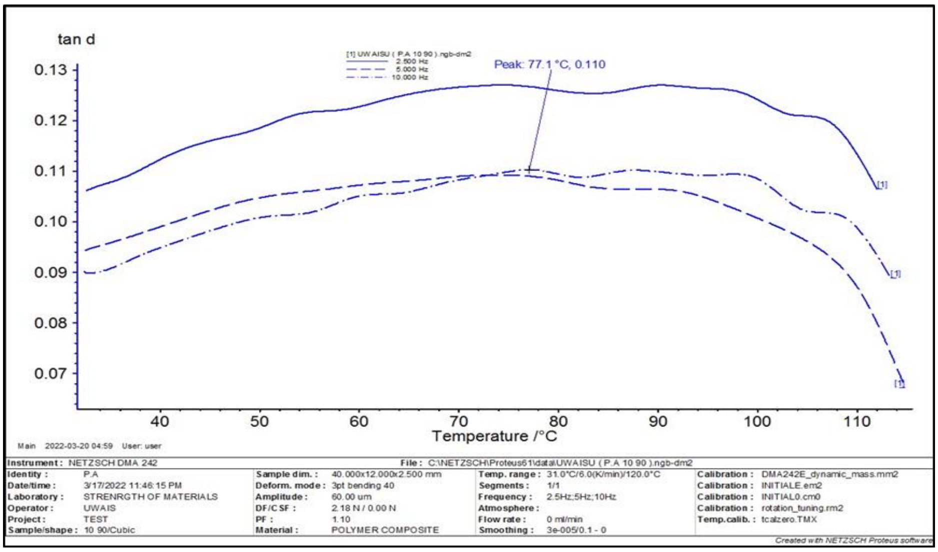
Date/time :	3/17/2022 7:11:18 AM	Deform. mode :	3pt bending 40	Segments :	1/1	Calibration :	INITIALE.em2
Laboratory :	STRENGTH OF MATERIALS	Amplitude :	60.00 um	Frequency :	2.5Hz;5Hz;10Hz	Calibration :	INITIAL0.cm0
Operator :	UWAIS	DF/CSF :	2.18 N / 0.00 N	Atmosphere :		Calibration :	rotation_tuning.rm2
Project :	TEST	PF :	1.10	Flow rate :	0 ml/min	Temp.calib. :	tcalzero.TMX
Sample/shape :	CONTROL/Cubic	Material :	POLYMER COMPOSITE	Smoothing :	3e-005/0.1 - 0		

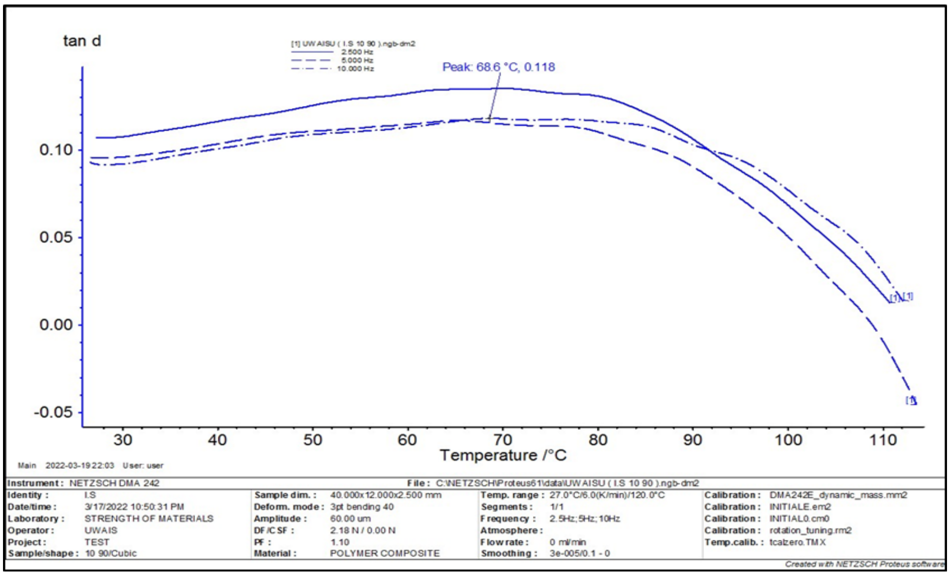
Figure 16: Damping parameter of 15 % PA reinforced LDPE composites at 2, 5 and 10 Hz.



Instrument: NETZSCH DMA 242 File: C:\NETZSCH\Proteus61\data\UWAISU (P.A 10 90).ngb-dm2

Identity :	P.A	Sample dim. :	40.000x12.000x2.500 mm	Temp. range :	31.0°C/6.0(K/min)/120.0°C	Calibration :	DMA242E_dynamic_mass.mm2
Date/time :	3/17/2022 11:46:15 PM	Deform. mode :	3pt bending 40	Segments :	1/1	Calibration :	INITIALE.em2
Laboratory :	STRENRGTH OF MATERIALS	Amplitude :	60.00 um	Frequency :	2.5Hz;5Hz;10Hz	Calibration :	INITIAL0.cm0
Operator :	UWAIS	DF/CSF :	2.18 N / 0.00 N	Atmosphere :		Calibration :	rotation_tuning.rm2
Project :	TEST	PF :	1.10	Flow rate :	0 ml/min	Temp.calib. :	tcalzero.TMX
Sample/shape :	10 90/Cubic	Material :	POLYMER COMPOSITE	Smoothing :	3e-005/0.1 - 0		

Figure 17: Damping parameter of 20 % PA reinforced LDPE composites at 2, 5 and 10 Hz.



Instrument: NETZSCH DMA 242 File: C:\NETZSCH\Proteus61\data\UWAISU (I.S 10 90).ngb-dm2

Identity :	I.S	Sample dim. :	40.000x12.000x2.500 mm	Temp. range :	27.0°C/6.0(K/min)/120.0°C	Calibration :	DMA242E_dynamic_mass.mm2
Date/time :	3/17/2022 10:50:31 PM	Deform. mode :	3pt bending 40	Segments :	1/1	Calibration :	INITIALE.em2
Laboratory :	STRENGTH OF MATERIALS	Amplitude :	60.00 um	Frequency :	2.5Hz;5Hz;10Hz	Calibration :	INITIAL0.cm0
Operator :	UWAIS	DF/CSF :	2.18 N / 0.00 N	Atmosphere :		Calibration :	rotation_tuning.rm2
Project :	TEST	PF :	1.10	Flow rate :	0 ml/min	Temp.calib. :	tcalzero.TMX
Sample/shape :	10 90/Cubic	Material :	POLYMER COMPOSITE	Smoothing :	3e-005/0.1 - 0		

Figure 18: The damping parameter of 25% PA reinforced LDPE composites at 2, 5, and 10 Hz.

The unfilled rLDPE and the composites' glass transition temperatures—which represent the point at which an amorphous solid material changes from a hard, brittle state to a softer, more flexible state—are also shown in the images. The unfilled rLDPE and the composites' glass transition temperatures—which represent the point at which an amorphous solid material changes from a hard, brittle state to a softer, more flexible state—are also shown in the images. From figure 15, the glass transition temperature of the unfilled rLDPE sample was found to be 50.7 ℃; by adding 15 % PA, it was found that this increased to 61.4 °C (Figure 16); (to 77.1 ℃) at 20 % weight percentage of fibre and finally drops (to 68.6 ℃) at 25 % weight percentage of the fibre. This indicates that incorporation of PA fibre into rLDPE improves its stiffness stability (Jacob, 2023; Jacob and Yusuf 2023).

4. 0 Conclusion

Research has been done on the effects of adding PA powder on the mechanical and dynamic mechanical characteristics of recycled LDPE composites. The following conclusions are drawn from the data:

- Incorporation of *Prosopis africana* wood powder into recycled LDPE improved its physico- mechanical properties; density is observed to decrease with increase in weight percentage of PA fibres with a minimum of 0.88g/cm^3 at 25 % of PA compared to 1.98g/cm^3 of the unreinforced rLDPE, while minimal water absorption of 6.08 % was recorded at 20 % weight fraction.
- Equally, with a 20% weight fraction of reinforcement, the maximum tensile strength of 58.5 MPa, stiffness of 2.05 GPa, flexural strength of 68.8 MPa, and hardness value of 70 Shores were achieved.
- The results of the dynamic mechanical properties showed that the maximum load bearing capacity and storage modulus (1.2 GPa) for a composite containing 20% PA fiber were found in comparison to 400 MPa for the unreinforced, while a decrease in loss modulus was noted with increasing temperature and frequency.
- This study demonstrates that incorporating *Prosopis africana* wood powder into recycled LDPE significantly enhances the composite's mechanical and thermal properties. These improvements suggest potential applications in various fields, including construction and packaging, contributing to sustainability by recycling plastic waste. Future research could explore optimizing fiber content and processing conditions to further enhance composite performance.

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