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EDITORS

STUDIES ON THE EFFECT OF COCOA POD AS FILLER IN POLYESTER COMPOSITES

Bolarinwa, M. A. and Babatope, B.*[1]
Engineering Materials Development Institute, P. M. B. 611, Akure
**Correspondence to niyibabatope@yahoo.com*

ABSTRACT

This work investigates the effects of surface treatment on cocoa pod on the mechanical properties of polyester composites. Reinforcement varying between 0% w/w to 10% was used in the preparation of the polyester composite specimens. Tensile and hardness tests were carried out on the test specimens with and without reinforcements and the effect of loading on the mechanical properties were correlated. This work has a significant impact for the conversion of waste products, especially cocoa pod that pollutes the environment to engineering materials. The study found that apart from the common use of cocoa pod in the soap making industry, it would also become important in engineering materials fabrication. This has implication for the wealth creation programme embedded in the vision 20, 2020 target on the floor.

Keywords: Surface treatment, reinforcement, mechanical properties, polyester composites, cocoa pod.

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[1] Permanent Address: Physics Department, Obafemi Awolowo University, Ile-Ife.

Introduction

Adding value to cocoa and its by-products in cocoa producing countries has often met with much debate (Sukha, 2003). Research findings have shown that in agriculture, huge quantities of residues which constitute wastes and often times, hazards are fibrous and polymeric in nature (Babatope (2005). A number of naturally-occurring fibrous materials have been used in the past as either fillers or reinforcing materials in polymers. Some examples include jute (Chakraborty et al. 1982), wood flour (Xanthos 1983), kenaf (Karnani et al. 1997), oil palm empty fruit bunch (Mohd Ishak et al. 1998), oil palm wood flour (Zaini et al. 1996), pineapple leaf (Joseph et al. 1993; Jayamol et al. 1996), sisal (Bisanda et al. 1992), coir (Joseph et al. 1993), banana fiber (Pothan and Thomas 2003) among others.

After the removal of the cocoa beans from the fruit for use especially in the beverage and confectionery industry, the remnants, often referred to as cocoa-pod husk, often constitute huge waste. They are often left to rot away in most cases. The direction of research in many developing countries is along the line of utilization of several naturally occurring materials in the development of new engineering materials. This is in view of the scarce foreign exchange and the huge cost of infrastructure development of conventional materials.

Traditional technologies have existed for ages on the use of cocoa-pod husk in soap making. Studies have been carried out along this direction to explore the active ingredients in this waste material, usually potassium carbonate (Afrane 1992) in order to extend its use in modern soap making processes. cocoa pod husks and cocoa beans shells have relatively high potassium contents and are also used in the manufacture of fertilizers or composts (Sukha (2003).

In composite materials, a very wide range of dissimilar materials are put together in service so as to achieve a new complex whose overall properties are different in type and magnitude from those of the separate constituents (Higgins, 1977). The effective method to increase the strength and to improve the overall properties of composites is to incorporate finely dispersed phases into the matrix since materials can be strengthened by dispersing particles of a second phase in them (Jastrzebski, 1977). In these wise, polymeric materials become much stiffer.

In this work, the resulting properties of polyester composites have been investigated mechanically in terms of tensile strength and hardness, having treated with filler (cocoa pod).

Hence, the objectives of this work include:

i. Incorporating cocoa pod as filler in different weight - to - weight percentages into the matrix of polyester composites to serves as reinforcement.
ii. Examining both the tensile strength and hardness of the reinforced composite specimens and the unreinforced ones serving as the control experiment.
iii. Comparing the resulting mechanical properties (tensile strength and hardness) of reinforced composite specimens with the unreinforced ones.

Materials and Methods

100g of polyester resin was measured in a beaker. 10g of cocoa pod was also measured and mixed with the polyester resin as filler for reinforcement. The mixture was placed inside an ultrasonic cleaner for 20mins for proper agitation. 1g of catalyst was added and stirred for 3mins, after which 0.5g of accelerator was added and stirred in for another 3mins. The resulting mixture was then cast into the different PVA coated aluminium moulds and allowed to cure. After 2hr 15mins, the samples fully cured and were annealed in the oven at 50°C for 1hr, on removal from the moulds. On cooling, they were again annealed in the oven at 80°C for another 3hrs, in other to completely overcome stickiness and allowed to cool down completely under the air conditioner. The procedure was thereafter repeated respectively with 7g, 5g, 3g, and 1g of cocoapod as filler reinforcement. Finally, the procedure was repeated again but without any cocoapod addition to serve as the control polyester composite specimens.

Material Testing

All the synthesized polyester composite specimens were simultaneously taken to the advanced materials testing laboratory for hardness test using the Micro hardness tester and tensile test using the Instron Universal tester.

Results and Discussion

Having carried out the tests mentioned above, the following results were obtained:

Hardness test results

Figure 1: Shows the graph of hardness versus % w/w cocoa pod as filler for reinforcement (loading). From the graph, the curve produced indicated that the hardness values of the tested specimens increased correspondingly as the percentage of cocoa pod introduced into the polyester composite continued to increase from 0% to 10%. The rate of increment was highest at 3% loading; this rate was less at 0% loading and 1% loading but reduced to the minimum above 3% loading.

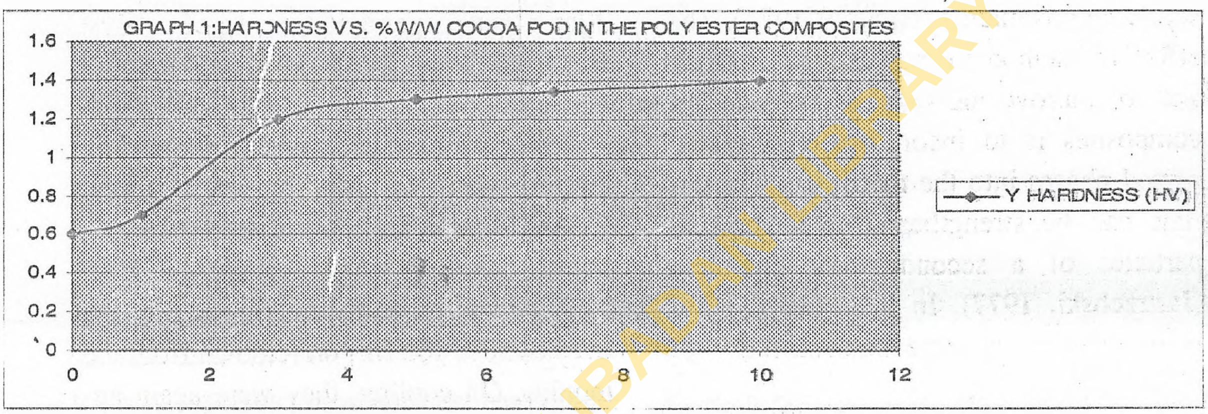
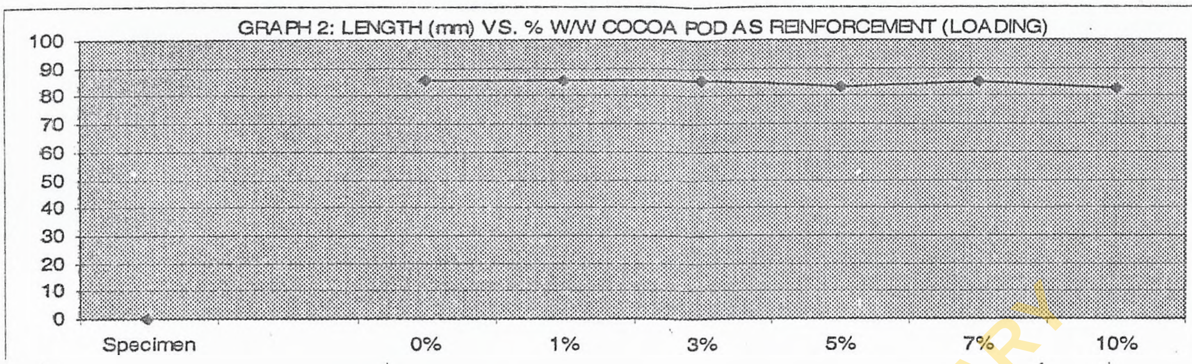


Fig. 1: Graph of Hardness vs. w/w cocoa pod loading as filler in polyester composites.

Tensile test results

Figure 2 (i): Shows the graph of length versus % w/w cocoa pod as reinforcement (loading). According to the details provided in the graph, the length of the polyester composite specimen increased a little with 1% loading from 85.39mm to 85.77mm. However, 3% loading resulted to a slight drop in the length of the product obtained back to 85.59mm. On 5% loading, the length drastically dropped to 83.48mm but simultaneously picked up a little at 7% loading to attain 84.88mm.At 10% loading, the length sharply dropped down to 82.56mm.



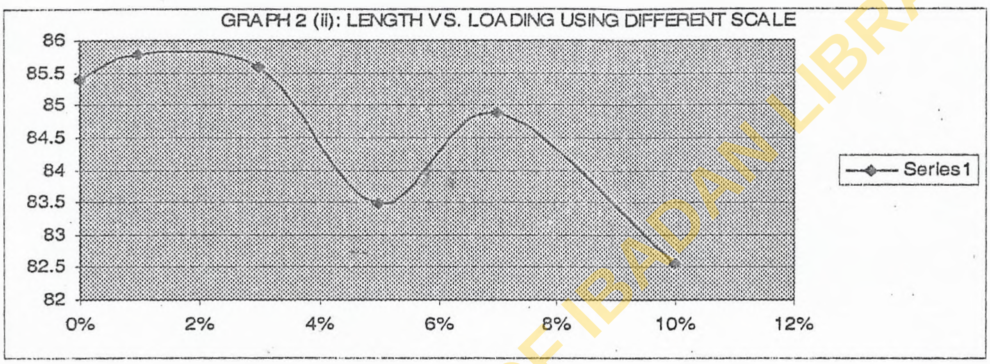
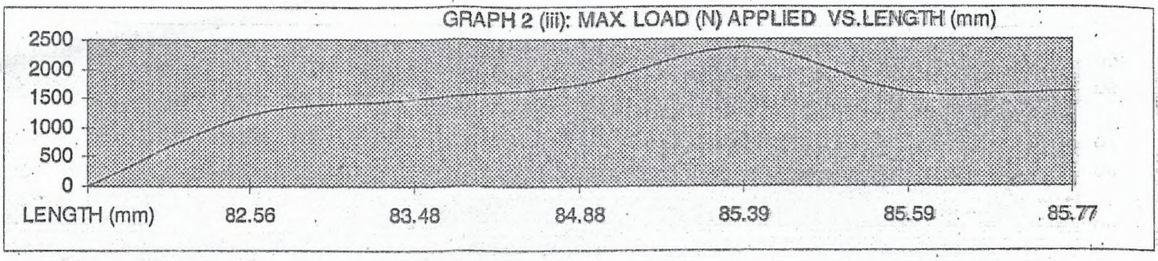
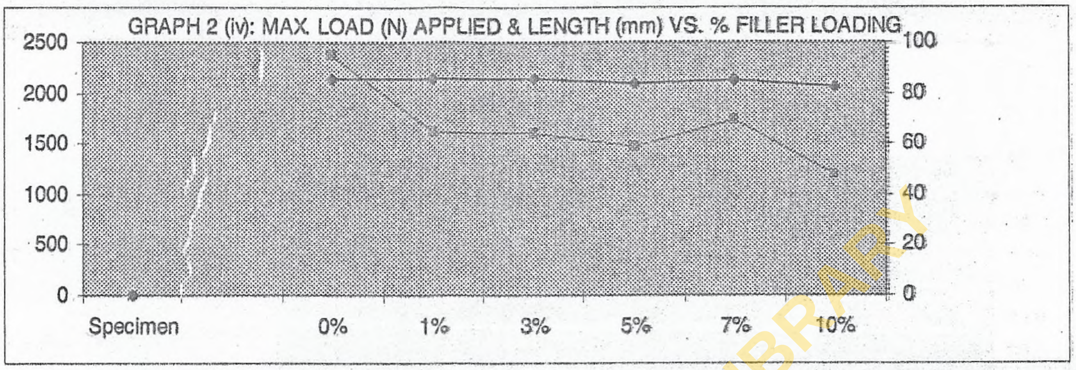


Figure 2 (iii): Shows the graph of length versus maximum load applied. From the curve, the polyester composite specimen with the highest length of 85.77mm (1% loading) withstood a maximum load of 1615.39N. The specimen with the second highest length of 85.59mm (3% loading) withstood a maximum load of 1596.57N. The specimen with the third highest length of 85.39mm (0% loading) withstood a maximum load of 2377.44N which is the maximum attainable maximum load. The specimen with the length of 84.88mm (7% loading) withstood a maximum load of 1728.24N. The specimen with the length of 83.48mm (5% loading) withstood a maximum load of 1465.86N while that with the length of 82.56mm (10% loading) withstood a maximum load of 1196.55N.

Figure 2 (iv): Shows the graph of maximum load applied & length versus % w/w cocoa pod loading. The values of maximum load obtained for each of the tested specimens fluctuated somehow.

For instance, the unreinforced (0% loading) polyester composite specimen withstood a maximum load of 2377.4N before failure but with 1% cocoa pod loading, the maximum load withstood rapidly reduced to 1615.40N as indicated by the curve of the graph.





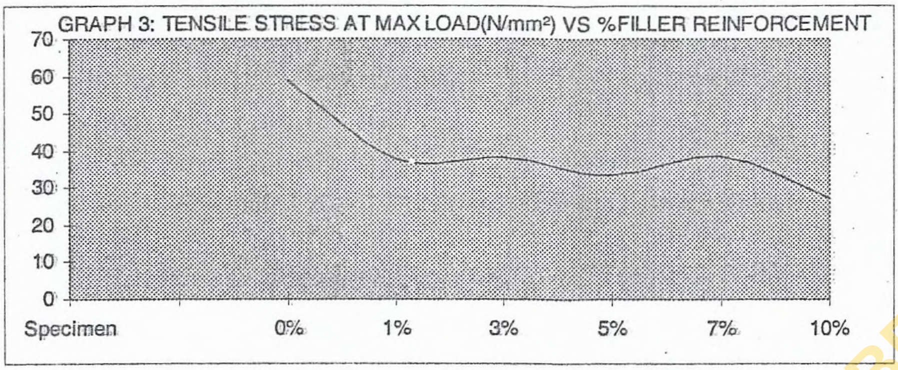
A further reduction, though slightly to 1595.60N was observed in the attainable maximum load on 3% cocoa pod loading. This reduction continued gradually to 1465.90N with 5% cocoa pod loading. A sharp rise was noticed in the graph curve as the maximum load attainable picked up to about 1728.20N. However, this drastically dropped again to 1196.60 N at 10% loading.

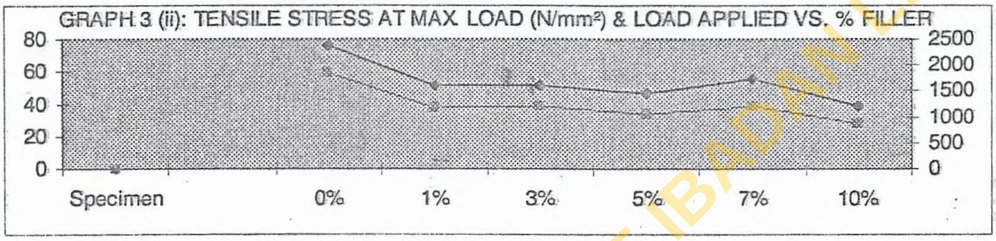
Figure 3 (i): Shows the graph of tensile stress at maximum load versus % w/w cocoa pod loading. The curve therein indicates that the polyester composite specimen with 0% loading possessed the highest tensile strength of 58.90N/mm², which dropped sharply to 37.65N/mm² at 1% loading. A slow but gradual increase to 38.60N was obtained at 3% loading which still dropped back to 33.73 on loading up to 5%. The curve climbed again as the tensile strength rose to about 38.68N with 7% loading. However, this drastically fell back to 27.17N on loading up to 10%.

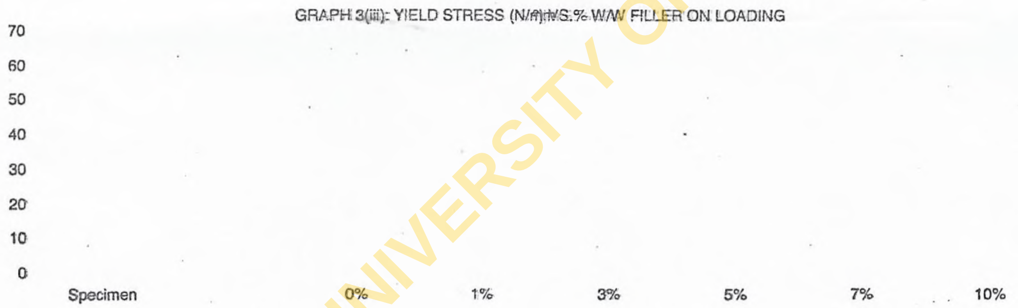
Figure 3 (ii): Clearly shows a corresponding relationship between the curve of tensile stress at maximum load and the applied load itself with each loading between 0% and 10%, such that a rise in one resulted to a rise in the other and a drop in one also led to a drop in the other one.

Figure 3 (iii): Shown in the graph is the yield stress curve which also follows the same pattern with a drastic fall when moving from 0% loading to 1% loading.

Figure 4 (i): Shows the graph of tensile strain at maximum stress versus %w/w loading. The resulting curve moves sharply in a downward direction, meaning a rapid drop. At 3% loading, it still dropped but very slightly only to pick up again at a negligible rate on 5% loading. The same rate continued very slowly up till 7% loading before it finally dropped down at 10% loading.







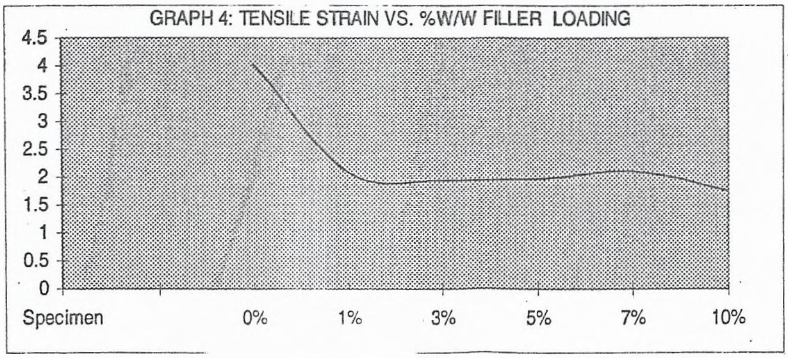
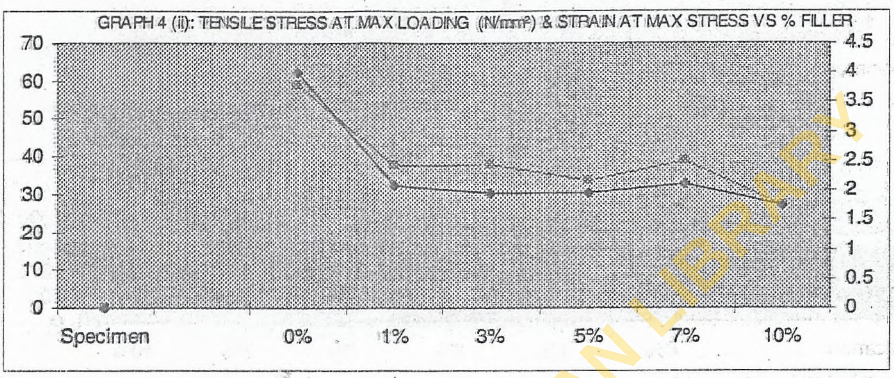


Figure 4 (ii): The stress and strain curves there in have similarities at 0% loading,1% loading, 7% loading and 10% loading, that is, they both dropped from 0% loading to 1% loading and 7% loading to 10% loading. They both also rose slightly on 7% loading. On the other hand. at 3% loading, while the tensile stress curve raised slightly, the tensile strain curve dropped slightly. At 5% loading, the tensile stress curve dropped a little but the tensile strain curve picked up slightly.

Figure 4 (iii): The curves of the strain produced and maximum load applied upon loading both have some similarities in their patterns, except at 5% loading, where the applied maximum load attainable reduced at a gradual rate from 1596.57N to 1465.86N while the resulting tensile strain increased but very slightly from 1.94 to 1.96.



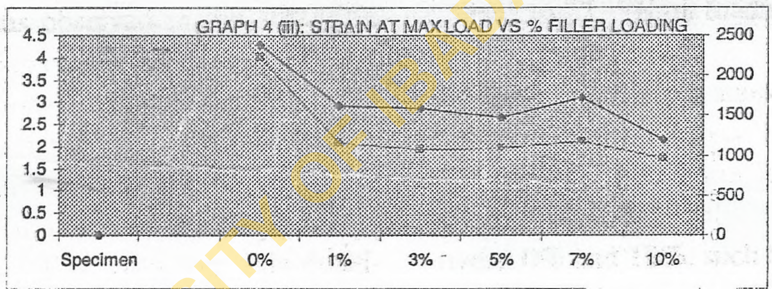


Figure 5 (i): Shows modulus of elasticity, E and maximum load. From the 2 curves plotted, it could be deduced that at 1% loading, while the E rose at a very gradual rate, the maximum load applied reduced at a similar rate. This trend repeated itself at 3% loading but thereafter continued in the same manner above 3% loading up till 10% loading.

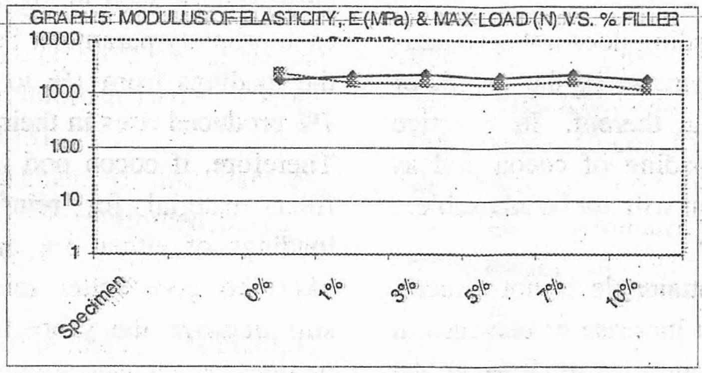


Figure 5 (ii): Shows the graph of modulus of elasticity, E. The curve displays a sharp rise from 0% loading to 1% loading in the values of the modulus of elasticity E obtained. This still continued to increase between 1% and 3% loading. However, this dropped above 3% loading to 5% loading but experienced another rise from 5% to 7% loading before it finally dropped gradually on 10% loading.

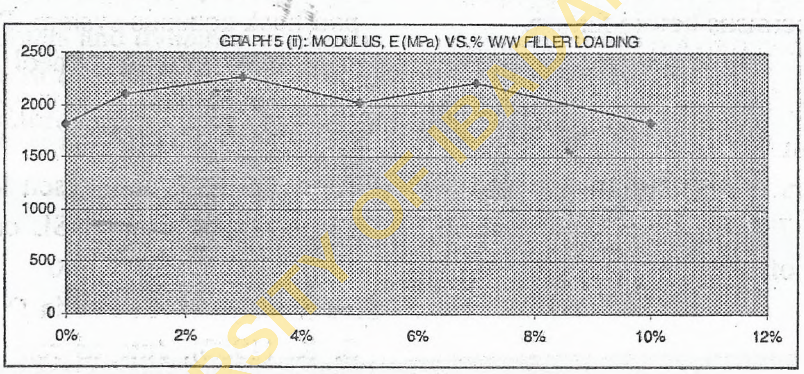
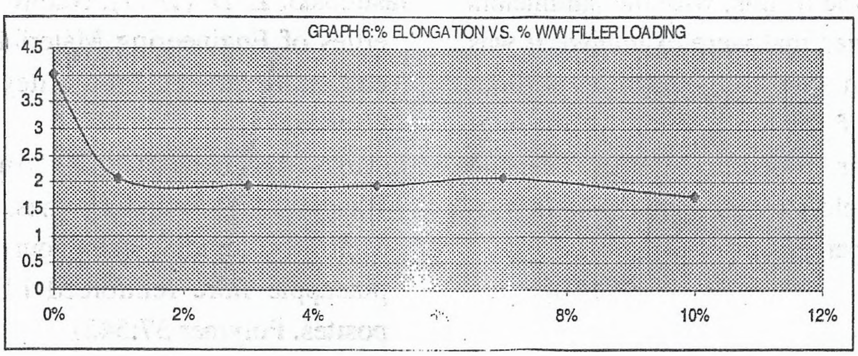


Figure 6: Shows the graph of % elongation versus loading. A sharp curve exists between 0% and 1% loading in the downward direction, implying a large reduction in the % elongation obtained on 1% loading. Above 1% to 5% loading, the values of % elongation recorded were almost constant. This however slightly rose between 5% and 7% loading before it finally dropped down on 10% loading.



Conclusion

Increase in the loading does not automatically imply an increase in the length of products resulting thereof. In practice therefore, 10% loading of cocoa pod as filler reinforcement will not be advisable.

Maximum load attainable is not directly proportional to an increase or decrease in % cocoa pod loading. The drop in the curve of the tensile graph was most pronounced on moving from 0% loading to 1% loading. This means that increase or decrease in length does not automatically result to an increase or decrease in maximum load attainable by the polyester composite specimens before failure.

Unlike others, the modulus of elasticity increased from 0% loading to 1% loading but like others dropped from 3% to 5% loading and 7% to 10% loading. The Hooke's law of elasticity was obeyed to some extent.

From the results obtained so far, the use of cocoa pod as filler for reinforcement should be considered if the hardness property of polyester composite materials is to be improved upon.

Also from the results, with the parameters and properties that were examined, it was clearly seen that the specimens without any form of reinforcement (0% loading) posses better properties in terms of tensile strength, yield strength, tensile strain produced and percentage elongation.

However, as seen in all the graphs, with each property parameter being considered, the loadings from 1% to 3% and 5% to 7% produced rises in their various graphs. Therefore, if cocoa pod is to be used as filler material for reinforcement, then loadings of either 3% or 7% are more likely to give better reinforcement and still improve the properties in terms of hardness and tensile strength.

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