Journal of Harbin Engineering University Vol 45 No. 4
ISSN: 1006- 7043 April 2024

Strength Analysis of Rubber Latex Composite Mixed with Custard Apple and Tamarind Seed Powder

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Abstract
This project of strength analysis of natural rubber mixed with custard apple and tamarind seed powder deals with the mechanical property enhancement of natural rubber latex sample. This project aims to intimate that the biodegradable and easily available materials like seed powders exhibit better mechanical properties when mixed with natural rubber latex. In this project varying proportional samples of custard apple seed powder and tamarind seed powder are mixed together with natural rubber latex solution along with formic acid (CH_2O_2). The natural rubber latex is mixed with both seed powders under four varying proportions, say 2.5%,5%,7.5% and 10%. With respect to the proportions of seed powders added certain proportional mixtures proved to be effective comparing to the pure sample mixture. The observations of the tests provided valuable insights on the enhanced properties of natural rubber latex and found suitable for applications in automotive, packing and manufacturing industries. This composition of natural rubber latex composite leads to the development of eco-friendly rubber composite based materials and helps in local and industrial manufacturing rubber composite products. The composite material made with natural rubber latex, custard apple and tamarind seed powder fabricated by hand layup process. By making totally of 13 samples (including the pure one) under various proportions (say 2.5%, 5%, 7.5% and 10%) tests such as tensile tear and compression tests are taken and the results are noted. The tensile test proves that the pure sample is the strongest proportion among all the 13 samples with a tensile strength of 0.849 N/mm^2. The mix sample of 2.5% proportion each resulted in a tensile strength of 0.825 N/mm^2 which is 2.59% less than that of tensile strength of pure sample. The tear test proves that the pure sample contains the lowest tear strength of 0.291 N/mm^2. The mix sample of 10% (5% custard apple seed powder and 5% tamarind seed powder) resulted in highest tear strength of 0.343 N/mm^2 which is 17.86% more than that of the tensile strength of pure sample. The compression test proves that the pure sample has the lowest compressive strength of 25.62 N/mm^2. The proportion of 10% custard apple seed powder resulted in a compression strength of 32.11 N/mm^2 which is 25.33% more than that of the compression strength of the pure sample.

Keywords: *Rubber latex composite, Custard apple, Tamarind seed powder, Natural fillers, Biodegradable materials, Mechanical properties*

1. Introduction

The main objective of this project is to understand the mechanical properties associated with natural rubber latex. In order to achieve this, the study focuses on incorporation of natural rubber latex with tamarind and custard apple seed powder. This approach is carried out in order to enhance the tensile, compressive and tear strength of natural rubber latex polymer with seed powders. The mixing of seed powder is classified into four proportions namely 2.5%, 5%, 7.5% and 10%. These proportional mixtures are individually achieved for both custard apple and tamarind seed powders. Then both powders are mixed together with natural rubber latex under half of their initial proportions.

In sensitive people, latex surgical gloves can produce contact urticaria and significant allergic responses, but the incidence of this sensitivity remains unknown. In the current study, 512 hospital staff were tested using a latex-glove scratch-chamber test: 23 (4.5%) were suspected, and 15 (2.9%) were shown to be allergic with latex prick and usage tests [1]. Natural rubber latex (NRL) has emerged as a major occupational health hazard in recent years, particularly among healthcare professionals. Some findings imply that the frequency of latex sensitization among occupationally exposed populations is comparable to that of the general population [2]. Throughout our research, the presence of live dagger

nematodes has been linked to the infectiousness of soils and soil preparations. Furthermore, the absence or rarity of Xiphinema outside of damaged plant patches shows that nematodes are frequently a limiting factor in arabis mosaic virus transmission [3]. Fresh NR latex included two main proteins, 14 and 24 kD, linked with rubber particles, as well as a range of acidic and basic proteins with molecular weights ranging from less than 14 kD to more than 100 kD in the B- and C-serum fractions [5]. After drying at 100°C and allowing moisture to evaporate from one surface, water-soluble proteins in wet natural rubber latex sheets moved to the surface [6]. The natural rubber latex allergens are found and replaced with better non allergenic materials [7].

2. Methods

2.1 Materials

Polyisoprene with specific gravity and melt flow index of 15g/min are purchased from Kurian Abraham Pvt Ltd, Kanyakumari which holds quality certifications under ISO 9001, ISO 13485 and ISO 14001.

2.2 Preparation of blends and composites

A total of 13 samples including one pure sample are prepared. Initially the pure sample making process starts with 300ml of pure rubber latex obtained from rubber tree (Hevea brasiliensis). The pure sample is poured into an aluminium tray of dimension 25mm x 15mm. Then 190ml of dilute formic acid is mixed with the 300ml of pure rubber latex solution. The solution is mixed quicker before the latex and the formic acid starts to react and start to solidify. Now the solution measures 490ml. This 490ml mixture is constant for all the thirteen samples. Only the seed powder proportion is increased with decrease in the 300ml of rubber latex. The pure rubber latex solution is kept closed under a temperature of 33°C for 3 hours. Now the sample is perfectly solidified. This same method is followed for all the remaining 12 samples which include 4 different proportions of tamarind seed powder, 4 different proportions of custard apple seed powder and 4 different proportions of mixture of both. The tamarind seed powder and the custard apple seed powder mixture are added in grams as 7.5g, 15g, 22.5g and 30 g. The mixture of both the seed powders are done with proportions 3.75g, 7.5g, 11.25g and 15g each. After solidification the samples are brought under a rubber sheet rolling machine where the samples are compressed to testing thickness of 3mm.

23 Characterization

2.3.1 Tensile Test

Dumbbell shaped specimens were punched out from the mould sheets in the milling direction. Tensile tests to determine tensile strength and Young's modulus were carried out according to the ASTMd41 method using the Universal Testing Machine with a load cell of 3kN. The testing specimens are cut in the dimension 115 * 25 * 3 mm^3. The tests were carried out with constant speed of 15mm/min. The specimen was tightly gripped with the testing machine with both the ends of the dumbbell shaped specimen perfectly fit on the upper and lower crossheads. Simultaneous measurement of stress and strain were made and data were recorded. The tensile test specimen image is displayed in Figure 2.1.

Figure 2.1 Specimen of Tensile Testing

2.3.2. Tear test

The composite specimens of dimensions 60 * 12.7 * 1 mm^3 were subjected to tear test using the same Universal Testing at a cross-head speed of 15 mm/min and a span length of 25 mm. The rectangular cross-sectional bar is hold with two supports and load is applied on the exact midpoint of the specimen. Both the supports and loading nose are cylindrical in shape. Simultaneous measurements of stress and strain were made and data were recorded. The tear test specimen image is displayed in Figure 2.2.

Figure 2.2 Specimen of Tear Testing

2.3.2. Compression Test

Compression Test was carried according to the ASTM D575 method. The composite specimen of dimensions 25mm height 12mm diameter was subjected to compression test using the same Universal Testing Machine at a cross-head speed of 15mm/min. The cylindrical shaped test

specimen is compressed up to the maximum of one-third of its original length. Simultaneously measurements of stress and strain were made and data were recorded.

2.4 Weight Fraction Calculation

The weight fraction of rubber latex composite mixed with tamarind seed powder and custard apple seed powder are shown in Figure 3. The varying proportions of the 3 different sample types are tabulated.

SAMPLE	RUBBER LATEX (weight %)	TAMARIND SEED POWDER (weight %)	CUSTARD APPLE SEED POWDER (weight %)
S1	100 % (300g)	0	0
S2	97.5 % (292.5g)	0	2.5% (7.5g)
S3	95 % (285g)	0	5% (15g)
S4	92.5 % (277.5g)	0	7.5% (22.5g)
S5	90 % (270g)	0	10% (30g)
S6	97.5 % (292.5g)	2.5% (7.5g)	0
S7	95 % (285g)	5% (15g)	0
S8	92.5 % (277.5g)	7.5% (22.5g)	0
S9	90 % (270g)	10% (30g)	0
S10	97.5 % (292.5g)	1.25% (3.75g)	1.25% (3.75g)
S11	95 % (285g)	2.5% (7.5g)	2.5% (7.5g)
S12	92.5 % (277.5g)	3.75% (11.25g)	3.75% (11.25g)
S13	90 % (270g)	5% (15g)	5% (15g)

3. Results And Discussion

3.1 Tensile Test Results

The tensile test is conducted and the elongation, cross sectional area, peak load are noted as observations. Varying sample proportions lead to varying load variations and varying fracture points. The observed values are calculated and the tensile strength of the rubber specimen mixed with custard apple seed powder and tamarind seed powder are listed in the table below.

The pure sample attains a tensile strength of 0.847 N/mm^2. The composite mixture of pure rubber latex mixed with 2.5% custard apple seed powder gives a tensile strength of 0.811 which is 4.26% less than the tensile strength of pure sample. The composite mixture of pure rubber latex mixed with 5% custard apple seed powder gives a tensile strength of 0.621 which is 26.69% less than the tensile strength of pure sample. The composite mixture of pure rubber latex mixed with 7.5% custard apple seed powder gives a tensile strength of 0.725 which is 14.40% less than the tensile strength of pure sample. The composite mixture of pure rubber latex mixed with 10% custard apple seed powder gives a tensile strength of 0.680 which is 19.71% less than the tensile strength of pure sample. The composite mixture of pure rubber latex mixed with 2.5% tamarind seed powder gives a tensile strength of 0.802 which is 5.31% less than the tensile strength of pure sample. The composite mixture of pure rubber latex mixed with 5% tamarind seed powder gives a tensile strength of 0.755 which is 10.86% less than the tensile strength of pure sample. The composite mixture of pure rubber latex mixed with 7.5% tamarind seed powder gives a tensile strength of 0.710 which is 16.17% less than the tensile strength of pure sample. The composite mixture of pure rubber latex mixed with 10% tamarind seed powder gives a tensile strength of 0.639 which is 24.55% less than the tensile strength of pure sample. The composite mixture of both tamarind and custard apple seed powders with 1.25% proportion each resulted in a tensile strength of 0.825N/mm^2 which is 2.59% less than the pure sample's tensile strength. The composite mixture of both tamarind and custard apple seed powders with 2.5% proportion each resulted in a tensile strength of 0.731N/mm^2 which is 13.69% less than the pure sample's tensile strength. The composite mixture of both tamarind and custard apple seed powders with 3.75% proportion each resulted in a tensile strength of 0.699 N/mm^2 which is 17.47% less than the pure sample's tensile strength. The composite mixture of both tamarind and custard apple seed powders with 5% proportion each resulted in a tensile strength of 0.710N/mm^2 which is 16.17% less than the pure sample's tensile strength. The tensile test results are shown in the figure 3.1.

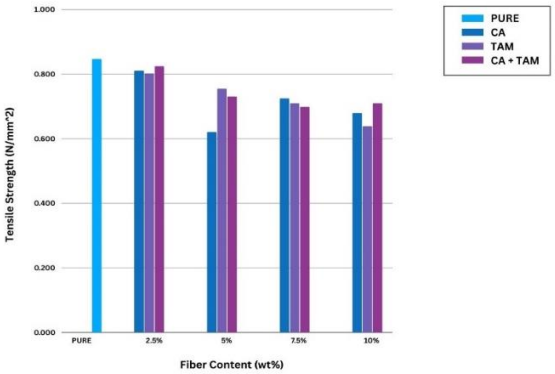

Figure 3.1 Tensile Strength Analysis Graph

3.2 Tear Test Results

The tear test is conducted and the elongation, cross sectional area, peak load are noted as observations. Varying sample proportions lead to varying load variations and varying fracture points. The observed values are calculated and the tear strength of the rubber specimen mixed with custard apple seed powder and tamarind seed powder are listed in the table below.

The pure sample attains a tear strength of 0.291 N/mm^2. The composite mixture of pure rubber latex mixed with 2.5% custard apple seed powder gives a tear strength of 0.294 which is 1.03% more than the tear strength of pure sample. The composite mixture of pure rubber latex mixed with 5% custard apple seed powder gives a tear strength of 0.324 which is 9.96% more than th e tear strength of pure sample. The composite mixture of pure rubber latex mixed with 7.5% custard apple seed powder gives a tear strength of 0.311 which is 6.87% more than the tear strength of pure sample. The composite mixture of pure rubber latex mixed with 10% custard apple seed powder gives a tear strength of 0.294 which is 1.03% more than the tear strength of pure sample. The composite mixture of pure rubber latex mixed with 2.5% tamarind seed powder gives a tear strength of 0.288 which is 1.03% less than the tear strength of pure sample. The composite mixture of pure rubber latex mixed with 5% tamarind seed powder gives a tear strength of 0.311 which is 6.87% more than the tear strength of pure sample. The composite mixture of pure rubber latex mixed with 7.5% tamarind seed powder gives a tear strength of 0.319 which is 9.62% more than the tear strength of pure sample. The composite mixture of pure rubber latex mixed with 10% tamarind seed powder gives a tear strength of 0.301 which is 3.43% more than the tear strength of pure sample. The composite mixture of both tamarind and custard apple seed powders with 1.25% proportion each resulted in a tear strength of 0.329 N/mm^2 which is 13.05% more than the pure sample's tear strength. The composite mixture of both tamarind and custard apple seed powders with 2.5% proportion each resulted in a tear strength of 0.311 N/mm^2 which is 6.87% more than the pure sample's tear strength. The composite mixture of both tamarind and custard apple seed powders with 3.75% proportion each resulted in a tear strength of 0.331 N/mm^2 which is 13.74% more than the pure sample's tear strength. The composite mixture of both tamarind and custard apple seed powders with 5% proportion each resulted in a tear strength of 0.343 N/mm^2 which is 17.86% more than the pure sample's tear strength. The tear test results are shown in the figure 3.2.

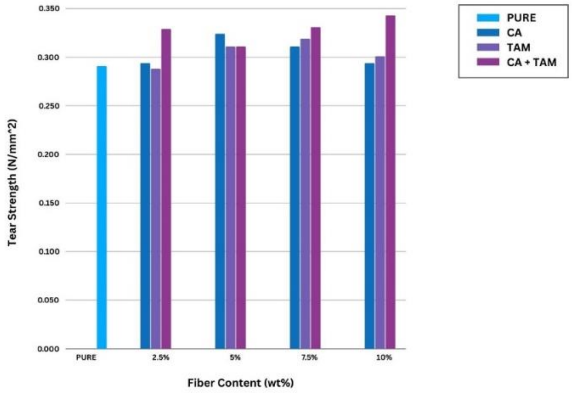

Figure 3.2 Tear Strength Analysis Graph

3.3 Compression Test Results

The compression test is conducted and the elongation, cross sectional area, peak load are noted as observations. Varying sample proportions lead to varying load variations and varying fracture points. The observed values are calculated and the compression strength of the rubber specimen mixed with custard apple seed powder and tamarind seed powder are listed in the table below.

The pure sample attains a compression strength of 25.62 N/mm^2. The composite mixture of pure rubber latex mixed with 2.5% custard apple seed powder gives a compression strength of 26.45 N/mm^2 which is 3.23% more than the compression strength of pure sample. The composite mixture of pure rubber latex mixed with 5% custard apple seed powder gives a compression strength of 26.95

N/mm^2 which is 5.19% more than the compression strength of pure sample. The composite mixture of pure rubber latex mixed with 7.5% custard apple seed powder gives a compression strength of 28.11 N/mm^2 which is 9.71% more than the compression strength of pure sample. The composite mixture of pure rubber latex mixed with 10% custard apple seed powder gives a compression strength of 32.11 N/mm^2 which is 25.33% more than the compression strength of pure sample. The composite mixture of pure rubber latex mixed with 2.5% tamarind seed powder gives a compression strength of 26.54 N/mm^2 which is 3.59% less than the compression strength of pure sample. The composite mixture of pure rubber latex mixed with 5% tamarind seed powder gives a compression strength of 27.93 N/mm^2 which is 9.01% more than the compression strength of pure sample. The composite mixture of pure rubber latex mixed with 7.5% tamarind seed powder gives a compression strength of 28.31 N/mm^2 which is 10.49% more than the compression strength of pure sample. The composite mixture of pure rubber latex mixed with 10% tamarind seed powder gives a compression strength of 31.27 N/mm^2 which is 22.05% more than the compression strength of pure sample. The composite mixture of both tamarind and custard apple seed powders with 1.25% proportion each resulted in a compression strength of 27.36 N/mm^2 which is 6.79% more than the pure sample's compression strength. The composite mixture of both tamarind and custard apple seed powders with 2.5% proportion each resulted in a compression strength of 27.21 N/mm^2 which is 6.20% more than the pure sample's compression strength. The composite mixture of both tamarind and custard apple seed powders with 3.75% proportion each resulted in a compression strength of 28.45 N/mm^2 which is 11.04% more than the pure sample's compression strength. The composite mixture of both tamarind and custard apple seed powders with 5% proportion each resulted in a compression strength of 30.21 N/mm^2 which is 17.91% more than the pure sample's compression strength. The compression test results are shown in the figure 3.3.

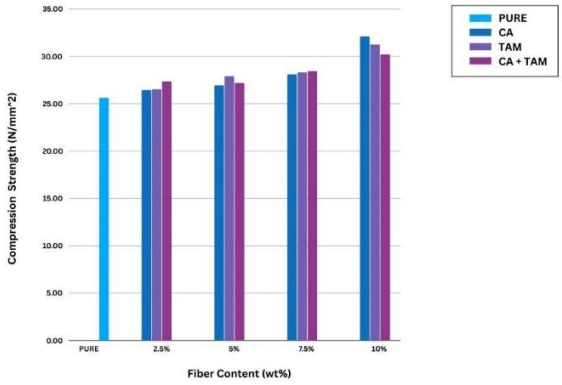

Figure 3.3 Compression Strength Analysis Graph

4. Conclusion

- The composite material made with natural rubber latex, custard apple and tamarind seed powder fabricated by hand layup process. By making totally of 13 samples (including the pure one) under various proportions (say 2.5%, 5%, 7.5% and 10%) tests such as tensile tear and compression tests are taken and the results are noted.
- The tensile test proves that the pure sample is the strongest proportion among all the 13 samples with a tensile strength of 0.849 N/mm^2. The mix sample of 2.5% proportion each resulted in a tensile strength of 0.825 N/mm^2 which is 2.59% less than that of tensile strength of pure sample.
- The tear test proves that the pure sample contains the lowest tear strength of 0.291 N/mm^2. The mix sample of 10% (5% custard apple seed powder and 5% tamarind seed powder) resulted in highest tear strength of 0.343 N/mm^2 which is 17.86% more than that of the tensile strength of pure sample.
- The compression test proves that the pure sample has the lowest compressive strength of 25.62 N/mm^2. The proportion of 10% custard apple seed powder resulted in a compression strength of 32.11 N/mm^2 which is 25.33% more than that of the compression strength of the pure sample.
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