Preparation and study of the mechanical properties of kenaf/natural rubber composites

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Abstract

Composites of Kenaf fibre with Natural Rubber latex were formed at different fibre contents level. It was observed that above 20% fibre content, the rubber latex was easily saturated with the fibres which made it difficult for the composites to form. It was also observed that as the fibre content increased, properties like dimension, density, compression set, flex fatigue resistance, abrasion resistance, work of rupture decreased. While properties like hardness, impact strength, breaking strength, yield strength increased with increase in fibre content. Generally it was observed that the physical properties tend to decrease while the mechanical properties increased with increase in fibre content.

1. Introduction and literature review

An ideal material from the application point of view should be strong, tough and light. Metals and their alloys are close to satisfying these requirements. They are strong and tough, but not very light. The plastics are light but lack stiffness, strength and toughness. An obvious approach to attaining an ideal material would be to combine two materials with complementary properties. Such composite materials will have the combined advantages of their constituents.

De and White (1996) reported that short fibre composites are finding ever-increasing applications in engineering and in consumer goods. They can offer a unique combination of properties or may be used simply because they are more economical than competing materials.

Fibre reinforcement of polymers improves the stiffness and the strength, and for many toughness may decrease in polymers that are already tough in unreinforced form. The dimensional stability is improved and in the cases of rubbery composites, better green strength is obtained.

Jog (1999) showed that natural fibres have recently attracted the attention of scientists and technologists because of the advantages that these fibres provide over conventional reinforcement materials. Kokta and Raji (1990) have also reported the gaining popularity of thermosets/short fibre composites.

These natural fibres are low-cost fibres with low density and high specific properties. They are biodegradable and non abrasive, unlike other reinforcing fibres. They are also readily available and their specific properties are comparable to those of other fibres used for reinforcements. However certain draw backs such as incompatibility with the hydrophobic polymer matrix, tendency to form aggregates during processing, and poor resistance to moisture greatly reduce the potential of natural fibres to be used as reinforcement in polymers. Thermal stability of natural fibre is another problem associated with their composites.

Kenaf is a bast fibre obtained from the stem of the plant. It belongs to the class of hibiscus cannabinus. It is a wild plant in tropical and subtropical Africa. It is a warm season annual fibre crop used in a manner similar to jute. The kenaf plant reaches the height of 3-8 m, kenaf is directly seeded with conventional grain drills after the soil surface has warmed and the danger of frost has passed.

Kenaf fibres are normally obtained by the process of retting. Danladi et al (2008) have shown that the fibre properties are influenced by the retting method. However, the fibres are known to be strong and tough, have continuous length that could be cut to the desired fibre length for either spinning or composites formation.

Natural rubber is obtained from the milk like cream from Hevea brasiliensis tree. The cream is normally concentrated to greater than 60%rubber solids, which contain rubber particles suspended in water. Natural rubber has found applications in tyre, globes, laminates and other aspects of life.

This work is aimed at preparing composites on natural rubber with varying proportions of Kenaf fibre so as to see the effects of fibre content on the properties of the composites

2. Methodology

The Kenaf fibres were obtained by the cold water retting method. The natural rubber latex was compounded according to the standard procedure Danladi et al (2008).

The fibres were cleaned to remove any leftover impurity and cut to about 1cm length, the compounded rubber latex was weighed out according to the desired amount and poured in to the mold and the corresponding quantity of Kenaf fibre added and cured in the oven at 120-140^{o}C for one hour.

2.1. Measurement of dimensional changes

The area of the composites were measured and compared with the mold area and the results are shown in Fig.1

2.2. Density determination

The densities of the composites were determined using water displacement method and the results are show in Fig.2

2.3. Determination of compression set

The Wallace compression set apparatus (constant stress) was used to determine the compression set of the composites according to the procedure for rubber articles. The effect of fibre content are shown in Fig.3

2.4. Determination of abrasion resistance

The Wallace Test Abrader Equipment S/No. 084025/1 by Brooks Inspection Equipment Limited (England) was used for the determination of the abrasion resistance of the composites according to the standard procedure for rubber materials. The results are shown in Fig.4

2.5. Determination of composites hardness

The Wallace Dead load hardness Tester for Rubber and Rubber like materials. I.S.O/R.48 1968(E) A.S.T.M. D1415 was used. The results are shown in Fig.5

2.6. Determination of flex fatigue resistance

The Wallace De Mattia Flexing machine (36-specimen Model F6) was used to study the effect of fibre content. The procedure was conducted according to the standard method for testing rubber articles. The results are shown in Fig. 6

2.7. Determination of impact strength

The izod impact tester model: IT 15 MAT 20, S/No: 010137 was used to carry out this test according to ISO procedure. The results obtained are shown in Fig.7

2.8. Determination of tensile properties

The apparatus used for this test is the Monsanto Tensometer 10, with part number TC915 and serial number 0274. The machine had a load capacity of 1000 kgf (1 N) /220lb/ft.

The samples were conditioned in the laboratory for 24 hrs at room temperature and dumbbell shaped test pieces were cut out of the sample. The test pieces were clamped between the jaws of the Tensometer at gauge length of 5cm. Cross head speed of 50cm/min was selected to run the experiment.

The machine was then started and the samples stretched at constant rate until the specimen ruptured. The load applied and the elongation values attained were read off the machine and recorded and plotted. From the plots of load/elongation curves, the tensile properties of the composites were calculated. From the graphs the mechanical properties of the samples were determined as shown in Figures: 8-11.

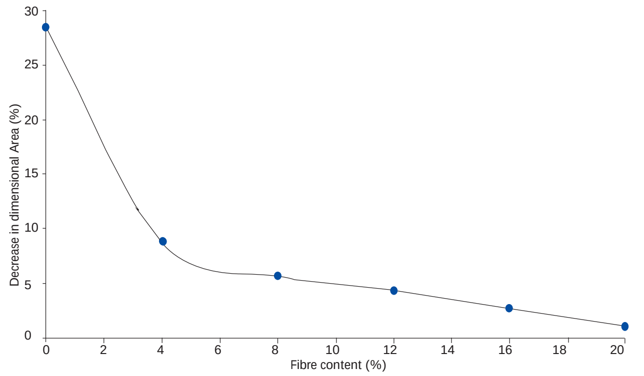

Fig.1 Effect of Fibre Content on Dimensional Changes of Natural Rubber/ Kenaf Fibre composites.

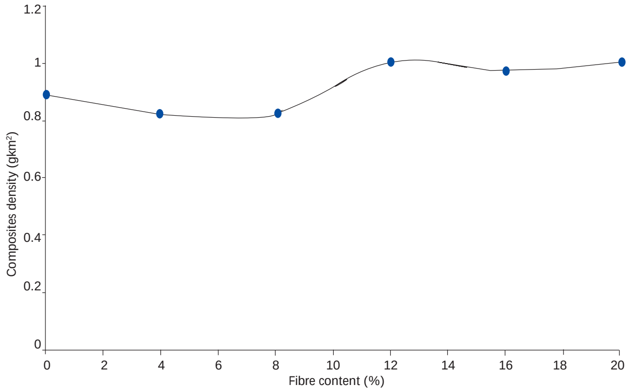

Fig.2 Effect of Fibre Content on Density of Natural Rubber/ Kenaf Fibre Composites.

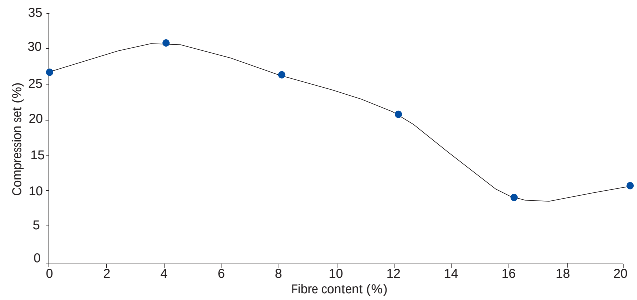

Fig.3 Effect of Fibre Content on Compression Set of Natural Rubber/ Kenaf Fibre Composites.

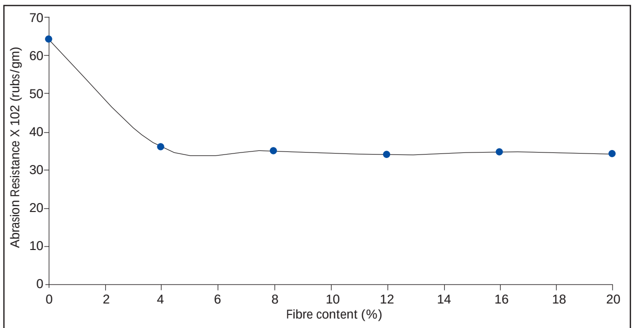

Fig. 4 Effect of Fibre Content on Abrasion Resistance of natural rubber/ Kenaf Fibre composites.

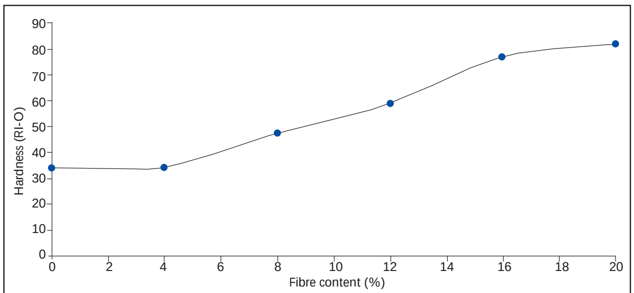

Fig.5 Effect of Fibre Content on Hardness of Natural Rubber/ Kenaf Fibre Composites.

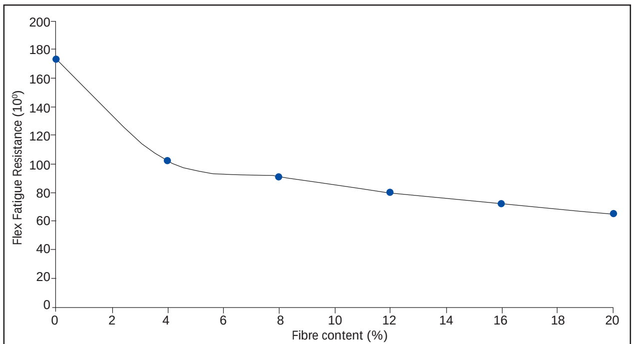

Fig. 6 Effect of Fibre Content on Flex Fatigue Resistance of Natural Rubber/ Kenaf Fibre composites.

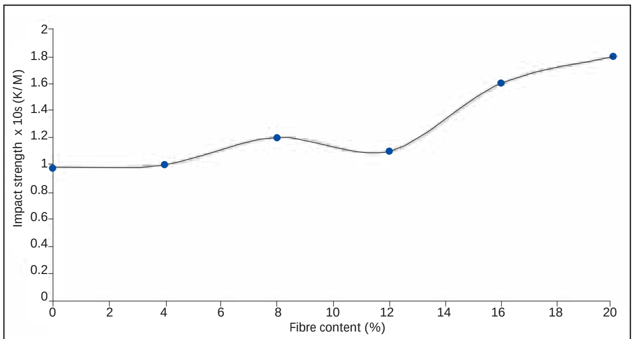

Fig.7 Effect of Fibre Content on Impact Strength of Natural Rubber/ kenaf Fibre Composites.

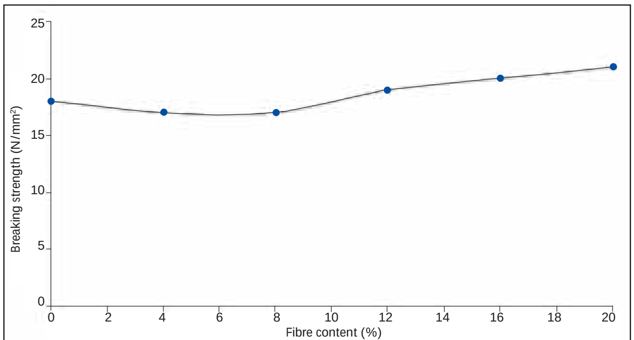

Fig. 8 Effect of Fibre Content on breaking strength of Natural Rubber/ Kenaf fibre Composites.

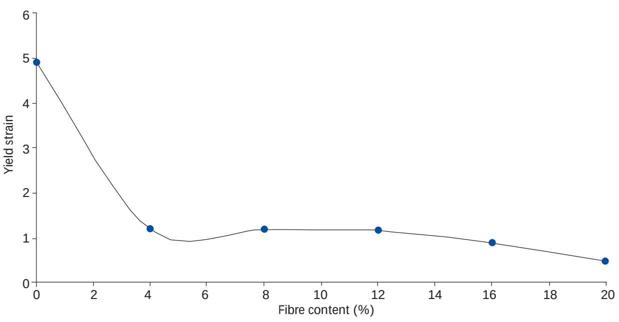

Fig.9 Effect of Fibre content on Yield Strain of Natural Rubber/ kenaf Fibre composites.

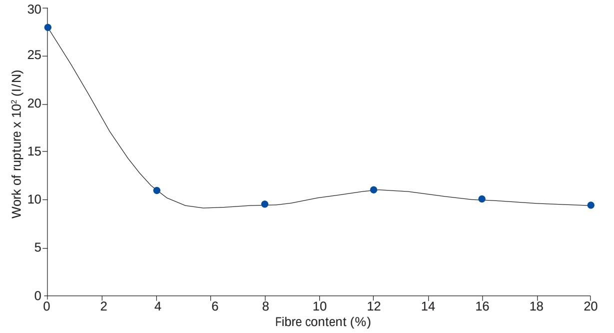

Fig. 10 Effect of fibre content on Work of Rupture of Natural rubber/ Kenaf Composites .

3. Results and discussions

3.1.1. Effect of fibre content on dimensional changes

Fig 1 shows that as the fibre content increased, there was a decrease in the dimension of the composites formed. Generally, as the content of the fibre in the composites increased the surface area was observed to decrease.100% natural rubber was observed to have the highest decrease of about 28.56%, while 20% Kenaf fibre content composite was seen to have about 1% decrease in the surface area. Similarly it can be seen that at about 0- 4% fibre content, the effect of fibre content on dimensional changes is more pronounced.

3.1.2. Effect of fibre content on density of composites

Fig.2 shows that as the fibre content increased, initially there was little or no change in composites density. However, between 8% and 12% fibre content, the density increased and then fluctuates about the same value up to 20% fibre content. The composites studied can be seen to have low density values, but the values are insignificantly affected with increase in fibre content.

3.1.3. Effect of fibre content on compression set of composites

The compression set values of the composites as observed in Fig.3 are seen to decrease between 4 and 16% fibre content and the slightly increased at 20% fibre content. As the fibre content increased the chances of voids being created in the composites increased, thus as the composites are compressed, they will have high tendencies to be compressed and crushed. Al-Qureshi (1999) reported that due to the medium level of crystallinity of cellulosic fibres, when present in composites can cause low values of compression set.

3.1.4. Effect of fibre content on abrasion resistance of composites

Fig.4 reveals that as the fibre content is increased, the abrasion resistance decreased up to 4%. Thereafter, the values appeared not to be affected by further increase. As fibres are introduced in to the rubber composites, they provide weak points in the composites, thus explaining the drop in the abrasion resistance values. However as the fibre content increased above 4%, the weak points have already been created in the composite structure thus allowing for the composites to be eroded. This explains the insignificant changes observed in the abrasion values above the 4% fibre content. Similar results have been reported by Khatua and Seabeil (2005).

3.1.5. Effect of fibre content on hardness of composites

The hardness values were observed to increase as the fibre content increased as shown in Fig.5. 100% natural rubber articles are known to be soft. However, as the kenaf fibres are added the hardness values. Kenaf fibres have been referred to as hard fibres due to the good crystallinity content, therefore adding them to the composites increases the hardness values.

Hardness by Tewary (1978) is calculated as a measure of the resistance of materials to cuts, scratches and other wear and tear of the surface. The results suggest that composite materials containing 8% fibre content and above can be used in applications were normal hardness values are required such as floor covering, roofing sheets, partition boards. etc. Composites of 0 – 8% fibre content have low hardness and cannot therefore be used where hardness is of paramount importance.

3.1.6. Effect of fibre content on flex fatigue resistance of composites

Fig. 6 shows the effect of fibre content on flex fatigue resistance of natural rubber/Kenaf fibre composites. It can be seen that as the fibre content increased, the values decreased. The decrease can be seen to be more drastic for 0-4%, This can be attributed to creation of weak points as a result of interfering with the polymerized network structure of the rubber.

Above 4% fibre content, the decrease is seen to be slow, this may be due to the fact that above this fibre content level, the structure of the composites have already been weakened and any increase in fibre content will not affect the structure much.

3.1.7. Effect of fibre content on impact strength of composites

The impact strength of the composites can be seen not to be affected from 0-12% fibre content as shown in Fig.7. However above 12% fibre content, the impact strength of the composites is seen to increase. This means that composites of 12% and above fibre content can withstand high impacts.

3.1.8. Effect of fibre content on breaking strength of composites

Fig.8 shows that the breaking strength of the composites increases with increase in fibre content. Breaking strength of a material refers to the material's ability to resist applied force. This implies that as the fibre content increases more load is needed to cause failure in the composites of natural rubber with kenaf fibres.

The strength values obtained in this work is similar to what has been reported by Kuruvilla et al (1999) while reviewing sisal fibre reinforced polyester and low density polyethylene composites.

3.1.9. Effect of fibre content on yield strain of composites

Fig.9 shows that as the fibre content increases the yield strain of the composites decreases. The decrease can be seen to be more pronounced between 0% and 4% fibre content. Thereafter the values almost remained the same. Yield strain is the strain at which permanent deformation of materials occur as the result of the action of stress. This parameter is of importance, and can to a large extent, determine the application of materials. Since rubber articles are elastic in nature it is expected that 100% rubber composites will have high yield strain. The inclusion of Kenaf fibres in the composite structure, interferes with the cross-linking of the rubber, hence it should be expected that the yield strain will decrease with the introduction of the fibres.

3.1.10. Effect of fibre content on work of rupture of composites

The work of rupture of the composites is seen in Fig.10 to decrease between 0 and 4% fibre content. As the fibre content was increased thereafter, the values remained almost the same with little variations. Work of rupture is a measure of toughness of a material. It is a measure of the energy a sample can absorb before it breaks.

This implies that composites of natural rubber with kenaf fibres are tough. However, as the fibre content increased the toughness of the composites is reduced especially between 0 and 4% fibre content. Danladi (2008) have studied the composite of some natural fibres with various polymeric materials. Kenaf fibre has been found to have high strength; hence their composites will be equally expected to be tough.

Conclusions

From the results obtained it can be concluded that varying the fibre content of natural rubber/ Kenaf fibre composites has effects on the properties of the composites. Properties like dimension, density, compression set, abrasion resistance, flex fatigue resistance, yield strain and work of rupture were all found to decrease with increase in fibre content of the composites. It was also observed that the decrease in these properties was most noticeable between 0 and 4% fibre content with little or no significant variation after the 4% fibre content.

Properties like hardness, impact strength and breaking strength were however observed to increase with increase in fibre content of the composites.

The values obtained generally suggest that natural rubber/ Kenaf composites can meet the engineering requirements of composite materials and can therefore find applications in both domestic and industrial applications.

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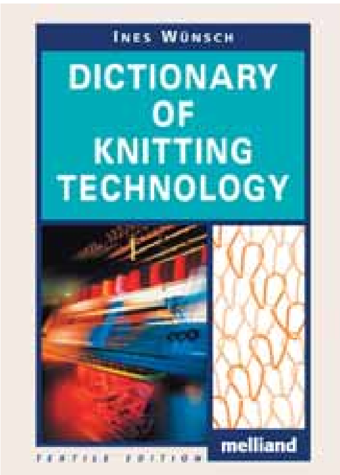
BOOK REVIEW:
Dictionary of Knitting Technology



The Dictionary of Knitting Technology explains up to 1,500 important terms from the knitting industry, including 380 figures. The dictionary combines explanations from construction and production technology with product describing terms.

Furthermore the dictionary contains a lot of structures and patterns for knitted fabrics: from opaque to filet net, from highly elastic to dimensional stable. Single or multicoloured knitted fabrics as well as fabrics with plain or structured surface are also displayed with its structures and patterns. So the dictionary is interesting for both, technologists and machinery manufacturers as well as designers and for those who are working in the product development.

Author

The author, Dr. Ines Wünsch, born in 1961, studied textile technology at the Technical University in Dresden, Germany. After three years' experience in the textile industry she returned to the Institute of Textile and Clothing Industry in Dresden, starting her career in research and teaching. With more than 20 years experience in Dresden, Reutlingen (both Germany) and Roubaix (France), Dr. Ines Wünsch is now a professor for textile engineering and product development at the Westsächsische Hochschule in Zwickau, Germany.

Target reader

The comprehensive edition of the dictionary is also a must for students who are studying textile technology, textile machinery construction and textile design as well as for career changes from other branches who are engaged in textile oriented questions.

Further information:

Dictionary of Knitting Technology:

Author: Ines Wünsch,

1st edition, 148,00 Euro,

hardback, 283 pages,

ISBN 978-3-86641-165-4

Verlagsgruppe Deutscher Fachverlag GmbH, Buchverlag, Mainzer Landstraße 251, 60326 Frankfurt-Germany.