Effect of Fibre Treatment on Mechanical Properties of SCF Reinforced Rubber Composite

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Abstract- **The natural fibre in its raw state has several drawbacks such as poor bonding, easy breakage, high moisture absorption low load carrying capacity etc.These factors limit the properties or performance of the composite when the fibres are added in raw state. In the present study, chemical and surface modifications are carried out on the cylindrica fibre in order to overcome its limitations and a new composite is fabricated with the treated fibre. The analysis of properties indicates that the chemical modification imparts a considerable improvement in the properties as well as the performance of the composite.**

Keywords—cylindrica; shore A; phr; decorticattion.

I. INTRODUCTION .

Natural fibre-reinforced polymer composites have gained attention among materials scientists and engineers in recent years due to the need to develop an ecofriendly material and to replace currently used synthetic fibres in fibre-reinforced composites. The excellent properties and the performance of natural fibres combined with their eco-friendliness are very important for their acceptance in engineering markets, such as the automotive, aerospace and building industries.

Natural fibre in its raw state has several drawbacks such as high moisture absorption, low thermal stability, bio and photo degradation, poor bonding efficiency etc. These drawbacks limit their performance as a reinforcing agent. These limitations are rectified by surface treatment and chemical modification of the fibre, which enhances the properties to a much better level. The surface modification of the fibres is done with chemical treatments following chemical reactions without destroying the fibrous nature.Chemical treatments on cellulose fibres change the morphological structures, macromolecular properties and chemical structure including the accessibilityof elemental groups.

In this study, a new rubber composite is manufactured with raw as well as modified Sansevieria Cylindrica fibre as the reinforcing agent. Raw and the treated fibres are used separately for fabricating the composite and the mechanical properties and the performance of the composite prepared from the modified fibres are found much better than that of the initially made raw fibre composite.

II. EXPERIMENTAL DETAILS

A. Fibre Decortication and chopping

Cylindrical fibre was extracted and decorticated from the leaves of Sansevieria cylindrical plant .The fibres are uniformly cut into sets of batches of lengths 3mm, 6 mm and 10 mm. The raw sisal fibres were chopped to different lengths viz., 2, 6 and 10 mm and these fibres were dried in an air oven at 70°C for 5 h. Raw fibres are initially used to find the composite which gives the optimum result. So, the quantity of fibre that is to be chemically modified is also prepared.

B. Surface and Chemical modification of Fibre

Surface Treatment

The different surface modifications carried out in the present work include mercerization, acetylation, benzoylation, peroxide treatment, and permanganate treatment.

Short sisal fibres were immersed in water at 25 0 C for 1 hour. After that, these fibres were washed several times with water in order to remove the easily extractable impurities from the surface of the fibres. The fibres were dried in an air oven at 70°C for two days and kept in polythene bags to prevent the moisture absorption.A 10% solution of NaCl is prepared and the untreated fibres were soaked in the salt water for 1 hour. These fibres were taken out and dried in air oven.The raw rubber solution prepared by boiling SBR in toluene. The alkali treated fibres were soaked in the resulting rubber solution and is kept for 30 minutes. Then these fibres were taken out, air-dried and kept in polythene bags.

Chemical treatment

Chemical treatments on the fibre are to modify the morphological structures, macromolecular properties and chemical structure of the fibre in its molecular level. It includes mercerization, acetylation, benzoylation and permanganate treat.

Fibres were immersed in 5% NaOH solution for different time intervals at room temperature and at boiling temperature (95°C). Finally the fibres were repeatedly washed with water containing little acetic acid and then dried in an air oven at about 70°C for 24 hrs.Acetylated fibre was prepared from the chopped raw cylindrica fibre. The fibre was first immersed in 18% aqueous NaOH solution at 35°C for one hour, washed with water several times and then dried. The fibres were soaked in glacial acetic acid for one hour, decanted and then soaked in acetic anhydride containing two drops of Con. H2SO4 for 5 minutes.

Benzoylation is done by suspending this fibre in 10% NaOH solution and agitating with 50 ml benzoyl chloride. The mixture was kept for 15 minutes, filtered, washed thoroughly with water and dried between filter paper. These fibres were then soaked in ethanol for 1 hour to remove the chloride and was finally washed with water and dried in the air oven at 70°C.

C. Moulding of test specimen

The fibre was mixed with rubber on a laboratory two roll mixing mill with size 150 X 300 mm as per ASTM at a friction ratio of 1:1.25. The mill opening was set at 0.2mm. The compounding ingredients were added in the exact order .The homogenization was done by passing the rolled sheet six times endwise through the tight nip gap of O.8mm and finally sheeted out at a nip gap of 3mm.

Fig 1. Moulded specimen

This sheet wasused for the processability studies and green strength measurements.

The test specimens for determining the physical properties were prepared in standard moulds by compression moulding on an electrically heated hydraulic press having 18 X 18 inch platens at a pressure of 200 kg/cm^2 on the mould. The rubber compounds were vulcanized upto their respective cure times at 150°C. Moulding were cooled quickly in water at the end of the curing cycle and stored in a cool and dark place for 24 hrs and were used for subsequent physical tests.

D. Characterisation of the specimen

Specimen with raw fibre which gives the optimum properties is analyzed first and then the compound with the modified fibre is tested. The results are compared and the enhancements in the properties are verified.

Stress-strain measurements were carried out at a cross head speed 500mm/min on a Schimadzu Model AG1 universal testing machine. Tensile modulus, tensile strength and elongation at break were measured according to ASTM D 412 87(method A). Dum bell shaped specimens were punched out of the moulded sheet and tests were carried out both along and across the grain direction..The hardness of the composite was measured using the Shore A type Durometer according to ASTM 224-81.

Fig 2. Tear and Tensile test specimen

III. RESULT AND DISCUSSION

Specimen with raw fibre is fabricated and tested in the primary stage for its mechanical properties. Modified fibre at same concentration and length is introduced after that and is analyzed. The results of the composite with treated fibre are then compared with composite with raw fibre and gum rubber in order to estimate the improvement in properties in each successive stages.

Tests were carried out according to ASTMdesignation using dumbbell specimens. All the above tests werecarried out at 26 ^{0}C..The sample was held tight by the two grips in a Zwick Universal resting Machine, the upper grip of which being fixed. The rate of separationof the power-actuated grip was 50cms per minute. The load at break wasread from the dial. The elongation at break was measured with the help of ascale. From the recorded loads, the stress was calculated on the basis oforiginal cross-sectional area.

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Tear property was tested as per ASTM D 624-81 test method, using un nicked 90° angle test specimens. This test was also carried out in the Zwick UTM, at a cross head speed of 500 mm per minute and at 28^{0}C. The tear strength values are reported in kN/m. The hardness of the samples was measured using a Shore A type Durometer.

Table 1. results of composites with different fibres

Properties / composite	Modified SCFR	Raw SCFR	Gum Rubber
TENSILE(Mpa)	10.846	10.181	7.663
ELONGATION (%)	633.198	593.835	580.638
MODULUS (Mpa)	2.472	2.343	1.670
TEAR (N/mm)	34.104	33.362	27.351
HARDNESS (Shore A)	69.031	68.666	50.137

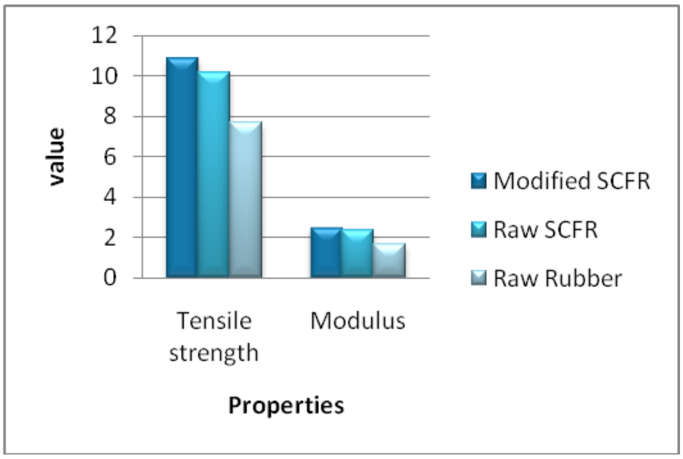

Fig 3. Tensile Property chart of modified, raw and gum specimen

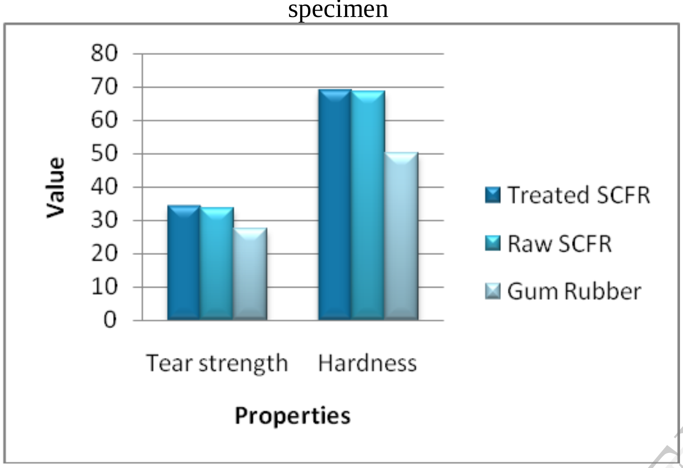

Fig 4. Tear and Hardness Property chart of modified, raw and gum specimen

The table and the bar charts show that the fibre treatment has made a considerable enhancement in the properties of the composite. Especially the tensile and tear strength are improved to a much better level by the reinforcement of cylindrical fibre, which further enhanced by the incorporation of treated fibre.

IV. MATERIAL STRUCTURE ANALYSIS

Microstructure of the composite is analyzed through the SEM imaging. SEM photographs of the composite at the cross sectional view is taken.

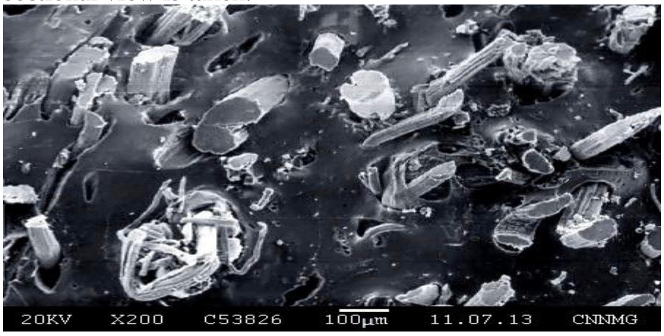

Fig 7. SEM image of composite

From the cross sectional view of the composite, it can be observe that the fibres are aligned almost uniformly and the concentration and dispersion of fibre in the matrix is almost uniform. This avoids the fear of irregular fibre orientation and fibre dispersion. Since the SEM of the composite shows that the fibre dispersion and orientation is almost uniform and aligned, which is within the acceptable level, fabricated composite itself confirmed to deliver expected properties. This neglect the need to fabricate a new composite.

APPLICATIONS

Short fibre composites are used in a wide area of applications. The main applications of short fibre reinforced rubber composites are hoses, V-belts, tyres etc.Short fibre reinforced rubber are also used in designing products such as tubing, where the swell can be minimized with decreasing elasticity and also in in rubber goods such as diaphragms, roofing, sheeting, moulding and sealants. The designed SCFR composites exhibit properties better than that of currently used natural fibre reinforced composite. So, SCFR can successfully replace them in these areas of applications.

V. CONCLUSION

Surface and chemical treatment are done on the fibre and is employed in the rubber matrix. The properties shown by the composite is compared with that of raw fibre composite and gum rubber specimen. A considerable improvement in the mechanical properties is achieved through the incorporation of treated fibre. This assures that an effective treatment and a high precision manufacturing can impart a much improvement in the mechanical properties. The fibre proves its reinforcing ability and can successfully replace the fibres that are adopted so far. So this will be a promising material and also this will be a cost effective economy class material with superior properties.

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