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Evaluation of the Sorption Properties of Natural Rubber Vulcanizates Filled with Cashew Nut Shell Powder as Filler

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Abstract: Natural Rubber was reinforced with Cashew nut shell powder as filler at 10-50g respectively. The samples obtained were evaluated for sorption properties which included the rate at which the respective samples absorbed some solvents like Toluene, Xylene Petrol, Kerosene, Chloroform, Acetone Methanol, Ethanol, N-hexane and Water. The sorption test revealed that Xylene has the highest percentage absorption. Which implies when used with natural rubber that was not reinforced with any filler, the rubber will dissolve in it forming a solution and even when filled with cashew nut shell powder will not be suitable for use were it can come in contact with xylene. The test revealed also that the increase in filler loading increases the percentage absorption of the filler.

Keywords: Cashew Nut Shell Powder, Natural rubber and Absorption

Introduction

Natural rubber is a high molecular weight polymer of isoprene which essentially cis- 1, 4 -configuration. The plants are 'tapped' that is an incision is made at the back of the tree and the sticky milky color latex sap is collected and refined into a usable rubber poly-isoprene and can be produced synthetically.

Natural rubber is a hydrocarbon polymer when properly compounded with other additives and moulded into the desired shape by means of various mould, it can be by the process of injection, extrusion and compression molding. Natural rubber is commonly produced of a latex tree called Heavabrasiliences which is originated from Brazil at which it was introduced to countries like Malaysia, Indonesia, Cote D'voire, Burma, etc is the world's largest single source of latex.

Natural rubber was the only polymers available for industrial exploitation before the advent of synthetic polymeric material and natural rubber are about 200 species. Chemical analysis showed that only cis-polyisoprene is the hydrocarbon component.

Rubbers make up a class of polymers known for their ability to undergo large recoverable deformations (Katchy, 2000). The unique behavior of this class of polymers include the ability to stretch to a number of times its original length exhibit high strength and modulus while stretched and retract rapidly to recover filly on release of the deforming stress.

The method of processing natural rubber has virtually remained the charged for more than six decades processing followed the routine of tapping the tree for the latex collection and coagulation sheeting (Lewis, 1970).

The Indians made balls of rubber by smoking the milky white latex of trees of the genus Havea that had been placed on a wooden paddle, to promote water evaporation and to cure the substance.

Several rolls of crude rubber were sent to France with an accompanying description of products made from it by the South Africans. Although it met with some use in water proofing boots, shoes etc it largely remained a wuseum curiosity. Crude rubber possessed the valuable properties of elasticity, plasticity, strength, durability, resistance to water, etc hence, products made from it hardened in winter, softened and became sticky in summer were attacked by solvents and smelled bad (Charles-Marie, 1735).

Sorption Properties of Natural Rubber

Polymers swell if they interact with the solvents at all, and the degree of interaction was determined by the degree of cross linking. The degree of the swelling can be measured or related to the thermodynamic properties of the system (Lebana, 1986).

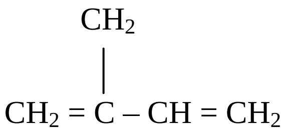
Interest was focused on the absorption of organic solvent because their ability to penetrate at different rate enhances the separation of component of their liquid mixture through polymeric membrane (Frollini et al, 2003).

The density of chain entanglement and chain ends, cross link density, compatibility of both polymer and liquid type and amount of filler in addition to viscosity of the penetrate liquid and the functionality of the cross links are determinants of the molecules transport of organic solvent in rubber vulcanizates (Patterman, 1986).

The transport of solvent through polymers is affected by polymer structure cross linking density, mode of cross linking, presence of fillers, penetrate size and temperature (Ski, 1970).

Structure of Natural Rubber

To understand the structure of rubber we shall concentrate on structure of isoprene. Isoprene is a conjugated diene containing double bonds at alternate position.

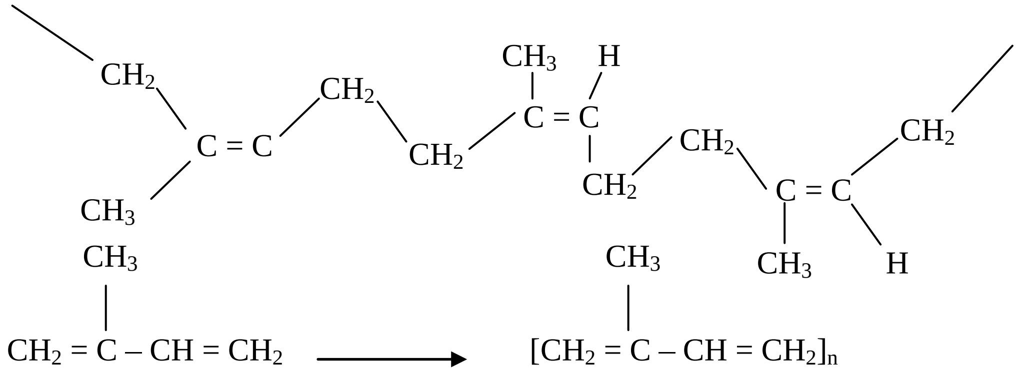


$$CH_2 = \overset{\overset{\displaystyle CH_2}{|}}{C} - CH = CH_2$$

Structure of isoprene: Monomer of natural rubber isoprene undergoes free radical polymerization like substituted ethylene isoprene polymerizes to give polyisoprene polymer, a simple alkene having each unit still containing one double bond.

Therefore, polymerization of isoprene may follow either of the two pathways; either of cispolymerization or trans-polymerization. The rubber formed from cis-polymerization is called cispolyisoprene or natural rubber. Similarly, the rubber formed from trans-polymerization is called synthetic rubber

isoprene (2-methyl -1, 3-butadience) under goes cis-polymerization to form natural



$$CH_2 = \overset{\overset{\displaystyle CH_3}{|}}{C} - CH = CH_2 \longrightarrow [CH_2 = \overset{\overset{\displaystyle CH_3}{|}}{C} - CH = CH_2]_n$$

Structure of N.R (cis-polisoprene)

By observing structure of natural rubber we can infer that there is no polar group in this structure. As a result of this, the intermolecular forces of attraction are weak Vanderwaal forces of attraction. These forces of attraction are further weakened because of the cis-configuration of all the double bonds that does not permit the close interaction of polymer chains. Thus, natural rubber does not have a straight chain but has a coiled structure which causes its elastic property. (Robert T. Marrisori, 1992).

Vulcanization of N.R

Vulcanization (curing, cross-linking) is one of the most important process for most of rubbcr technologies. During vulcanization the rubber compound is changing to elastic final producevulcanizate (rubber). This is done by consecutive and parallel changes of chemical and physical nature. The reason for vulcanization is the creation of cross-links below rubber macromolecules at which three dimensional network of rubber matrix is formed. The part of vulcanizate network are also physical bonds like hydrogen bond, polar or dispersed powers b/w individual macromolecules or their snails, which were created at preparation or processing of relevant rubber compound

Fillers

Fillers are the second major additive used in natural rubber compounding. They constitute the second largest material, in term of quantity in a rubber compounding after base polymer rubber (Ese, 2000)

Fillers are materials that are particles in nature which are added to rubber mixers to modify the physical and to a small extent the chemical property that improves the processing characteristics and reduce cost (Less 1968).

Materials and Method

Materials

The materials used for this work are as follows:

Natural rubber, Zinc oxide, Stearic acid, TMQ, cashew nut shell powder (Anacardiurnoccidetale), MBTS, CBS, Processing oil and Sulphur

Equipment and Apparatus Table 1

Table 1

S/N	Equipment	Manufacturer name	Model Number
1	Two role mill	Reliable rubber and Plastic machinery company	5185
2	Hydraulic hot-press	Carver Inc. hydraulic press	3851-0
3	weighing balance	Metler instrument Ltd	AE 200

Method

Cashew nut shell was collected from source, washed, dried, ground and sieved which gave rise to CNSP

Table 2

S/N	Ingredient	Parts per hundred (PPHR)
1	Natural rubber	100
2	Zinc oxide	50
3	Stearic acid	2.0
4	TMQ	1.5
5	Filler (AONSP)	Variable (10-50)
6	MBTS	3.0
7	CBS	1.5
8	Processing oil	2.0
9	Sulphur	2.5

Compounding of Natural Rubber with Anacardium Occidentaic Nut Shell Powder

The two roll mill was switched on and the nip of the rolls was tightening before feeding in the rubber material through the nip of the roll. It was allowed to pre-masticate in order to reduce the molecular weight of the rubber after which a band and a bank was formed in between the nip of the roll. The activator (zinc oxide and stearic acid) was added, allowed to mix for two minutes followed by the antioxidant (TMQ) which was allowed to mix for another two minutes beforethe filler was added and mixing was done within two minute. The incorporation was done by the help of processing oil. The accelerator (MBT) was added, mixed for 2 minutes alter which the last additive was added which is the vulcanizing agent (sulphur). The cross-mixing was done very fast about 1-2 minutes to avoid premature vulcanization. The Nip of the rollers was adjusted to a desired thickness and the compounded material was sheeted out, kept for some hours for stress relaxation.

Curing of Compounding Sample

The curing of compound material was done on a hydraulic press (model 385 l-0).The temperature of the machine was set at 130°C and then pre-heated for 10 minutes. The compounded material was placed into the mould and was placed into the mould and was charge into the hot press at temperature of 13 0°C and pressure of 20 bar. The mould was left for five minutes and the materials were allowed to flow and occupy the shape of the moved cavity, the sample was taken for sorption analysis.

Sorption Test

Blends of different sizes were cut and weighed on an electronic balance having an accuracy of 0.00g. The cut samples were put into 50 different sample bottles with cover. 40m1 of toluene were poured into 5 cut samples bottles of different filler loading. The sample was repeated for N-hexane, xylene, water, petrol, kerosene, chloroform, methanol, ethanol and acetone in a room temperature. At the expiration of the specified time (i.e. 72 hours), the blends were removed from the sample bottles, wiped free from the solvents and weighed using the electronic weighing was completed in less than 40 seconds, so as to keep the error due to solvent evaporation from the sample surface at a minimum (Danwanichakul et al, 2006).

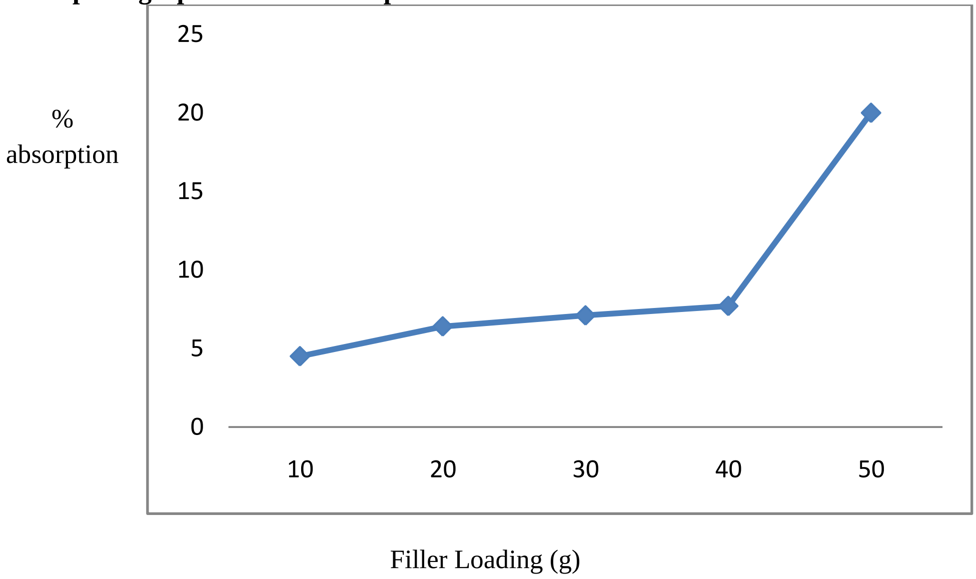
Result and Discussion

Results of Sorption in Ethanol

Table 3

S/N	Filler Loading	W_1	W_2	% Absorption
1	10	2.2	2.3	4.5
2	20	1.5	1.6	6.7
3	30	1.4	1.5	7.1
4	40	2.6	2.8	7.7
5	50	1.0	1.2	20

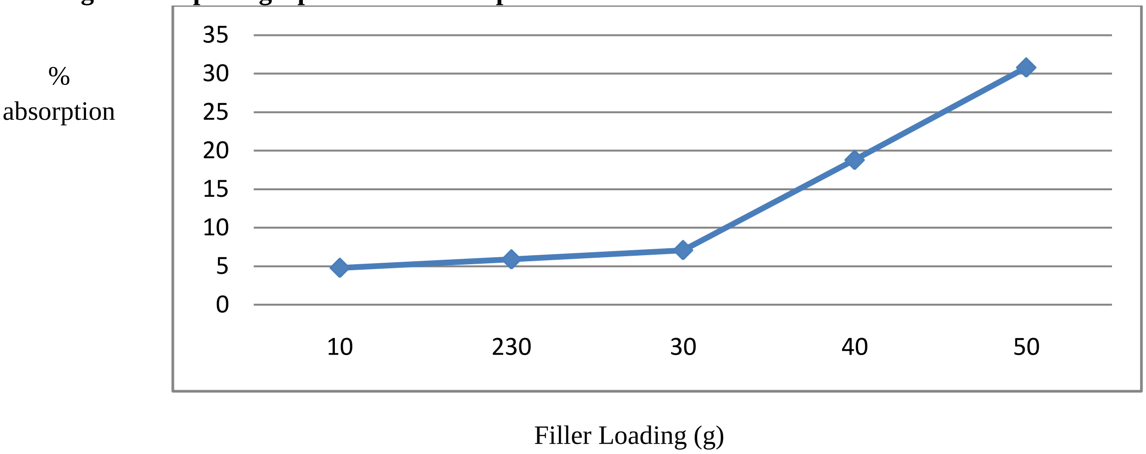
Fig 1: Sorption graph of rubber Compound in Ethanol



Result of Sorption in Water
Table 4

S/N`	Filler Loading	W_1	W_2	% Absorption
1	10	2.1	2.2	4.8
2	20	1.7	1.8	5.9
3	30	1.4	1.5	7.1
4	40	1.6	1.9	18.8
5	50	1.3	1.7	30.8

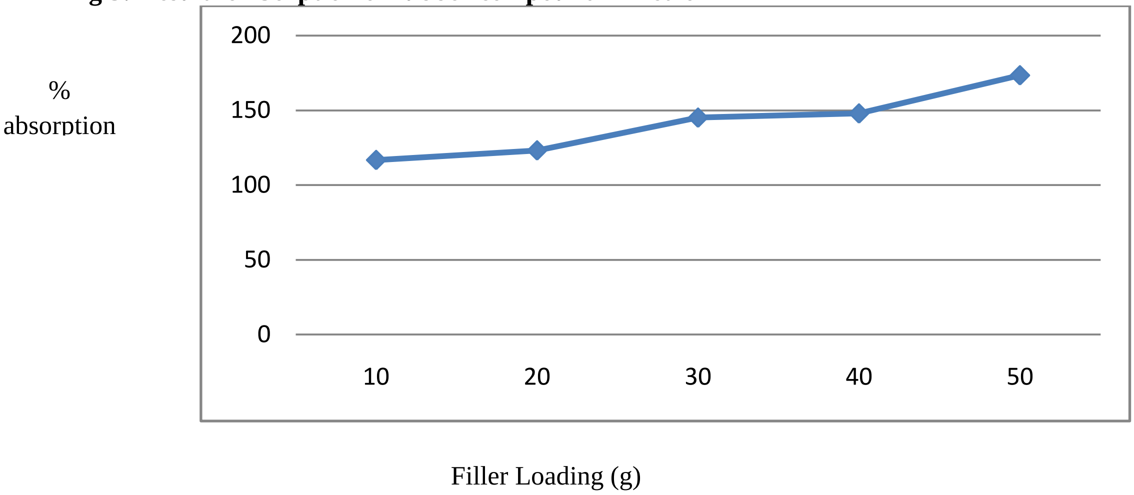
Fig. 2: Sorption graph of rubber compound in Water



Result of Sorption in Petrol
Table 5

S/N	Filler Loading	W_1	W_2	% Absorption
1	10	1.2	2.6	116.7
2	20	1.3	2.9	123.1
3	30	2.0	4.9	145
4	40	2.3	5.7	147.8
5	50	1.5	4.1	173.3

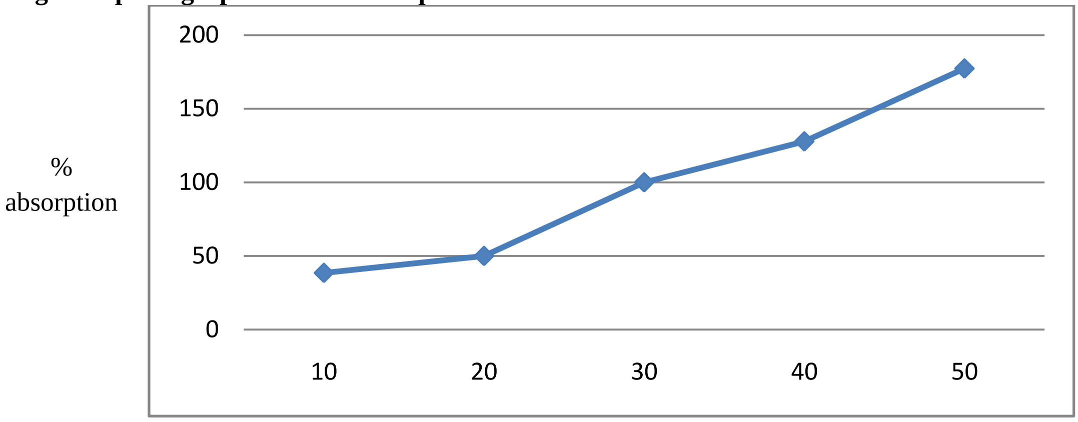
Fig 3: Result for Sorption of rubber compound in Petrol



Result of Sorption in Chloroform
Table 6

S/N	Filler Loading	W_1	W_2	% Absorption
1	10	1.3	1.8	38.5
2	20	2.4	3.6	50
3	30	1.8	3.6	100
4	40	1.8	4.1	127.8
5	50	2.2	6.1	177.3

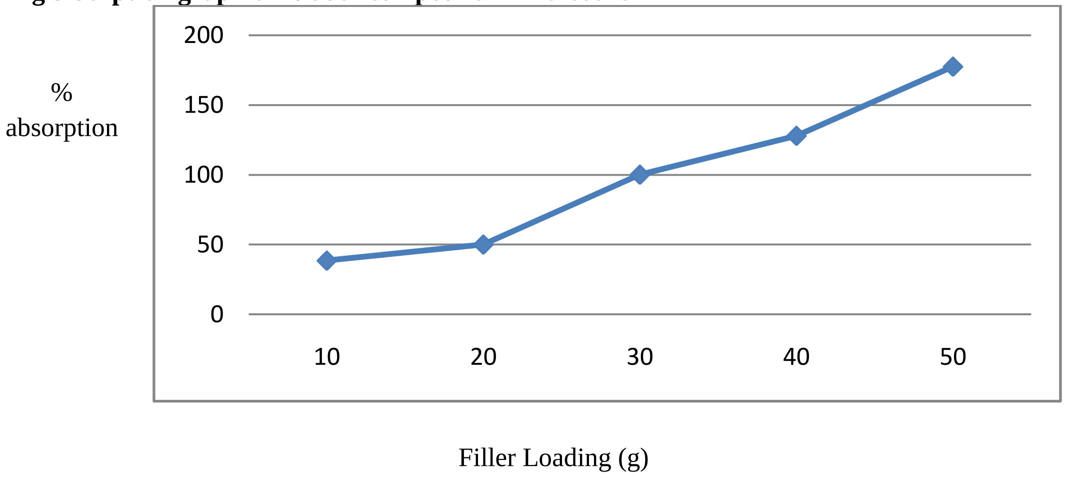
Fig 4 Sorption graph of rubber compound in Chloroform



Result of Sorption in Kerosene
Table 7.

S/N	Filler Loading	W_1	W_2	% Absorption
1	10	1.9	4.1	115.8
2	20	2.5	5.6	124
3	30	1.2	2.8	133.3
4	40	1.3	3.3	153.8
5	50	1.4	3.7	164.3

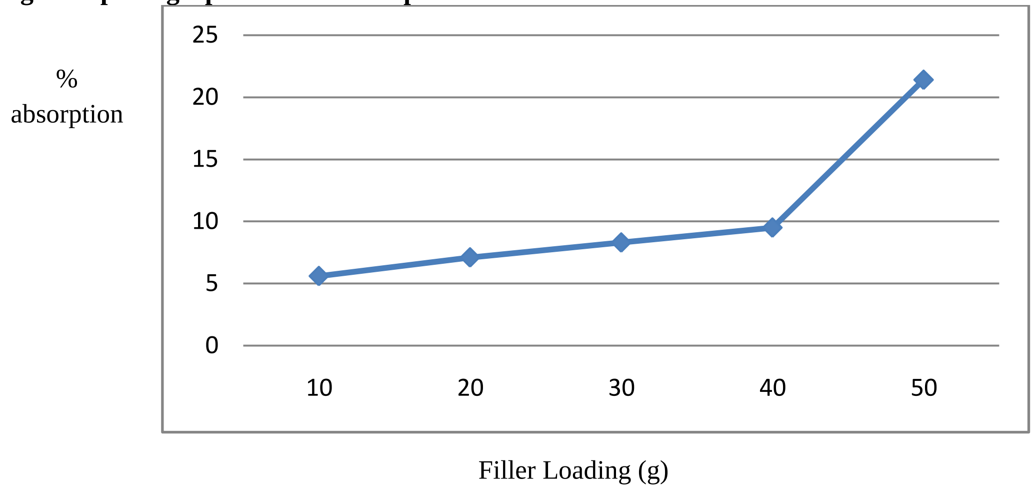
Fig 5 Sorption graph of rubber compound in Kerosene



Result of Sorption in Methanol
Table 8.

S/N	Filler Loading	W_1	W_2	% Absorption
1	10	1.8	1.9	5.6
2	20	1.4	1.5	7.1
3	30	2.4	2.6	8.3
4	40	2.1	2.3	9.5
5	50	1.4	1.7	21.4

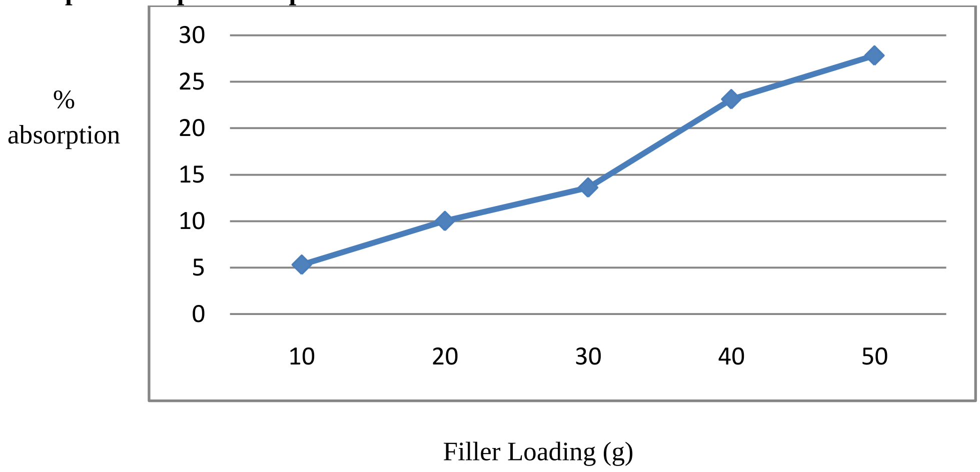
Fig 6 Sorption graph of rubber compound in Methanol



Result of Sorption in Acetone
Table 9.

S/N	Filler Loading	W_1	W_2	% Absorption
1	10	1.9	2.0	5.3
2	20	2.0	2.2	10
3	30	2.2	2.5	13.6
4	40	1.3	1.6	23.1
5.	50	2.2	6.1	177.3

Fig 7 Sorption Graph of compound in Acetone

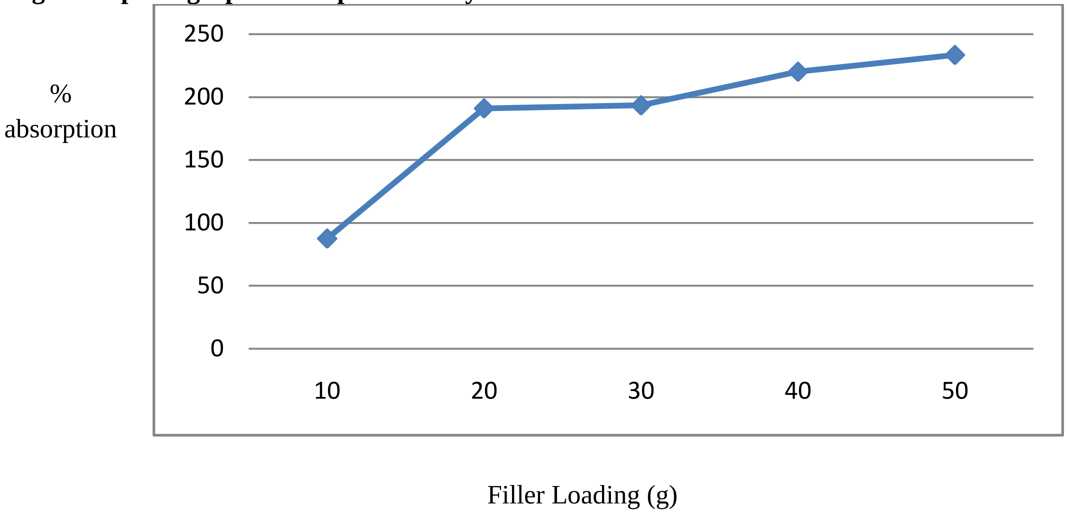


Result of Sorption in Xylene

Table 10

S/N	**Filler Loading**	**W_1**	**W_2**	**% Absorption**
1	10	1.6	4.6	87.5
2	20	2.2	6.4	190.9
3	30	1.5	4.4	193.3
4	40	2.5	8.0	220
5	50	1.8	6.0	233.3

Fig 8: Sorption graph of compound in Xylene

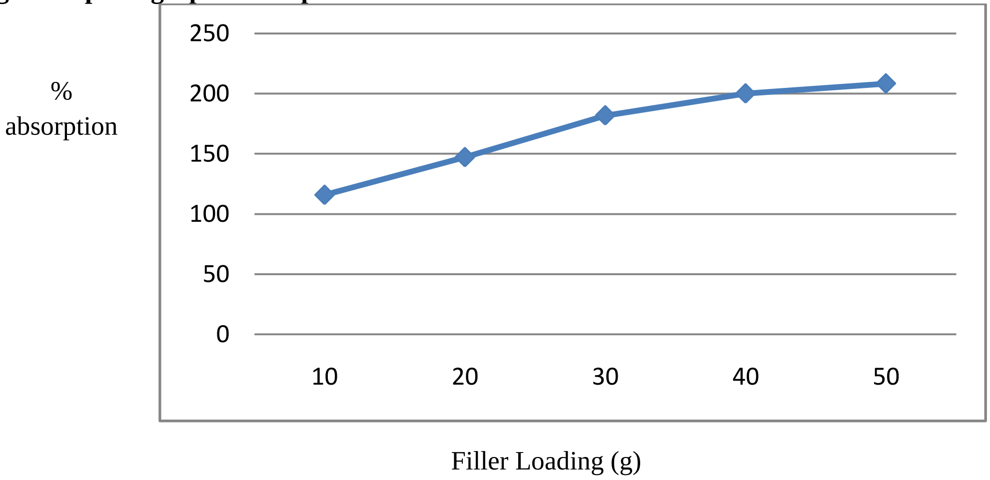


Result of Sorption in Toluene

Table 11

S/N	**Filler Loading**	**W_1**	**W_2**	**% Absorption**
1	10	1.9	4.1	115.8
2	20	1.7	4.2	147.1
3	30	2.2	6.2	181.8
4	40	1.5	4.5	200
5	50	1.2	3.7	208.3

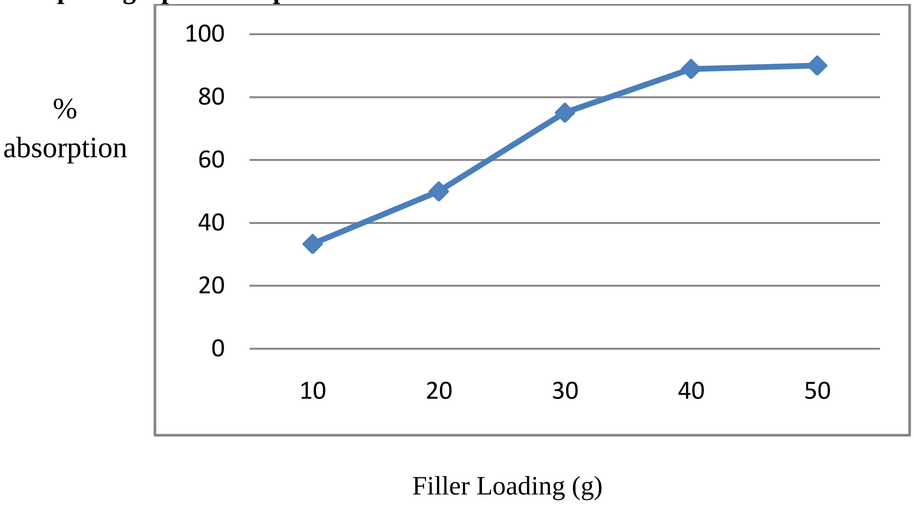
Fig 9: Sorption graph of compound in Toluene



Result of Sorption in N-hexane
Table 12

S/N	Filler Loading	W_1	W_2	% Absorption
1	10	2.1	2.8	33.3
2	20	1.8	2.7	50
3	30	1.2	2.1	75
4	40	1.8	3.4	88.9
5	50	1.0	1.9	90

Fig. 10 Sorption graph of compound in N-Hexane



KEY:

X axis – represents filler loadings
Y axis – Represents % Absorption of the solvents

Discussion of Results

Sorption in Toluene:

The sorption data of toluene into N.R blends filled CNSP obtained at different filler loading of 10, 20, 30, 40, &50 were determined and expressed as the percentage absorption of toluene by the sample was calculated using (Danwanichakul et al, 2006).

$$\% \, Absorption = \frac{Original\ weight - initial\ weight}{Initial\ Weight} \times 100$$

Graph of a toluene vulcanizate filled with CNSP obtained at any particular filler loading was plotted against the filler loading as shown in fig. 9. The result showed initial increasing trend in the rate the toluene sorted until maximum absorption was attained from 115.8-181.8 after which an equilibrium absorption was reached and the % of toluene absorbed contained to increase from 200 -208.3. The result also showed that at any particular filler loading, the vulcanizate absorbed work toluene.

The observed increase in toluene sorption with increase in filler loading is caused by increased in surface area of the filler (CNSP) due to the elimination of volatile matter that are deterious to blend — filler interfacial interaction.

Sorption in Ethanol:

The graph of a % Absorption of toluene of the vulcanizate filled with CNSP obtained at any particular filler loading was plotted against the filler loading as show in Fig 1. The result showed initial increasing trend at the rate of ethanol absorbed from 4.5 — 7.7 at the filler loading of 10-40

after which a maximum increase from the % Absorption of ethanol from 7.7-20 at the filler loading of 40-50 was at.

The result showed that at a filler loading of 40-50, the sample absorbed more ethanol than absorbed at the filler loading of 10-40.

Sorption in water:

The result of the % absorption of water absorbed by the vulcanizate in fig 2. Showed an initial increasing trend at the rate of water absorbed (4.8, 5.9, 7.1) at the filler loading from 10-30 after which a maximum increase in the % absorption from 7.1 to 18.8 and finally to 30.8 at a tiller loading from 30, 40 — 50 was attained. The result showed that the sample absorbed more water at the filler loading from 10-3 0.

Sorption in petrol:

The result of the % absorbing of petrol absorbed by the vulcanize in fig. 3. Showed an equal increasing trend at the rate of petrol absorbed (i.e at 116.7, 123.1, 145,147.8 and 173.3) at the filler loading from 10-50 was attained. The result showed that the vulcanizate absorbed less petrol at the filler loading of 30-40g at which the % absorption was from 145-147.8%.

Sorption in Chloroform;

The result of the % absorption of chloroform absorbed by that vulcanizate in fig 4. Showed an equal increasing trend at the rate of petrol absorbed (i.e. at 38.8, 50, 100, 127.8 and 177.3 at the filler loading from 10-50 was attained. The result showed that the vulcanizate absorbed more chloroform 127.8-177.3 and from 50-100% at the filler loading of 40-50 and 20-30g.

Sorption in Kerosene:

The result of the % absorption of kerosene absorbed by the vulcanizate in Fig 5.absorbed showed an equal increasing trend at the rate of kerosene absorbed (i.e at 115.8, 124, 133.3, 153.8, at the filler loading from 10-50 was attained. The result showed that the vulcanizate absorbed more kerosene from the range of 133.3 at the filler loading from 30-40 (i.e. at filler loading of 40, the vulcanizate absorbed more kerosene which is 153.8%).

Sorption in Methanol:

The result of the % absorption of methanol absorbed by the vulcanizate in fig 6..absorbed an initial increasing trend at the rate of methanol absorbed (at 5.6, 7.1 8.3 and 9.5) at the filler loading from 10-40 after which a maximum increase in the % absorption of methanol absorbed from 9.5-21.4 at the filler loading from 40-50g, was attained. The result showed that the vulcanizate absorbed more methanol at the range of 9.5-21.4 at the filler loading from 30-40. (i.e the rate at which the vulcanizate absorbed methanol at the filler loading of 50 was light (% absorbed was 21.4).

Sorption in Acetone:

The result on the % absorption of Acetone by the vulcanizate in Fig 7. Showed that the vulcanizate absorbed more Acetone at the filler loading of 30-50 giving rise to a % absorption from 13.6 which increased to 32.1 at 40g of filler loading and finally to 27.8% at 50g of filler loading. The result showed that the vulcanizate absorbed more acetone in the % absorption of 23.1 at the filler loading of 40g as the range between 13.6% and 23.1% higher compared to that from 23.1%-27.8%.

Sorption in xylene:

The result on the % absorption of xylene absorbed by the vulcanizate in Fig 8. Showed (lilt the vulcanizate absorbed more xylene at the filler loading of 10-20 from the % absorption of xylene from 87.5-190.9. it further showed that the vulcanizate absorbed more xylene at the 0,4) absorption of 190.9 in the filler loading o9f2Og as the range between 87.5-190.9 is higher conveyed to that absorbed from 190.9 %-220% and from 220-233.3 respectively at the filler loading from 20-50.

Sorption in N-hexane:

The result on the % absorption of N-hexane absorbed by the vulcanizate in fig 10.Showed that the vulcanizate absorbed more N-hexane at the filler loading of 30g with the % absorption of 75. It further showed that the vulcanizate absorbed more N-hexane at the % absorption of 75 as the range between 50%-70% of the S solvent absorbed was higher compared to that absorbed at the filler loading of 10, 20, 40 and 50

Conclusion and Recommendation

Conclusion

Conclusively the percentage of a solvent absorbed by carbonized cashew nut shell (CNSP) filled by N.R blends showed an initial increasing trend until maximum absorption was reached after which an equilibrium absorption was attained at which time the mass of the absorbed solvent remains constant. Xylene as one of the solvents used in studying the sorption properties of natural rubber has the highest assumption rate as such, Xylene can used in dissolving vulcanized natural rubber without filler to form a solution

The rate at which the samples absorbed the solvent was very high (Solvent like Tuluene, Xylene, Petrol Kerosene) unlike other solvent like water which had the list percentage assumption, Chloroform, N- Hexene

Recommendations

This research work revealed certain sorption properties of filler (Anarcadiumoccydentale) nut shell powder blends with natural rubber. In other to modify and establish these findings the following recommendation have been put forward for further research.

i. Further work should be done on sorption test to reveal some essential solvents that can be absorbed by NR.as most of them can be used in the production of adhesives
ii. Constant weight of the filler should be ensured as the volatile matter in the filler will affects the bond strength of the vulcanizate

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