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Swelling Properties of Natural Rubber Compound Filled Carbonized Cashew Nut Shell Powder, Jatropha seed shell and Carbon black as Hybrid Fillers

Okele A.I.[1], Gimba C.E.[2], Mamza P.A.P.[2] and Abba H.[2]

[1]Department of Polymer Technology, Nigerian Institute of Leather and Science Technology, P.M.B 1034, Samaru-Zaria, Kaduna State

[2]Department of Chemistry, Ahmadu Bello University, Zaria Kaduna State

Corresponding e-mail: walislove4real@yahoo.com, Mobile: +234(0)8039224240

ABSTRACT

Jatropha seed shell powder: carbon black and Cashew nut shell powder: carbon black was used as hybrid fillers to reinforce Natural rubber compound. The fillers were loaded at 0, 30:0, 25:5, 20:10, 15:15, 10:20, 5:25 and 0:30 respectively. Preliminary characterization was carried out on the fillers viz: FTIR and XRD. The compounds were analysed for absorption studies using water, petrol, kerosene and diesel. The obtained results revealed that compounds filled with 5g CB/25g CNSP had better results in all the three solvents except for water which gave the best result at compound filled with 20g CB/10g JSSP with the absorption rate of 1.17%. The present of C-H, C=H makes the fillers compactible with natural rubber when compounded together.

Key words: Carbonisation, Absorption, Natural rubber, Solvent and Filler

INTRODUCTION

Nowadays, the environmental preservation is a permanent concern and in this respect, several studies are being envisaged with the aim to transform rejects into useful materials, which could be disposed of with no damage to the environment or even better into reutilizable goods from ecological and economic point of views [1]. Polymer materials are fundamentally devised for definite relevancies because of their construction and properties. Regularly, a polymer needs modifications for a superior range of functions that may need dissimilar structural or physical properties. One modification technique is adding fillers to a polymer to generate a composite with improved properties, such as enhancement in mechanical strength, electrical conductivity or thermal stability. The utilization of nanoscale fillers to supplement the properties of polymers has led to significant improvement in polymer nanocomposites (PNC). The nanoscale fillers used as reinforcement materials for nanocomposites contain nanofibers, nanoplatelets, nanoclays, etc. PNC exhibited superior mechanical performance and improved barrier properties at very low loading levels compared to conventional filler composites [2].

Carbonization process has added advantage over direct combustion of cashew nut shell. In direct combustion, vapors of an anacardic acid are released which may cause harm to eyes. Carbonization process of cashew nut shell produced char as well 25-30 percent, cashew nut shell liquid (CNSL) by weight. Industrial applications of the CNSL-based products are numerous and include fungicide, pesticide, insecticide, brake linings, paints and primers, foundry chemicals, lacquers, cements, and specialty coatings [3].

The demand for polymers in many applications has experienced a steady growth over the years. Rubbers, being a major form of polymers have not been left out. Rubber is an organic material which can be stretched to at least 300% its original length and returns back to the initial length immediately the deforming force is removed [4].

Reinforcement of rubber by carbon blacks has been intensively studied. It is generally accepted that the reinforcement of elastomers and the improvement of other properties, to a large extent, are associated with the chemical and physical interactions between the polymer matrix and carbon blacks. The entanglement of rubber molecules on the car- bon black surface is supposed to play an important role for rubber attachment on carbon blacks [5].

Natural fibers are hydrophilic in nature as they are lingo cellulosic, which contain strongly polarized hydroxyl groups, but thermoplastic show hydrophobic nature. Natural fibers show a high level of moisture absorption and in- sufficient adhesion between untreated fibers and the thermoplastics polymer matrix, such as polyolefin's. Due to high water absorption and less interfacial bonding characteristics, the application of these composites are restricted [6].

The key issues in the polymer nanocomposites are: uniform dispersion of nanoparticles against their agglomeration due to vanderwaals bonding in the processing of nanocomposites, alignment of nanofiller in the matrix, volume fraction, manufacturing rate and cost effectiveness. In order to improve the dispersion and interfacial property of polymer nanocomposites, the surface of nanoparticles should be treated [2].

The objective of this work is to see the rate of absorption in the hybridization of fillers on natural rubber composites.

EXPERIMENTAL

Materials

Cashew nut shell was locally sourced from Auchi community of Edo State. Natural rubber was obtained from Rubber Research Institute of Nigeria, Iyanomo, Benin city, Edo State. All other compounding additives used (zinc oxides, stearic acid, trimethylquinoline, sulphur, mercaptobenzodisulphide, carbon black) are of analytical grades and products of British Drug House (BDH), England.

Equipment

The equipment used are Endocott test sieve shaker, by Endocott test sieve ltd., London, Ball Miller by Pascal Engineering Co. Ltd. Sussex, England, Furnace, soxhlet apparatus, beakers, stop watch and Two roll mill, Reliable Rubber and Plastics Machinery, model 5189, Agilent CARRY 630 FT-IR, MiniflexRigaku D/max III C for XRD.

Methods

Table -1 Formulation for the rubber compound

				Formulations (PPHR) grams					
S/No	**Ingredients**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Natural rubber	100	100	100	100	100	100	100	100
2	Zinc oxide	5	5	5	5	5	5	5	5
3	Stearic acid	2	2	2	2	2	2	2	2
4	TMQ	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
5	MBT	3	3	3	3	3	3	3	3
6	CB/CNSP, CB/JSSP	00	0/30	5/25	10/20	15/15	20/10	25/5	30/0
7	Processing oil	2	2	2	2	2	2	2	2
8	Sulphur	3	3	3	3	3	3	3	3

Key: TMQ: Trimethylquinoline, MBT: Mecarptobenzothiazole, CB: Carbon Black, CNSP: Cashew nut shell powder, JSSP: Jatropha seed shell

Preparation and Characterization of Nano Filler

Jatropha seed shell powder was winnowed to remove sand particles and other adhering foreign bodies and then washed. The washed Jatropha seed shell was placed in the planetary mill with a spherical grinding media which consists of planetary balls (< 0.1mm diameter) made of hardened steel (0.24 to 0.95cm diameter). The Jatropha seed shell and the grinding media were placed in a stationary tank followed by an agitation with an armed shaft rotating at 250rpm. The forces of shear and impact exerted by the grinding media on the Jatropha seed shell reduced it to a dispersion of fine powder. The resultant slurry formed was discharged, air-dried and further oven-dried. The cake was further extracted with N-hexane to discard off the oil in the Jatropha seed shell and was carbonized at the temperature of 200 ^{o}C, the residue was ball milled using the top-down technique (i.e. critical speed grinding under a continuous process of approximately 48hrs) to a fine particle size. Standard tests method was used to characterize the semi-nano powder for moisture content (ASTM 1509) at 105°C, pH (ASTM 1512) and particle size [7].

Compounding of the composites

The compounding of the rubber with other additives were done using a laboratory two roll mill in accordance with ASTM D3184-80 method at temperature of 70 ± 5°C, followed by in-situ moulding and curing at 130°C with a hydraulic press machine.

FTIR (Fourier Transform Infra - Red Spectroscopy)

A Nicolet 6000 FT-IR, Thermo Scientific, UK are used to obtain spectra for the fillers. KBr disk sample preparation methods were followed in taking infrared spectra. Fillers are ground and mixed with KBr at the ratio 1:99 then the mixer are pressed under vacuum to form pellets. FT-IR spectra are recorded in a range of 4000 - 650 cm^{-1} at a resolution of 8 cm^{-1} with 30 scans [6].

X-Ray Diffraction (XRD)

X-ray diffraction analysis are carried out on SIETRON- ICS x-ray diffractometer in order to confirm the particle size of the hybrid fiber with a diffraction angle of 20˚ - 60˚ and intensity in the range of 0 to 400 cps [6].

Absorption Test

The effect of solvent absorption on hybrid fillers reinforced natural rubber composites are investigated in accordance with ASTM D-570. The specimens were dried in an oven at 80˚C for 2 hours and then are allowed them to cool to room temperature in desiccators before weighing the initial weight. Solvent absorption tests were conducted by immersing the composite specimens in distilled water, petrol, kerosene and diesel in beaker at room temperature for 48hours. After immersion for 48 hours, the specimens were taken out from the solvents and all surface solvents were removed with a clean dry cloth or tissue paper. The specimens were re-weighed and the final weight was noted. The moisture absorption was calculated by the weight difference. The percentage weight gain of the samples was measured after 48 hours [6].

RESULTS

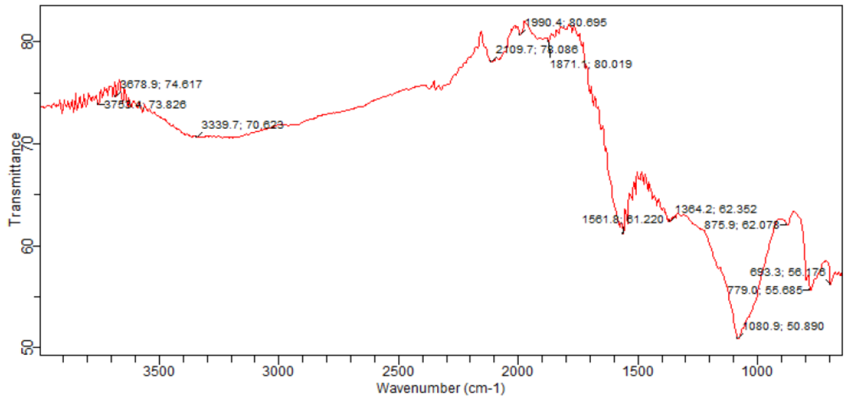

Fig. 1 FTIR of Cashew nut shell powdercarbonised

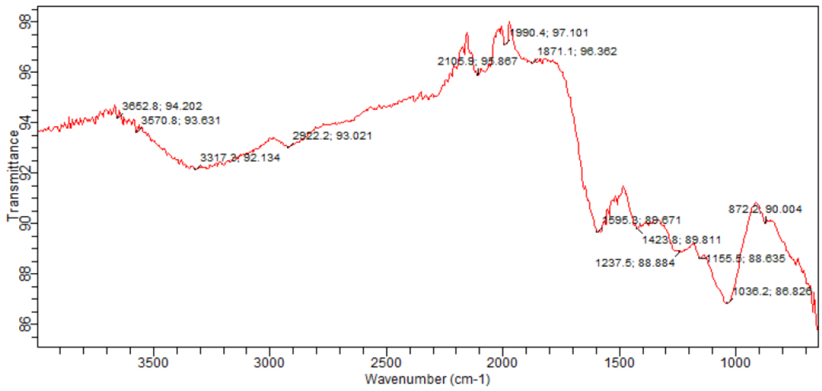

Fig. 2 FTIR of Jatropha seed shell powder carbonised

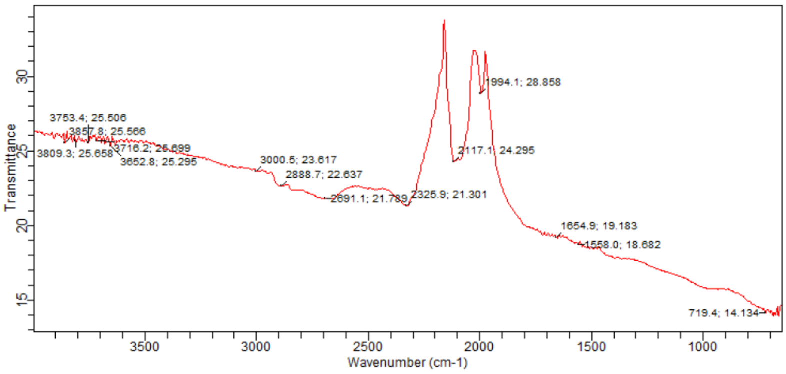

Fig. 3 FTIR of Carbon black

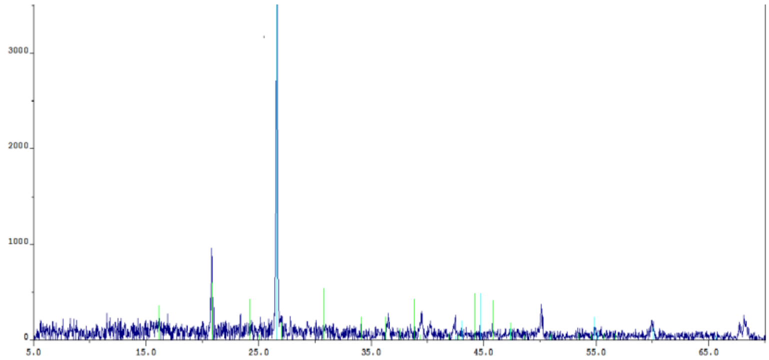

Fig. 4 X-ray Diffraction of Cashew nut shell powder

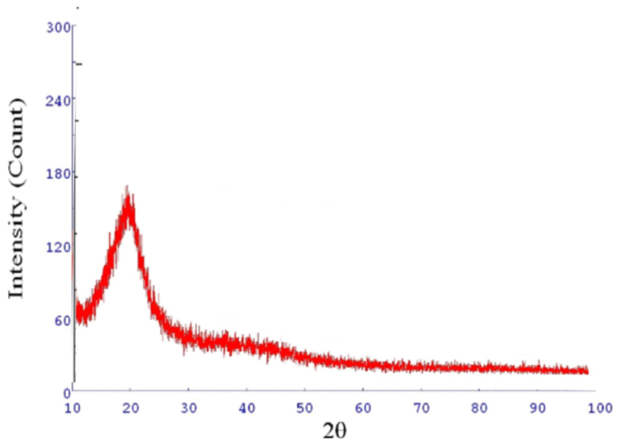

Fig. 5 X-ray Diffraction of Jatropha Seed shell

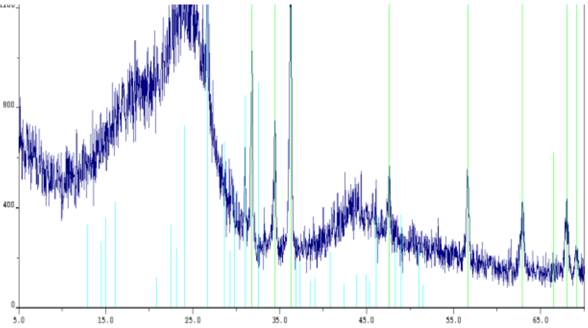

Fig. 6 X-ray Diffraction of Carbon black

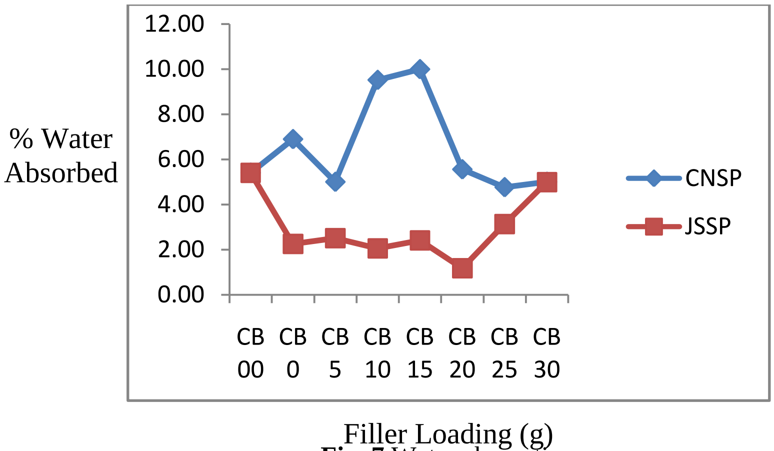

Fig. 7 Water absorption

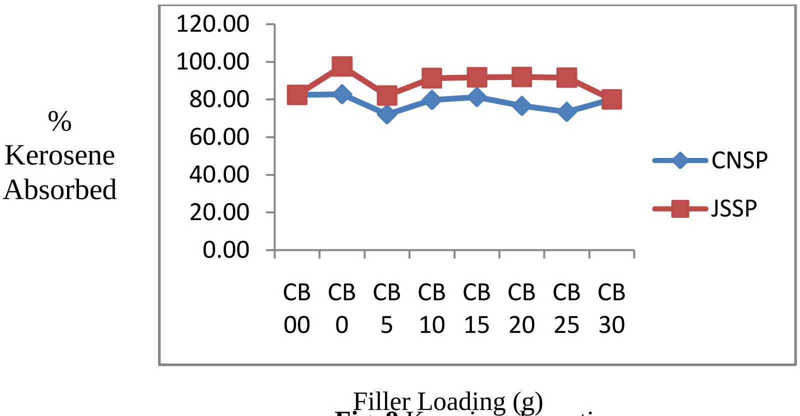

Fig. 8 Kerosine absorption

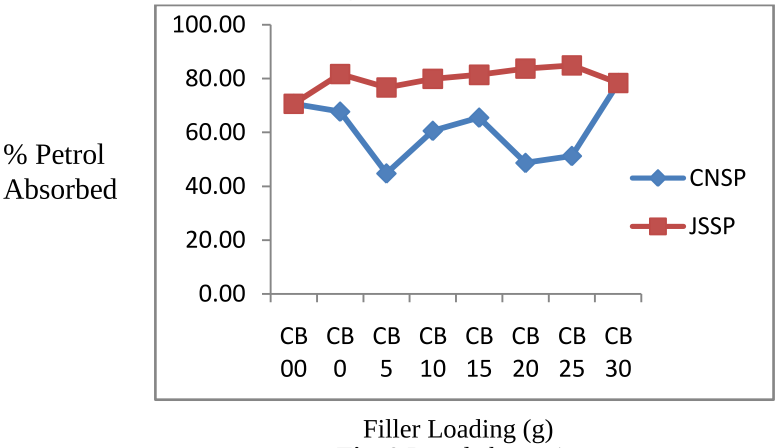

Fig. 9 Petrol absorption

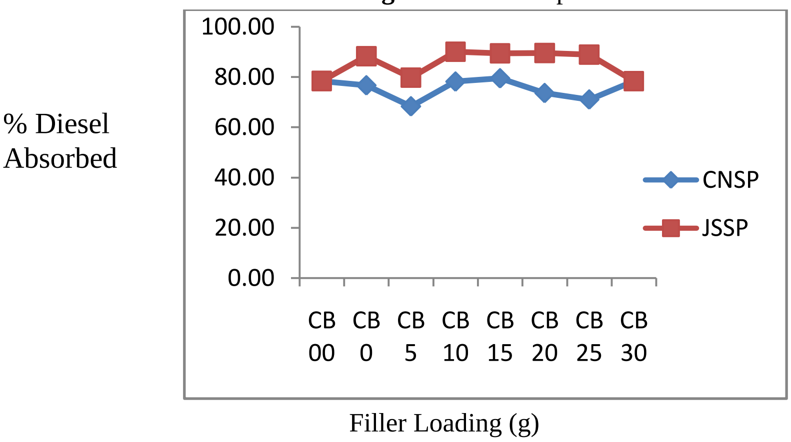

Fig. 10 Petrol absorption

DISCUSSIONS

The infra-red spectra of the fillers were determined using an Agilent Carry 630 FT-IR spectro photometer to determine the functional groups presents in the filers. The two major regions of the spectrum of interest to the organic chemist are the functional groups and the finger print regions. Figure 1 shows result for carbonized CNSP with observable peaks of 333.97 cm^{-1} (OH) stretching vibrational frequency, 1561.8 cm^{-1} either (C=C or C=O) stretching vibration. Figure 2 showed the result of carbonized JSSP showed a sharp peak at 3317.2 cm^{-1} (OH), 2922.2 cm^{-1} (CH) stretch and 1593.5 cm^{-1} (C=O) stretch, this is due to COOH in the oil. Figure 3 show the FT-IR of carbon black with and observable peaks between 2691.1 cm^{-1} – 2888.7 cm^{-1} which falls in the C-H region and is as a result of stretching vibrational frequency.

Figures 4-6 showed the XRD analysis conducted on the fillers at Bragg's angle 2θ of 5^o-70^o for CB and CNSP, and 10^o - 90^o for JSSP which showed a pattern at 2θ of 10^o -30^o for JSSP with a projection at 2θ of 20.30^o while that of CB shows a pattern of 2θ of of 12^o -28^o and 36^o -46^o with a projection at 2θ of 55^o and 10^o respectively. While that of the CNSP showed a pattern of 2θ at 28.8^o, 26.6^o and 35.5^o respectively. The differences in the peaks positions of this projections and intensity can be associated with structural differences of the samples [8].

The absorption of natural rubber vulcanisate filled with hybrid semi nano fillers (Jatropha seed shell powder, cashew nut shell powder and carbon black) were studied.

Natural rubber compound was filled with CB/JSSP and CB/CNSP as hybrid fillers. The compounds were analysed with water, kerosene, petrol and diesel respectively.

The water absorption as showed in figure 7 generally revealed that compounds filled with JSSP/CB absorbed lesser water compared to those filled with CNSP/CB at equal loadings of 2/25, 10/20, 15/15, 20/10 and 25/5 of JSSP/CB absorbed CNSP/CB respectively. The compound filled with 30g JSSP alone had better absorption rate than those filled with 30g CB and 30g CNSP respectively with absorption rate of 2.25%, 5%, and 6.90%. The best compound with the least percentage water absorbed is that of 20g CB/10g JSSP with the absorption rate of 1.17%.

Figure 8 shows the result for kerosene absorption for both fillers (CNSP and JSSP) the results were not too far from each other but with CNSP/CB having a general better results compared to those filled with JSSP/CB. The best compound in this case was that filled with 5g CB/25g CNSP with 72.06% rate of absorption against the JSSP/CB counterpart with 81.98% absorption rate and both results are better than that of the compound of the unfilled which absorbed 82.38%. Comparing the lone fillers, compound filled with 30g CB has the best absorption rate of 80% compared to those filled with 30g CNSP and 30g JSSP with absorption rate of 82.72% and 97.42% respectively.

Figure 9 clearly shows the results obtained for percentage rate of petrol absorption. From the results obtained, it was glaring that compounds filled with CB/CNSP had superior rate of petrol absorption (lower absorption) to those filled with CB/JSSP were compounds filled with 30g CNSP had 67.68%,30g JSSP had 81.68% and 30g CB with 78.30% respectively. The best hybridized result of this compound is that filled with 5g CB/25g CNSP with 44.74% absorption as against that filled with 5g CB/25g JSSP which had 76.63% petrol absorbed.

Figure 10 shows the results obtained for compounds subjected to diesel absorption. From the obtained results, CB/CNSP still had a better absorption rate (lower absorption) than the compounds filled with CB/JSSP. The compound filled with CNSP 30g alone had an absorption rate of 76.69%, which that of 30g JSSP had 88.19%, while that of CB 30g is 78.30% respectively. The best compound in this study was that filled with 5g CB/25g CNSP with an absorption rate of 68.83%.

CONCLUSION

The utilization of cashew nut shell powder, jatropha seed shell and carbon black as hybrid fillers has actually proven their effectiveness in terms of absorption rate as the best hybridized result was showed at 5gCB/25g CNSP making the utilization of carbon black less in rubber compounding and making the agro-waste finds its important in commercialization in the rubber industry most especially when the product in view will be utilized in a place where such solvents can come in contact with the composite.

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