

Studies on the Mechanical Properties of Carbonized/Uncarbonized Cornhub Powder Filled Natural Rubber/Acrylonitrile Butadiene Rubber Bicomposite.

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Abstract- The influences of carbonized /uncarbonized cornhub powder on the vulcanizate properties of natural rubber/acrylonitrile butadiene rubber have been studied. The filler used in this work was corn hub powder. Filler loading used was 0-30 wt. % at two particle sizes (0.1 μ m and 0.15 μ m). Results show that the tensile strength, abrasion resistance, hardness and modulus of elasticity all increased with increase in filler loadings at the two particle sizes investigated, while flex fatigue, rebound resilience, elongation at break and compression set all decreased with increase in filler loadings at the two particle sizes investigated. The study shows that particle size and the nature of filler have a lot to play on the effectiveness of the filler in polymer composites. The smaller sized filler showed improved mechanical properties due to better filler-matrix interaction. The result therefore proved that corn hub can be used as alternative filler for elastomers where strength and hardness are required.

(SBR) (Chaudhari et al, 2005), acrylamide (Chowdhury et al, 2011), polypropylene (Merabet et al, 2012) and chitosan (John and Rao, 2009). Kazi et al. (2013) studied the physicochemical, thermo-chemical and swelling properties of vulcanized natural rubber latex film; and the effect of diospyros peregrina fruit extracts. Results showed an improvement in tensile strength, tensile modulus and storage modulus of vulcanized natural rubber latex film with addition of fruit extracts compared to control film due to their crosslinking effect. Acrylonitrile butadiene rubber is generally resistant to oil, fuel, and other chemicals. Its ability to withstand a range of temperatures from -40°C to +108°C makes it an ideal material for automotive applications. Nitrile rubber is more resistant than natural rubber to oils and acids, but has less strength and flexibility. Nitrile rubber is generally resistant to aliphatic hydrocarbons.

Generally, the blending of two or more polymers makes it possible to obtain a material with properties superior to those of individual constituents and thus, be used in application areas that are not possible with either of the constituent polymers in the blend.

Elizabeth et al. (2008) studied the blends of natural rubber and hydrogenated nitrile rubber containing chemically modified natural rubber with emphasis on dichlorocarbon natural rubber (DCNR). Results revealed an interaction of DCNR with the blend constituent. The modified blend exhibited overall improved mechanical properties. The improvement in ageing resistance of the blend showed that the degradation resistance of natural rubber could be significantly improved with respect to heat, oil and ozone by blending with hydrogenated nitrile rubber and modifying with DCNR containing 15% chlorine.

Filler materials have reinforcing power which enhances the modulus and any failure composite property. The major disadvantage of incorporating agricultural fillers into a synthetic polymer is their incompatibility (Lei et al, 2007; Mantia et al, 2005). Natural fibres are hydrophilic in nature whereas synthetic polymers are hydrophobic. The hydrophilic characteristics of natural fibres leads to a high moisture absorption, causing dimensional change in the fibre and resulting in the swelling of manufactured composite (Mirbagher et al, 2007) and ultimately rotting through fungi attack.

The major causes of this biodegradation are the presence of hemicelluloses in natural fibres, whereas lignin is prone to ultra-

I. INTRODUCTION

The study of curing time and mechanical properties of polymer composites provides a valuable means for additional characterization of polymer blends. These processes are the limiting factors affecting polymer end-use application because they may lead to destruction in polymer properties. Natural rubber and nitrile rubber are known for their outstanding properties making them more useful for a wide range of applications. The disadvantage in any can be complimented by the other through blending.

Natural rubber an elastic macromolecule has inherently low mechanical and thermal stability properties. Natural rubber is highly sensitive to thermal decomposition and anti-oxidation and therefore undergoes thermal ageing when exposed to heat, air and ozone resulting in poor mechanical, thermal and swelling properties. In order to improve the mechanical properties, rubber is blended with different types of anti-oxidant and particulate fillers such as silica (On et al, 2012), clay (Qureshi and Qammar, 2010), carbon black (Choi et al, 2012) and carbon nanotubes (Atieh et al, 2010) to expand applications in various field.

Recently, improvement of the material properties of natural rubber has been reported via grafting and/or blending with different types of polymers, such as styrene butadiene rubber

violet degradation but thermally stable (Akpa, 2005). Carbonization is aimed at curbing these short comings posed by natural fibres for use in rubber vulcanizates (Sukru et al, 2008). Aguele and Madufor, (2012) studied the effect of carbonized coir on the physical properties of natural rubber composite. Result obtained compared favourably with carbon black reinforced composite. They maintained an increasing trend with increasing filler loadings. For tensile strength and modulus, there was no sharp increase shown upon addition of filler. The result for elongation at break, compression set and flex fatigue showed a falling trend as filler loadings were increased.

Natural cellulose fibers from different bio renewable resources have attracted the considerable attraction of researchers all around the globe owing to their unique intrinsic properties such as biodegradability, easy availability, environmental friendliness, flexibility, easy processing and impressive physico-mechanical properties. Natural cellulose fibers based materials are finding their applications in a number of fields ranging from automotive to biomedical. Natural cellulose fibers have been frequently used as the reinforcement component in polymers to add the specific properties in the final product. A variety of cellulose fibers based polymer composite materials have been developed using various synthetic strategies (Vijay and Manju, 2014). Seeing the immense advantages of cellulose fibers, in this article we discuss the processing of bio renewable natural cellulose fibers; chemical functionalization of cellulose fibers; synthesis of polymer resins; different strategies to prepare cellulose based green polymer composites, and diverse applications of natural cellulose fibers/polymer composite materials. The article provides an in depth analysis and comprehensive knowledge to the beginners in the field of natural cellulose fibers/polymer composites. The prime aim of this review article is to demonstrate the recent development and emerging applications of natural cellulose fibers and their polymer materials.

The effective utilization of raw natural fibers as indispensable component in polymers for developing novel low-cost eco-friendly composites with properties such as acceptable specific strength, low density, high toughness, good thermal properties, and biodegradability is one of the most rapidly emerging fields of research in polymer engineering and science. However, raw natural fiber-reinforced composites are the subject of numerous scientific and research projects, as well as many commercial programs (Vijay et al, 2014).

Hybrid composites offer a combination of advantages of constituent components to produce a material with determined properties. (Rahaya et al, 2014) prepared woven hybrid composite by hand lay-up method in laminate configuration. Kevlar/kenaf hybrid composites were fabricated with total fibre content of 30% and the ratio of Kevlar/kenaf varies in weight fraction of 78/22, 60/40, 50/50, 26/74 and 32/68, respectively. The Kevlar/epoxy and kenaf/epoxy were also prepared for comparison. The mechanical properties of hybrid, kenaf/epoxy, and Kevlar/epoxy composites were tested. Morphological properties of tensile fracture surface of hybrid composites were studied by scanning electron microscopy (SEM). Results have been established that themechanical properties of kenaf-Kevlar hybrid composites are a function of fibre content. The hybrid composites with Kevlar/kenaf (78/22) ratio exhibited better

mechanical properties compared to other hybrid composites. This result indicates the potential of Kevlar-kenaf hybrid composite for impact applications.

The influence of soy flour (SF) concentration on the thermo-mechanical and rheological properties of soy flour (SF) as potential reinforcement in thermoplastic elastomers (TPEs) was studied by Thakur et al, 2014. Soy and poly(styrene-butadiene-styrene) triblock copolymer composite films were prepared using conventional thermoplastic polymer processing techniques. The results suggest that environmentally friendly soy flour reinforced thermoplastic elastomers exhibit excellent properties and offer great potential to replace traditional synthetic elastomeric materials. The solvent-less synthesis of novel low-cost polymer composites was reported, as procured using environmentally friendly soy flour and SBS triblock copolymer. The SF/SBS triblock copolymer green composites exhibit a significant improvement in storage modulus over the investigated temperature range and various mechanical/thermal properties.

In recent years, biodegradable polymer composites have attracted considerable attention due to inadequate and depleting petroleum resources and to replace nonbiodegradable synthetic polymers posing environment problems. (Ye Feng et al, 2014) studied the mechanical properties of biodegradable composites based on polypropylene carbonate (PPC)/eggshell powder (ESP) the solution-casting method using chloroform as the solvent. Tensile properties; Thermal degradation were found to improve. In this work, blends of natural rubber/acrylonitrile butadiene rubber have been prepared using carbonized and uncarbonized corn hub powder filler of particle size 0.1 and 0.15 μm . The mechanical properties of the composites produced were studied. Also the effects of carbonization and filler loadings on the mechanical properties of the composite have been investigated.

II. EXPERIMENTAL

2.1 Materials

Natural rubber used in this study conforming to the Nigerian Standard Rubber Grade 10 (NSR 10) of density 0.92g/cm³ and specific gravity 0.92 was obtained from Rubber Research Institute, Iyanomo, Benin City Edo State. The acrylonitrile butadiene rubber (NBR) used in the study was obtained from Benin City, Edo State while other vulcanizing ingredients such as stearic acid, zinc oxide, sulphur, tetramethylthiuram disulphide (TMTD), trimethyl quinine (TMQ), processing oil (dioctylphthalates (DOP), and carbon black were purchased from a Chemical Store in Benin City. Cornhub (CH) powder was used as filler in the blending of natural rubber /acrylonitrile butadiene rubber composite. The cornhub fibre was sourced locally from Auchi Edo State and is among the waste produced from the production of maize. The cornhub was washed to remove sand particles sun dried and milled to fine powder. The powder was then carbonized at 600°C and sieved to two particle sizes 0.10 and 0.15 μm . The fine powder was then collected and used for the blending.

2.2 Preparation of natural rubber/nitrile rubber composites

Table 1. Compounding recipe for filler reinforced NR/NBR composites

Materials	Carbonized (phr)	Uncarbonized (phr)
Natural Rubber	60	60
Acrylonitrile Butadiene Rubber	40	40
Stearic acid	2	2
Zinc oxide	5	5
TMTD	1	1
TMQ	0.5	0.5
sulphur	3	3
Processing oil	5	5
Filler	0,10,15,20,25,30	0,10,15,20,25,30

phr-part per hundred resin

Filler- Cornhub (CB), and Carbon black

Two different sets of natural rubber/ acrylonitrile butadiene rubber (NR/NBR) composites were prepared. (NR/NBR) filled carbonized cornhub and NR/NBR filled uncarbonized cornhub were prepared at different filler loadings. Carbon black was used as a reference filler. Blends of acrylonitrile butadiene rubber and natural rubber were prepared by melt mixing, carried out in a Brabender Plastic Order Model PLE 331. Natural/synthetic rubber mastication took 6 minutes, the rubber blend produced was then transferred to a two-roll mill (set at 170°C, rotating at 35 rpm with a nip clearance of 2.5 mm) which converted it from an irregularly shaped mass to flat sheets. The temperature of the mill was reduced to 90°C before the introduction of the vulcanizing agent and accelerators to prevent premature curing of the compound mix. Curing was carried out for 15 minutes. The blends were compression moulded at 140°C with a pressure of 10MPa for 12 mins. Samples for testing were then punched out from these moulded sheets.

2.3. Determination of the mechanical properties of the composite

The mechanical properties of the composites were determined using standard test procedures. The mechanical properties were determined using Monsanto tensile tester model

1/m at a cross speed of 50mm/minute using dumbbell test pieces of dimension (45 x 5 x 2mm). The test sample where tested in the machine giving straight tensile pull, without any bending or twisting. The machine measured both the tensile stress and the tensile strain.

III. RESULTS AND DISCUSSION

The mechanical properties of carbonized and uncarbonized cornhub filled NR/NBR composites have been investigated using Monsanto tensile testing machine. The variation in the mechanical properties of NR/NBR blends are given in Tables 2 to 4, and the values obtained from these tables are graphically represented in the Figures below.

The particle sizes of corn hub powder investigated were 0.1µm and 0.15µm respectively, while filler loadings of 0-30 wt % were used in preparing natural rubber/ acrylonitrile butadiene rubber composite. The variation for mechanical properties of natural rubber/ acrylonitrile butadiene rubber composite with filler contents and particle sizes are graphically represented in figures 1 to 8.

Table 1: The effect of carbonized corn hub powder (CCH) content on the mechanical properties of natural rubber/ acrylonitrile rubber (NR/NBR) composite at different particle sizes.

Eiller particle size (µm)	Filler content (%)	Mechanical Properties								
		Tensile strength (N/mm ²)	Elongation at break (%)	Modulus (N/mm ²)	Compression set (%)	Specific gravity (SG)	Hardness (IRAD)	Abrassion resistance (%)	Rebound resiliance (%)	Flex fatigues
0.10	0.00	9.48	886	1.13	28.61	1.006	44	40.10	87.1	2.1
	10.00	17.30	528	2.30	14.23	1.016	62	41.80	83.8	5.02

	15.00	24.85	501	2.68	13.91	1.040	55	42.60	82.8	4.12
	20.00	25.08	462	2.78	11.88	1.050	60	44.10	79.3	3.89
	25.00	26.12	403	2.89	9.11	1.066	64	46.30	75.4	3.28
	30.00	26.54	338	2.95	7.01	1.083	66	48.90	73.5	3.00
0.15	0.00	9.48	886	1.13	28.61	1.006	44	40.10	87.1	2.1
	10.00	14.80	583	2.05	16.42	1.019	53	41.00	83.0	6.01
	15.00	18.10	521	2.09	12.00	1.031	56	41.20	81.9	5.98
	20.00	20.20	482	2.19	10.92	1.049	61	41.90	78.1	5.09
	25.00	23.19	428	2.28	9.86	1.072	66	42.40	74.3	4.97
	30.00	23.85	402	2.45	0.02	1.075	69	45.40	72.4	4.75

Table 2: The effect of uncarbonized corn hub powder (UCCH) content on the mechanical properties of natural rubber/ acrylonitrile butadiene rubber (NR/NBR) composite at different particle sizes.

Filler particle size (μm)	Filler content (%)	Mechanical Properties								
		Tensile strength (N/mm^2)	Elongation at break (%)	Modulus (N/mm^2)	Compression set (%)	Specific gravity (SG)	Hardness (IRAD)	Abrasion resistance (%)	Rebound resiliency (%)	Flex fatigue
0.10	0.00	9.48	886	1.13	28.61	1.006	44	40.10	87.1	2.1
	10.00	10.16	509	1.54	16.83	1.003	49	41.50	83.6	5.00
	15.00	12.15	494	1.58	14.91	1.022	51	42.00	82.0	4.03
	20.00	14.01	468	1.69	10.16	1.030	54	43.20	78.8	4.01
	25.00	15.32	402	1.88	9.31	1.033	58	45.30	76.9	3.88
	30.00	16.35	396	2.15	8.11	1.035	62	46.20	69.8	3.25
0.15	0.00	9.48	886	1.13	28.61	1.006	44	40.10	87.1	2.1
	10.00	10.01	601	1.47	20.33	1.002	51	40.90	73.8	6.13
	15.00	11.89	581	1.53	18.11	1.012	59	41.20	72.1	5.62
	20.00	13.00	509	1.68	16.01	1.021	60	42.00	70.0	5.45
	25.00	15.11	444	1.69	15.23	1.028	63	42.90	69.1	5.13
	30.00	15.84	402	1.85	10.03	1.031	65	43.80	68.8	4.23

Table 3: The effect of carbon black on the mechanical properties of natural rubber/ acrylonitrile butadiene rubber (NR/NBR) composite at different filler loadings

Filler content (%)	Mechanical Properties								
	Tensile strength (N/mm^2)	Elongation at break (%)	Modulus (N/mm^2)	Compression set (%)	Specific gravity (SG)	Hardness (IRAD)	Abrasion resistance (%)	Rebound resiliency (%)	Flex fatigue
0.00	9.48	886	1.13	28.61	1.006	44	40.10	87.1	2.1
10.00	26.18	506	2.43	10.18	1.042	52	42.85	77.9	4.21
15.00	26.54	498	2.86	10.01	1.066	58	43.60	76.9	40.1
20.00	30.19	450	3.02	9.22	1.081	59	44.20	75.4	3.41
25.00	30.85	401	3.28	8.98	1.102	62	46.10	73.6	2.92
30.00	35.20	356	3.88	6.01	1.108	66	48.88	73.8	2.92

3.1 Tensile Strength

The tensile strength of natural rubber/acrylonitrile butadiene rubber composites increased with increase in filler loading for the two particle sizes investigated, and are higher than the tensile strength of the unfilled natural rubber/acrylonitrile butadiene

rubber vulcanizate. The reason for the increase in tensile strength is presumably attributed to the nature of surface properties, particle sizes and surface area. This increase in tensile strength is in accordance with Onyeagoro, 2012. Carbon black filled vulcanizate has the highest tensile strength and carbonized corn

hub filled vulcanizate has a higher tensile strength than uncarbonized corn hub filled vulcanizate. The blends with particle size with 0.1µm have higher tensile strength than those of 0.15µm particle size, due to higher surface area by the lower particle sized blends which leads to better filler/matrix interaction. However, the properties will be more improved when filler particle sizes smaller than 0.1µm is used because the smaller the particle size, the better filler/matrix interaction.

Furthermore, when the filler content is above 30%, the tensile strength of the composite will be affected due to the hydrophilic nature of natural fibres. The vulcanization properties of natural rubber/ acrylonitrile butadiene rubber have been improved by using carbonized corn hub powder because during carbonization, some volatile materials are removed and also there is the removal of water of hydration which leads to improvement in mechanical properties.

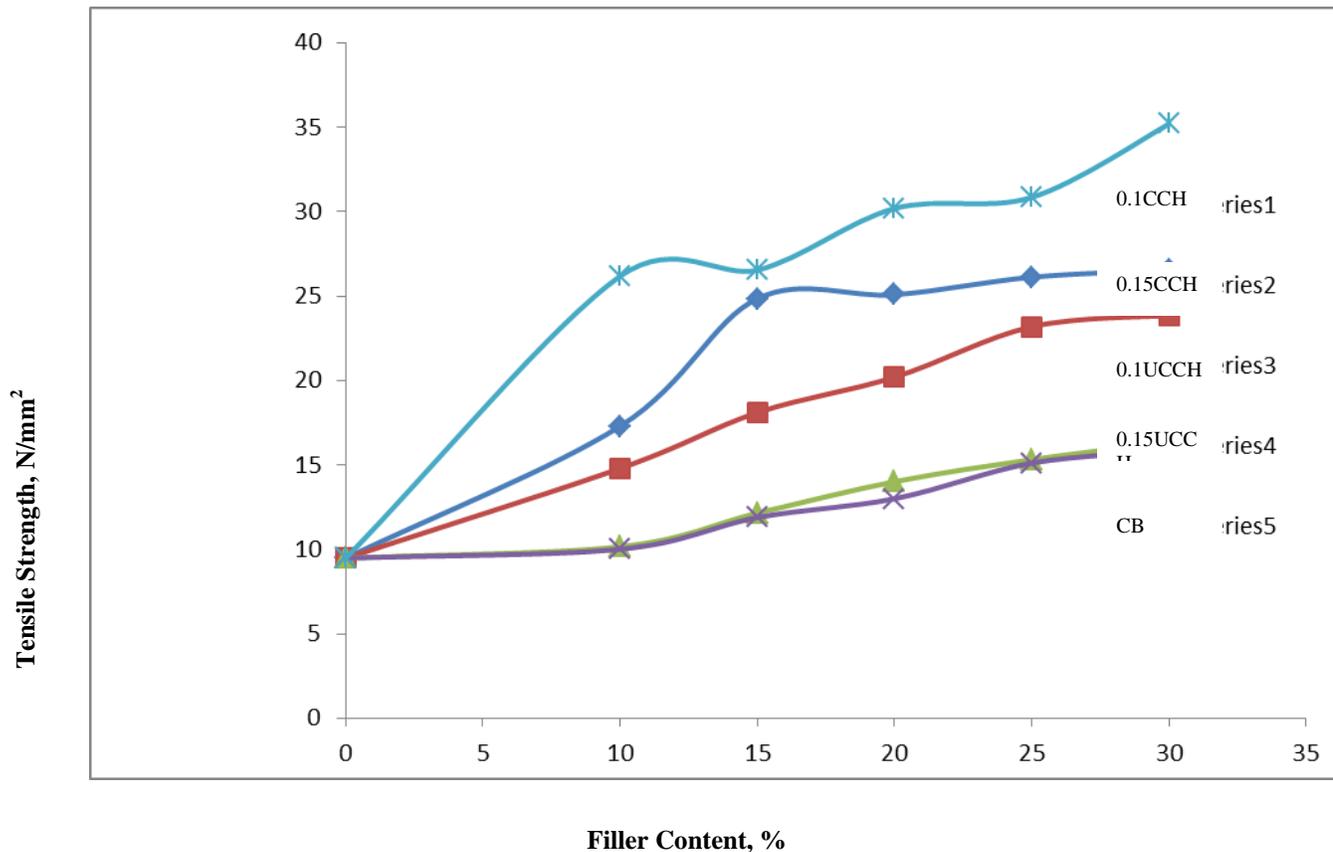


Fig 1: Plot of tensile strength versus filler content for natural rubber/acrylonitrile butadiene rubber/ corn hub composite at different particle sizes.

3.2 Compression Set

The compression set is given by the equation:

$$\text{Compression set (\%)} = \frac{T_0 - T_r}{100 T} \times 100$$

Where T_0 is the initial thickness of the sample and T_r is the recovered thickness of the sample.

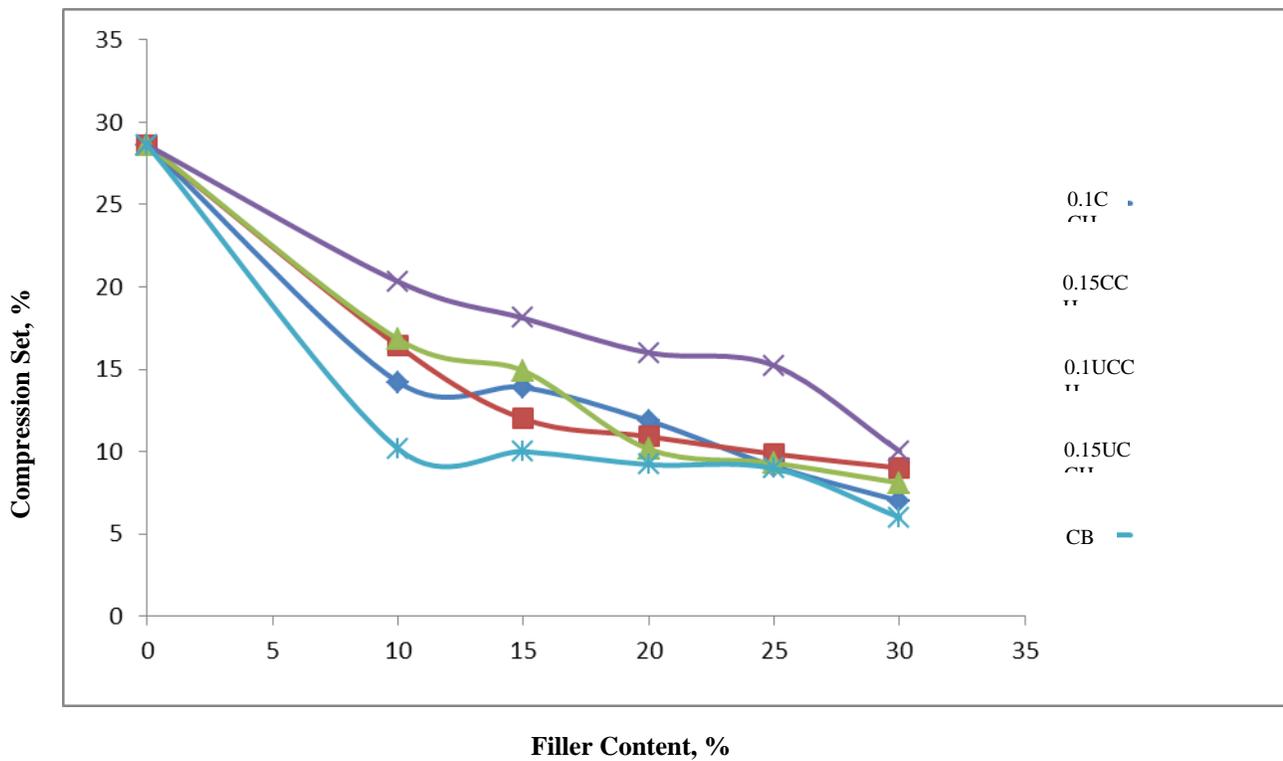


Fig 2: Plot of compression set versus filler content for natural rubber/acrylonitrile butadiene rubber composite at different particles sizes.

From the above Figure compression set of natural rubber/acrylonitrile butadiene rubber composites decreased with increase in filler loading for the two particle sizes investigated, and are lower than the compression set of the unfilled natural rubber/nitrile butadiene rubber vulcanizate. The reason for this observation may be as a result of the amount of filler incorporated into the matrix, the degree of dispersion of fillers and its particle sizes. The uncarbonized cornhub filled vulcanizate has the compression set higher than that of carbonized corn hub and carbon black filled vulcanizates. Its compression set increased with increase in particle size. Carbon back filled vulcanizate has lowest compression set. Generally vulcanizates of the particle size of 0.15µm had higher compression set than that of 0.1µm

3.3 Modulus of Elasticity

From Figure 3, it is evident that modulus of natural rubber/acrylonitrile butadiene, rubber increased with increase in filler loading for the two particle sizes investigated and are higher than the modulus of the unfilled natural rubber/acrylonitrile butadiene rubber vulcanizate. The carbonized cornhub filled vulcanizates has higher modulus than uncarbonized filled vulcanizates, while carbon black filled vulcanizate has the highest modulus. This may be explained in terms of the difference in the filler properties. The fact that corn hub filled vulcanizates had larger particle sizes and hence smaller surface area compared to carbon black can lead to poor filler polymer interaction and account for a low modulus observed in corn-hub filled vulcanizate. 0.1µm particle size filled vulcanizate had higher modulus than 0.15µm particle size filled vulcanizates. This also was as a result of poor filler polymer interaction at increase particle sizes.

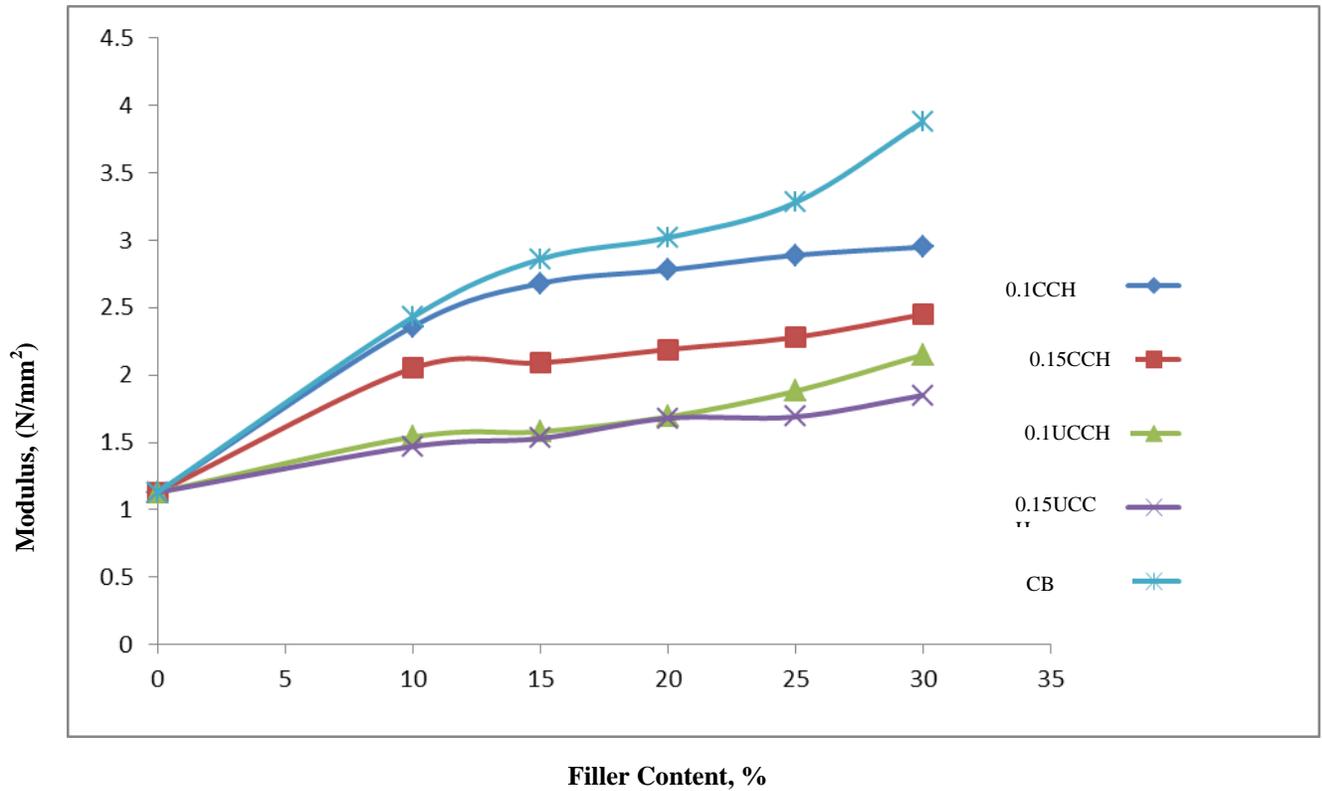


Fig 3: Plot of modulus versus filler content for natural rubber /acrylonitrile butadiene rubber composite at different particles sizes

3.4: Elongation at Break

The elongation at break of natural rubber/ acrylonitrile butadiene rubber decreased with increase in filled loading for the two particle sizes and was lower than the elongation at break of unfilled natural rubber/ acrylonitrile butadiene rubber vulcanizate. The decrease in elongation at break may be due to interaction of the filler particles with the polymer phase leading

to the stiffening of the polymer chain and hence resistance to stretch when stress is applied. Uncarbonized corn-hub filled vulcanizate had a higher elongation at break than carbonized corn hub filled vulcanizate while carbon black filled vulcanizate had the lowest. vulcanizate with 0.15 μ m particle size had higher elongation at break than 0.1 μ m particle size vulcanizates.

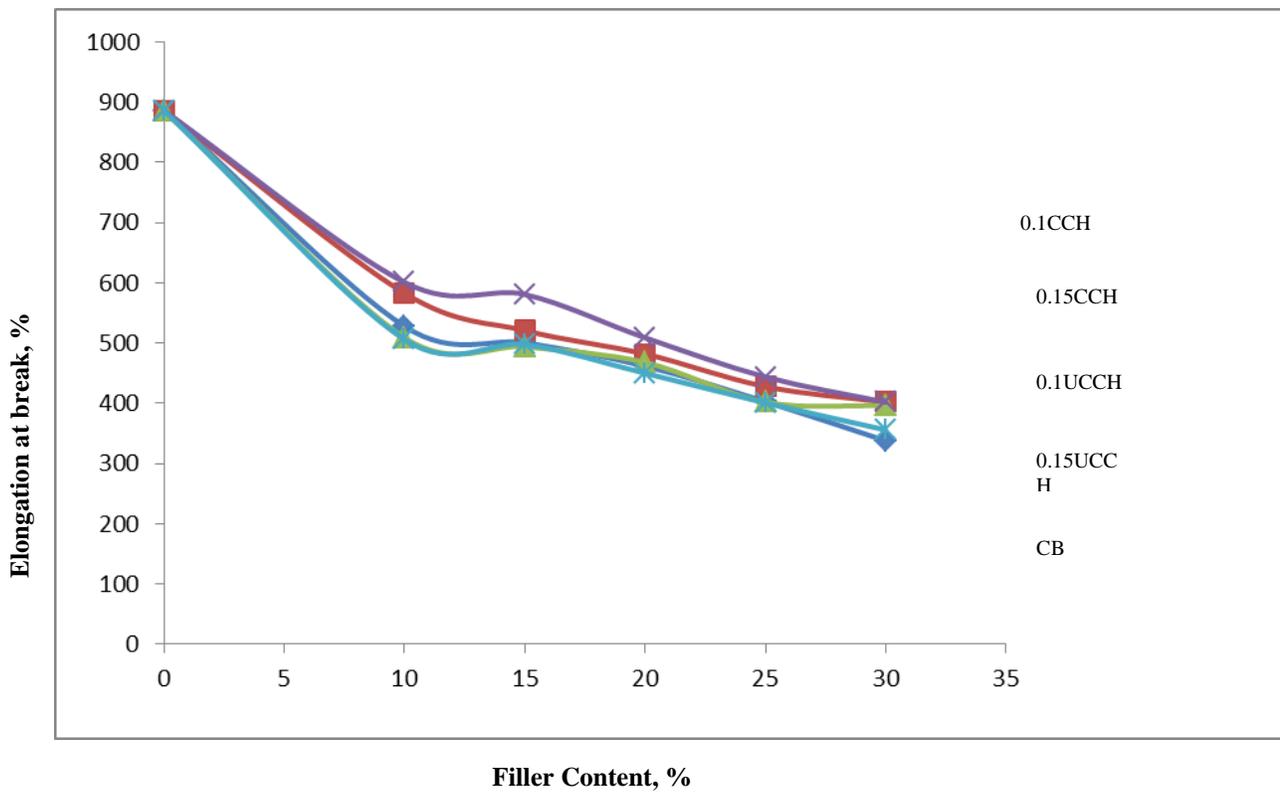


Fig. 4: Plot of elongation at break versus filler content for natural rubber /acrylonitrile butadiene rubber composite at different particles sizes

3.5 Specific Gravity

The specific gravity of the filled systems all increased with increase in filler loading for the two particle sizes investigated. At any given filler loading, the specific gravity of the composites

increases with decrease in filler particle size. The higher specific gravity shown by filled systems may be due to the degree of dispersion of the fillers or more uniform filler dispersion.

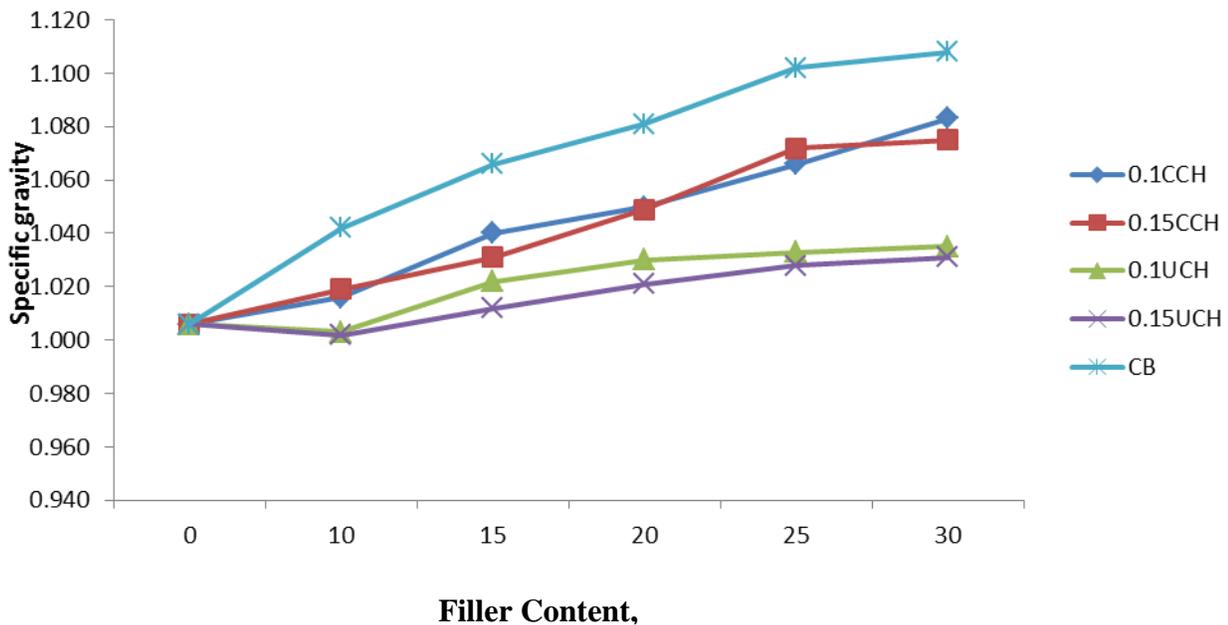


Fig. 5: Plot of specific gravity versus filler content for natural rubber /acrylonitrile butadiene rubber composite at different particles sizes

3.6 Hardness

The standard dead method of measurement covers rubbers in the range of 30 to 35 according to International Rubbers Hardness Degrees (IRHD). This method was adopted and used for the hardness test. The hardness of natural rubber/acrylonitrile butadiene rubber composite increased with increase loading for

the two particle sizes investigated and were higher than the hardness of unfilled natural/acrylonitrile butadiene rubber vulcanizate. As filler particles get incorporated in the composite, the elasticity of the chain was reduced resulting in a more rigid rubber vulcanizate.

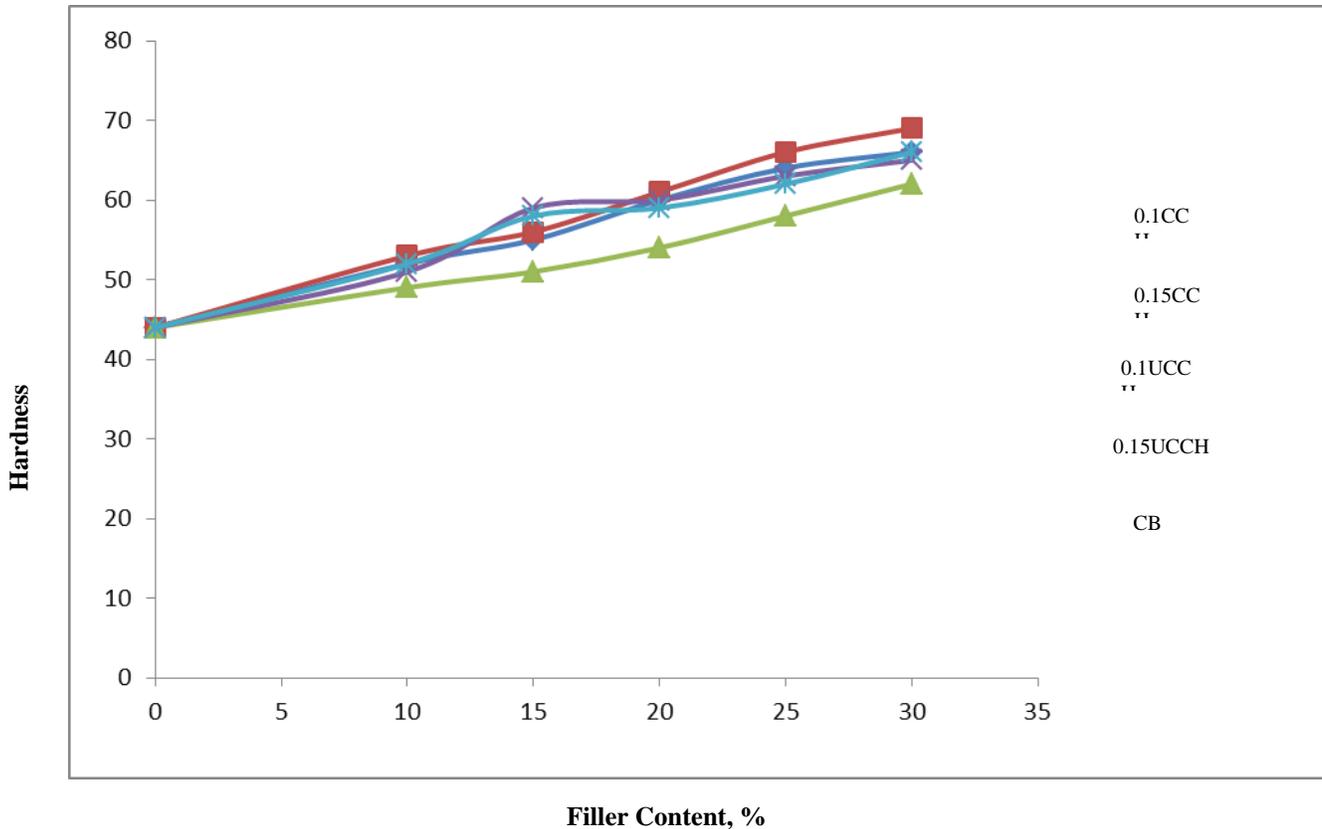


Fig. 6: Plot of hardness versus filler content for natural rubber /acrylonitrile butadiene rubber composite at different particles sizes.

3.7 Abrasion Resistance

From the mean of the four revolutions of the abrasive wheel, abrasion resistance was calculated using the equation below.

$$\text{Abrasion resistance} = \frac{\text{Volume loss of the standard}}{\text{Volume loss of the sample}} \times 100$$

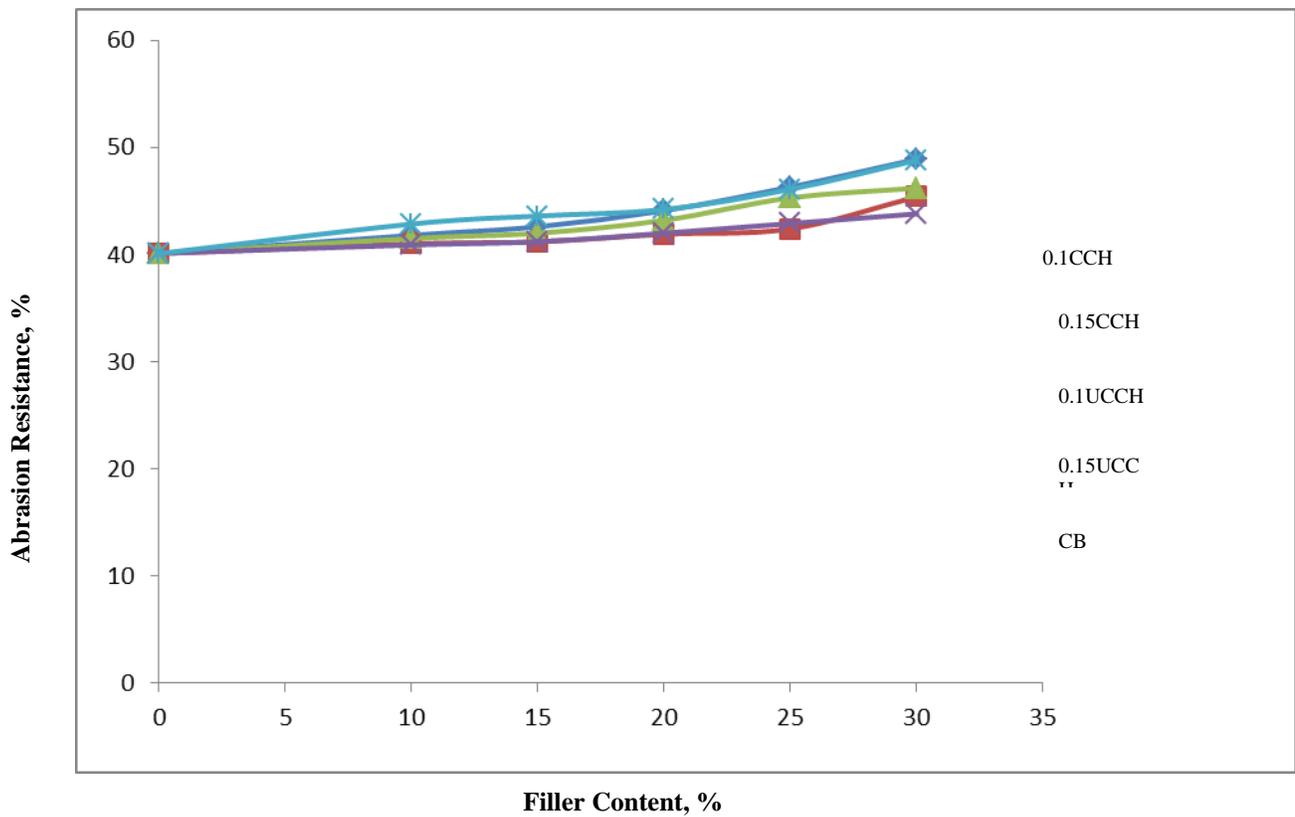


Fig 7: Plot of abrasion resistance versus filler content for natural rubber /acrylonitrile butadiene rubber composite at different particles sizes.

The abrasion resistance of natural rubber/acrylonitrile butadiene rubber composite increased slightly with increase in filler loading for the two particle size investigated, and were higher than the unfilled natural rubber/acrylonitrile butadiene rubber vulcanizate. Abrasion resistance for carbonized corn hub filled vulcanizate was slightly higher than uncarbonized corn hub filled vulcanizate. There was little or no difference in the abrasion resistance of corn hub filled vulcanizates and carbon black filled vulcanizates.

3.8 Rebound Resilience

The rebound resilience of natural rubber/acrylonitrile butadiene rubber composite decreased with increase in filler

loading for the two particle sizes and were lower than rebound resilience of unfilled natural rubber/acrylonitrile butadiene rubber vulcanizate. The rebound resilience of carbonized corn hub filled vulcanizate and uncarbonized filled vulcanizate were almost the same. The composites with 0.1, 0.15 μ m carbonized, and 1.0 μ m uncarbonized were both higher than that of carbon black filled vulcanizate while the composite with 0.15 μ m particle size was the lowest. Increase in particle size has little significant effect on the rebound resilience. Cornhub filled vulcanizate of particle size 0.15 μ m had rebound resilience slightly higher than that of 0.1 μ m particle size. The higher value of corn hub filled vulcanizates may be as a result of difference in filler properties.

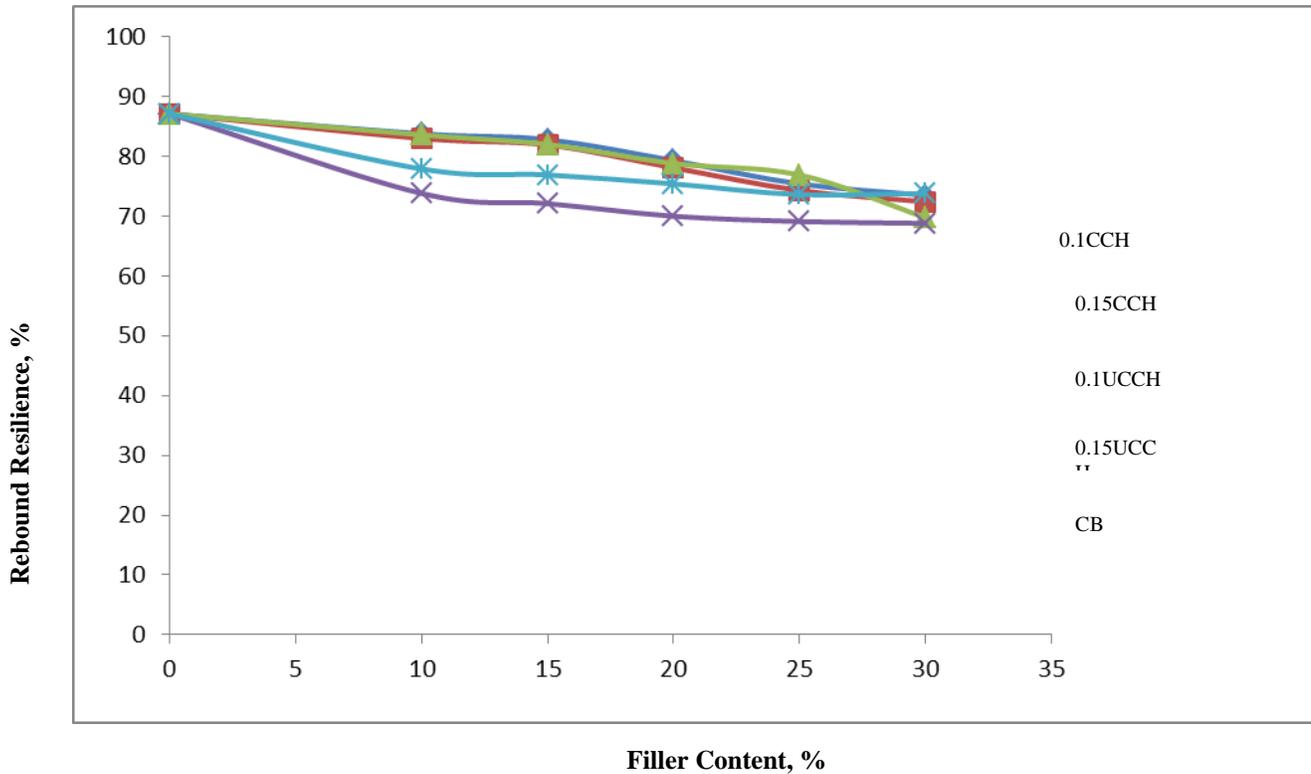


Fig.8: Plot of rebound resilience versus filler content for natural rubber/acrylonitrile butadiene rubber composite at different particles sizes.

3.8 Flex Fatigue

The fatigue of natural rubber/acrylonitrile butadiene rubber composite decreased with increased filler loading for the two particle sizes and were both higher than flex fatigue of the unfilled natural rubber/acrylonitrile butadiene rubber vulcanizate. The flex fatigue for carbonized corn hub filled

vulcanizates had little or no difference with that of uncacbonized filled vulcanizate but are both higher than that of carbon black filled vulcanizate. This difference may be due to the smaller surface area of the corn hub filled vulcanizate. 0.15 μ m particle sized vulcanizate had higher fatigue than 0.1 μ m particle size vulcanizate.

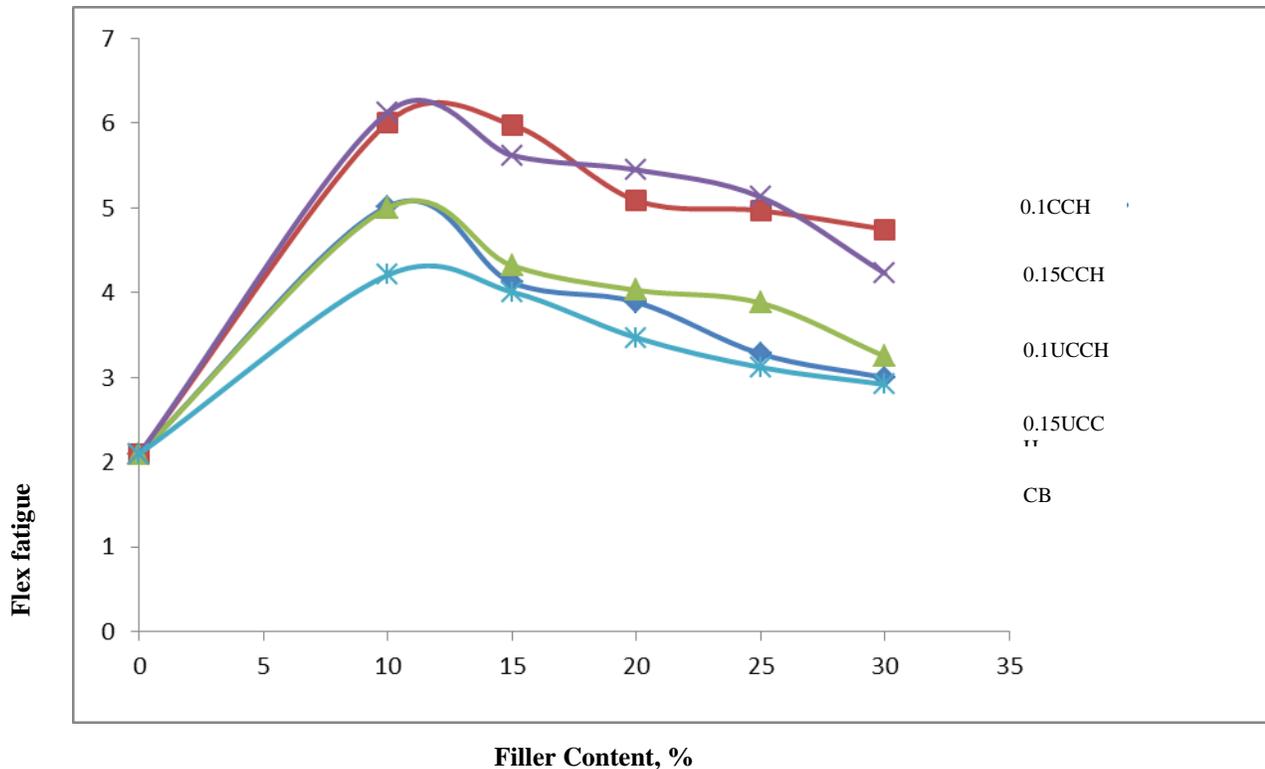


Fig. 9: Plot of flex fatigue versus filler content for natural rubber/acrylonitrile butadiene rubber composite at different particles sizes.

IV. CONCLUSION

The mechanical properties of corn hub powder filled natural rubber/acrylonitrile butadiene rubber and the effect of filler loadings and filler particle sizes for both carbonized and uncarbonized cornhub powder have been studied. The carbonized cornhub powder improved the vulcanization properties of natural rubber/acrylonitrile-butadiene rubber blend. The improvement in the vulcanizate properties is supported by the data on the increased content of tensile strength in the blend samples (Table 1).

The mechanical properties were found to improve further with carbonized filler of smaller filler particle sizes. The use of carbonized cornhub powder as fillers in the blend samples revealed significant improvement in the vulcanizate properties of blends at low carbonized cornhub powder filler loading of 10 phr comparable to the results obtained with blend samples reinforced with only carbon black. . Consequently, carbonized cornhub powder can serve as potential substitute filler to carbon black in the rubber industry, in the production of low-cost/high volume rubber products where strength is not critical. Huge foreign exchange spent on importation of carbon black will be saved with concomitant reduction in the price of rubber products. Carbonized cornhub was also found to be good reinforcing filler for blends such as natural rubber/acrylonitrile butadiene rubber where oil resistance is of great importance.

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