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European Journal of Advances in Engineering and Technology, 2018, 5(12): 961-966

Research Article ISSN: 2394 - 658X

Effects of Semi-Nano Filler Blends (Jatropha seed shell powder and Carbon black) on the Mechanical Properties of Natural Rubber Composites

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ABSTRACT

Jatropha seed shell powder and carbon black were used as hybrid fillers to reinforce Natural rubber compound. The fillers; Jatropha seed shell powder and carbon black were loaded at 0, 30:0, 25:5, 20:10, 15:15, 10:20, 5:25 and 0:30 respectively. The Jatropha seed shell was characterized for particle size, pH and moisture content, the results were 625.4 d.nm at 63.8% and 381.7 d.nm at 36.2 %, 7.31 as pH and 0.57% as moisture content respectively. The mechanical analysis viz; tensile strength, hardness, compression set and abrasion resistance were also carried out and the best abrasion resistance is at compound filled with 30g JSSP alone with 0.40% abrasion followed compounds filled with 25g JSSP/ 5g CB and 20g JSSP/ 10g CB with 0.75% and 0.84% abrasion resistance respectively. The unfilled compound reveals a tensile strength of 0.30 Mpa and when 30g JSSP was loaded alone without carbon black, the tensile strength revealed 1.40 Mpa which gave a better results to when JSSP and CB were both hybridized at JSSP 25g/ CB 5, JSSP 20g/ CB 10g, and JSSP 15g/ CB 15g which reveals 1.0 Mpa, 1.10 Mpa and 1.20 Mpa respectively. The compounds filled with 30g JSSP and 30g CB both reveals a hardness values of 35 IRHD and 41 IRHD with that of CB given a better hardness result compared with that of JSSP at the same loading.

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Key words: Jatropha, Shell, Natural rubber, Filler and Hardness

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INTRODUCTION

In recent years exhaustive research has been carried out on utilizing natural rubber as efficiently as possible to produce superior quality filler reinforced polymer composite for a wide range of application [1].

Natural rubber alone does not possess the necessary physico-mechanical properties that are required by rubber manufacturers. Fillers are widely used additives and the largest in quantity among others in the manufacture of rubber product. Particulate fillers such as carbon black, calcium carbonate and china clay are widely used as reinforcing filler in the industries [2].

Composites consist of one or more discontinuous phases embedded in a continuous phase. The discontinuous phase is usually harder and stronger than the continuous phase and is called the 'reinforcement,, or 'reinforcing material', whereas the continuous phase is termed as the 'matrix'. Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent [3].

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. 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 [4].

Reinforcing fillers most often used are Carbon black and silica (SiO_2), calcium carbonate ($CaCO_3$) is also utilized as filler for rubber. Efficiency of the reinforcing filler depends on several factors such as particle size, surface area and shape of filler. Recently there has been a growing interest in the use of renewable resources such as bamboo and wood or products like rice husk, chitin and coir as fillers for polymers Benefits of these fillers include low cost, light weight, biodegradability and so on. In Thailand, fishermen harvest cuttlefish for food skeleton of cattle fish is removed during cooking, which results in large amount of agricultural waste products of cuttlebone. Can cattle bone be used as a new biomass, since cattle bone is mainly composed of $CaCO_3$ and chitin [5].

Elastomers are presently used in wide areas of application, such as wires, cables and automobiles, due to their light weight, hydrophobicity, easy maintenance and processing. Nevertheless, they have been usually applied in the filled state since Mote and others discovered the reinforcement of rubber by carbon black a century ago [6].

Materials, Equipment and Methods

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, Advanced Material Testing Machine, Zwick/Roell, India, Muver Francisco Irles Hardness tester model 5019, Wallace compression set machine, model C84025/2, Setra abrasion test equipment, model 11884 and Two roll mill, Reliable Rubber and Plastics Machinery, model 5189.

Methods

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 seedshell 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^{o}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^{o}C, followed by in-situ moulding and curing at 130^{o}C with a hydraulic press machine

Tensile Strength

These tests were conducted in accordance to ASTM D412. Tensile tests were carried out at room temperature using an Advance Material Testing machine model 3366 with a load cell 1kN. Pre-moulded dumbbell shaped specimens with dimensions of 50 X 8 X 4 mm^3 were used to perform the experiment at a loading speed of 200 mm/min.

Hardness test

The hardness test of a rubber is the relative resistance of the surface to indentation by an indentor of specified dimension under a specified load. Hardness of the vulcanisates was determined by standard dead load method (BS903 part A 26) [8].

Abrasion resistance

Wallace Akron tester was used in accordance with BS method

Abrasive resistance index = (S) 1000/ T ………………. (1) [8].

Compression set

Wallace compression set machine (Mode/Ref No (2, H_2^{50}) was used to determine the compression set of the vulcanizates.

Compression set % = t_0- tr/t_0 X 100 …………… (2) [8].

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/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, JSSP: Jatropha seed shell powder.

RESULTS AND DISCUSSION

Results

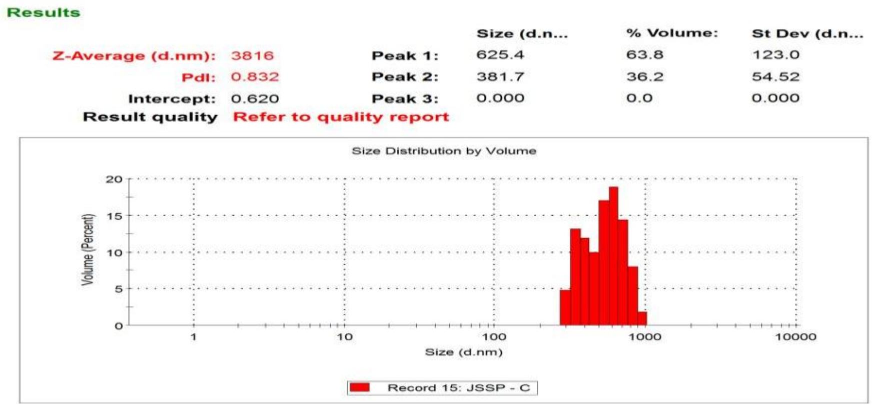

Fig. 1 Dynamic light scattering of JSSP

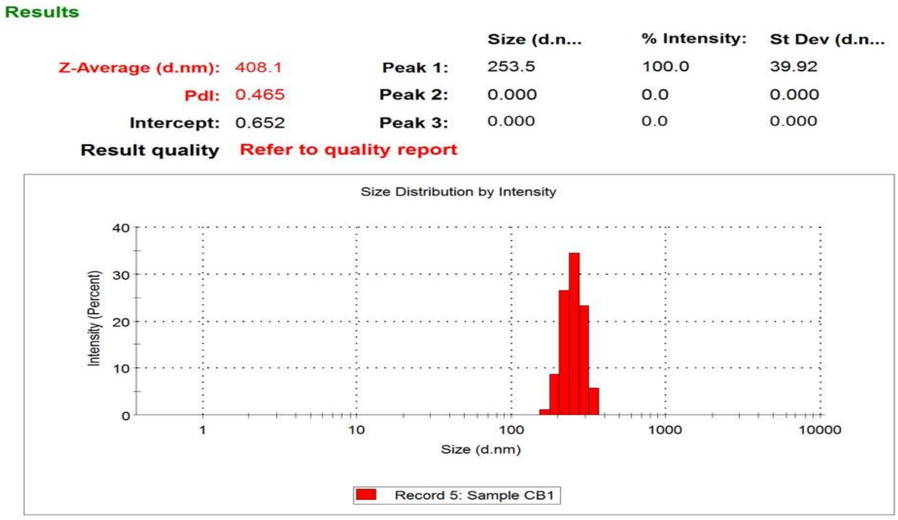

Fig. 2 Dynamic light scattering of CB

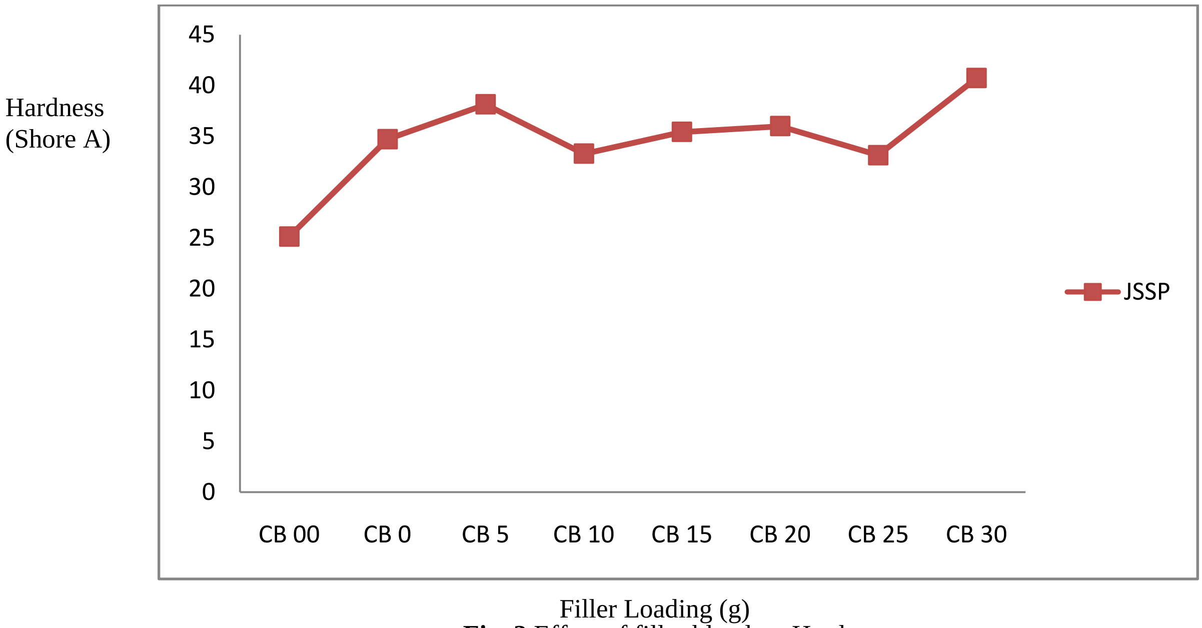

Fig. 3 Effect of filler blend on Hardness

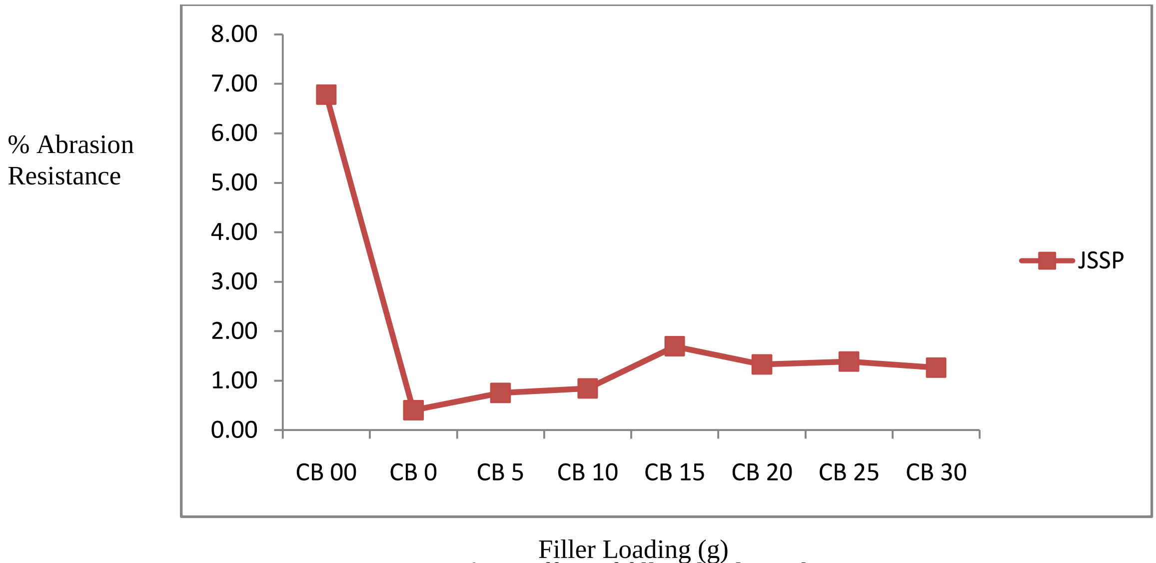

Fig. 4 Effect of filler blend on Abrasion

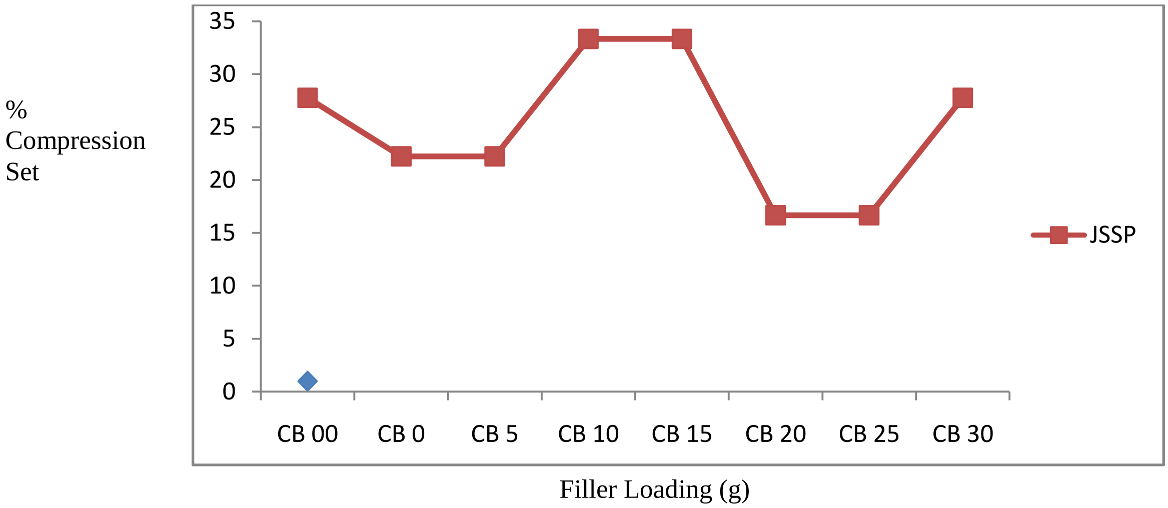

Fig. 5 Effect of filler blend on Compression set

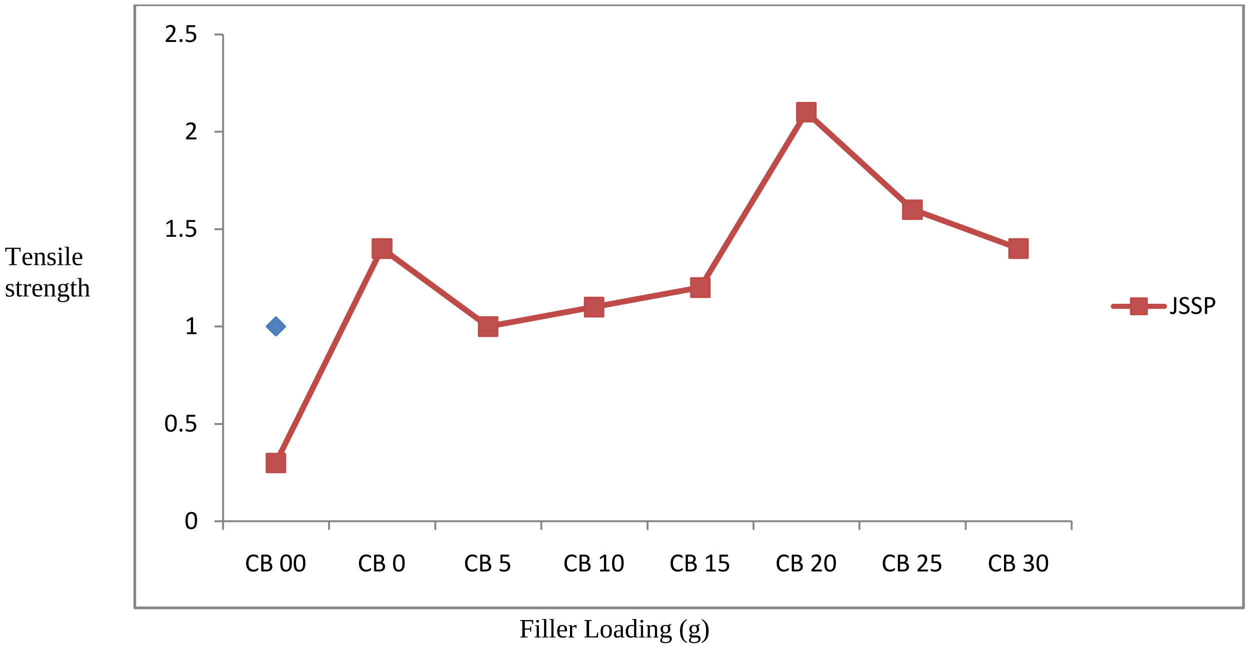

Fig. 6 Effect of filler blend on Tensile strength

Discussion

Natural rubber was hybridized with carbon black and Jatropha seed shell powder at different proportions and were analysed for particle size and mechanical tests viz; tensile strength, hardness, abrasion resistance and compression set.

Figure 1 shown the result for the Dynamic light scattering of the filler which shows that the particle size of the particles of Jatropha seed shell (JSSP) is about 625.4 d.nm at 63.8% and 381.7 d. nm at 36.2% respectively while that of carbon black in figure 2, fell within 253.5 d.nm at 100% revealing uniform particles of the filler compared to that of the JSSP.

The hardness as shown in figure 3 shows that there was increase generally as the hybridization was filled compared to that of the unfiled compound. The compounds filled with 30g JSSP and 30g CB both reveals a hardness values of 35 IRHD and 41 IRHD with that of CB given a better hardness result compared with that of JSSP at the same loading, but when the compounds were blended with both fillers at JSSP 25g/ CB 5g, JSSP 20g/ CB 10g, JSSP 15/ CB 15g and JSSP 10g/ CB 20g respectively reveals that there was a drop in the hardness value as the amount of JSSP loaded was reducing with hardness values of 38, 33, 35, 36 and 33 IRHD respectively.

Figure 4 shows the result of percentage abrasion resistance which reveals reinforcement as the fillers were dosed into the compound compared with the unfilled compounds. The unfilled compound has the poorest percentage abrasion resistance with 6.78% abrasion resistance compared with the filled compound. The best abrasion resistance is at compound filled with 30g JSSP alone with 0.40% abrasion followed compounds filled with 25g JSSP/ 5g CB and 20g JSSP/ 10g CB with 0.75% and 0.84% abrasion resistance respectively. The highest abrasion resistance in the hybridized compounds was noticed at compounds filled with 15g JSSP/ 15g CB with percentage abrasion resistance of 1.69%, at this point, compounds filled alone without hybridization revealed that JSSP have a better abrasion resistance to CB when filled with natural rubber compound at 30 pphr respectively.

Figure 5 shows the result for compression set of the compounds. The poorest percentage compression set was seen in compounds filled with JSSP 20g/ CB 10g and JSSP 15g/ CB 15g with 33.3 % compression set higher than that of the unfilled compound with JSSP 10g/ CB 20g and JSSP 5g/ CB 25g which gave the best compression set with 16.7% compression set respectively for both compounds.

The tensile strength as shown in figure 6 reveals that as the amount of JSSP was reducing from 25g JSSP/ 5g CB to 5g JSSP/ 25g CB , the tensile strength was increasing compared to the unfilled compound. The unfilled compound reveals a tensile strength of 0.30 Mpa and when 30g JSSP was loaded alone without carbon black, the tensile strength revealed 1.40 Mpa which gave a better results to when JSSP and CB were both hybridized at JSSP 25g/ CB 5, JSSP 20g/ CB 10g, and JSSP 15g/ CB 15g which reveals 1.0 Mpa, 1.10 Mpa and 1.20 Mpa respectively. The best tensile strength was shown at loading of JSSP 10g/ CB 20g with a tensile strength of 2.10 Mpa. Compounds loaded with JSSP 30pphr and CB 30pphr alone reveals the same tensile strength of 1.40 Mpa to which JSSP at semi nano scale revealed considerable reinforcement as compared with CB.

CONCLUSION

This research as presented here in this paper is a preliminary work in progress and the effects of semi-nano hybridization of fillers (Carbon black and Jatropha seed shell powder) were investigated. The main aim of the research was to see how carbonized semi-nano particles of agro-waste can be hybridized with carbon black N330 to reduce the cost of production when reinforced with natural rubber.

The obtained results reveals that carbonized semi-nano JSSP is a reinforcing filler when processed and hybridized with carbon black, this studies indicated that by further reducing the particle size of JSSP will further make it a better reinforcing filler as an agricultural waste hence converts waste to wealth as the abrasion resistance result has revealed that compound loaded with 30 pphr of JSSP gave a better result that that filled with 30 pphr of CB, as abrasion resistance is one of the mechanical analysis used to ascertain if a filler is reinforcing or not.

Acknowledgement

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

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