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# Synthesis, Raman spectroscopy and mechanical properties of SBR-aluminum oxide nanocomposites

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#### ABSTRACT

Styrene butadiene rubber is seen as one of the great vast chemical substances utilized as attachment, hence we talked about in this investigation to enhance its properties. The nano composites have been organized by way of mechanical mixing the use of two-roll mills. Aluminum oxide nanofiller suspensions have been brought to SBR elastic and the scrape and spectral studies have been overviewed. This investigation covers the have an effect on of aluminum oxide on reflex tests of SBR elastic bolstered with aluminum oxide particles. Mechanical test outcomes confirmed that enhancement in flexile strength, lengthening and tear resistance. Scrape check outcomes confirmed that the aluminum nano particles ought to decorate the scrape opposition of Styrene Butadiene rubber mould because of fantastic properties of alumina nano particles. The composites had been set up with (2 to 12 wt%) of nano aluminum oxide molecules. The effects had proven that the rigidity and curve excellent are enhanced. © 2020 Elsevier Ltd. All rights reserved.

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#### 1. Introduction

The business significance of chemical compounds has been using severe purposes in the shape of compound in a number field. Materials are primarily dependent on the measurement of added substances; there are few classes of these mixtures. On the off chance that measurement of components to the chemical compound primarily based mixture is much fewer than one hundred wavelength, this class of compound named nano composites. Nano composites primarily dependent on chemical substances have been pulled in latest duration [1-4]. As of late, enthusiasm for making use of of elite polymer composite substances is accelerated for designing applications. So as to supply sheltered and monetary parts, these substances have to have notable mechanical and tribiological residences joint with enormously safety from debasement and low weight [5]. SBR is considered as possibly the first-rate elastic that is utilized in the mechanical applications. The technology of this engineered SBR used to be no longer correctly sought after in the United States or someplace else on the planet till the stockpile of frequent elastic had been abridged via hostilities work-

\* Corresponding author. E-mail addresses: wbgurnule@gmail.com, rani.bharne@gmail.com (R.V. Mankar). outs in the Pacific at some point of the late Thirties and in advance of time table of the Forties decay [6].

Likewise, SBR is generally utilized in cutting-edge purposes as engineered elastic. SBR has excessive filler-stacking ability, excessive safety from flex, excessive safety from inception of break, and scratch obstruction that make the SBR actually essential in more than a few constructing and mechanical purposes [7]. In complex functions, rubber is utilized as precept network. There are several appears into have examined the have cause on nano fillers and delivered materials on the rubber execution. Notwithstanding, a few inquires about highlight on thinking about the combo of rubber with distinctive elastic substances that ought to be utilized in complex and nano complex functions. Guo chipped away at the rubber nano complex by nanotubes and by nearness of methacrylic corrosive [8]. Gu and colleagues joined SBR elastic with everyday elastic to figure vital lattice for nano complex readiness [9]. They utilized organo bentonite on the SBR primarily found nanocomposites and introduced that the nano bentonite increased reflex houses of elastics. Liquefy blending has been perceived for its adaptability and excellent to make utilize of in particular for business functions. For SBR elastic primarily found nanocomplex, liquefy blending should be lone of the vital guides for putting up

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nanocomplex. Lai and colleagues organized nanocomplex primarily found SBR elastic by using liquefy blending [10].

They blended its substances by clump blender. For improving the effects, they utilized since mud nano platelets by blending technique. Mohan and mates utilized Banbury blender for planning SBR elastic and frequent elastic mixes for checking out reflex homes [11]. Nano structured substances won superb significance in the previous period on report of its broad vary of possible purposes in several regions. Chemical nanocomplex symbolizes a choice to comprehensive crammed chemical. Due to its nanometer dimension of elements, the non-complex showcase clearly accelerated homes when in contrast by the original chemical or traditional complex [12,13]. These consist of extended modulus and force, reduced gasoline absorptive, elevated solid and warmness confrontation [14,15]. Amalgamation of rubber by different chemical and non-chemical substances is single of the topics that concerned in latest duration. In invented story, the 2 components medium making plastic or sponge rubber have been recycled. Elastic and adhesive aggregate mould is organized in a few mechanisms for its curse effects. Zhao and co-workers inspected on stalled phenol and acrylo nitrile butadiene elastic compounds [16]. They said almighty the present mixture ought to be recycled as excessive overall presentation moist matter. Elastic substances are concerned for flexible houses and adhesive substances exhibit true heated and reflex effects. Yu and co-workers organized the nano rubber units for enhancing the friction effect of epoxy adhesive [17]. They combined elements with the aid of reflex amalgamation and suggested the downhill friction effect via slab onwheel rasping and put on controller. They mentioned that unique put on charge of adhesive material have been lowered by incorporation of nano rubber units. In the present task, we scrutinized on the scrape residences of 2 components mould nano composites collected of styrene butadiene rubber (SBR) in the company of aluminum nano oxide. The acquired analysis marks are talk about in feature in the going with parts of the current examination.

#### 2. Material characteristics

In the first place, aluminum oxide particles were scattered in toluene with incredible mixing and filler suspension used to be collected at 30 °C. At that factor rubber latex used to be blanketed into the filler suspension and united up to consistent unification of rubber into nano filler. Combo was once compacted at 30 °C. At that factor washed with water some instances and in a while dry at 70 °C for 12 h. At that factor rubber-nanofiller was once shaped.

SBR-nanofiller were once blended in with one of a kind fixings seemed in the table. The rubber-nanofiller then were once processed at 150 °C. Combo of rubber-nano compound had been straightforwardly utilized on two-roll mill and mixing for 16 min, at that factor consisting of each and every necessary fixing is recorded in Table 1 and adding for 10 min. After that the consequential complex had been formed at 150 °C.

#### Table 1

System	for	rubber	nanocom	nosite
System	101	TUDDCI	nanocom	ρυδιιί

#### 2.1. Elemental analysis

The examination has been done utilizing basic instrument, at Sophisticated Analytical Instrumentation Facility, Cochin. The level of components, for example, carbon, hydrogen, nitrogen and sulfur current in the elastic nanocomposite were controlled by essential investigation.

#### 2.2. FTIR spectroscopy for SBR-aluminum oxide nanocomposites

FTIR spectra of rubber-nanocomposites had been decided by means of the usage of IR- Affinity shimadzu spectrophotometer.

#### 2.3. Raman spectroscopy for SBR-aluminum oxide nanocomposites

The Raman dissipating checks have been carried out utilising a T64000 Jobin-Yvon spectrometer. To restriction the light sway, rubber, rubber by filler had been enlightened by an argon-krypton molecule laser (Innova 70C Coherent mannequin) functioning at wavelength 647.1. Rays pillar used to be engaged via a × one hundred enhancement focuses of a confocal amplifying focal point (BX40 Olympus). Each array was once accumulated in the recurrence lengthen 400–3500 cm<sup>-1</sup> extra than 60 s and by ten assortments to maintain left since digital apexes and everyday establishment. (From NCL Pune, India).

#### 2.4. Mechanical properties

To inspect elasticity, elongation at smash and tear opposition residences utilize a malleable T10 Monsanto Tensometer in accordance to ASTM D 412. It comprising of two mouths, one constant and different shift unexpectedly 500 mm/min (IRMRA, Thane).

#### 2.5. Abrasion resistance

Test is completed by means of system kind (wallace take a look at gear, HZ 50) as ASTM D 2228. The system moving with 250 Watts, the place the instance is set contacting the switch, the change flip 500 cycle for 5 min (IRMRA, Thane) and later on decided the big difference in load when the test.

#### 2.6. Swelling study

The crosslinking width of all the vulcanized models was directed by the equalization developing system utilizing toluene as dissolvable. The reestablished trials of acknowledged weight were allowed to develop for 7 days in fresh toluene at 30 °C. Later each 24 h dissolvable have been modified by fresh toluene. Seven days, attempts were extracting out and followed liquid was immediately emptied by smirching with blotter and gauged immediately. It was once void dry at 80 °C till steady load was obtained. Crosslinking

Factors Parts per hundred ratio SBR 100 100 100 100 Aluminum oxide (filler) 0 2 10 12 2 2 2 2 Stearic acid Zinc oxide 5 5 5 5 2. 2'-dithiobis 0.5 0.5 0.5 0.5 Tetramethyl thiuram disulfide (TMTD) 0.2 0.2 0.2 0.2 N, N'-diphenyl P-phenylene diamine 1 1 1 1 Sulphur 2 2 2 2

thickness Ve, described by the amount of deftly unique chains for each part amount was directed by Flory–Rehner equation (1)

$$V_{e} = -\left[ln(1 - V_{r}) + V_{r+}X_{1}V_{r}^{2}\right] / \left[V_{1}\left(V_{r}^{1/3} - V_{r}/2\right)\right]$$
(1)

where, Ve – framework chain width,  $V_1$  – molar extent of liquid, Vr – quantity division of versatile in swollen framework and  $X_1$  – Flory–Huggins flexible dissolvable association factor.

#### 3. Results and discussion

#### 3.1. Elemental analysis

Total four versatile nanocomplexs were examined at STIC, Cochin University, for C, H, N and S. The observational condition for four compounds rubber, rubber-Aluminum oxide (2), rubber-Aluminum oxide (10) and rubber-Aluminum oxide (12 phr) were settled dependent on Carbon, Hydrogen, Nitrogen and Sulphur by emissary system. Recorded results are viewed as incredible simultaneousness with the decided characteristics. Since specific formula, the test heap of a singular reiterating part was resolved. Investigative information for four rubber-Aluminum oxide nanocomposites are displayed in Table 2.

#### 3.2. FTIR spectroscopy for SBR-aluminum oxide nanocomposites

Fig. 1 indicates FTIR spectra of distinct stacking measurements of alumina particle. In the entire spectra, the expansive top at recurrence 3400 is allocated to broaden the fluctuation of -OH gathering, extending fluctuation alongside the consume water. Peak at recurrence 1041 and 610 is a direct result of O-Al broadening fluctuation intermediary time of nanoalumina. The top at recurrence 1110 and 475 is a direct result of antisymmetric and symmetric extending of C-O gathering. The nearness of two pointed groups at recurrence run 2930 and 2840 and one top about recurrence 1455 for every spectrum of SBR matrix notwithstanding the assimilation groups compare to the fluctuation of particular utilitarian gathering. Small groups of about a recurrence scope of 2930 and 2840 are the brand gatherings of similarity and uneven extending of the broadening fluctuation of -CH<sub>2</sub> gathering, separately [18,19]. Recurrence 1450 is contrasted with bowing vibrations of -CH<sub>2</sub> gathering. Every one of these apexes is seen on the scale of SBR-matrix in Fig. 1. This is furthermore reinforced by the nearness of a crew at recurrence 1085, which is the marque set of alkenes gathering. Peak at recurrence 1600 is named to nearness of a OH gathering. Peak at recurrence 1550 is allotted to modify in the plane science of  $Al_2O_3$  nano particles. The tops at recurrence 1310 and 1185 are a direct result of nearness of regular signs of CN extending. 565 cm<sup>-1</sup> and 830 cm<sup>-1</sup> are identified with the extending fluctuation of -Al-O. 758 cm<sup>-1</sup> identifies with -Al-O-Al- expanding fluctuation. At recurrence, 1045-1028 thinks about to the extending fluctuation of the -C-C- bond. Recurrence go



**Fig. 1.** FTIR spectra of rubber-nanocompound (a) unfilled (b) 2 phr composites (c) 10 phr composites (d) 12 phr composites.

1465 is allotted to the lopsided disfigurement of  $\rm CH_3$  and the divide twisting of  $\rm CH_2.$ 

## 3.3. Raman spectroscopy for SBR-nano aluminum oxide nanocomposites

As showed by the composition, the proximity of degradation and extension of cross linking specialists, contents and other flexible factors into elastic are principle cause of light parasite banner in Raman disseminating series, especially with the beam enthusiasm outline in the unquestionable territory. Quantum return of the light technique is much higher than Raman strategy, and right now essential spectroscopic information is secured. Unquestionably perceive the brand gatherings of SBR rubber and SBRnanocomposites, the condensed versatile lacking aluminum oxide were at first picked to perform Raman spectroscopy. The spectrum of rubber and SBR-alumina composites is taken a gander at in (Fig. 2) and group coursework are done reliant on relationship with composing spectrum. The Raman apexes of rubber are simply for the most part consigned in the composition. This task permits a whole acknowledgment for which Raman examination of styrene and butadiene flexible is extraordinary bearing. Symmetric and unbalanced -CH<sub>2</sub> and -CH<sub>3</sub> broadening fluctuations commonly appear in the 2845–3058  $\text{cm}^{-1}$  area. Unmistakably, -C = C- broadening fluctuations of rubber are seen at 1666 and 1642 cm<sup>-1</sup>, exclusively. There are a couple of secured indications of SBR rubber and SBR-alumina composites which can't be used to perceive their

Table 2
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Elemental investigation information of SBR-aluminum oxide nanocomposites.

Factors	(% of C) obs. Cal.	(% of H) obs. Cal.	(% of N) obs. Cal.	(% of O) obs. Cal.	(% of S) obs. Cal.	Empirical	
						Formula	Mass
SBR	83.44	8.11	2.56	5.85	2.34	C <sub>38</sub> H <sub>44</sub> N <sub>1</sub> O <sub>2</sub> S	546.993
	(81.44)	(8.05)	(2.31)	(5.08)	(1.39)		
SBR-aluminum oxide (2 phr)	83.44	8.11	0.26	5.85	2.34	C38H44 NO2S	546.993
	(82.42)	(8.10)	(0.20)	(4.80)	(2.30)		
SBR-aluminum oxide (10 phr)	83.90	9.15	0.24	5.59	1.12	C40H52NO2S	572.667
	(82.90)	(8.15)	(0.20)	(4.59)	(1.10)		
SBR-aluminum oxide (12 phr)	80.88	9.16	1.20	6.70	2.30	$C_{40}H_{54}N_1O_4S_1$	644.935
	(79.78)	(8.15)	(0.20)	(6.20)	(1.88)		



Fig. 2. Raman spectra of SBR rubber-nanocompound (a) unfilled (b) 2 phr composites (c) 10 phr composites (d) 12 phr composites.

duties; appropriately simply the trademark tops allowing detachment will be revolved around. Raman spectrums of vacant rubber examination at different merge area are showed in Fig. 2. The results illustrate that power of Raman tops depends on the blend association. The forces of trademark signs at frequency 1002, 1302, 1602 and 3058 will when all is said in done addition with growing aluminum oxide content in SBR flexible, while the intensity of the separated brand gatherings of SBR at frequency 1371, 1128 and 496 decay. The pinnacle at range 1666 isn't liable to elastic extent and used as an inside benchmark. This association, is possible to confirm piece in the blends by scheming the force extent of brand indication of every versatile against blend extent. It could be noted that main signs at range 1371 and 1302 of - $CH_3$  strayed misshapening and =C-H- in flat mutilation for SBR elastic, independently, be picked for construct an arrangement twist. This is because these picked apexes have the top objectives and the trademark apex at range 1371 isn't secured.

#### 3.4. Mechanical properties

#### 3.4.1. Tensile study for SBR-Nano aluminum oxide nanocomposites

Increase of Aluminum oxide (Fig. 3) shows an growth of elasticity. The fixation increments, rigidity increments. Such conduct may be clarify that filler particles will occupy the area among elastic chains, in this way gave an unbending production with improved



Fig. 3. Impact of nano alumina on tensile property.

rigidity (13.2 Mpa). The estimations of rigidity appears in Table 3 [18]. Interpolate of elastic series into coatings brought about growth in rigidity. The improvement in effects occurs in light of the upper polymer nanofiller collaborations than filler-filler associations. The practical gatherings are joined into the polymer; the pressure is substantially extra proficiently moved from the polymer framework to the inert filler, bringing about a upper increment in elastic effects. The main thrust for interpolate starts from the solid hydrogen holding. An increment of tensile energy is observed for SBR rubber and aluminum oxide particles.

## 3.4.2. Elongation property for SBR-Nano aluminum oxide nanocomposites

Lengthening effect will increase by the extension of nano alumina filler as (Fig. 4). This is due to the fact of the dissemination of extremely well alumina particles during the elastic series and ropes the elastic series so upgraded enlarging which mirror on lengthening. The estimations of most intense prolongation at wreck regarded in Table 3 [18]. Fig. 4 is lengthening at ruin (%) arc of nanocompound including altering share of nano aluminum oxide. The lengthening at destroy of every structure will increase by an amplify in the bunch proportion of nanofiller. The growth at greater loading is due to the fact of the enhancement in stress of the fabric and was once possibly triggered by using the limit in flexile crystallization [19].

### 3.4.3. Tear resistance property for SBR-Nano aluminum oxide nanocomposites

This study associated to the flexile effect so tear confrontation will increase by extending measures of the nano alumina as (Fig. 5) it extensions to a most intense estimation of 6 Mpa at 12 pphr of nano alumina for undefined rationalization from lately referenced on account of versatile property that the fillers will occupy the regions between elastic series and increment the reflex linkage between them the present lead to superior tear resistance. Fig. 5 is the tear quality bends of the framework as an element of the mass level of nano aluminum oxide substance. SBR elastic crammed aluminum oxide famous a growth in tear quality, demonstrating the block provided in the SBR elastic in order to improve the break engendering and the great fortification of aluminum oxide particle. SBR isn't always crystallizable underneath excessive strain, and in this manner the strengthening fillers are by and large merged to yield satisfactorily excessive mechanical properties [19,20]. In par-

Table 3
Mechanical testing for unfilled and filled rubber-nanocomposite.

Compounds	1	2	3	4
Tensile strength	12.1	12.4	12.8	13.2
Elongation, %	460	510	515	520
Tear resistance	4.7	5.2	5.6	6
Abrasion Resistance %	20	20	15	10
Cross link density $\nu \times 10^{-4}$	2.63	3.05	3.31	3.33







Fig. 5. Impact of nano alumina on tear resistance.



Fig. 6. Impact of nano alumina on abrasion resistance.

ticular, the thinly distributed elastic coatings deflect the tear way, which accordingly concedes elevated tear protection from nanofillers.

### 3.4.4. Abrasion resistance property for SBR-Nano aluminum oxide nanocomposites

Fig. 6 exhibit that extension of alumina in rubber framework for example 2 pphr, the stack decrease of elastic is reliable and for 10 pphr, the mass decrease of elastic is reducing because of nano alumina acts as a nanofiller which now not touch by scraped area stack. 12 pphr. the load decrease of elastic is again decreasing until the point that it accomplishes 10% considering the way that nano particles will be a cutoff mass decrease. As the hardness builds scraped area misfortune, which is an extent of fortress, should decrease and this is replicated in (Fig. 6). Rubbers nanocomplex shows wonderful scraped spot property and common mechanical properties for their broad assortment of employments [21]. The broadened crosslink thickness which achieves extended stiffness and modulus finally offers climb to the overhaul of scraped spot opposition. It will in general be seen that decrease scraped spot misfortune is watched. This upgraded scraped spot opposition in the SBR-nano alumina packed composites is additionally a direct result of the greater elastic filler collaboration [19].

#### 4. Conclusions

Rubber mixes with and except aluminum oxides nano particle have been arranged effectively. For planning of elastic nano composites, mechanical mixing utilizing two-roll mill method has been chosen. Spectral properties are likewise checked. For scraped spot results ASTM D2228 computer have been utilized. Scrape area grades exhibited that the volume stacks defeats substance of SBR elastic example. Abrasion area content is greater than scraped area substance of SBR elastic stand complex. It indicted that an extension of scraped spot substance of SBR elastic examples. Additionally, with option of nano alumina to SBR elastic example, scraped area substance of tests diminished. It may be a direct result of good effect of aluminum oxide nano particle on the reflex and material properties of SBR flexible.

#### **Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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