PREPARATION AND CHARACTERIZATION OF NANO SILICA FILLED STYRENE BUTADIENE RUBBER COMPOSITE FOR AUTOMOTIVE TYRE TREADS

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Abstract

This Research focuses and investigations about the change in the tire quality and to expand the life of the tire by including nano materials in each layer of tire. It has been usually recognized that molecule scattering and interfacial cooperations are crucial in deciding a definitive execution of polymer composites. As of late all tire organizations are utilizing nanocarbon dark as nanofiller material, it is exceptionally costly than different nanofillers, consequently in this examination work, the nano silica is brought into styrene-butadiene elastic (SBR) to research the impacts of surface modification on the scattering of silica and interfacial communication of the elastic composites. Here silane...
is utilized as coupling operator, it gives great holding and
great dispensor for polymer composites. So in this explo-
ration we are utilized silane content in various parts (1,2,3,4
and 5pphr). It has been shown that unobtrusive change in
surface science of silica radically enhances its dispersibility
in elastic grid, prompting much enhanced available surfaces
and much total interfacial response. It diminishes tire wear,
moving protection and enhances wet footing. Mechanical
and Thermal properties, for example, Tensile quality, Hard-
ness test, Elongation at break and Scanning electron mag-
nifying lens (SEM), Thermo Gravimetric Analysis (TGA)
were investigated and Nano silica composites demonstrates
huge change in all viewpoints prompts applications in tire
producing forms.

**Key Words:** Styrene- Butadiene Rubber, Silica, Silane,
Nano Composite, Tyre cost Reduction, Rolling Resistance.

1 Introduction

Tyre is a complex composite consists of several types of rubbers,
fillers, reinforcing fibres, steel cords and various other ingredients
which are used in the rubber formulations and while building it.
The automotive manufacturing companies are trying to develop
better tyre performance properties such as mileage, load carrying
capacity, durability, cushioning, low rolling resistance, puncture re-
sistance etc., lead the researchers to look for various types of rein-
focing materials for tyre [1]. Because of powerless mechanical ex-
cection of normal rubbers, the fortification of elastic by lling with
different llers, for example, carbon dark and silica is fundamental
for the vast majority of viable applications. It is outstanding that
the scattering of llers and the interfacial collaborations are two es-
ential factors in deciding the nal execution of elastic composites
[2].

Abrassive wear of a milder material is because of the misfort-
une from the rubbing interface because of the sliding of harder ill
temper over it. Endeavors are consistently being put to enhance
the tribo-properties of virgin materials by creating composites by
including llers. For rough wear circumstances, as a rule, parcel of
change is accounted for by incorporation of eficient llers, for ex-
ample, nano silica, carbon dark, and so on. A composite is characterized as a mix of at least two materials with various physical and compound properties and recognizable interface. Principle focal points of composites are high particular solidness and quality, high durability, brilliant consumption protection, low thickness and warm protection.

The main objective of the present work is to study the effect of nano silica on the mechanical, thermal and properties of styrene (C6H5CH=CH2)- butadiene (CH2=CH-CH=CH2) rubber (SBR) nanocomposites (NC) and its application in calendaring reinforcement process in tyre industry to enhance functional properties of calendered fabric [4]. its being an intrinsically slower curing material compared to natural rubber. precipitated silica is the preferred type of silica used, because of the low price and better mixing of it with the rubber material. The white color of silica and their small primary particle size, give rise to a remarkably high reinforcing efficiency and it provides the highest reinforcement to rubber products. The main uses of silica are in the truck tires and treads of passenger for traction and low rolling resistance [5]. Green tires have these days a piece of the overall industry of around 30

Figure 1 Triangle of objectives

2 MATERIALS AND METHODOLOGY

Polymer nanocomposites are new class of materials possessing improved mechanical strength, thermal stability, flame retardancy and dielectric properties. Nanocomposites are the materials that are manufactured by the dispersion of nanofillers (at least one dimension in nanometers (µ100 nm) into the macroscopic materials. Nanocomposites have recently attracted significant research interest due to their improved strength and modulus, better thermal and chemical stabilities etc.
A. Classification of Polymer Nanocomposites

Depending upon the type of the matrix material, polymer nanocomposites can be classified as thermoplastic, thermoset and elastomeric nanocomposites. Thermoplastic nanocomposites: The polymers used to make thermoplastic nanocomposites include acetal, fluoropolymers, polyethylene, polypropylene, nylon, polycarbonate, polystyrene, PVC, etc. Thermoset nanocomposites: These thermosetting nanocomposites can be impregnated into fiber reinforcements such as glass, silica, quartz, carbon / graphite, aramid, polyethylene, boron or ceramic and upon curing lead to laminates or nano modified polymer matrix composites.

B. Nano fillers

Organically modified Montmorillonite (OMMT) Carbon Nanotubes Nano silica (Silicon dioxide - SiO2)

C. Nano silica

It is generally known as Aerosil. Aerosil is profoundly scattered, undefined, exceptionally unadulterated silica that is delivered by high-temperature hydrolysis of silicon tetrachloride in an oxyhydrogen gas fire. It is a white, soft powder comprising of roundly molded essential particles. The normal molecule estimate is in the scope of 7-15 nm and the particular surface territory go in the vicinity of 50 and 380 m2/g. Rather than the accelerated silica it doesn’t have an obviously characterized agglomerate size. Molecule estimate dispersions wind up more extensive and the propensity to shape agglomerates is diminished. Siloxane and silane bunches are arranged on the surface of the seethed silica particles. Silane is in charge of hydrophilic conduct, which decide the collaboration of the molecule with natural and nonorganic materials.

The surface of the particles can be easily modified by reacting the silanol group with various silanes and silazanes, resulting hydrophobic particles. The main properties of silica are high interfacial area, Excellent Reinforcement, Better thermal stability and Excellent dielectric properties, etc. The Nano silica mainly used in some areas they are to adjust the rheological properties of silicone rubber, coatings, plastics, printing inks, adhesives, lubricants. It is used as reinforcing filler in elastomers, It is used as thickening agent in adhesives and paints and it is used as anti-settling agent and a free-flow aid.
**D. Raw materials**

Figure 2 Raw materials

Styrene-butadiene rubber (SBR) 1502. Precipitated silica (specific surface area of 200 m²/g) was provided by astrra Chemicals, Chennai. SI69 Silane was received from industry. Other rubber additives, including zinc oxide (ZnO), stearic acid (Sta), N-cyclohexyl-2-benzothiazole sulfone-amide (CZ), tetra methyl thiuram disulfide (TMTD), sulfur (S) were industrial grade and used as received.

**E. Preparation of SBR Composites**

For preparation of SBR composites, SBR was first blended with silica on a two-move blender for 5 min, and afterward different added substances were included progressively. The fundamental detailing of the composites is as per the following: SBR 100 g; silica, 40 g; Silane 1 g; ZnO, 5 g; Sta, 1 g; CZ, 1.5 g; TMTD, 0.5 g; S, 1.5 g. From that point forward, the blend was aggravated for another 5 min. The came about mixes were then pressure formed into 150 x 150 mm thick sheets at 160 °C for streamlined curing time, which is controlled by a vulcameter.

**TABLE I SHOWS THE COMPOSITION OF THE RUBBER NANOCOMPOSITES RECIPE**

<table>
<thead>
<tr>
<th>Compounding ingredients</th>
<th>phr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Styrene-Butadiene Rubber 1502</td>
<td>100</td>
</tr>
<tr>
<td>Nano Silica</td>
<td>40</td>
</tr>
<tr>
<td>SI69 Silane</td>
<td>1.2-3.4-5</td>
</tr>
<tr>
<td>N-cyclohexyl-2-benzothiazole</td>
<td></td>
</tr>
<tr>
<td>sulfone-amide (CZ)</td>
<td>1.5</td>
</tr>
<tr>
<td>Zinc oxide</td>
<td>5.00</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>1.00</td>
</tr>
<tr>
<td>TMTD</td>
<td>0.50</td>
</tr>
<tr>
<td>Sulfur</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**3 EXPERIMENT**

The Nano silica was mixed with SBR under controlled condition in a lab scale Banbury mixer with rotor speed of 50 rpm and a
laboratory two roll mill at 35°C. The nanocomposites were prepared with 0, 1, 2, 3, 4, 5 Si69 Silane.

Figure 3 Banbury Mixer

The mixing was conducted in two stages and 8 h maturation time was given in between the first and second stages for getting good homogenization. SBR and the other required chemicals were weighed as per the formulation.

The mixed compound was again masticated in two roll mill for getting a good dispersion of fillers in the mix. The mixed compound rolled through a laboratory two roll mill to achieve 3mm thickness and stored for 24 h at room temperature. The vulcanization of the rubber compound was carried out in a hydraulically operated press at 160°C for 10 minutes preparing for each specimen then composite compressed into 150×150×3 mm size mould.

Figure 4 Two roll mill

A. CHARACTERISATION

Rubber properties such as compound mooney viscosity as per ASTM D 1646 and cure characteristics as per ASTM D7271 were studied for the green compound to determine the cure indices. Mechanical properties of the prepared SBR-SILICA nanocomposites such as tensile strength and percentage elongation at break as per ASTM D-412, and hardness as per ASTM D 2240 were investigated. Thermo gravimetric analysis was conducted to study the
thermal stability of the SBR-SILICA nanocomposites. A high resolution scanning electron microscope (HRSEM FEI Quanta FEG 200) was used to examine the morphology of the fractured surface of the nanocomposite and Thermogravimetric analysis (TGA) was conducted on a TGA Q50 thermogravimetric analyzer at a heating rate of 10°C/min under a nitrogen atmosphere.

4 RESULTS AND DISCUSSION

A. Morphological Studies
Morphological study is a method for investigating the structure, geometry, polarity and molecular orientation of polymeric materials. In this study, scanning electron microscopy is used to investigate the dispersion of nanofillers in the polymeric matrix material.

Scanning Electron Microscopy (SEM)
In scanning electron microscopy, pictures of the example are delivered by examining it with an engaged light emission which is thermionically radiated from the electron firearm fitted with a tungsten fiber cathode. The electron is filtered in a raster check design. The electrons connect with the particles in the example, delivering different signs that is distinguished and contain the data about the examples surface geology. Surface morphology of the nanocomposites was examined by utilizing Scanning electron microscopy (FEI Quanta FEG 200-High Resolution Scanning Electron Microscope) worked at 30 kV from the cracked surface of the ductile examples. The example surfaces were gold-covered by sputtering before SEM examination to maintain a strategic distance from electro static charging during examination.

Figure 5 SEM micrograph of 5phr silne Silica-SBR composite

scanning electron microscopy (SEM) investigation was improved the situation guaranteeing the nature of scattering of silica nano filler in the lattice. Mechanical examinations demonstrated 5phr
silane based SBR nanocomposite is the best hopeful. Consequently SBR-Silica 5 phr silane nanocomposite was subjected to SEM examination and the particular micrographs watched are appeared in Figure 5. The SEM micrographs unmistakably demonstrated an intercalated structure, homogeneously scattered into the rubber matrix.

**B. Measurement of Mechanical Properties**

The effect of nanosilica content on the mechanical properties, for example, rigidity and extension at break of styrene butadiene elastic based nanocomposites was examined and the outcomes are exhibited in Gragh 1 and 2 separately. Silica is outstanding fortifying filler for SBR because of the nearness of solid filler elastic associations. Elasticity of SBR - nanosilica nanocomposites was observed to be expanded by the expansion of 5phr of silane. Rate extension at break was observed to be expanded up at stacking of 5phr silane to the nanocomposite. The qualities for rate extension were diminished as the level of silane content expanding. This might be a direct result of the more filler - filler association. The impact of nanosilica content on hardness of SBR - nanocomposites is appeared in Gragh 3. With expanding silane content, the typical pattern of expanding hardness has been taken note.

GRAPH 1 Effect of Nano silica content on tensile strength of SBR nanocomposites

**Elongation Test:**

\[
\text{Elongation} = \left( \frac{(L - L_0) \times 100}{L_0} \right)
\]

$L$ - Observed distance between the benchmarks on the stretched specimen. $L_0$ - Original distance between the benchmark before stretching.
GRAPH II Effect of Silane content on % elongation at break of SBR-Nanocomposite

**Hardness Tests:** Hardness test measures the resistance of the material to a small rigid object pressed onto the surface at certain force. Hardness of the samples were checked as per ASTM D-2240 using Hardness (Shore A).

GRAPH III Effect of Silane content on hardness of SBR-nanocomposites

**C. Measurement of Thermal Analysis**

Thermo gravimetric Analysis (TGA): Thermo gravimetry measures changes in the mass of an example that happen when it is dynamically warmed at steady rate. These progressions identify with the response amid deterioration, the loss of unstable material and the responses with the encompassing air. The segments of polymer volatilize at various temperature, this prompts a progression of weight reduction steps that enable the part to be quantitatively estimated. TGA inspects the mass changes as an element of temperature in the examining mode. Tests were checked from 0 - 800 C. Changes in the example weight were recorded electronically by change in voltage yield from a direct factor differential transformer.
GRAPH IV Thermo Gravimetric Analysis

TGA was conducted on Nano silica-SBR composite to assess the uniting content. The composite withstand the temperature upto 362.49°C, after starting there radically weight lossed up to 549°C, it was because of the arrival of physically adsorbed water, and the drying out of silanol gatherings. At the temperature lower than 362.49°C, the weight reduction started from the arrival of water is diminished. This is sensible as the silane builds the hydrophobicity of silica and thus obstructs the retention of water.

5 CONCLUSION

In literature all were tried to disperse silica, as well as trying to used silica as nano filler it was very difficulty so they are using carbon black as nano filler in automobile tyres. In this work the Nano silica is introduced into styrene- butadiene rubber (SBR) to investigate the effects of surface modification on the dispersion of silica and interfacial interaction of the rubber composites. Here we were increased silane content 1 to 5phr it gives better Mechanical properties compared with literature but elongation going to decrease. This is due to the diffusion of very fine nano silica through the rubber chains and support the rubber chains so enhanced stretching which reflect on elongation. So if we use nano silica below 40phr then it will give good mechanical properties and good dispersion. It has been leading to much improved accessible surfaces and much complete interfacial reaction. It reduces tyre wear, tyre cost, rolling resistance and increases wet traction.
References


