International Journal of Trend in Research and Development, Volume 3(3), ISSN: 2394-9333
www.ijtrd.com

# Mechanical & Tribological Properties of Artificial Rubber (SBR) By Adding $SiO_2$ & Sea Sand Nanoparticles

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**Abstract--** The aim of this research is to study the effect of nano silica and sea sand which use as a filler with loading level (1, 1.5, 2 pphr) on mechanical properties as well as Tribological properties of SBR such as Tensile strength, elastic modulus, hardness, elongation, and wear resistance. The results show that on addition of small quantities of nano silica and nano sea sand an increase of mechanical properties as well as tribological properties.

***Keywords:*** *Artificial Rubber, SiO2, Sea Sand*

## I. INTRODUCTION

Nanotechnology is regarded as the most revolutionary technology of the 21st century. It can be used in many fields and ushers material science into a new era. The size of Nanoparticles is mostly in the range of 2–120 nm. In recent years, the application of inorganic Nanoparticles as additives has been receiving considerable attention today; many methods have been used for the preparation of metal Nanoparticles, such as metal vapor deposition, chemical reduction and thermal decomposition. Nano composites are composites in which at least one of the phases shows dimensions in the Nanometre range (1 nm = $10^{-9}$ m).

In the rubber industry, the tires industry consumes almost 70% of the total styrene butadiene rubber (SBR) production, since SBR has suitable properties of very good ageing resistance low temperature properties and good abrasion resistance. Styrene-butadiene rubber is a copolymer of styrene ($C_6H_5CH=CH_2$) and butadiene ($CH_2=CH-CH=CH_2$), with a Tg of approximately -55℃. SBR usually incorporates accelerators in its compounding formulations, its being an intrinsically slower curing material compared to natural rubber[1].

The word tribology was first reported in a landmark report by scientist Sir Jost in 1966. The word is derived from the Greek word tribos meaning rubbing, so the literal translation would be "the science of rubbing."' Its popular English language equivalent is friction and wear or lubrication science, alternatively used. The latter term is hardly all-inclusive. Dictionaries define tribology as the science and technology of interacting surfaces in relative motion and of related subjects and practices. In most of the cases, the friction is considered as a negative side effect concerning energy loss following every process of the power transmission. However, the friction has significant positive side effects, because it is an indispensable prerequisite for the movement of people, machines, transportation means and others. Efficiency of these movements mostly depends on the friction between rubber and different materials such as metals, concrete, earth, wood, plastic, etc.[6]

### *A. Objective of the Experiment:*

1. To improve the Mechanical properties Rubber.
2. To improve the Tribological properties of Rubber.
3. To increase the reliability of Rubber.
4. To reduce maintenance requirements and longer service intervals.

## II. EXPERIMENTAL PART

### *A. Materials*

The rubber batch materials consist of silica of 1 pphr, and sea sand of 1.5 and 2 pphr. Styrene –Butadiene Rubber (SBR 1712 and SBR 1502), Reclaim rubber, zinc oxide, stearic acid, paraffin wax, TDQ, Acinox ZC, DOP oil, sulfur, Carbon black (N 375), N-cyclohexyl-2-benzothiazole sulfonamide (CBS), which supplied by Rayat Plantations Pvt. Ltd, company.

### *B. Preparation Method*

The steps of processing recipe master batch with different mixing time are:

1. Passing of (SBR 1502- SBR 1712) rubber between the two rolls for several times with decreasing the distance between the two rolls to the extent of (0.5-1) mm at temperature of laboratory.
2. Adding reclaim rubber to them, and banding for 2 minute.
3. During the process, rubber pieces are passing between rollers in horizontal and vertical state alternatively for several times for obtaining homogenous materials
4. Add the zinc oxide and repeat mixing for 3 minute, then addition of stearic acid.
5. Addition the carbon black and DOP oil alternatively and repeat mixing for 5 minutes.
6. Addition of accelerator CBS and repeat mixing for 4 minute, then addition of antioxidant.
7. Finally, adding the sulphur, TDQ, And Acinox ZC with pre-blending.
8. The mixing process continues for more time in order to get a good homogenization and decrease mill opening to (0.5-1 mm) for increasing the homogenously and the efficiency of mixing.

Table 1: Formula for Preparation of Rubber.

| CONTENT | PPHR | WEIGHT(Kg) |
|---|---|---|
| STYRENE BUTADINE RUBBER 1502 | 20 | 0.8 |
| STYRENE BUTADINE RUBBER 1712 | 80 | 3.2 |
| RECLAIM RUBBER | 4 | 0.16 |
| ZINC OXIDE | 1.5 | 0.06 |
| STEARIC ACID | 1 | 0.04 |
| PARAFFINE WAX | 1 | 0.04 |

| | | |
|---|---|---|
| TDQ | 0.5 | 0.02 |
| ACINOX ZC | 1 | 0.04 |
| DOP | 8.5 | 0.34 |
| SULPHUR | 1.75 | 0.07 |
| CARBON BLACK N-375 | 60 | 2.4 |
| CBS | 1 | 0.04 |

### *C. Rubber Samples with Variation in Nano Particles*

0 - Base Rubber
I - Silica [ 1 pphr ]
II - Sea Sand [ 1.5 pphr ]
III - Sea Sand [2 pphr]

Table 2: Weight of different nanoparticles in kilograms.

| Nano Particles | I | II | III |
|---|---|---|---|
| Silica 1 pphr | 0.0084 kg | | |
| Sea Sand 1.5 pphr | | 0.0125 kg | |
| Sea Sand 2 pphr | | | 0.168 |

## III. CHARACTERIZATION AND TESTING

### *A. Mechanical Tests*

To examine tensile and elongation at break and modulus of elasticity properties use a tensile Test Machine according to the ASTM D412. It consisting of two jaws, one fixed and the other moving quickly 500mm / min. All Tests are taken two times that is for before aging and after aging. [Stored rubber samples for 24 hours at 150 degree Celsius in Furnace.]

### *B. Hardness Test*

The test for hardness samples carried on according the ASTM D 2240 by using a device (Shore A hardness), and calculated the average value of hardness.

### *C. Wear Test (Tribological Test)*

To examine wear of different rubber samples use a Pin on Disc type of Tribometre. This machine is primarily intended for determining the tribological characteristics of wide range of materials under conditions of various normal loads & temperatures (optional). A stationary rubber pin mounted on a pin holder is brought into contact against a rotating disc at a specified speed as the pin is sliding, resulting frictional force acting between the pin and disc are measured by arresting the deflecting pin holder against a load cell. Both normal load and speed can be set as desired.

## IV. RESULTS AND DISCUSSIONS

### *A. Mechanical Tests Results*

The detailed description of Mechanical tests briefly discussed below

### *a. Tensile Strength*

The below figure 1 shows addition of small quantity of Nano particles shows an increase of the tensile strength. Such behaviour can be explain that in case of small quantities, particles will be fill the spaces between rubber chains, thus gave a rigid structure with better tensile strength(134.19 Kg/sq. cm).

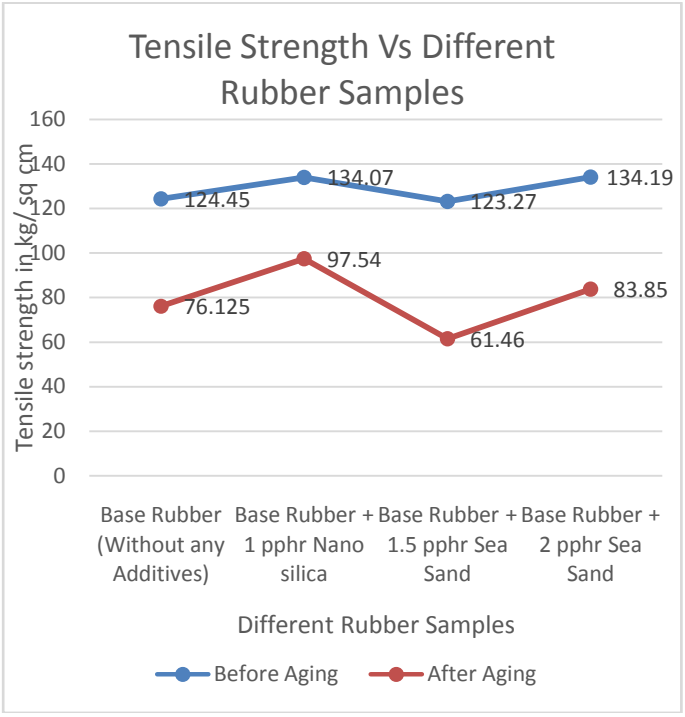


Figure 1: Comparison of Tensile Strength vs. Different Samples

Blue line represents the tensile strength of rubber samples before aging. Rubber with 2 pphr Nano sea sand shows maximum tensile strength of 134.19 Kg/ sq. cm. Red line represents the tensile strength of rubber samples after aging. Rubber samples with 1 pphr Nano silica shows maximum tensile strength of 97.54 Kg/sq. cm.

### b. Hardness test

In Figure 2 shows hardness property increases with small quantities of the Nano silica. it reach to the maximum resists value 67 BHN for before aging and 77 BHN for after aging at 2 pphr of sea sand due to silica act as filler that it strengthen the recipe and makes it resistance the applied forces, which gives high hardness value and this agreed with the increase in modulus of elasticity. In general hardness increases, even at high amounts of Nanoparticles.

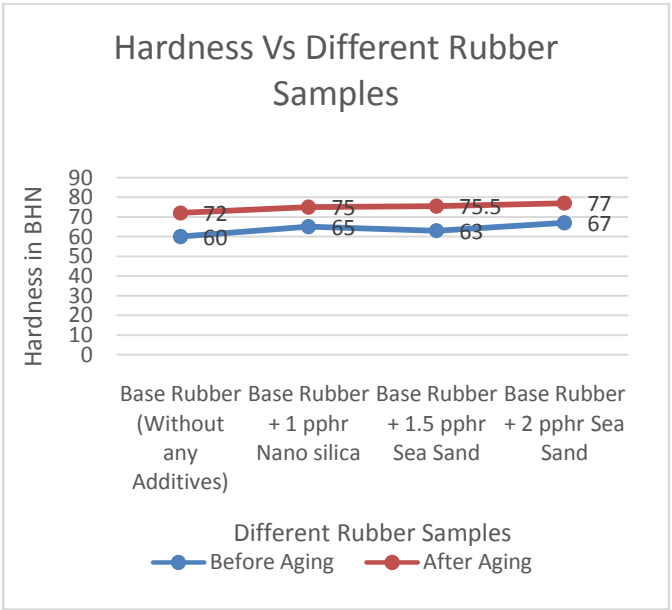


Figure 2: Comparison of Hardness Value vs. Different Samples.

***c. Elongation Test***

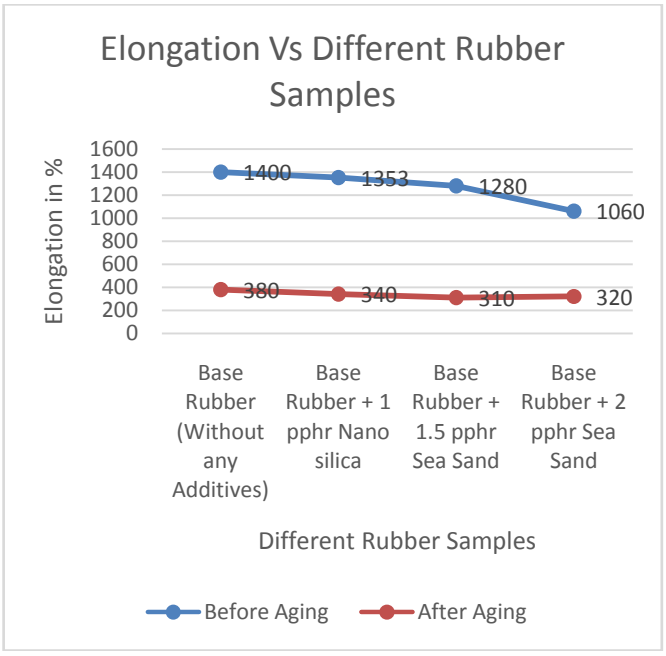


Figure 3: Comparison of Elongation vs Different Samples.

The above fig 4.1.3 shows the elongation property decreases with the addition of small quantities of Nano silica present in the sea sand, because the rubber is highly stretching so that when very fine particles fill the spaces, it will be restrict the movement of chains and then decrease elongation property.

***d. Modulus Test***

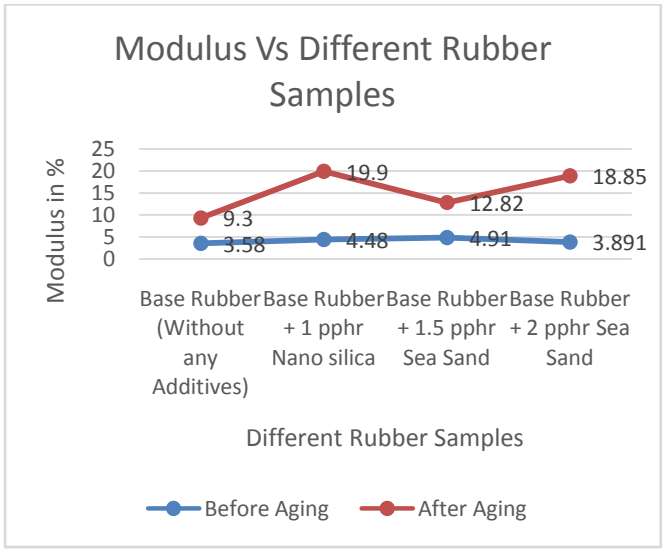


Figure 4: Comparison of Modulus Vs Different Samples.

As the inversely proportional of elastic modulus to the elongation property, Figure 4 shows an increase in the modulus of elasticity with small amounts of the Nano silica and sea sand of 1 pphr for after aging condition. Due to the fineness of particles makes it easy to distribute between rubber chains, so increase the modulus of elasticity.

***e. Wear Tests***

The Following Figure 5 shows the comparison of wear of different rubber samples, for 0.3 kg of load and 0.5 kg of load.

In Figure 5 blue line shows the wear of four different rubber samples that is base rubber, 1 pphr Silica Nanoparticles added rubber, 2 pphr sea sand Nanoparticles added rubber and last is 1.5 pphr sea sand Nanoparticle added rubber sample for 0.3 kg of load. The first sample of base rubber showed maximum wear as compared to other rubber was 95 for 0.3 kg of load. Second rubber sample of 1 pphr Nano silica showed lowest wear among the all was 25 micrometre. The third sample of 2 pphr of sea sand showed 46 micrometre of wear, and last sample of 1.5 pphr of sea sand showed 65 micrometre of wear for 0.3 kg of load on it.

In Figure 5 red line shows the wear of four different rubber samples that is base rubber, 1 pphr Silica Nanoparticles added rubber, 2 pphr sea sand Nanoparticles added rubber and last is 1.5 pphr sea sand Nanoparticle added rubber sample for 0.5 kg of load. The first sample of base rubber showed maximum wear as compared to other rubber was 118 for 0.5 kg of load. Second rubber sample of 1 pphr Nano silica showed lowest wear among the all was 42 micrometre. The third sample of 2 pphr of sea sand showed 61 micrometre of wear, and last sample of 1.5 pphr of sea sand showed 81 micrometre of wear for 0.5 kg of load on it.

At the end below figure, two line shows that wear occurred in the base rubber sample is maximum among all four samples and the wear occurred in the rubber sample with 1 pphr Nano silica is minimum among all four samples.

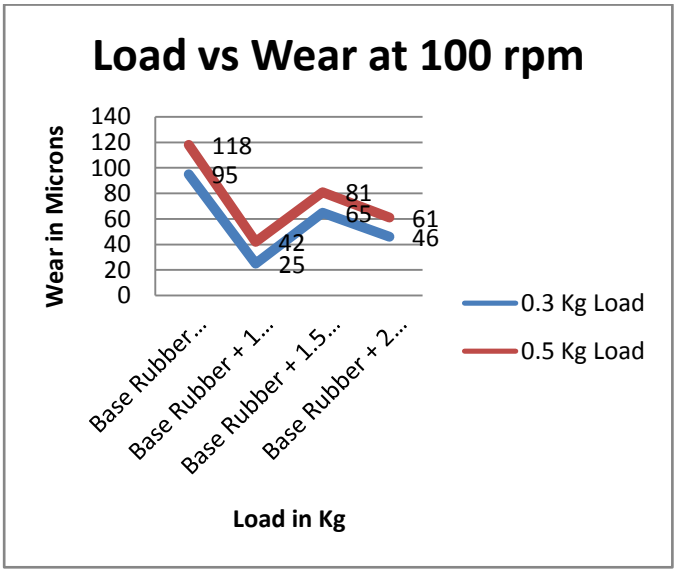


Figure 5: Graph of Load vs Wear.

## CONCLUSION

On addition of Small quantities of Nano silica and sea sand are improved the mechanical properties comparing with high quantities this is due to the fact that silica at low concentration act as a filler to fill the spaces in the recipe of SBR composite. At high quantities, Nano-particles acts as micro-particles and aggregate between chains with irregular distribution in rubber matrix, so that reduce the properties. At 1 pphr of Nano-silica and 2 pphr of sea sand which give better tensile strength, Hardness Modulus, Elongation and Minimum Wear give 134.19 Kg/sq. cm, 67 BHN for before aging and 77 BHN for after aging, 19.9 Kg/sq. cm, 1060% and 25 micrometre respectively. Any addition percent of Nano-silica, result in increasing hardness. The elongation property decreases with the addition of small quantities of Nano silica this is due to the diffusion of very fine Nano silica through the rubber chains and support the rubber bond so enhanced stretching.

The base rubber sample pin gives the maximum wear as shown in the figure. It shows 95 micrometre wear for 0.3 kg load and 118 micrometre wear for 0.5 kg load.

The Rubber sample pin with 1 pphr Nano silica gives less wear as compared to base rubber as shown in figure. It gives 25 micrometre wear for 0.3 kg load and 42.5 micrometre wear for 0.5 kg load.

The Rubber sample pin with 2 pphr sea sand gives less wear than the base rubber as shown in the figure. It gives 46 micrometre wear for 0.3 kg load and 61 micrometre wear for 0.5 kg load.

The Rubber sample pin with 1.5 pphr sea sand gives also less wear than the Base rubber as shown in the figure. It gives 65 micrometre wear for 0.30 kg load and 83 micrometre wear for 0.5 kg load

At 2 pphr of Nano-sea sand is which give better tensile strength, wear resistance, Hardness, elongation, Modulus property as the cost of sea sand is very low as compared to Nano particles of silica.

### *References*

[1] "Effect of Nano silica on the mechanical properties of Styrene-butadiene rubber (SBR) composite"; Jaleel Kareem Ahmed, Mohammed H. Al-maamori, Hajir Mohammed Ali; Vol. 4, No. 2-1, 2015, pp. 15-20. doi: 10.11648/j.ijmsa.s.2015040201.14;2015.

[2] "Rubber composite fibers containing silver Nanoparticles prepared by electrospinning and in-situ chemical crosslinking";Q. Hu1, H. Wu, L. Zhang, H. Fong, M. Tian; Vol.6, No.4 (2012) 258–265;2011.

[3] "The overall effect of reactive rubber Nanoparticles and Nano clay on the mechanical properties of epoxy resin";Mona A. Ahmed , Usama F. Kandil , Neviene O. Shaker, Ahmed I. Hashem; June 2015.

[4] "Modification of carbidic austempered ductile iron with Nano ceria for improved mechanical properties and abrasive wear resistance" Xiaoguang Sun, You Wang, D.Y.Li, GuodongWanga; Dec. 2012.

[5] "The Mechanical Properties of Epoxy Composites Filled with Rubbery Copolymer Grafted SiO2"; Jianing Gao, Junting Li, Brian C. Benicewicz , Su Zhao, Henrik Hillborg and Linda S. Schadler; Jan 2012.

[6] "Bharat Bhushan "Principle and application of tribology" A wiley-Interscience Publication (1999) ISBN 0-471-59407-5

[7] "Nano particles in Automobile Tires"; Dr. Giftson Felix,Dr. G.SivaKumar; e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 4 Ver. I;Jul- Aug. 2014.

[8] "Tyre damage: Causes and avoidance"; www.continental-tires.com; Car tyres 2014.

[9] "A Review on Nanoparticles: Their Synthesis and Types", Saba Hasan,2015.

[10] "Epoxy Layered Silicate Nanocomposites", Becker O., Simon G.P.; AdvPolymSci, 179: 29–82, 2005.

[11] "Improving the dispersion of Nanofillers in silicone polymers by surface treatment", Ramirez I., Jayaram S., Cherney E. A., and Gauthier M.;Proceedings of the ESA Annual Meeting on Electrostatics, West Lafayette, Indiana, USA,2007.

[12] "Rubber Nanocomposites: preparation, properties, and applications", Thomas S., Stephen R.; ISBN 978-0-470-82345-3, India, 2010.

[13] "Mechanical behavior of particle filled elastomers" Jorgen S. B., Mary C. B.;Rubber Chem. Technol., Vol. 72, pp. 633–656, 1999.

[14] "Rubber Technology: Past, Present, Future", Bellanderet M., Kari L., Persson S. and Stenberg U., Annual Transactions of the Nordic Rheology Society, Vol. 14, 2006.

[15] "Occurrence, behavior and effects of Nanoparticles in the environment";Bernd Nowack , Thomas D. Bucheli ;June 2007.

[16] "Science and technology of rubber"; Mark J. E., Erman B., Eirich F.R.;Third Edition, 2005.

[17] "Rubbery Materials and their Compounds"; Brydson, J.A.; London and New York: Elsevier Applied Science. 1988.

[18] "Rubber Nanocomposites: preparation, properties, and applications"; Thomas S., Stephen R. ;ISBN 978-0-470-82345-3, India, 2010.

[19] "Advances in Polymer Science"; Heinrich G.; Advanced Rubber Composites, 239, DOI 10.1007/978-3-642-19504-4, Springer-Verlag Berlin Heidelberg, New York, 2011.

[20] "Amorphous Silica"; Waddell W.H., Evans L.R.;Encyclopedia of Chemical Technology, Wiley online library;2000.

[21] "Mechanical and tribological properties of natural rubber reinforced with carbon blacks and Al2O3 Nanoparticles"; Ji-Fang Fu,Wen-Qi Yu, Xing Dong, Li-Y Chen, Hai-Sen Jia, Li-Yi Shi, Qing-Dong Zhong ,Wei Deng; Jan. 2013.