The Iraqi Journal For Mechanical And Material Engineering, Vol.12, No.3, 2012

STUDY THE EFFECT OF MOLYBDENUM TRI-OXIDE AS FILLER ON PROPERTIES OF SBR

Abeer. A. Abed

Babylon University, College of Materials Eng.

Abstract:

In the current research (which is done in the laboratories of Babylon Tires Factory), Studying the effect of molybdenum trioxide upon the characteristics of curing system of styrene- Butadiene rubber (SBR) has been carried out by using Oscillating Disk Rehometer according to the ASTM D-2084 specification. The Results showed that the effect of addition (Molybdenum trioxide) to styrene butadiene rubber in proportions of (0, 7.5,15,22, and 28) phr (per hundred percent). Molybdenum tri-oxide uses to enhance the hardness, the tensile strength and Reometric properties of the rubber. The result showed that the cure time and scorch time decreased when torsion stress and filler content increased also the tensile strength and hardness advanced with the filler content increased. The hardness developed significantly from (62) to (68) shore (A) when molybdenum trioxide added therefore the rebound and elongation decreased.

الخلاصة:

تم اجراء هذا البحث في معمل الاطارات .تم دراسة تاثير ثلاثي اوكسيد الموليبنيوم على خواص الانضاج لمطاط (SBR) وذلك باستخدام Reometric oscillating disk وطبقا للمواصفة العالمية D2084 ASTM اظهرت النتائج تاثيراضافة ثلاثي اوكسيد الموليبدنيوم لمطاط (SBR) وبنسب (صفر, 7.5 , 15, 22, 28) %.

استخدام ثلاثي اوكسيد الموليبدنيوم يحسن الصلادة و مقاومة الشد و خواص الانسياب للمطاط .

حيث اضهرت النتائج ان زمن النضج و زمن الحرق يقل مع زيادة كل من مادة التقوية و عزم الالتواء وكذلك

1. Introduction :

There are significant quantities of mineral filler used in rubber compound. These include both natural and synthetic filler like silica, calcium carbonate and mica. Molybdenum tri-oxide is a recent addition to the family of inorganic filler. Molybdenum tri-oxide improves the efficiency of friction lining. According to Nakajima and Kudo the brake disc temperature increase during breaking the heat energy is first borne by the two contact surfaces of the brake namely the brake distance and the brake pad [1].

molybdenum tri-oxide was used to prevent the cracking of friction lining under high temperature conditions and it has a relatively high melting point of approximately 800C^{o} [2], Also inherent physicochemical properties which differ from those of their respective bulk phases and an isotropic morphologies facilitate functionalization and self-assembly processes of material with regard to potential applications of functional Nano device, besides carbon nanotubes. Molybdenum trioxide is an active component in supported catalysts, chemical sensors and cathode of rechargeable ion batteries. .

Green, anisotropic uniform single crystal molybdenum trioxide filler was used as reinforcing effect, reduced cost, reduce shrinkage during molding and increase dimension stability. Green molybdenum trioxide has inherent physicochemical properties, and there anisotropic morphology facilitate functionalization therefore its used in potential application [3- 5].

Styrene Butadiene rubber (SBR) is a copolymers produced from butadiene and styrene like natural rubber the molecular chains are cross linked by Vulcanization sulfur and reinforced with carbon black .SBR is cheaper than natural rubber and is widely used as synthetic substitute for it. SBR has good wear and weather and good tensile properties.it has poor resistance to fuel and poor tear resistance. SBR used in the manufacturing of tires, hose, pipes, conveyor belts and cable insulation .Table (1) give the properties of SBR. [6- 8].

Fillers are used to alter the properties of the rubber therefore it makes sense to first look briefly at the performance of the unfilled polymers. So that the material with suitable properties, improve processing, lowest price, provide reinforcement and strength enhancement to the rubber.[7and 9]

Table (1) the properties of SBR.

Property	value
Tensile strength	24 MPa
Percentage elongation	600
Glass temperature	-58^{o}C
Service temperature	(-50-80) ^{o}C
Resistance to oil and gas	Poor
Resilience	Good

2. Experimental work (Preparations)

Firstly, during the mastication process the mixing and homogenizing all constituents which used with the rubber in order to prepare the recipe by using laboratory mill, and the ingredients used with rubber were shown in Table (2).

Table (2) Formulation for Rubber Compounding

Materials	**Amounts(phr)**
SBR	100
ZNO	1.5
Stearic acid (SA)	1
Anti-oxidant	1
Medoplast oil	8
Wax	1
Sulfur	1
Accelerator	1
Carbon black	62.5
Reclaim	12

Then the sequence below is followed for preparation:

1. The molybdenum tri-oxide particles were sieved by using sieves. it was found that molybdenum tri-oxide is (0.004) mm in average particle size the rubber passed rubber between mill rollers at 70^{o}C, then the rubber recipe had been cooled to room temperature, finally the sulfur and accelerator MBS had been used.
2. Samples tested: The samples were tested according to ASTM D-2084 by using device in which there is oscillating disk oscillate in (1.6 Hz) and with constant capacity (1.3 degree) around the center point which form shear strain on the tested samples . The torque required to oscillate the disk proportion with young modules therefor the device gives indicates about curing characteristics. [10]
3. For measuring hardness and resilience the samples had been prepared by preheating dies up to 100^{o}C with dimensions for the die equal to (180 ×200 ×6.5 mm), next the die is filled with rubber recipe and put under hydrostatic compaction, then the recipe had been pressed under 500 psi and 160^{o}C for 15 min to complete the vulcanization, after that the samples had been cooled for (10-15 hr) and finally they were ready to be tested according to the ASTM-D 2240 (shore A hardness).
4. ASTM-D 3182 and D-13192 standards had been followed to prepare the samples of tensile strength and elongation respectively. First the die is heated and filled with rubber recipe, next it is pressed under 500 psi with 145^{o}C for 45 min, then after the completion of vulcanization we had extracted the slices and let them to cool for 12 hr in order to be tested.[11]

3. Results and discussion:

3.1 Rheometric properties:

Table (2) shows the rheometric parameters obtained for the SBR formulations without Molybdenum trioxide, with 7.5, 22 and 28 phr of molybdenum trioxide as filler. The curing system studied at a temperature of 175°C. The minimum torque (34 N.m), which is proportional to the viscosity of the uncured compound, increases by the addition of the filler; the treatment of the latter increases even more the viscosity of the system. The viscosity increased with crosslink increase during the treatment of vulcanization by using sulfur. On the other hand, the maximum elastic torque (36.18

N.m) values increase with the presence of the molybdenum trioxide as shown in figure (1); nonetheless, the rise in this parameter for the formulations with the treated filler is less significant. In general, the no presence of fillers restricts deformation, and consequently, the compound becomes harder and stiffer thereby increasing the torque of vulcanizes.

Scorch time decreases gradually when molybdenum trioxide content as shown in figure(2) that's due to molybdenum trioxide affect in hydrothermal process (temperature, time, concentration and retaining high acidity) therefore the composites without filler show higher scorch time and curing time due to the rise in the porosity. By adding the filler the interaction between the molecules increase and the curing reaction facilitates by filler content increase so that the manufacturing process being faster. Similar development was indicated by Ming Tian, Lijun Cheng and Liqun Zhang the bonding properties established by using febrile silicate due to the good dispersion of that filler material therefore the torque and curing characteristic developed.[12]

Table (2) rheometric properties

Torsion stress(Ib.in)	Scorch time (min)	Vulcanization time(min)	phr	Sample number
34	1.32	2.81	0	1
31.6	1.17	2.69	7.5	2
31.8	1.19	2.76	15	3
34.07	1.18	2.79	22	4
36.18	1.08	2.49	28	5

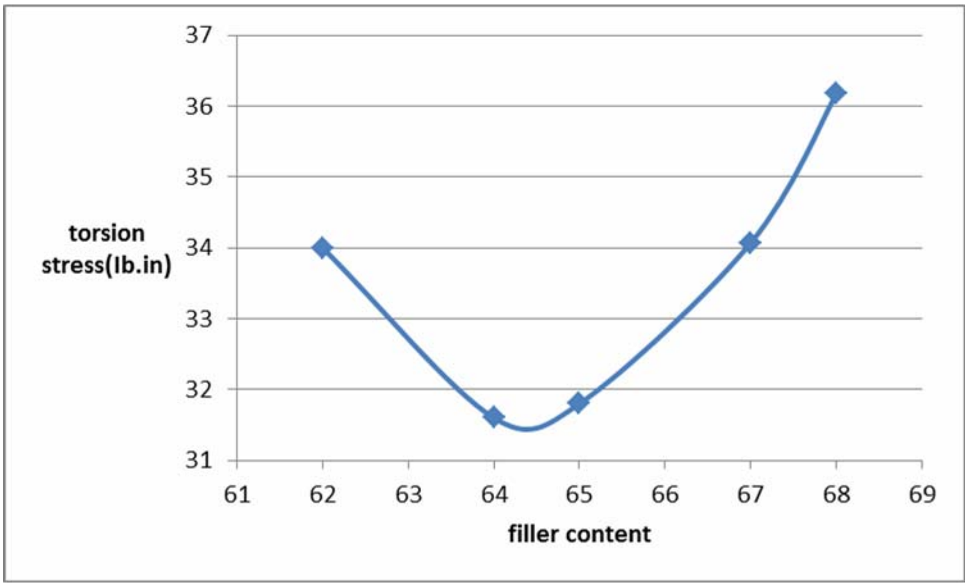

Figure (1) the effect of filler content on the torsion stress

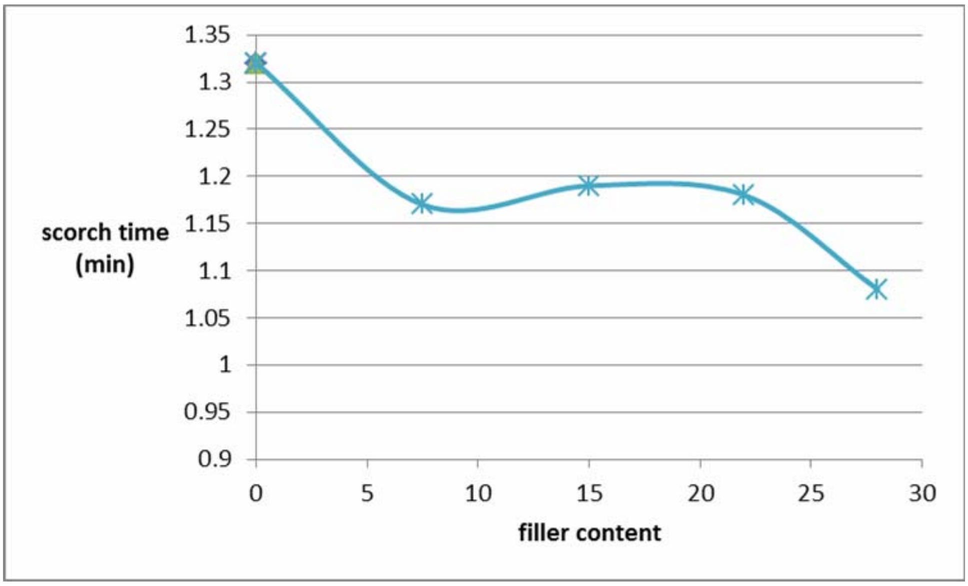

Figure (2) the effect of filler content on the scorch time

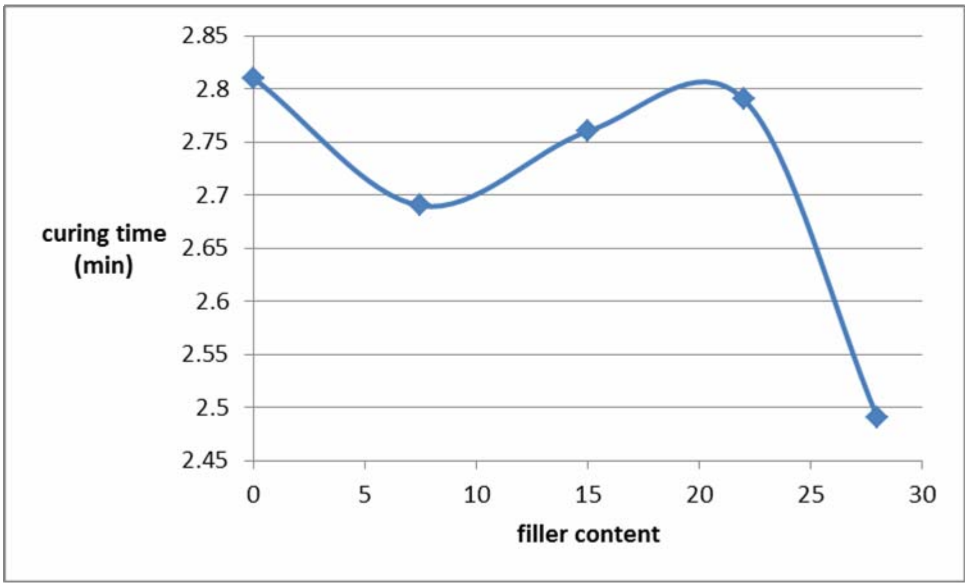

Figure (3) the effect of filler content on the curing time

3.2 Mechanical properties:

Table (3) represents the mechanical properties of vulcanizes (formulations without molybdenum trioxide, with 7.5, 15, 22, and 28 phr of molybdenum trioxide). The hardness of the samples increases with the increase of the ratio of the filler as shown in figure (4). Table (3) shows the hardness and the rebound of the samples (1-5). The hardness increases when the filler ratio increases due to the density increase. Molybdenum trioxide has (0.004) micron in average particle size therefore it is filling the spaces in the structure due to that small size and the hardness increased.

The reason behind that is the high hardness of the fillers because the high filler ratios lead to increase the penetration between the molecules due to the anisotropic structure of molybdenum trioxide also due to the high filler volume fraction (reclaim and molybdenum trioxide)

Table (4) Mechanical properties

Elongation	Rebound	Tensile strength(MPa)	Hardness Shore A	phr	Sample number
296	55	13.7	62	0	1
358	44.4	15.2	64	7.5	2
328	38.3	13.3	65	15	3
313	36.2	14	67	22	4
310	33.4	14.2	68	28	5

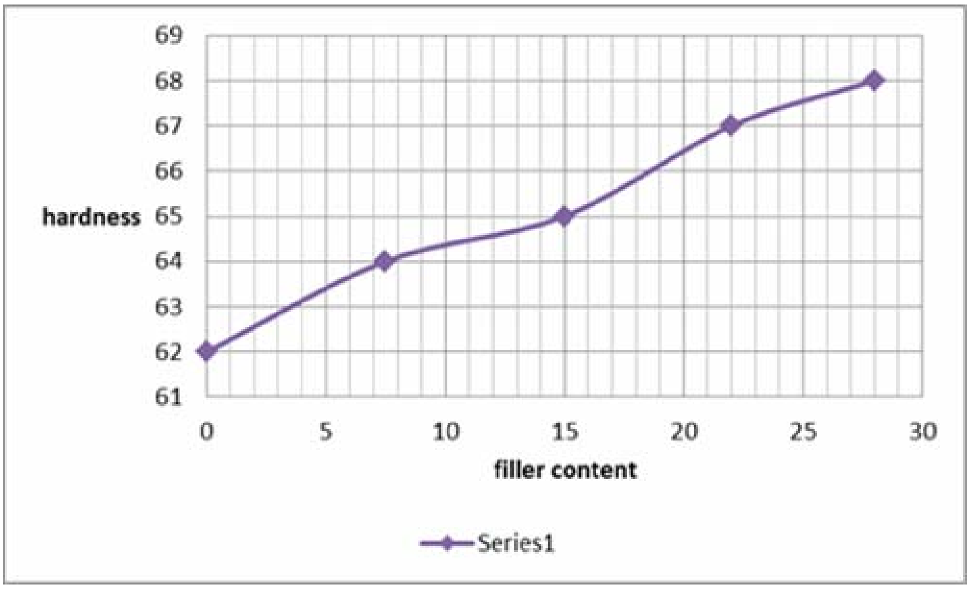

Figure (4) the effect of filler content on the hardness

When molybdenum trioxide content increase the rebound decreased because higher percentage of filler may lead less widely distributed particles which in turn reduce the inter particles distance and decreased the homogenous structure of the composite material .

The impact resistance usually suffers when anisotropic fillers are used because the sharp edges act as stress concentrators during the long axis of the anisotropic crystal therefor the rebound decreased as shown in figure (5).

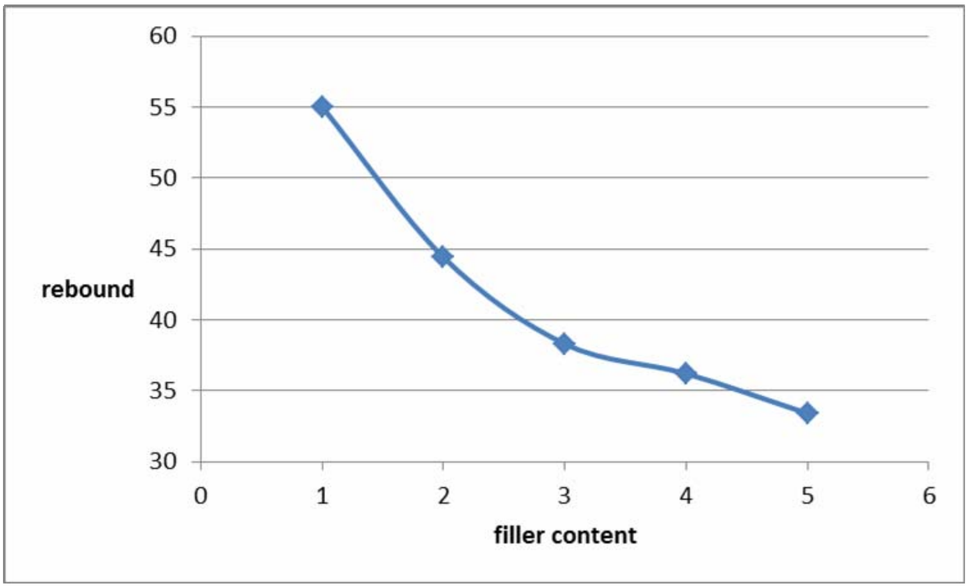

Figure (5) the effect of filler content on the rebound

The elongation increase with filler content increase from (296-358) as shown in figure (6) that is due to the reasonable filler content which let the rubber molecules slipped above each other, after adding more filler the material be stiffer and harder due to that the filler particles hinder the chains movement and the filler particles grouped and the material be less homogenous so the elongation decreased.

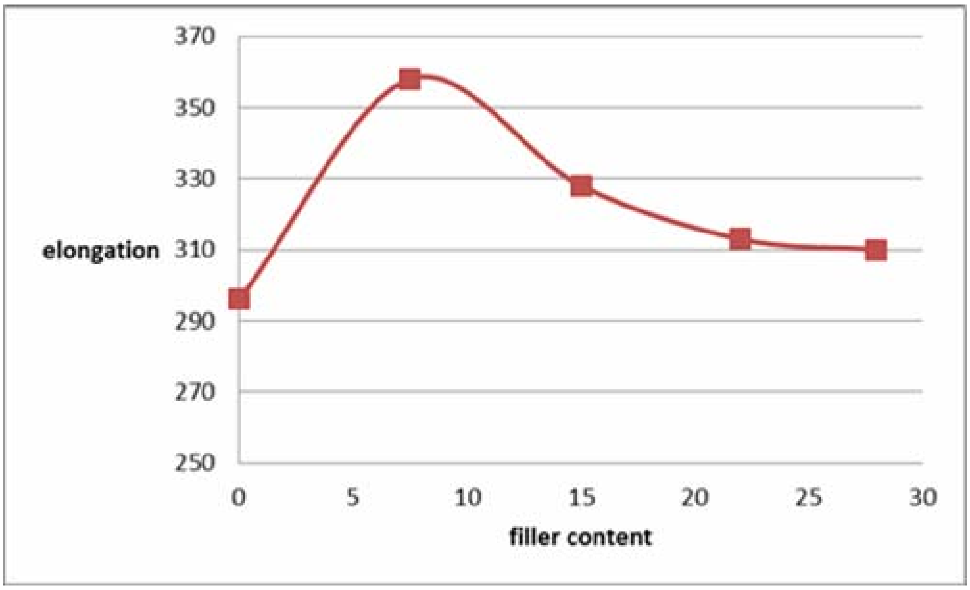

Figure (6) the effect of filler content on the elongation

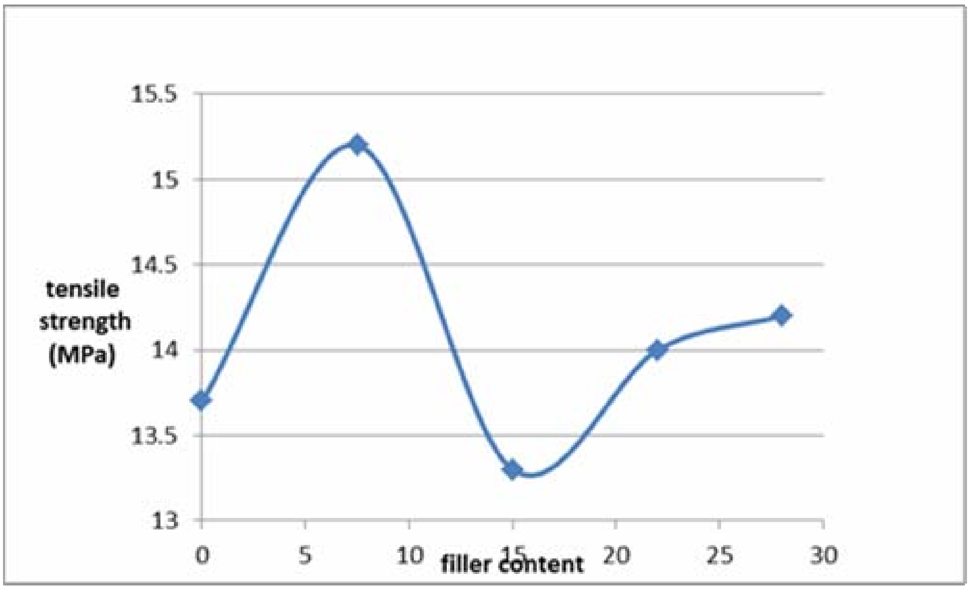

Figure (7) the effect of filler content on the tensile strength

The tensile strength increases with the increase of the filler material content as shown in figure (7). When the load increased the tensile strength increased because the filler material carry the loads applied, transferred it to the matrix and prevent crack growth. The space between the chains decreased when filler content increase therefore the tensile strength increased at the first stage. At the second stage the tensile strength decreased due to filler particles segregate As a result of adding more filler content the material be less homogenous. The filler segregation behaves as holes in the structure so the tensile strength draws back. At the third stage the hardness increased and the rebound decreased because the hard filler particles_dispersed through the structure with high content. Filler particles hinder the growth of dislocations, so the material is stiffer .The movement of molecular chains were restricted therefore the tensile strength increased.

5. Conclusions:

1. The increase of MoO3 addition till 7.5 pphr increases the tensile strength.
2. The torsion stress increase with filler content increase.
3. The hardness increase with filler content increase.
4. The rebound decrease with filler content increase.

5. The increase of MoO3 addition till 7.5 pphr increase the elongation and the elongation decreased when filler content increase more than 7.5 pphr.
6. The processing time decreased because the curing time, scorch time decreased with filler content increase.

References:

1. S. Luther et, al ,"continuous mixing of silica filled rubber mixtures with planetary roller extruder", Kautschuk Gummi Kunststoffe 58. jarhgang, Nr. p.p.371-375, August 2005.

2. D Chann and G W Stachowiak, “Review of Automotive Brake Friction Materials", Proc. Instn Mechanical Engineering, vol. 218 part D: Journal of Automobile Engineering, 2004.

3. Mary riad,"structurl aspect and surface properties molybdenum composite oxide catalysts",p.p.9-18, 2010.

4. Liang Fang,"green synthesis and characterization of amisotropic uniform single-crystal α MoO3 nanostructures",p.p. 2401-2408,J . phys.Chem.C 2007.

5. Aparajita Dash,"prepertion characterization and catalytic applictions of MoO3 clusters dispresedon ZrO_2.

6. M.Ali Ansarifar et,al,"reinforcing effects precipitated on properties of some vulcaizates of styrene- butadiene rubber",p.p.153-161, February 2000.

7. D.A.Baeta,et,al,"the use of styrene butadiene rubber as a potential filler in nitrile rubber"p.p.23-31,January 2009.

8. W.Bolton,"engineering materials technology"Butterworth Heinemann-Great Britain,1998.

9. Abear Adnan Abd,"evolution of resins and fibers content for friction materials industry",Babylon university college of engineering,2009.

10. Annual Book of ASTM Standards, part 28 , 1971.

11. Blow, S., , "Testing and Identification of Rubber", Galgatia puplication Pvt. Ltd(1998)

12. Ming Tian,1 Lijun Cheng,2 Liqun Zhang." Interface and Mechanical Properties of Peroxide Cured Silicate Nanofiber/Rubber Composites", July in Wiley Inter Science http://www.interscience.wiley.com __2008.