VOL. 2 ISSUE 3, MARCH-2013 ISSN NO: 2319-7463

Effect of TiO_2 Percent on Transmission Properties for (X-Ray) of Rubber Compound (SBR)

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Abstract: Radiation shielding garments are commonly used in hospitals, clinics and dental offices to protect medical patients and workers from unintentional direct and secondary radiation exposure during diagnostic imaging. To Decrease the Exposure of Ionizing Radiation in this research discuses this problem. The use of composite materials is an effective method for altering the performance of Polymer in engineering plastics, rubber, and fiber materials. Composite materials are used for many reasons Such as lowering cost the Industrial ,Shielding Protection, In this study, 8 different rubber compound were prepared by using (SBR) with Titanium Dioxide (**TiO_2**) at different ratio (10,30,40,50,60,70,80 and 100) pphr. The physical properties such as Tensile, Elongation, Young Modulus, Compression and (X-Ray) transmission were Studied.

Introduction

In principles, the basic properties of the elastomers come from its nature. However the incorporation of other ingredient into the matrix can modify the properties. The process of the introducing the chemicals or additives into the rubber to modify its properties is called rubber compounding. A good compounding needs to consider many aspects such as environmentally safe, good processability, satisfactory service life and minimum production cost. The different types of additives and chemical contribute to the above factors. Table 2.3 shows some ingredients and their function in rubber compounds [1].

The early stage of the rubber compounding is the softening process of raw rubber by mastication. Sometimes the peptisers will be added. In rubber industry, the widely used equipment to masticate rubber is two roll mills. The mastication is normally applied to SBR [2]. The synthetic rubber seldom needs prior mastication because they are tailored made and can be processed directly. The mastication time of SBR is longer than synthetic rubber because the SB is normally supplied in high Mooney Viscosity. Mastication time of SBR is normally controlled within 15 minutes whereas the synthetic rubber is just only 2 minutes [3]. Mastication process is also important to produce a homogenous dispersion of filler into the rubber matrix. The filler can be only dispersed well in rubber matrix when certain viscosity is achieved. The proper viscosity can improve the processibility of rubber compounds [4]. Basically, there are two categories of mastication process, i.e. mastication without peptisers and mastication with peptisers. The mastication without peptisers requires high shear force of two roll mills or internal mixer to break down the polymer chain and consequently reduce the molecular weight. The mastication process depends on the temperature. As the temperature increase, the elastomers soften and consequently absorb less mechanical energy. This is due to the polymer molecules can flow more easily [5]. The high temperature can cause oxidative attack and increase the rate of chain scission consequently reducing the viscosity. The mechanical degradation will then occur and lead to the excessive Vulcanization is a process that increases the overall elasticity of rubber by locking the chains to each other through chemical crosslinks. The slippage behavior of the plastic-like material would change to more dimensional stable material [7]. The most common use of crosslink agent in rubber is sulfur because it is inexpensive and plentiful. This crosslinker can link the double bonds of the rubber chains together. SBR and SBR are always crosslinked by this type of vulcanization process due to the only small amount of sulfur to be used [8].

Generally, there are a number of sites which are attractive to sulfur atoms along the rubber molecules called cure sites. In the vulcanization reaction, the eight membered ring of sulfur breaks down in smaller parts with varying numbers of sulfur atoms. Figure 1 represents the sulfur cross-linking process of poly-isoprene. One or more sulfur atoms can attach itself to the double bond, and then, the sulfur can grow until it reaches the other cure sites of double bonds. The sulfur bridge can vary from two to ten atoms. The length of the sulfur chain can affect the physical properties of the vulcanization [9]. The shorter the sulfur crosslink give the better heat resistance to rubber vulcanizate. Thus, the EV vulcanization system which has lower polysulfide crosslinks gives better heat and aging resistance.

However, the high crosslink in the rubber vulcanizate produce very good dynamic properties. The dynamic properties are important in tyre side wall industry. Good flexing properties can reduce the formation of cracks and consequently minimize the failure of the rubber products [10].

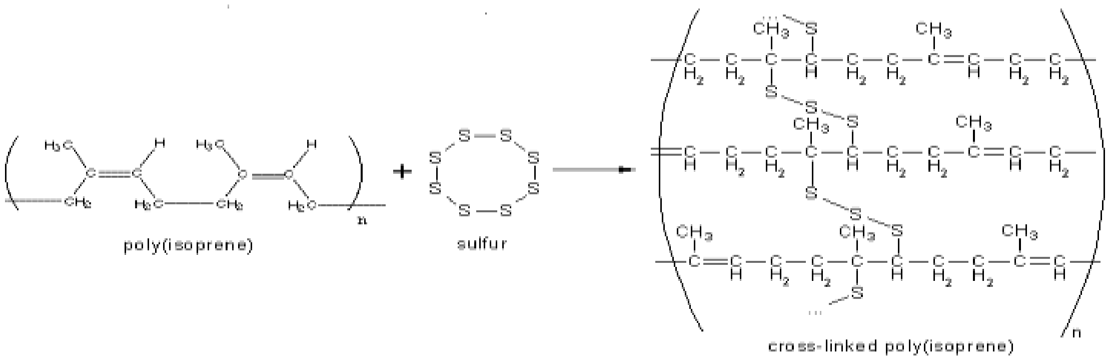

Figure 1: The sulfur crosslinking process of polyisoprene [11].

Three categories of sulfur vulcanization system are used in rubber technology, i.e. conventional vulcanization (CV), semi-efficient vulcanization (semi-EV) and efficient vulcanization (EV). The difference between these systems is the ratio of sulfur and accelerator added into the rubber compounds. Different properties of the vulcanizate can be obtained by varying the sulfur to accelerator ratio [11,12]

Experimental

All materials are used in this research come from Babylon Factory Tire Manufacturing , Iraq . The structure of materials is as follows .

*Styrene-butadiene rubber (SBR) with styrene content 23.5%, Moony viscosity at 100ºC = 50, specific gravity 0.94(gm/cm^3), ash content 1%, there are two types of E-SBR in the market . One of them is the hot rubber which is product at 150 ºC, whereby the molecular weight is high and depolymerization can occur at high temperature.
SBR was first discovered by E. Tchunkur and A. Bock by an emulsion polymerization process in 1929. These emulsion SBR (E-SBR) called Buna S, is easierfor processing compare to other Buna grades SBR another type of E-SBR, cold rubber is using aredox initiator to lower the polymerization tempreture to 5ºC and the chain modifier is applied to control the molecular weight [13,14].

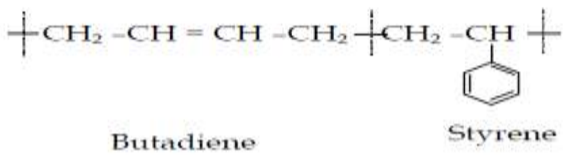

Figure (2) the chemical formula of SBR

*Titanium Dioxide (**TiO$_2$**) is found in abundance in nature as the minerals limonite (FeTiO3), rulite (**TiO$_2$**) and sphere (CaSiTiO5) among other. The Theoretical density of (**TiO$_2$**) ranges from 3895 Kg/m3 for anatase to 4250 Kg/m3 for rutile. The molecular weight is 79.865, melting point 1843ºC , Four naturally occurring titanium dioxide polymorphs exist rutile, anatase, brookite and titanium dioxide. Anatase and rutile are tetragonal boorkite is orthormbic and titanium is monoclinic.

In all four polymorphs, titanium is coordinated octahedral by oxygen, but the position of octahedral differs between polymorphs. Titanium dioxide has also been product as engineered non-material , which may be equi-dimensional crystals or sheet and composed of either titanium dioxide-rutile or titanium dioxide-anats.
A tubular structure has been product from scrolling layers of titanium dioxide-anats , Which result in fibers with on outer diameter of about 6 nm and inner of about 3 nm . Non-scrolled nano-fibers have also been produced from (**TiO$_2$**) "anatse" and (**TiO$_2$**) with diameter of 20-100 nm and length of (10-100 µm) [15, 16].

- Antioxidant (6PPD) is a materials of composition [N-(1,3-dimethylbutyl)-N- phynel-P-phenlenediamine]: specific gravity 1.0 (gm/cm3) [17].
- Sulfur: Pale yellow powder of sulfur element, purity 99.0%, melting point 112ºC, specific gravity 2.04-2.06 (gm/cm) [18].
- Zinc Oxide: fine powder , purity 99% , specific gravity 5.6 (gm/cm3) [19].
- Steric acid: melting point 67-69 ºC , specific gravity 0.838 (gm/cm3) [16].

Table (1), the chemical composition for rubber recipe [15]

Compounding ingredients	pphr
Rubber SBR	**100**
(TiO_2)	**Variable**
Satiric Acid	**1.5**
TMTD	**0.6**
Sulfur	**2**
Zinc Oxide	**3**

Results and Discussion

Many tests is carried on to define the extent of the addition effect of the different of (**TiO2**) on the properties of (SBR) rubber, such of this test are:

Tensile Test:

This test is carried on according to ASTM D-471-57T specification. The test results for tensile strength are shown in Figure (3). It is seen that the tensile strength of composite increases with increase in value of (**TiO2**) because with the grain of titanium dioxide surface area and it have not the same shape make it to increase cross linking with rubber chain deal to surface area is increase.
But we see at the last percent (100 %) that is decrease because the matrix could not have the filler (**TiO2**).

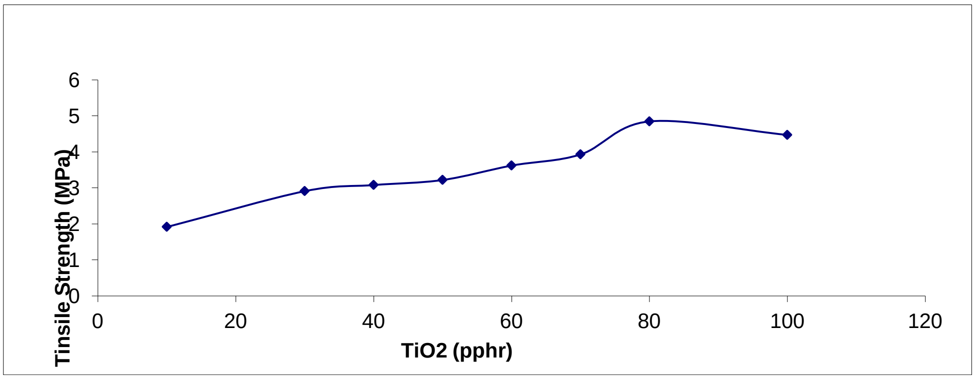

Figure (3) Effect of (**TiO_2**) on the SBR Tensile

Elongation Test:

This test is carried on according to ASTM D-471-57T specification. The test result for Elongation are shown in Figure (4) It is seen that the Elongation increase with percent of (**TiO_2**) at the first three value and become decrease because physical interaction between the (**TiO_2**) and rubber chain, when the grain of filler resistance Elongation.

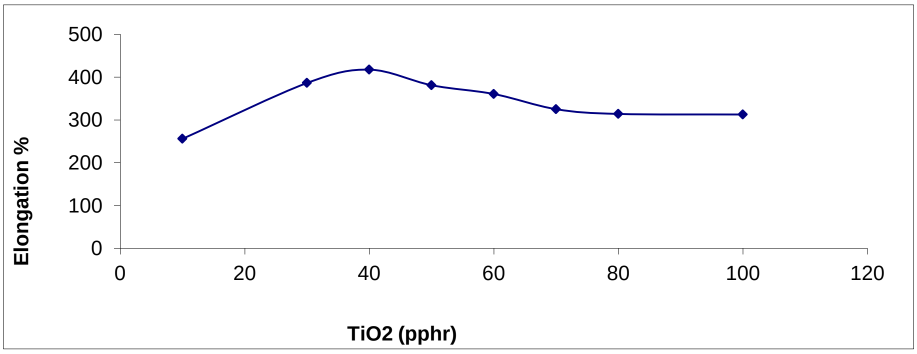

Figure (4) Effect of (**TiO_2**) on the SBR Elongation

Elastic Modulus Test:

Figure (5) shows a linear increasing between elastic modulus versus (**TiO_2**) weight percent. This is due to why decomposition of phenol tack resins which acts suitable fillers, phenol especially when combined with suitable filler, phenol resins have good chemical and thermal resistance, dielectric strength and dimension stability. Thus addition of phenol results in decreasing of the elongation and increasing of the tensile strength thus the modulus of elasticity increases.

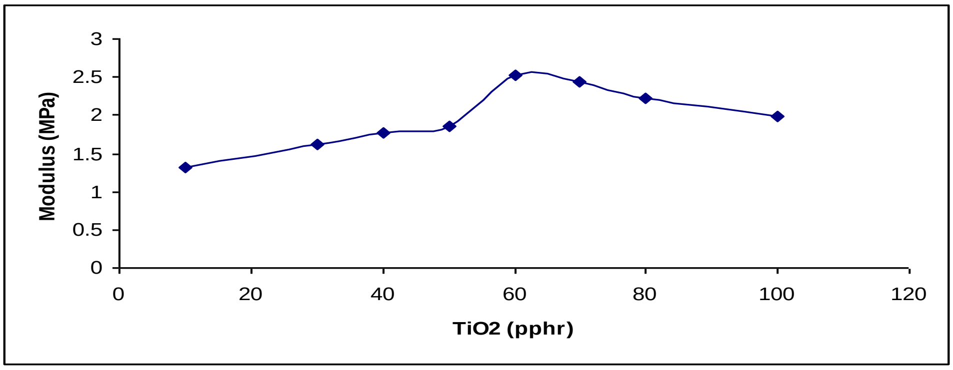

Figure (5) Effect of (**TiO_2**) on the SBR Elasticity

Hardness Test:

Figure (6) shows the shore hardness is plotted against the loading level of reinforcing filler (**TiO_2**) for SBR respectively. From this figure it can be seen that rubber hardness shows significant increment with the increasing loading level of reinforcing of (**TiO_2**). Titanium dioxide reinforcing filler have fine green size, this mean that (**TiO_2**) has larger surface area, which in contact with rubber mostly by physical bond composite with strong bond made it harder by impeding the matrix motion along the stress direction .

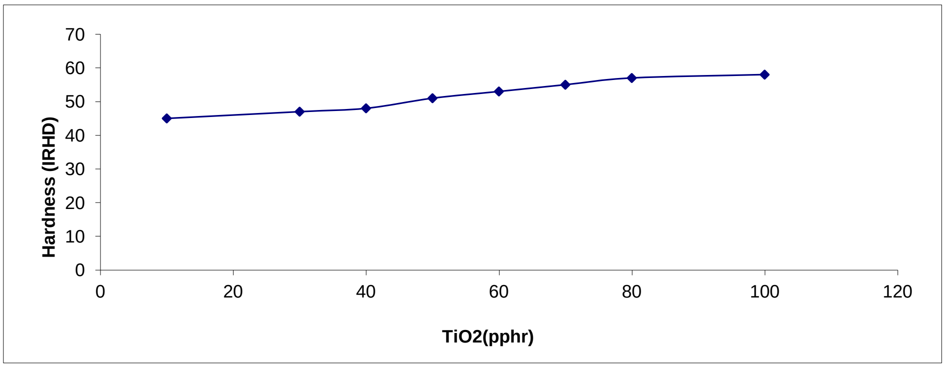

Figure (6) Effect of (**TiO_2**) on the SBR Hardness

Resinonance Test:

The relation between Resinonance and hardness is inverse relation, from figure (7) show the resinonance decrease when (**TiO_2**) percent increase, because the cross linking between rubber chain that absorb energy and transferred it to heat among the rubber chain. Value of resinonance decrease when hardness or cross linking increase.

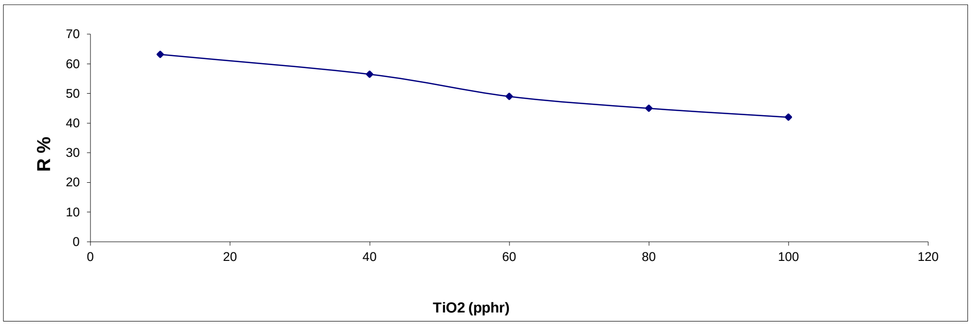

Figure (7) Effect of (**TiO_2**) on the SBR Resinonance

Compression Test:

This test is carried on according to ASTM D-471-57T specification. The test results for compression are shown in Figure (8). Because interaction between filler (titanium Dioxide) and rubber (SBR) that lead to increasing of cross linking at 3-dim, (**TiO_2**) properties same grain size that mean it have large surface area helped it to connected with all chain polymer and resistance the load and pressure instead of covalent bond or hydrogen bond when keep surface without Buckling .

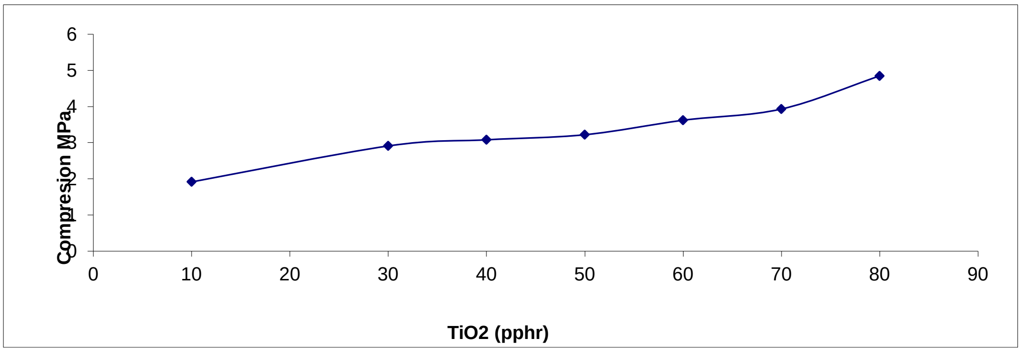

Figure (8) Effect of (**TiO_2**) on the SBR Compression

(X-Ray) Transmission Test:

Titanium Dioxide is especially efficient to absorb X-Ray in the 30-120 KeV range because of the electronic structure. the molecular weight is 79.865 depending on the application , many artificial structure incorporating lead dioxide, have thus be can used to absorb X-Ray, for example this investigation rubber gloves filled with lead dioxide powder are used to insure a good protection to operators exposed to ionizing radiation hospital. Figure (9) shown that (X-Ray) contract when increasing of (TiO_2) value where (TiO_2) enjoy from some properties such as absorb and scattering (X-Ray) and interaction between materials led to increasing of composite materials to contract X-**Ray** .

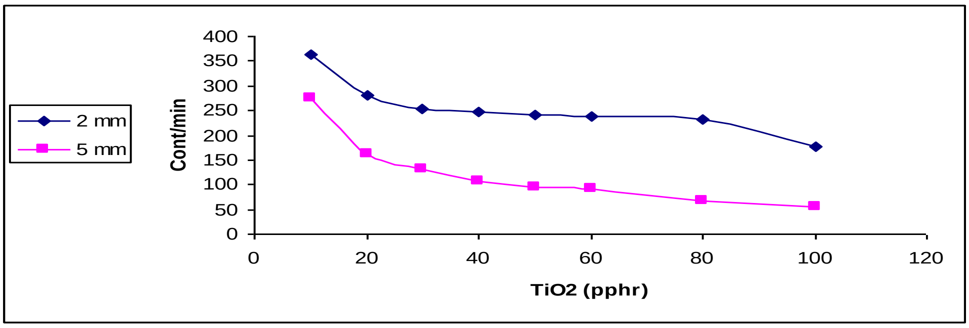

Figure (9) Effect of (**TiO_2**) on the SBR (X-Ray) Transmission

Conclusion

- Transmission of (X-Ray) that increasing with loading of (TiO_2) percent.
- Cross linking between compound material that increasing (X-Ray) transmission.
- We can make shielding from Titanium dioxide Compound.

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