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Research Article

Shielding for Gamma Ray and Beta Particles Made from Rubber Composite

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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 discuss 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, the aim of this study is to made and evaluation the shielding from rubber composite that protect from Gamma Ray and beta particle. Therefore , 8 different rubber compound were prepared by using (SBR) with Titanium Dioxide (**TiO2**) at different ratio (10,30,40,50,60,70,80 and 100) pphr, Then the physical properties such (Gamma -Ray) Transmission , beta particle Transmission also Mass liner coefficient from composite material to Gamma Ray and beta particle the results of this project illustrated that Transmission of (Gamma -Ray) is decreasing with loading of (TiO2) percent .*

Keywords: *Radiation shielding garments, Gamma Rays, Beta particles*

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 (1) shows some ingredients and their function in rubber compounds .
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 . 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 . 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 . 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 . 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. 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 cross-linked by this type of vulcanization process due to the only small amount of sulfur to be used.

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 polyisoprene. One or more sulfur atoms can attach itself to the double bond, and then

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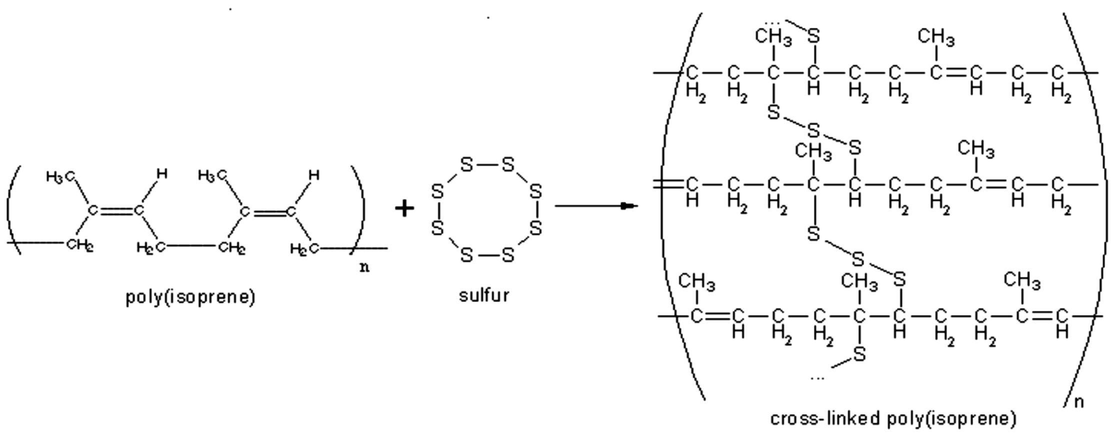

Figure 1 Sulfur crosslinking process of polyisoprene

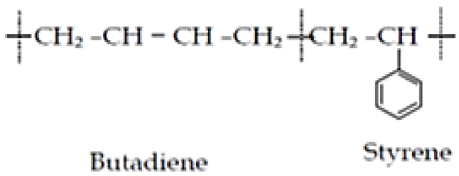

Figure 2 Chemical formula of SBR

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. 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.

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

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 1ooºC = 50 , specific gravity 0.94 (gm/cm), 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 easier for processing compare to other Buna grades SBR. Another type of E-SBR , cold rubber is using are dox initiator to lower the polymerization temperature to 5ºC and the chain modifier is applied to control the molecular weight.

Titanium Dioxide (TiO_2) is found in abundance in nature as the minerals lmenite ($FeTiO_3$), rulite (TiO_2) ,and sphere

($CaSiTiO_5$) 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 nonmaterial , which may be equidimensional 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 diametr of about 6 nm and inner of about 3 nm . Non-scorlled nanofibers have also been produced from (TiO_2) anatse and (TiO_2) with diameter of 20-100 nm and length of (10-100 µm)

- Antioxidant (6PPD) is a materials of composition [N-(1,3-dimethylbutyl)-N- phynel-P-phenlenediamine] :specific gravity 1.0 (gm/cm3).

- Sulfur : Pale yellow powder of sulfur element, purity 99.0% , melting point 112ºC. Specific gravity 2.04-2.06 (gm/cm).
- Zinc Oxide : fine powder, purity 99% , specific gravity 5.6 (gm/cm3).
- Steric acid : melting point 67-69 ºC , specific gravity 0.838 (gm/cm3).

Table 1 the chemical composition for rubber recipe

Compounding ingredients	pphr
Rubber SBR	100
(TiO)	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:

(Gamma -Ray) Transmission Test

Lead Dioxide is especially efficient to absorb Gamma -Ray in the, have thus be can used to absorb Gamma -Ray , for example this investigation rubber gloves filled with Titanium dioxide powder are used to insure a good protection to operators exposed to ionizing radiation hospital. Figure (3) shown that (Gamma-Ray) contract when increasing of (TiO2) value where (TiO2) enjoy from some properties such as absorb and scattering (Gamma-Ray) and interaction between materials led to increasing of composite materials to contract Gamma-Ray (10),(11).

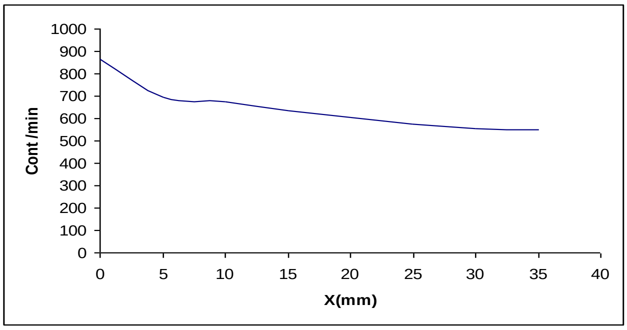

Figure 3 Effect of (TiO2) on the SBR (Gamma-Ray) Transmission

(Beta Particles) Transmission Test

Electron are charging particles (positive or negative) that is light interaction with atoms electron through coulomb scattering (12). exactly same Heavy charge particle interaction .at the conclusion with electron atoms we note Electron effect from force there for that take Erratic path that is not normally line as same of heavy particle .have Range (that describe distance particle take it inter material to stop of motion) will be inverse of range electron . Relation between decrease of energy at range length describe by Beth especially heavy particle. except escape of energy by Coloum Effect (12),(13).from this figure Beta particle losses Energy by interaction with this material (14),(15).

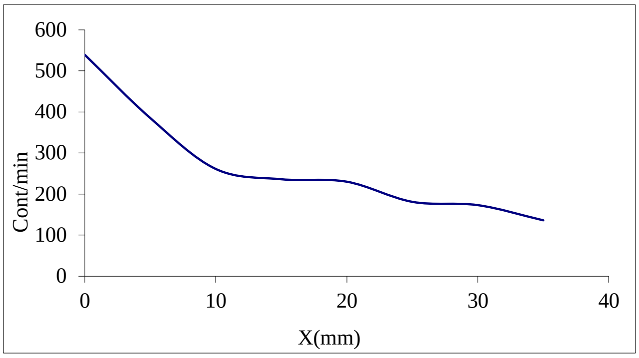

Figure 4 Effect of (TiO2) on the SBR (Beta particle) Transmission

Another physical parameter that illustrated the efficiency of this composite to prevent the Gamma ray and Beta particles from penetration is Mass liner coefficient where tables (2),(3) show Mass liner coefficient from composite material to Gamma Ray and Beta particle

Table 2 Mass liner coefficient from composite material to Gamma Ray

X(mm)	Mass coefficient
0	0.00096
5	0.00182
10	0.00275
15	0.00282
20	0.00351
25	0.00376
30	0.004076
35	0.00444
40	0.00558

Table 3 Mass liner coefficient from composite material to Gamma Ray

X(mm)	Mass coefficient
0	0.0012
5	0.0018
10	0.0021
15	0.0029
20	0.003
25	0.0038
30	0.004
35	0.005
40	0.0063

From tables (2),(3) shows the mass linier coefficient increase with the increase of thickness of composite because Energy of radiation is losses in many cases inside the matter such as columbic collision where loss some of kinetic energy when the Particle or radiation inter material ,(16),(17),(19) in other side everybody charging that is motion losses its energy as photon. There for interaction between Gamma Ray , beta particle with our material give good result as a protective from radiation

Conclusion

1. Transmission of (Gamma -Ray) that decreasing with loading of (TiO2) percent.
2. Cross – Linking between compound material that decreasing (Gamma -Ray) transmission.
3. We can making shielding from Titanium dioxide Compound.
4. We can making shielding from Titanium dioxide Compound at a lot of branch of live especially scientific and government .

References

Mohammad H. Al-Maamori, Oday H. Al-Bodairy , Nehad A. Saleh , Effect of TiO2 Percent on Transmission Properties for (X-Ray) of Rubber

Compound (SBR) (2013), *International Journal of Enhanced Research in Science Technology & Engineering.* Vol.2, No.7.

V.Bogush (June 2005),Application of Electroless Metal Deposition for Advanced Composite Shielding Materrials *J, of Optoelectronics and Advanced*,Vol.7,No.3.

Mohammad H. Al-Maamori, Oday H. Al-Bodairy , Nehad A. Saleh (2013), Effect of PbO percent on mechanical properties of Rubber Compound (SBR) , *International Journal of Enhanced Research In Science Technology & Engineering.* Vol.2,No. 2319-7463.

Robert Lituri, Joe Deforte ,Bonding Rubber Thermoplastic Elastomerers (2005),*J. of The Latite Design guide for bondidng Rubber and TPEs*, Vol.2,No.5.

KuaZula Natal , Darul Ehsan , D. Grove (1999) , Manfacture and General Properties of Titanium dioxide Pigments , *Tioxide Group*.

Cao xuan viet (2008), Curing Characteristics Mechanical prorerties Morphology of Surface Modifation montmorilonite Filled Natural rubber Nano Composites ,M.sc.thesis, *Sains Malaysia University.*

Leny Mathew (2009), Development of Elastomeric Hybrid Composite Based on Synthesised Nano Silica and short Nylon Fiber ,Ph.D.Thesis , *Cochin University of Science and Technology*.

Herbert,W.Friedman,Mike,S.Singh (2003)Radiation Transmission Mesurements for Alightweighet Fabric,*Radiation S,Biscayne Blend,Miami*.

V. Bogush (June 2005),Application of Electroless Metal Deposition for Advanced Composite Shielding Materrials *J. of Optoelectronics and Advanced*,Vol.7,No.3.

S.E.Gwaily,H.H.Hassn,M.M.Badawy (2002), NaturalRubber Composites Thermal Neutron Radiation Shieldes II-H_3BO_4 /NR Composites,*www.elesrier.com Polytest*

Sattoshi Mikami (2005) ,Tadayoshi Yoshida,Chie Takada and Norie Tsujimura,Neutron Dose Assement Using an Ebonite in Criticality Accident ,*Japan Nuclear Cycle Development Institute*

Ragaa A.Aly ,F.A.Gaber,Mona S.Saleh (2010),Radiation Safty of Cancer Breast Patient During Radiotherpy,*J .of Nuclear and Radiation Physics,*Vol.5,No.1&2.

S.Goyanes ,C.C.Lopez, G.H.Rubiolo ,F.Quasso and A.J.Marzocca (2008), Thermal Properties in Cured Natural rubber/ Styrene Butadiene Rubber Blend *, J. of European Polymer* ,Vol .44,No. 152.

Ming Tian ,Lijun Cheng ,Wenli Liang and Liqun Zhag (2006), Overall Properties of Fibrillar Silicate /Styrene –Butadiene Rubber NanoComposites *,J .of applied Polymer Science* , Vol .101 ,No.273.

Tapani Alasaarele (2011), Atomic Layer Deposited Titanium Dioxide in Optical Waveguiding Applications *,School of electrical Engineering*

Nehad A. Saleh , Oday H. Al-Bodairy ,Mohammad H. Al-Maamori (2012), Effect of TiO2 percent on Mechanical Properties to Rubber Compound (SBR) , *J.of Iraqi Polymer* **,** Vol.15 No.1.

J. karger ,J. Gremmels , Kaiserslautern and A.Mousa (2009) , Application of hygrothermally Decoposed polyurethane in Rubber Recipes , *J. of Kautschuk Gummi Kunsts Toffee* , Vol ,53 , No .9 .

Jim Lee (2006) , Microstructure and Properties of Zinc Oxide Nano- Crystaline Thin Films And Composite ,Ph.D. Thesis ,*Anckland University*.

Mohammad H. Al-Maamori, Oday H. Al-Bodairy , Nehad A. Saleh (2012), Effect of pbo with rubber composite on Transmission of (X-Ray) *, J. of Natural and Applied Science,* Vol , 3 , No .3.