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Research Article

Effect of Tungsten Percent on Transmission Properties for (X-Ray) of Styrene Butadiene Rubber

Oday H. Al-Bodairy[a], Mohammed H. Al–Maamori[b] , Ali I. Al-Mosawi[c] and Nehad A. Saleh[a]

[a]Physics Department , College of Science , Babylon University ,IRAQ
[b]College of Engineering Materials, Babylon University ,IRAQ
[c]Technical Institute-Babylon, Babylon ,IRAQ

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Abstract

This paper gives a comparative study on the new developments in non-destructive controls of the composite materials and applications in the manufacturing engineering and also reviews essentially the performance and advantages of X-rays computed tomography (XR-CT) medical scanner about its usage at multiple scales (macro, micro, meso and nano), the method and also the terminology. Subsequently, it will deal with the chosen materials to share the performances of this technique for the very different industrial applications The scientific technical revolution of our day is associated with wide introduction of non-ionizing fields (such as electromagnetic) in almost every aspect of life in addition to the wide use of ionizing radiation in medicine research and manufacture. Understanding the mechanism of interaction of electromagnetic (EMFs) fields with biological cells and cell membrane is important to modern day cell technology and medicine., 4 different rubber compound were prepared by using (SBR 1502) type of Styrene Butadiene rubber in level and each recipe reinforced with Tungsten (W) at different ratio (20,50,70 and 100) pphr (part per hundred)and using Titanium Dioxide (TiO_2) at constant ratio (60) pphr at all compound. All of compound measure the transmission of (X-Ray).

Keywords: *Transmission Properties, Styrene Butadiene Rubber.*

Introduction

Ionising radiation is generally characterised by its ability to ionise atoms and molecules of matter with which it interacts. It can be classified into two categories: on the one hand there is directly ionising radiation, which consists of charged particles such as electrons, protons or alpha particles. (NCRP Report No. 98, 2000;.M. Marx *et al*, 2001) The charged particles interact strongly with orbital electrons of atoms in the medium and through collisions, ionisation in the medium is produced. Bremsstrahlung is emitted, if the interaction takes place with the Coulomb field of the atomic nucleus. Indirectly ionising radiation on the other hand is made of neutral particles such as neutrons or electromagnetic radiation (photons). First energy of the neutral particles is transferred to charged particles in the medium and in a second step the released charged particles directly ionise the medium (C.Kelsey, Mettler FA.,2004, S.Kumazawa *et al*,2002).

The recommendations of both those organizations for tolerance doses for radiation workers have decreased by a factor of 5–10 since 1934. This decrease is the result of increased knowledge of the risks from radiation exposure, an increased desire among workers to avoid the harmful side effects of radiation, and improvements in technology (NCRP Report No. 98, 2000; S.Kumazawa *et al*;2002; M. Broadbent and L. Hubbard,2006). Although the recommended limit for radiation workers has not changed greatly since about 1958, the philosophy toward radiation protection and limits has changed dramatically. The limit is now regarded as an upper limit of acceptability. The principle of ALARA (as low as reasonably achievable) is used to ensure that most exposures will be well below the accepted limit. Experience with the ALARA principle and the limit of 5 rem (50 mSv) per year has allowed the average (A, Quinn *et al* ,1997). exposure of workers in the United States with the exception of interventional radiologists and cardiologists to decline steadily to about 5% of the limit. The increased use of fluoroscopy by anesthesiologists for pain therapy and during radiation therapy procedures has further expanded the risk to health care providers

Although the acute effects of radiation are not commonly a problem, the stochastic effects of radiation remain a concern. The probability of the occurrence of stochastic effects is directly related to the radiation dose, but the severity of these conditions is not related to the total dose received (Y. MY *et al* ,2005).

*Corresponding author: Mohammed H. Al–Maamori

Stochastic effects include carcinogenesis and genetic mutation; they are of particular concern because there is no threshold dose below which the radiation induced effects will not occur. The no stochastic effects, such as radiation-induced cataracts, do have a threshold dose, and above this threshold the severity is directly related to the dose. Stochastic events are considered to occur at all doses, but the less the frequency, the lower the dose thus, the principle of ALARA (NCRP Report No. 98, 2000; S.Kumazawa *et al*;2002; M. Broadbent and L. Hubbard,2006; Hendee WR,2007). This article focuses on the use of a new radiation protection device intended to reduce both the unit dose and the overall level of radiation experienced by radiation workers during interventional radiology procedures.

Theory

When a well –collimated narrow beam of (X-Ray) passing through a sample of thickness (t) composed of a single element of atomic number Z and assume that no scattered photons reach the collimated detector. The ratio of the intensity of X –rays emerging from the targ*et al*ong the incident direction to the incident intensity is given by (V. Manjunathaguru and T K Umesh ,2006) :

$$I/I_o = \exp(-\mu t) \quad (1)$$

where μ is the linear attenuation coefficient of the target, which is related to the mean free path (τ) in the target and the atomic cross –section (aσ) by the expression

$$\mu = 1/\tau = n\, a\sigma. \quad (2)$$

The mass attenuation coefficient (μ/ρ) is given by(G. K Sandhu *et al* ,2002) :

$$\mu/\rho = 1/\rho \;\; NA\, a\sigma/\rho A \quad (3)$$

where ρ is the density of the material, NA is Avogadro's number and A is the atomic weight. Thus for an idealized narrow –beam geometry, where the secondary radiations are not seen by the detector, the attenuation can be described by the well-known law(B J Kirby *et al*,2003):

$$\ln(I/I_o) = -\sigma N x \quad (4)$$

where Io is the incident intensity, I is the emergent intensity, σ is the total interaction cross section of the molecule, N is the number of molecules per unit volume, and x is the thickness of the slab. The product σ N is known as the linear attenuation coefficient μ.

The equation (4) can be rewritten in the following form known as Beer's law(Madsen OR *et al* ,2000):

$$\varepsilon = \frac{1}{\ln 10} NA\sigma = \frac{1}{\ln 10} M\, \mu/\rho \quad (5)$$

where ε is the extinction coefficients, $\frac{1}{\ln 10}$ = 0.4343, M is the mass (g).

In the present case atomic cross section σi have been obtained from mass attenuation coefficient μ/ρ using the following expression :

$$\sigma i = \frac{Ai}{N_A} (\mu/\rho)i\,. \quad (6)$$

Where Ai is the atomic mass of the constituent element i, NA is the Avogadro's number whosevalue is 6.02486 x1023then effective electronic cross section,

$$\sigma^{el} = \Sigma\, fi\, \sigma i/Zi \quad (7)$$

where Zi is the atomic number of element i.

and finally effective atomic number Z^{eff} have been alculated using equation (8) (Kawrakow I.,2000).

$$Z^{eff} = 0.28\, A^{eff\;\,1.329-0.047\ln E}\, E^{0.092} \quad (8)$$

Mass attenuation coffecient from composite and blend can be calculated from equation (9) (Shivaramu *et al* ,2001).

$$\mu_{m.c} = \sum_i \left(W_i \left(\frac{\mu}{\rho}\right)_i \right) \quad (9)$$

Both a single element and composite materials, three processes-photoelectric, Compton and pair production (G. K. Sandhu *et al* ,2002) .At agiven photon energy, the interaction is proportional to (Zn) where n is between 4 and 5 for the photoelectric effect,1 for the Compton effect, and 2 for pair production(S Gowda *et al* ,2004).For the purposes of energy radiation attenuation, a heterogeneous material, consisting of a number of elements in varying proportions, can be described as a fictitious element having an effective atomic number Z^{eff} (S Gowda *et al* ,2005).The parameter Z^{eff} is very useful in choosing a substitute composite material in place of an element for that energy depending on the requirement. The energy absorption in the given medium can be calculated by means of well-established formulae if certain constants such as Z^{eff} and Ne of the medium are known. Among the parameters determining the constitutive structure of an unknown object or material, one should especially note the effective atomic number. In fact(Y. Du *et al* ,2006), this value can provide an initial estimation of the chemical composition of the material. AlargeZ^{eff} generally corresponds to inorganic compounds and metals. While a small Z^{eff}(<10) is an indicator of organic substances. Z^{eff}also finds its utilization in the computation of some other useful parameters, namely the absorbed dose and build-up factor(S R Manohara and S M Hanagodimath l ,2007).

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^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. Another type of E-SBR , cold rubber is using are initiator to lower the polymerization temperature to 5ºC and the chain modifier is applied to control the molecular weight(S.Goyanes *et al* ,2008) .

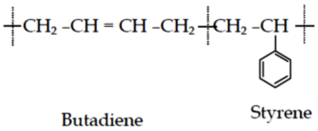

Figure (1) the chemical formula of SBR

* Titanium Dioxide (TiO_2) is found in abundance in nature as the minerals lmenite ($FeTiO_3$), rulite (TiO) , and sphere (CaSiTiO5) among other the theoretical density of (TiO_2ranges 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 which result in fibers with on outer diametr of about 6 nm and inner of about 3 nm . Non-scorllednanofibers have also been produced from (TiO_2) "anatse" and (TiO_2) with diameter of 20-100 nm and length of (10-100 µm) (G. S. Brady *et al* ,2000).

* Tungsten (also known as Wolfram and represented by the letter W in the periodic table) is a naturally occurring element that exists in the form of minerals or other compounds but typically not as a pure metal,atomic number from it 74 , density is 19.25 gm/cm^3 Derived from the Swedish word "tung" for heavy and "sten" for stone, it is traced to the 1781 identification of calcium tungstate by Swedish chemist, Karl Wilhelm Scheele. "Scheelite" and another mineral, "Wolframite", are the most important sources of tungsten(J.Christian *et al* ,2011) .

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

Sulfur : Pale yellow powder of sulfur element, purity 99.0% , melting point 112ºC . specific gravity 2.04-2.06 (gm/cm) (S. Gnanam and V. Rajendran l ,2004) .

Zinc Oxide : fine powder , purity 99% , specific gravity 5.6 (gm/cm^3).

Steric acid : melting point 67-69 ºC , specific gravity 0.838 (gm/cm^3) (L. kantiyong ,2009) .

Table (1) Chemical composition for rubber recipe (S.Goyanes *et al* ,2008)

Compounding ingredients	pphr
Rubber SBR	100
(TiO_2)	60
Tungsten	variable
Satiric Acid	1.5
TMTD	0.6
Sulfur	2

Result

The absorb coefficient (µ) depends on the absorbing material. It is determined by the crossed by the (X-Ray) beams and their nature. It is thus more convenient to relate the absorption coefficient to the volume mass of material .It leads to eq. (M. Tian *et al* , 2006)

$$I = I_o \exp\left(-\frac{\mu}{\rho}\rho\chi\right) \qquad (10)$$

Where (ρ) is the volumic mass of matter, (ρ^x) is the mass per unit area of Layer of materials of thickness (x) (ρ^x) called mass thickness eq(11) introduces the mass absorption coefficient µ/ρ (m/kg) . It can also be written (J. H. Heinbockel *et al*, 2000).

$$\frac{\mu}{\rho} = \frac{dI}{I}\frac{1}{\rho dx} \qquad (11)$$

In the case of an composite materials ,the mass absorption coefficient is obtained as (V. TBN *et al* ,2005).

$$\left[\frac{\mu}{\rho}\right]^{comp} = \Sigma\left[\frac{\mu}{\rho}\right].C^{i} \qquad (12)$$

Radioprotection

Tungsten de is especially efficient to absorb X-Ray in the 30-120 KeV range because of the electronic structure. The molecular weight to PbO 223.2, e density of PbO is 9.53 gm/cm^3 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 agood protection to operators exposed to ionizing radiation hospital. Figure (2) shown that (X-Ray) contract when increasing of (W) value where (W) 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 .

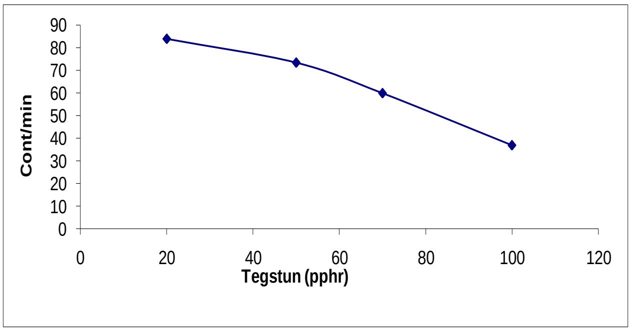

Figure (2) W Transmission for X-Ray

Hardness Test

Dioxide reinforcing filler have fine grain size , this mean that Figure (3) shown the shore hardness is plotted against the loading level of reinforcing filler (**W**) for SBR respectively. From this figure it can be seen that rubber hardness shows signification increment with the increasing loading level of reinforcing of (**W**). Titanium **W**) 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.

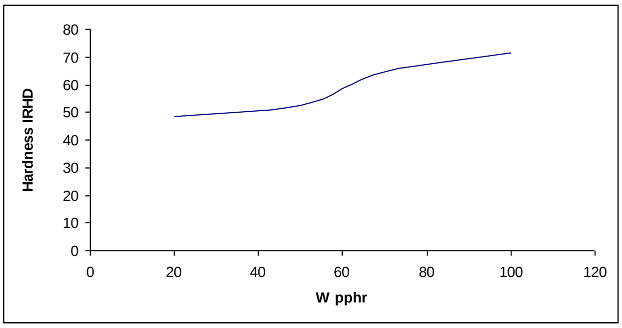

Figure (3) Effect of (W) on the SBR Hardness

Resonance Test

The relation between resonance and hardness is invers relation, from figure (4) show the resonance decrease when (**W**) percent increase, because the cross linking between rubber chain that absorbs energy and transforms it to heat among the rubber chain. Value of resonance decrease when hardness or cross linking increase.

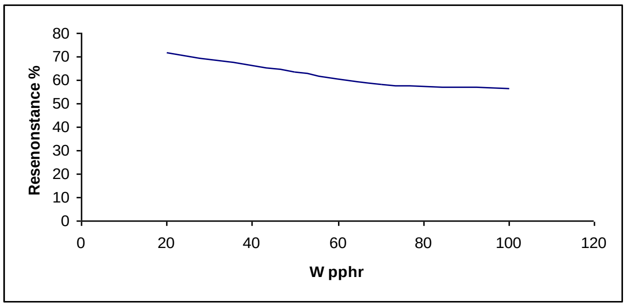

Figure (4) Effect of (W) on the SBR Resinonance

Wear Test

Figure (5) shows the wear rate of SBR versus the loading level of reinforcing fillers respectively. This figure show that the wear rate of SBR is inversely proportional with the loading level of reinforcing filler and the relationship is non-linear. This mean that the rubber reinforced with (**W**) fill has decreased the wear rate. This is because the reinforcement is decreased due to failure at the matrix–reinforcement interface or in the reinforcement interface or in the reinforcement itself.

Compression Test

This test is carried on according to ASTM D-471-57T specifications. The test results for Compression are shown in Figure (6).

Because interaction between filler (Tungsten) and rubber (SBR) that lead to increasing of cross linking at 3-dim. (**W**) 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 .

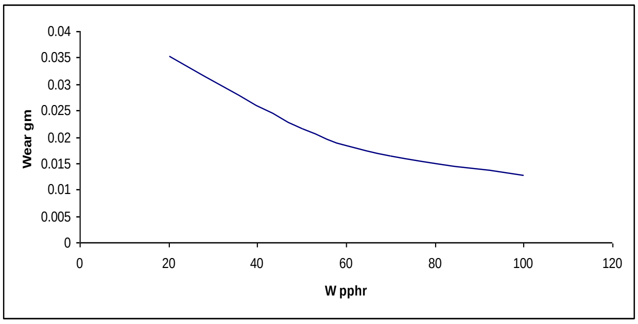

Figure (5) Effect of (W) on the SBR Wear

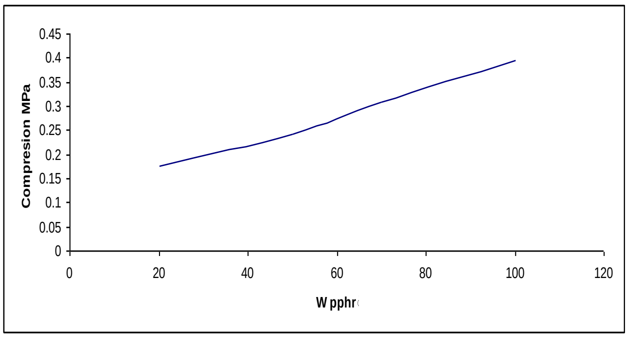

Figure (6) Effect of (W) on the SBR Compression

Conclusion

- Transmission of (X-Ray) increases with loading of (Tungsten) percent.
- Cross – Linking between compound materials that increasing (X-Ray) transmission.
- (Tungsten) that is material enjoy from properties that can be absorbed and scattering (X-Ray).

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