EFFECT OF CHLOROPHYLL PERCENT ON TRANSMISSION PROPERTIES FOR (X-RAY) OF RUBBER COMPOUND (SBR)

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ABSTRACT

Ionizing radiation is known to be harmful to human health and heredity. The attenuation of radiation can be achieved by either placing the source of radioactivity at a distance from the personnel and objects surrounding it or by constructing a shield effective enough to absorb most of the radiation before it penetrates the matter. Shielding is mostly required against X-rays and gamma rays, which are very penetrating. Various materials which are used for shielding include lead, copper, bismuth, steel, concretes and organic compounds such as oils, paraffins, plastics and rubber. The shields could take different forms like blocks, plates, rods, pellets, clothing etc , 5 different rubber compound were prepared by using (SBR 1502) type of Styrene Butadiene rubber in level and each recipe reinforced with Chlorophyll molecular (Cll) at different ratio (20,40,60,80 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: X-Ray, radiation, styrene butadiene rubber, chlorophyll

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. [1, 2] 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 [3, 4].

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 [1, 4, 5]. 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 [6].

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

ISSN-L: 2223-9553, ISSN: 2223-9944
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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 [7].

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 [1, 4, 5, 8]. 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

Gamma rays or γ–photon*s* have a definite probability of passing unchanged through a given thickness of matter. The intensity *I* (photons per unit area per unit time) decreases as function of the matter thickness *x* by the well-known attenuation formula:

$$I(x) = I0 \cdot \exp(-\mu \cdot x)) \qquad (1)$$

_it is better to state the thickness of the attenuating matter by its "weight per area", that is, the product of thickness and density**:** x·**ρ**. Here the unit can then be, for example mg/cm2. The attenuation law can be rephrased to give:

$$I(x) = I0\exp((-\mu/\rho)\cdot(x\rho)) \qquad (2)$$

When thus used, μ /ρ is called the mass attenuation coefficient. In general, the mass attenuation coefficient is less sensitive to the actual physical state of the attenuator, such as pressure and temperature,etc.

The half-value layer thickness is the thickness of a layer that causes are 50% reduction in intensity:

$$x1/2 = \ln(2) / \mu \text{ or } x1/2\rho = \ln(2) / (\mu/\rho) \quad (3)$$

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 [11]:

$$\ln(I/Io) = -\sigma Nx \qquad (4)$$

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 [12]

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

Where ε is theextinction 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 [13]

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

Where Ai is the atomic mass of the constituent element i, NA is the Avogadro's number whose value is 6.02486 x1023. Then effective electronic cross section,

$$\sigma_{el} = \Sigma \text{ fi } \sigma i/Zi \qquad (7)$$

Where Zi is the atomic number of element i and finally effective atomic number Z_{eff} have been calculated using equation (8) [14].

$$Z_{eff} = 0.28 \, A_{eff}^{1.329-0.047 \ln E} E^{0.092} \qquad (8)$$

Mass attenuation coffecient from composite and blend can be calculated from equation (9) [15].

$$\mu_{m.c} = \Sigma_i (W_i (\frac{\mu}{\rho})_i \qquad (9)$$

Both a single element and composite materials, three processes-photoelectric, Compton and pair production [16]. At a given 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[17].For the purposes of□□□nergy □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} [18].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 [19], this value can provide an initial estimation of the chemical composition of the material. A large Z_{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 [20].

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 1oo℃ = 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 ℃, 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 5℃ and the chain modifier is applied to control the molecular weight [21].

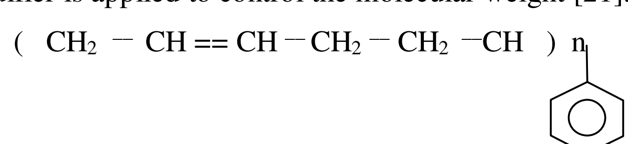

Figure 1. The chemical formula of SBR

ISSN-L: 2223-9553, ISSN: 2223-9944
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* Titanium Dioxide (TiO_2) is found in abundance in nature as the minerals lmenite (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.

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) [22]

* Chlorophyll that green molecular in Plants cell that done to concentrate highly Energy in Photosynthetic Apparatus. Actually chlorophyll as not single cell but that family of cross molecular, we can gat of (Cll) in simple experiment by using some solvent when extract it from plants cell. Chlorophyll fluorescence intensity of dark adapted photosynthetic organisms follows a characteristic variation in time after the onset of illumination. This effect is well known as fluorescence induction or the Kautsky effect [23, 24]

a. Antioxidant (6PPD) is a materials of composition] N-(1, 3-dimethylbutyl)-N-phynel-P-phenlenediamine]: specific gravity 1.0 (gm/cm3).
b. Sulfur: Pale yellow powder of sulfur element, purity 99.0%, melting point 112ºC. Specific gravity 2.04-2.06 (gm/cm) [25].
c. Zinc Oxide: fine powder, purity 99%, specific gravity 5.6 (gm/cm3).
d. Steric acid: melting point 67-69 ºC, specific gravity 0.838 (gm/cm3) [26].

Table 1. the chemical composition for rubber recipe [21]

Compunding ingredients	*Pphr*
Rubber SBR	100
(TiO_2)	60
Cllk	Variable
Satiric Acid	1.5
TMTD	0.6
Sulfur	2
Zinc Oxide	3

RESULT

The absorb coffeicient (µ) depends on the absorbing material. It is determind by the crossed by the (X-Ray) beams and their nature. It is thus more convient to relate the absorption coefficient to the volumic mass of material .It leads to eq. [27]

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

Where (ρ) is the volumic mass of matter, ($\rho\chi$) is the mass per unit area of Layer of materials of thickness (x) ($\rho\chi$) called mass thickness eq(11) introduces the mass absorption coefficient μ/ρ (m/kg) . It can also be written [28].

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

In the case of composite materials, the mass absorption coefficient is obtained as [29].

$$[\frac{\mu}{\rho}]_{comp} = \Sigma[\frac{\mu}{\rho}].C_i \qquad (12)$$

Radioprotection

Titanium Dioxide is especially efficient to absorb X-Ray in the 30-120 KeV range because of the electronic structure, Actually chlorophyll as not single cell but that family of cross molecular., have thus be can used to absorb X-Ray, for example this investigation rubber gloves filled with Chlorophyll material are used to insure a good protection to operators exposed to ionizing radiation hospital. Figure (2) shown that (X-Ray) contract when increasing of (Cll) value where (Cll) 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 .

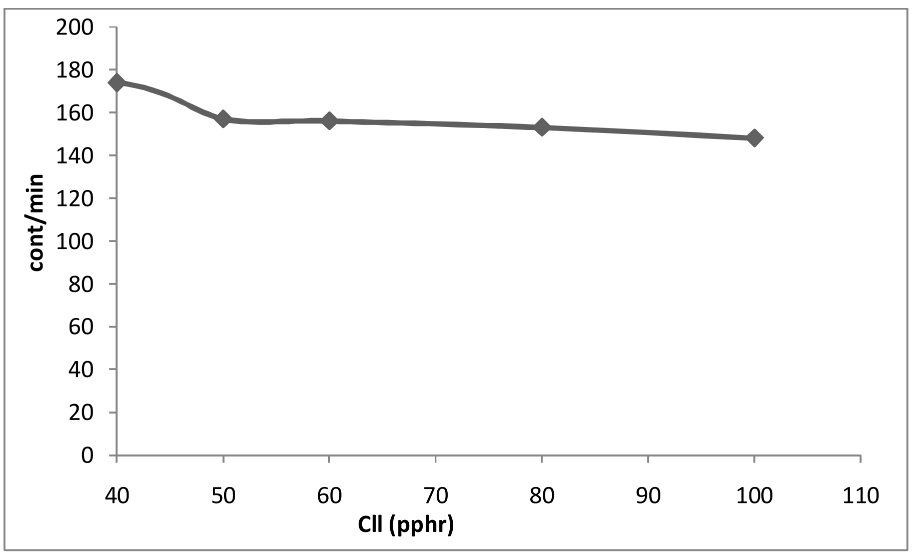

Figure 2. Cll Transmission for X-Ray

Tensile Test

This test is doing on according to ASTM D-471-57T specification. The test result for tensile strength are shown in Figure (2).in addition to Rubber Compound Distinguishing that having (TiO_2) at ratio (60% pphr) that best compound because have best properties of Tensile, Elasticity Modulus and Elongation, (Cll) adding to compound and from figure that show decreasing from Tensile because using acetone as solvent to extract with compound to be or get torn rubber chain that decrease tensile.

ISSN-L: 2223-9553, ISSN: 2223-9944
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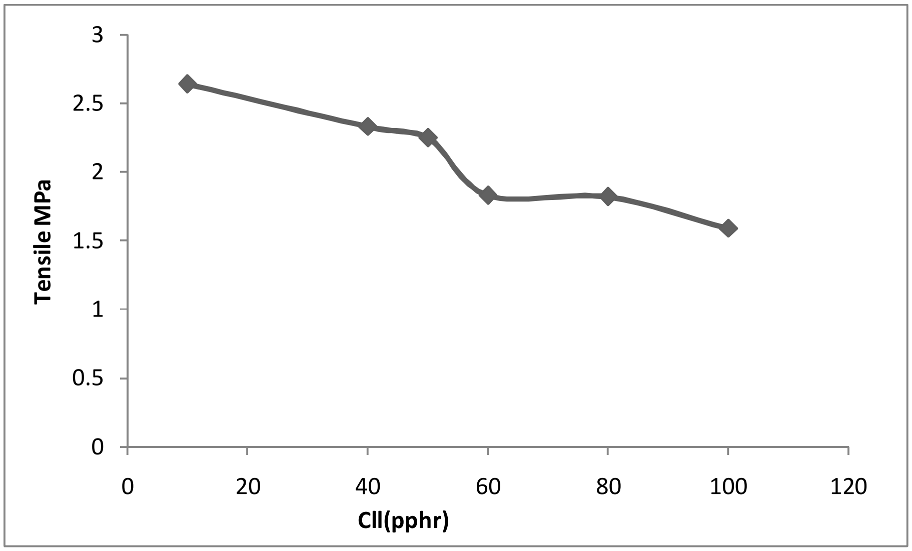

Figure 2. Effect of (Cll) on the SBR Tensile

Modulus of Elasticity

This test is doing on according to ASTM D-471-57T specification. The test result for Modulus of elasticity are shown in Figure (2).in addition to Rubber Compound Distinguishing that having (TiO_2) at ratio (60% pphr) that best compound because have best properties of Modulus of elasticity, Tensile and Elongation, (Cll) adding to compound and from figure that show decreasing from Modulus of elasticity because using acetone as solvent to extract with compound to be or get torn rubber chain that decrease Modulus of elasticity.

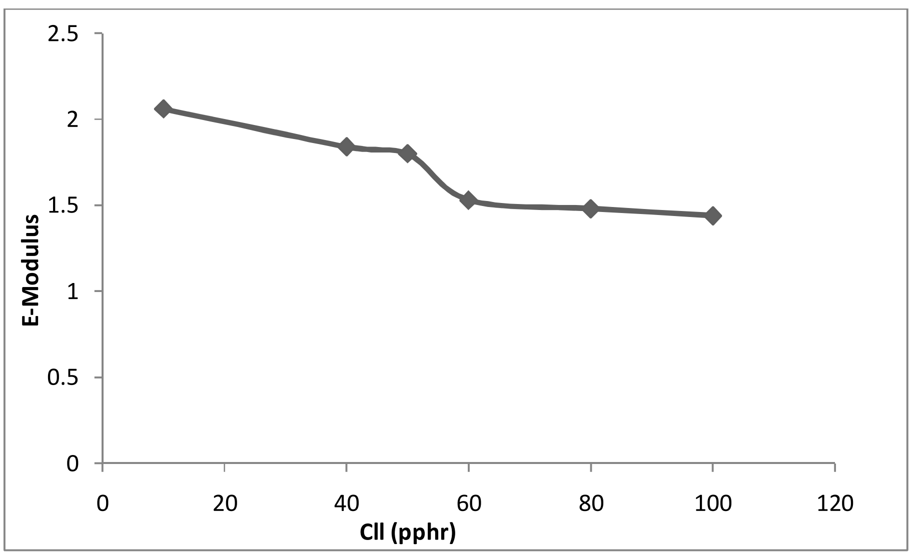

Figure 3. Effect of (Cll) on the SBR Elasticity

Elongation

The test result for Elongation are shown in Figure (4) it is seen Elongation increase with percent of (Cll).the reason of that because chlolorophyl materials are using as Plasticizers and in last give compound increase Elongation .

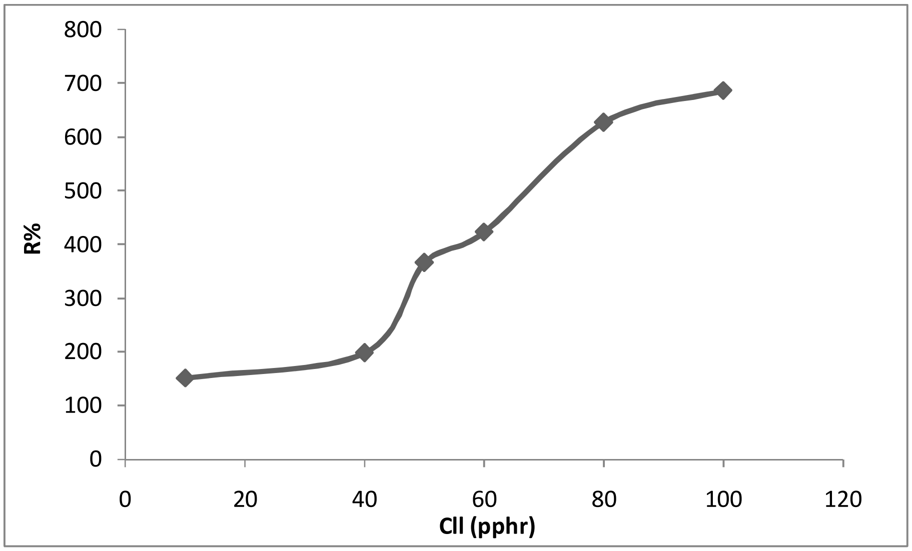

Figure 4. Effect of (Cll) on the SBR Elongation

Hardness

Figure 5 shows decrees in hardness Value because chlorophyll material that adding as plastizer materials where it diffusion among rubber chain that lead to weaken Intermolecular Interaction Forces from rubber chain, to separate it because (Cll) big molecular that lead to create hole between chain. Where acetone adding to compound and through shaping acetone transform as steam making hole in rubber chain that lead decrease in cross linking.

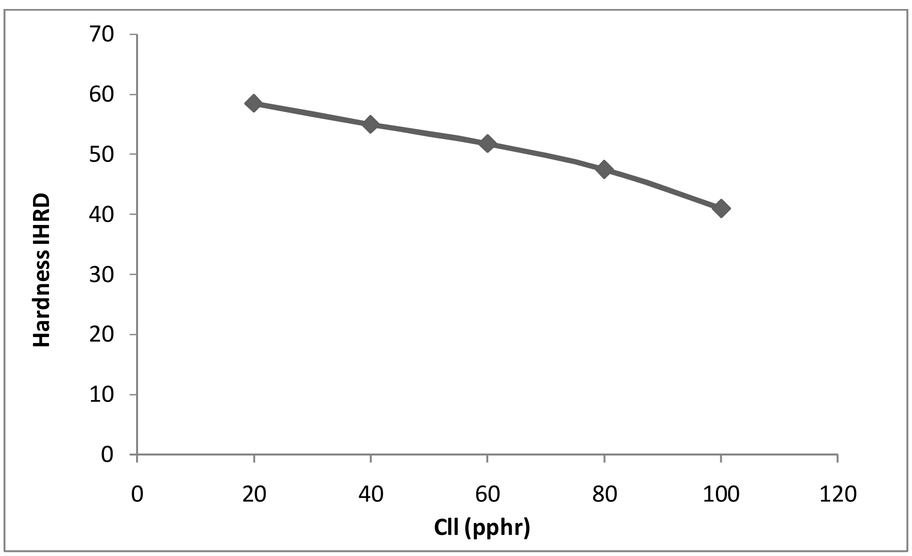

Figure 5. Effect of (Cll) on the SBR Hardness

CONCLUSION

1. Transmission of (X-Ray) that increasing with loading of (Cll) percent .
2. Cross – Linking between compound materials that increasing (X-Ray) transmission.
3. (Cll) that is material enjoy from properties that can be absorb (X-Ray).
4. We can using Chlorophyll as colors and Plasticizers instead of colors and Plasticizers industrialization that having harmful properties

ISSN-L: 2223-9553, ISSN: 2223-9944
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