EFFECT OF PbO WITH RUBBER COMPOSITE ON TRANSMISSION OF (X-Ray)

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ABSTRACT

The best way to Protect from Radiation in keeping the " ALARA " principle , where always trying to reduce the amount of potential radiation exposure to " As Low As Reasonably Achievable " , To protect from Radiation are by applying the flowing three principle of radiation protection one of them is Shielding .There for in this research preparation composite materials to protect Radiation, 5 different rubber compound were prepared by using (SBR 1502) type of Styrene Butadiene rubber in level and each recipe reinforced with Lead Dioxide (PbO) at different ratio (20,40,60,80 and 100) pphr (part per hundred)and using Titanium Dioxide (TiO2) at constant ratio (60) pphr at all compound. All of compound measure the transmission of (X-Ray.)

Keywords: PBO, Transmission Properties, X-Rays, SBR

INTRODUCTION

Ionizing radiation is known to be harmful to human health and heredity [1]. 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 [2] . 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 etcwhich can act as fillers for ducts, trenches and penetrations. Shielding pellets are useful in areas that are irregular in shapes or inaccessible to personnel. X-Ray radiations are best absorbed by dense materials and heavy atoms such as lead and barium [3].

Where there are no space limitations, lead oxide (PbO). In addition to this, organic materials containing higher numbers of hydrogen atoms in a given volume such as poly Isoprene etc., acts as an exceptional base material for X-Ray shielding [4] . However these are much more easily damaged by ionizing radiation than ceramics and metals. The present study involving Rubber (SBR) PbO composites was carried out with the aim of exploring the possibility of using plastic and metal oxide composites for X-Ray attenuation where ordinary blocks and rods can not be used e.g., in empty spaces between the walls, ducts, trenches etc. Ionizing radiation is radiation that has enough energy to remove electrons from atoms or molecules when it passes through or collides with a material [5] .

The loss of an electron with a negative charge that causes an atom to become positively charged is called ionization. When ionizing radiation interacts with skin, it gives its energy to the body tissues. X-rays and γ-rays are the most popular types of ionizing radiation. X-ray irradiation is generated when a strong electron beam bombards metal inside a glass tube. The frequency of this radiation is very high: 0.3-30 x1018 Hertz. The main difference between these two types of ionizing radiation is that X-rays originate in the electromagnetic field surrounding the nucleus whereas γ-rays are created in the nucleus [6] . The amount of ionizing radiation a patient receives is referred to as the radiation dose. Absorbed radiation dose, or the amount of energy absorbed per unit weight of the organ or tissue, is expressed in units of gray (Gy) or rad.

One Gy dose is equivalent to one joule of radiation energy absorbed per kilogram of tissue weight. Rad is the older but still used unit of absorbed dose. The conversion factor from Gy to rad is that one gray is equivalent to 100 rad (FDA, 2003) [7] . To better understand relative dose levels, doses of 30, 32, and 35 Gy were applied in this research. A typical dose for an adult mandibular molar radiograph taken at the dentist office is 4 mGy and 65 mGy for a standard adult panoramic radiograph. The doses of radiation in this experiment were for cancer treatment and were much larger than a normal X-ray in a doctor's office. The effective dose is regarded as an expression of dose in terms of its biological effect [8]

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 target along the incident direction to the incident intensity is given by [9]

$$I/Io = \exp(-\mu t) \qquad (1)$$

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 ($a\sigma$) by the expression

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

The mass attenuation coefficient (μ/ρ) is given by[10]

$$\mu/\rho = \frac{1}{\rho}\, NA\, a\sigma/\rho\, A \qquad (3)$$

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 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 [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,

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

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].

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

Both a single element and composite materials, three processes-photoelectric, Compton and pair production [16] .At 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[17].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} [18].

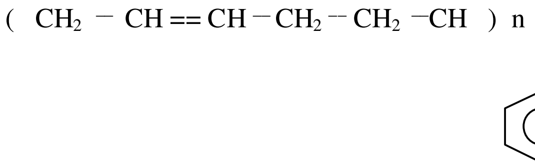
The parameter Z_{eff} is very useful in choosing a substitute composite material in place of an element for that energy depending on the requirement. The energy absorption in the given medium can be calculated by means of well-established formulae if certain constants such as Z_{eff} and Ne of the medium 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. Alarge 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 100 ºC = 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[21] .



$$(CH_2 - CH == CH - CH_2 - CH_2 - CH) n$$

Fig.1: the chemical formula of SBR

* 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]

* Lead Oxide (PbO) semiconductor nanoparticles were prepared by Chemical synthesis method The molecular weight is 223.2,dinsiyu 9.53 gm/cm^3 , melting point 888 °C [23]

* 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[24,25]

- 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) [26] .
- 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) [27]

Table.1: Chemical composition for rubber recipe [21]

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

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. [28]

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

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 [27].

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

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

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

RADIOPROTECTION

Lead Doixide 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.

ISSN-L: 2223-9553, ISSN: 2223-9944
Vol. 3, No. 3, November 2012

Figure (2) shown that (X-Ray) contract when increasing of (PbO) value where (PbO) 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 . In addition to (Pbo) improve the mechanical properties such as hardness and specific gravity. shown the shore hardness is plotted against the loading level of reinforcing filler (PbO) for SBR respectively. From this figure it can be seen that rubber hardness shows signification increment with the increasing loading level of reinforcing of (PbO).

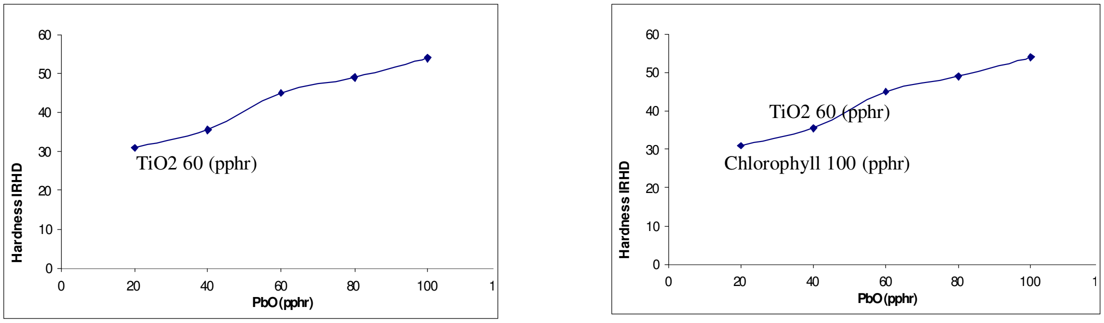


Fig.2: Effect of PbO (pphr) on hardness of (SBR) Compound

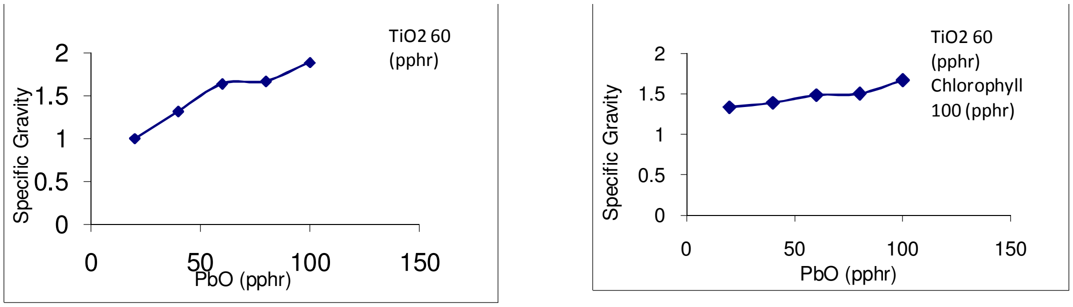


Fig.3: Effect of PbO (pphr) on Specific Gravity of (SBR) Compound

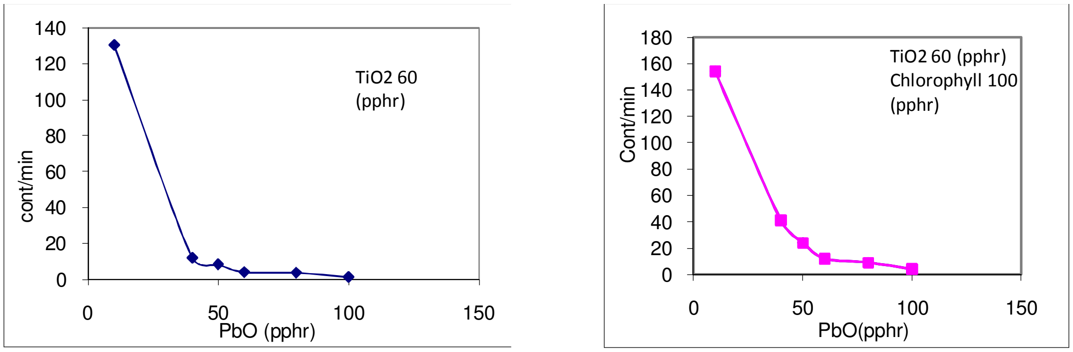


Fig.4: Effect of PbO (pphr) on Transformation of (X-Ray)

CONCLUSION

1. Transmission of (X-Ray) that increasing with loading of (PbO) percent .
2. Cross – Linking between compound material that increasing (X-Ray) Protected (X-Ray) .
3. (PbO) that is material enjoy from properties that can be absorb and scattering (X-Ray).
4. (PbO) increase value of hardness when increasing interaction between filler and Rubber Chain.

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