تصميم المواد البوليمرية النانوية من مادة الرصاص من أجل التدريع الإشعاعي للإشعاعات المؤينة

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ملخص البحث:

يعرض هذا البحث طريقة جديدة لتصميم اذرع وقائية للحماية من الإشعاعات المتأينة باستخدام تركيبة رقيقة جدا من مادة الرصاص nano-sized of lead عند حجم 3 مم , ممزوج بمادة بوليمرية (الايبوكسي) . العينات صنعت بنسب مختلفة من مادتي الرصاص و البوليمرك, حيث تمت عملية خلط هذه المواد بطريقتين مختلفتين وهي طريقة خلط مسحوق والطريقة الأخرى هي زرع أيون. لقياس معامل الامتصاصية لهذه العينات و دراسة مدى كفاءتها لاستعمالها في تصميم أذرع واقية و ذات قدرة عالية في امتصاص الأشعة المتأينة بالتالي الاستفادة من تقنية النانو الحديثة , تم معايرة جميع العينات باستخدام اختبار الحيود بالأشعة السينية (آلة تصوير الثدي الشعاعي) .

DESIGN OF NANOSTRUCTURED POLYMERIC Of Lead FOR RADIATION SHIELDING OF IONIZING RADIATIONS

Abstract:

This paper scrutinizes the design of shielding to protect from ionizing radiation by using non-sized lead mixed with polymeric materials (epoxy-hardener). The samples made in 3mm of thickness with different percentages of lead and polymeric materials. All the samples have calibrated using X-ray diffraction test (mammogram machine). The process of mixing these materials have done in two different ways, which are powder mixing method, and the other way is the ion implantation.

Introduction:

Since the discovery of X-rays by Roentgen in 1895, the dangers of these rays and other radiation ionized have been reported by several articles. Since then, researchers have been looking for the way to reduce the damage caused by these materials [1-3]. These concerns prompted the researchers and scientists to expire and explore a shielding to save the workers from the damage that may inflict these rays [4]. The microstructure of polymeric of some materials such as lead, gold and other materials have been studied and became commonplace for shielding against x-rays radiation [5]. However, the previous studies found that the pest material for using as ionizing shielding is the lead then the tungsten then the gold comes in the third place [6]. Unfortunately, due to some lacks on properties on glass-lead such as the high cost and heavy. However, due to the seriousness of the ionized radiation, these shields are still in need of standards and specifications and requirements more stringent and the power to protect workers and the general public from exposure to these rays [7]. Thus, polymers have unique properties like low density, ability to form intricate shapes, optical transparency and low manufacturing cost. All that properties give it great potential in many important applications were that glass could not meet. However, polymer materials still under study and it’s achieve are still limited due to their inherent softness and low thermal stability [8-14].

In medicine, the radiation shielding were contrived from barium sulfate as a potential alternate for the lead apron used most commonly for medical radiation shielding. Six types of radiation shielding sheets made from a combination of tungsten, molybdenum, rubber and silicon with a barium sulfate base were used, and their transmission doses were compared with those of a lead standard. This mixture was more economical than the existing lead free shielding aprons. In order these materials used to reduce the harmfulness and increase the economic viability with a sheet showing a similar shielding effect as lead [15,16]. The degree of these transformations depends on the organization of the polymer and the conditions of treatment during, before and after irradiation. However, for ionizing radiations shielding purposes, heavy elements such as lead or its compound is the best option for use as filler in epoxy systems because it is the most common shielding material used against ionizing radiation [17].

It is recognized recently, that the applications of nanotechnology has become very dependent on micro-structured and nano-structured materials. From this point it became important to publicize polymers, which can be defined as compounds consisting of molecules that thousands of single-covalent, in conjunction with the molecular weight of 10^4 , 10^6 and a radius of rotation of 5-100 nm. One type of polymer is called epoxy. The Epoxy is any of various usually thermosetting resins capable of forming tight cross-linked polymer structures characterized by toughness, strong adhesion, and low shrinkage, used especially in surface coatings and adhesives. The epoxy system configuration have been studied in recent years for improve its physical and chemical characteristics such as fragility and inherent low thermal deterioration in epoxy matrix [18].

Another study:

The addition of tin to lead increases the rate of radiation attenuation, especially scattered beam that has low energy because the reduction of the tin (K-edge) is 29keV, while it is 88keV for lead. At work area the attenuation by tin metal is better than lead, whereas it reduces the significant amount of weight (as shown in figure 1). The apron made of alloy improves of the prevention and it's better than apron that made of lead only. Approximate weight of the apron is:

- 5.4Kg/m^2 for equivalent apron pb 0.5mm.
- 3.6-4.5Kg/m2 for equivalent apron is made of a mixture equivalent (≈0.4mm pb).
- 3.24Kg/m2 for equivalent apron pb 0.3pb [19].

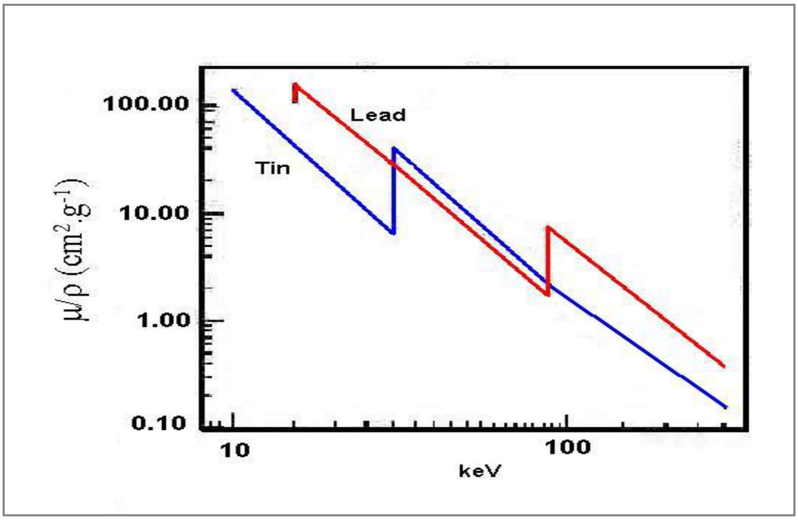

Figure 1 mass attenuation coefficient

The theory:

Absorption coefficient or coefficient of attenuation in physics is the value determines the permeability of light in the material, or permeability of the particle in the material. A large absorption coefficient means that the transmissive ray in the material attenuates (weakens) during the penetration of the material, and a small absorption coefficient means that the material is transparent to the ray passing through it. The absorption factor is defined as the reciprocal of the length [20].

Article Metrics

The Beer-Lambert equation:

Describes the relationship between the intensity of the transmitting ray I I_0. And the falling ray By the Beer-Lambert Law , which states:

$$I = I_o e^{-\alpha x}$$

Where:

x : It is the permeability distance in the material

α : Absorption coefficient (or linear attenuation coefficient).

The Half Value Layer is the value of the material that reduces the intensity of the incident ray in half.

Engineers use these equations to calculate, for example, the thickness of walls to protect from harmful radiation. We obtain the absorption coefficient of a substance by dividing the intensity of the transmitting ray by the intensity of the incident ray $I \backslash I_0$.

The relationship between the linear moderation factor and the weighted moderation factor is that the weight attenuation coefficient is equal $\alpha \backslash \rho$,

Where : ρ It is the density g / cm ^{3} [21].

The aims:

This project will be offered a new approach for the design of the shielding of protection from the rays ionized using nano-structured of lead polymeric materials. In addition, be the reaction of this combination using devices such as TEM, SEM, XRD will be studying, and that to make sure that it will be effective shields for protection from ionizing radiation and that it met the safety requirements in radiation imaging (MRI) in medicine. Moreover, these materials are supposed to be of desirable properties such as strength, corrosion resistance, electrical conductivity and structural integrity.

Table 1: shows the percentages of the components and the total weight

Mass percentage	PbO	Epoxy	Hardener	Total 'g'
10 %	1	6	3	10
20%	2.4	6.4	3.2	12
30%	4.5	7	3.5	15
40%	7.2	7.2	3.6	18

1. **Properties Characterization**

The x-ray test

The samples have tested using Mammogram machine as in figure-2, by placing a sample under the X-ray tube which leaded to parallel the rays to the sample. The results sated on tables 2 , 3, 4, 5 below.

Figure 2: Mammogram x-ray machine

10%			
X-ray tube voltage 'kV'	I_0 'mR'	I 'mR'	I/I_0
22	32.77	1.405	0.042875
25	55.73	3.155	0.056612
30	105.5	7.89	0.074787
35	143.5	14.94	0.104111
40	205	24.12	0.117659
45	254.5	35.03	0.137642
49	315	44.79	0.14219

Table 2: the results of test 10% of lead of the sample

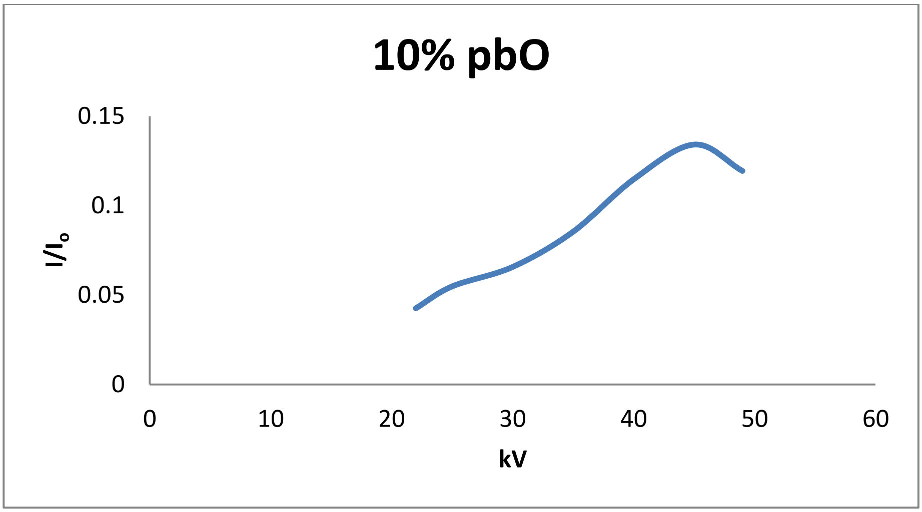

Figure 3: shows the absorption of nano-sizes sample

20%			
X-ray tube voltage 'kV'	I_0 'mR'	I 'mR'	I/Io
22	32.77	0.00765	0.000233
25	55.73	0.0223	0.0004
30	105.5	0.0811	0.000769
35	143.5	0.2855	0.00199

40	205	0.7961	0.003883
45	254.5	2.05	0.008055
49	315	3.32	0.01054

Table 3: the result of test 20% of lead on the sample

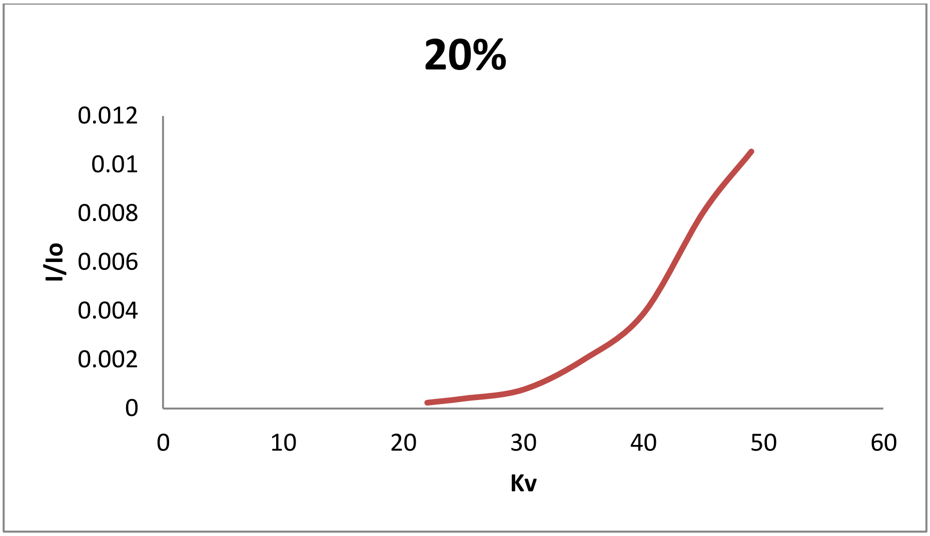

Figure 4: shows that the absorption of 20% of nano-sized lead

30%			
X-ray tube voltage 'kV'	**I_0 'mR'**	**I 'mR'**	**I/Io**
22	32.77	0.00185	$5.65*10^{-05}$
25	55.73	0.0067	0.00012
30	105.5	0.03835	0.000364
35	143.5	0.1983	0.001382
40	205	0.6597	0.003218
45	254.5	1.775	0.006974
49	315	3	0.009524

Table 4: shows the results of the 30% of the lead sample

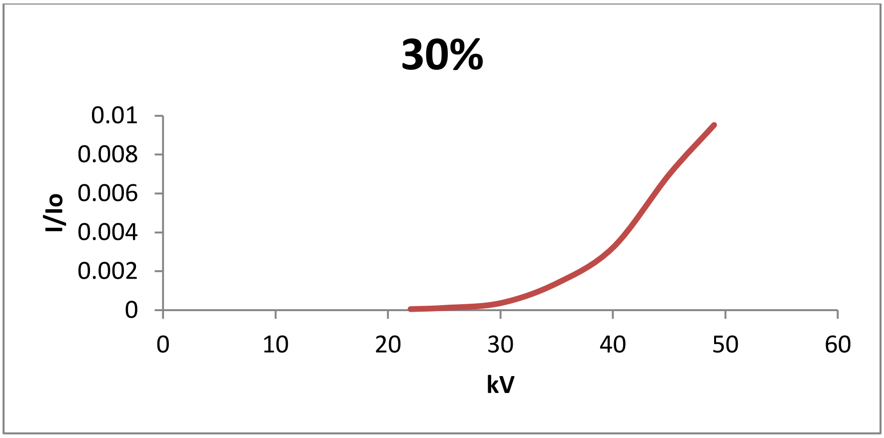

Figure 5: shows the rate of the 30% nano-sized lead

40%			
X-ray tube voltage 'kV'	I_0 'mR'	I 'mR'	I/I_0
22	32.77	0	0
25	55.73	0.0005	$8.97*10^{-06}$
30	105.5	0.00415	$3.93*10^{-05}$
35	143.5	0.03155	0.00022
40	205	0.001492	$7.28*10^{-06}$
45	254.5	0.5037	0.001979
49	315	0.9853	0.003128

Table 5: shows the result of 40% nano sized of lead

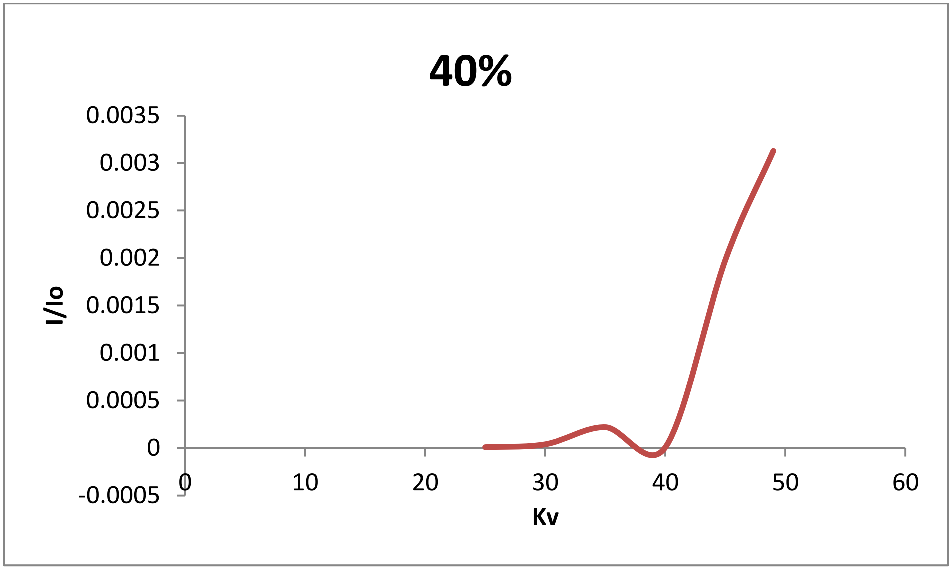

Figure 6: shows the rate of 40% of nano sized lead

Discussion:

The result have got was quite acceptable for 20% and 30% of lead weigh, whereas the rate of the nano-structure lead of 30% was better than the 20% as figure 3, 4 are shows. This means the absorption of the X-ray by nano-sized lead sample with 30% weigh was more than the absorption for 20% sample and that what we looking for and what this experiment aims. Whereas, for the 40% of nano sized of lead weight the results shows some weakness of radiation transmission in the beginning until 40 KV we see the absorbed for the radiation rate became increasing with good results of $0.7*10^{-6}$ mR. Regrettably, the 10% nano-sized sample wasn't as we expected as figure 2 shows, but it wasn't that bad comparing with other study as we included above witch the transmission attenuation reach to $50*10^{-4}$mR as we see in fegure1.

Some lacks in the results have got could be due to an error during the weight or could be due to volatilization when mixing powder. Because that some samples need to remake by fix the weight of the materials.

Future study:

X-rays and Gamma-rays Attenuation

X-ray and gamma machines will use to examine all the samples prepared at the energy between 40kv and 100 kv respectively. It will be placing a sample at a distance of 100 cm under the X-ray tube so that the rays are parallel to the sample. For the detection of X-rays scattered from the sample using solid-state detector based on the film plate.

To monitor gamma rays when passing through the sample the experiences of Geiger and Muller will be used. Also we are looking for repeat this samples using micro-structure of lead.

List of Abbreviation:

KeV	Kilo-electron volt
mA	Milli-ampere
OM	Optical microscopy
pbO	Lead oxide
SEM	Scanning electron microscopy
TEM	Transmission electron microscopy
XAS	X-ray absorption spectroscopy

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