Absorption Coefficient Measurement of Bremsstrahlung Radiation in Nano Composite

The 5th International scientific Conference on Nanotechnology& Advanced Materials Their Applications (ICNAMA 2015)3-4 Nov, 2015

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Abstract

In The present work has been prepare samples of polymer and the formation of composite material at different rates (20%, 50% &70%) of nano lead to clarify the difference in the spectrum absorption bremsstrahlung rays through the process of exponential equations graphic representation of the rate correction as a function of energy within the range (0.1 –1.7) MeV using NaI(Tl) energy selective scintillation counter with $^{90}Sr/^{90}Y$ negative beta source. It was getting also attenuation coefficient of the prepared samples to the same range of energy through graphic representation of natural allegartm count rate as a function of the thickness of absorbent material as the gradient relationship diagrams represents absorption coefficient. The result shows a directly relationship, between the thickness of the absorbent material and the absorption factor. The result, also show that, a reversal relationship, between the absorption factor and the energy of beta particle. The results shows that , the samples prepared of good absorption for beta particles and absorb bremsstrahlung rays and this efficiency is relatively unchanged according to the proportion of nano lead additives which shows a positive impact of the materials prepared in the process of radiation shielding.

Keywords: Epoxy (EP), polyurethane (PU), intensity (I), Particles range (R), Absorption coefficient (μ).

قياس معامل الامتصاص لاشعه الكبح في المواد النانويه البوليمريه المتراكبه

الخلاصة

تم في هذا البحث تحضير عينات من مواد بوليمريه وتكوين ماده متراكبه وبنسب وزنيه مختلفه (20% - 50% - 70%) من ماده الرصاص النانوي .وقد تم توضيح الفرق في طيف امتصاص اشعه الكبح من خلال المعادلات الاسيه لعمليه التمثيل البياني لمعدل التصحيح كدالة للطاقه ضمن المدى (0.1 الى 1.7) ميكا الكترون فولت باستخدام منظومه الكاشف الوميضي (يوديد الصوديوم المنشط بالثاليوم) ومصدر جسيمات بيتا السالبه (السترونتيوم- 90) . وتم الحصول على معامل الامتصاص للعينات المحضره لنفس مدى الطاقه من خلال التمثيل البياني بين اللوغارتم الطبيعي لمعدل العد كداله لسمك الماده الماصه حيث ان ميل العلاقه البيانيه يمثل معامل الامتصاص.وقد تم استنتاج العلاقه الطرديه بين سمك الماده الماصه ومقدار الامتصاص والعلاقه العكسيه بين معامل الامتصاص مع مقدار الطاقه.دلت النتائج المستحصله على كفاءه العينات المحضره في امتصاص جسيمات بيتا وتوهين اشعه الكبح وهذه الكفاءه تتغير نسبيا تبعا لنسبه الرصاص المضافه مما يدل على الاثر الايجابي للمواد المحضره في عمليه التدريع الاشعاعي .

الكلمات المفتاحية : الايبوكسي، البولي يوراثين، الشده، مدى الجسيمات، معامل الامتصاص.

http://doi.org/10.30684/etj.2015.116691
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INTRODUCTION

With a rapid development in science technology, nuclear technology is widely used in electricity generation, industry, and medical care, which have increased people's probability to come into contact with different kinds of radiation. Different radiation protection materials were developed to reduce the harm of radiation to the human body. Concrete and lead products have been widely used in fixed type nuclear reactors and accelerator protection; however, mobile nuclear power plants, nuclear waste transport and storage containers, and space vehicles require a particular weight and volume. Thus, lighter and more efficient materials of radiation protection have been required in these occasions. Due to the low density and the easy processing characteristics, a new type of material which is a polymer based compound material filled with radiopaque powder is now becoming more and more popular.

Because of its good thermodynamic and structural properties, especially its good radiopaque ability, epoxy resin is widely used in these areas: circuit design, radiation shielding, information technology, and space technology; generally it is used in making polymer compound materials [1]. In 2012 Dong Yu et al studied effects of WO3 particle size in WO3/Epoxy resin radiation shielding material [2]. Noor Azman et al in 2013 studied characterization of micro-sized and nano-sized tungsten oxide-epoxy for radiation shielding of diagnostic X-ray [3]. M.A. El-Sarraf et al in 2013 studied, the usability of epoxy/ilmenite (EP/IIm) composite material as a radiation shielding in many applications and a restoration/injection mortar for cracks developing in biological concrete shields [4]. In 2015 Le Chang et al studied the preparation and characterization of tungsten/epoxy composite for γ-rays radiation shielding [5].

According to the traditional radiation shielding theory, the attenuation effect of a shielding material is irrelevant to its microstructure, but mainly depends on factors of the type, energy of radiation, element composition and density of the material.

When an incident beta particle with the intensity of I_0 collide perpendicularly with an absorber with the thickness of x, the intensity (I) passing through the absorber can be evaluated by usual attenuation equation [6], μ is absorption coefficient:

$$I(x) = I_{\circ} e^{-\mu x} \quad \ldots (1)$$

Polymer Blends

Polymer blends is a mixture of two or more polymers in the required amounts, with no covalent bonds between them, or that are not bonded to each other. Therefore, blending of polymers is an excellent method for improving the different properties of polymers [7].The polymer uses in this work is thermosetting polymers different ratio of (EP + PU), thermosetting have cross-linked or network structures with covalent bonds with all molecules. They do not soften but decompose on heating. Once solidified by cross-linking process they cannot be reshaped [8].

Composite Materials

A composit material can be defined as macroscopic combination of two or more materials (reinforcing elements, fillers, and composite matrix binder), differing in form, or composition on a macro scale. The constituents retain their identities, that is, they do not dissolve or merge completely into one another although they act in concert. Normally, the components can be physically identified and exhibit an interface between one another. A composite material is created from a powder (or reinforcement) and an appropriate matrix material in order to maximize specific performance properties also composite uses in this work contain blend with different ratio of lead. [9]

Material and Methods

The materials used to prepare the composite samples as a shield with different thicknesses of this work are; Epoxy Resin (EP) **EUXIT 50** (Swiss Chem.), polyurethane (PU) **EUXIT TG10** (Swiss Chem.) and Lead nano powder.

Preparation of EP/ PU blend

To prepare the EP/PU Blend an exact amount of special hardener is added to the resin with weight ratio of hardener to resin 1:3. The content is mixed thoroughly by a fan type stirrer until the mixture becomes homogeneous.

A sufficient amount of isocyanate hardener is also added to resin (PU) with weight ratio of hardener to resin 1:9. The content is also mixed thoroughly by a fan type stirrer before adding epoxy to the mixture.

The epoxy/ polyurethane blend are prepared with weight ratio of both polymers as (60%EP)/ (40%PU), which is the best compatibility blend [7].

Preparation the composite

By the same manner of previous preparation a ratio of blend (60%EP) / (40%PU), the lead/EP/PU composite are prepared with three weight ratio of lead as shown in table (1).

Table (1): weight ratio of lead in samples.

weight ratio of lead	Sample code
20%	N
50%	L
70%	M

The mixture was placed in a circular templates it's Diameter proportional to the Diameter Detector For the most accurate results as shown in figure (1).

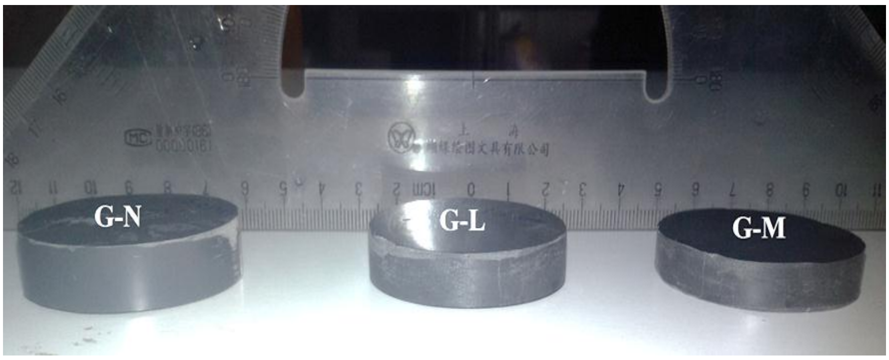

Figure (1): polymer composite samples.

Experimental setup

The experimental arrangement with the electronic configuration is schematically shown in Fig.2. The assembly was placed in lead castle. The energy calibration was performed using a set of standard gamma sources.

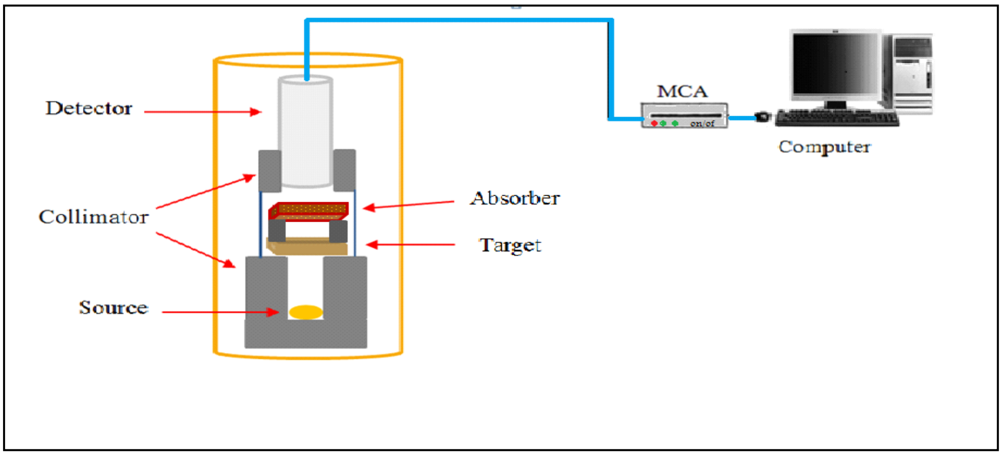

Figure (2): Schematic of experimental setup.

Source

The radioactive source is a ^{90}**Sr/**^{90}**Y** Compound in corporate ceramic insert doubly encapsulated in st-steel capsule x117 beta source which activity was about 0.85 mCi when the measurements took place. ^{90}Sr is a beta emitter, with a half-life of 28.8 years decaying into ^{90}Y; so, the energy rang (0.546-2.274) MeV [10].

Beta particle range

The maximum range, R_{max}, (material independent) of a beta particle can be computed from an empirical formula given by Katz and Penfold [11]:

$$R\ (gm/cm^2) = 4.12E^n\ (MeV) \quad \ldots\ (2)$$

Where

E = the maximum beta energy in MeV.

$n=1.265-0.0954\ \ln E_{max}$.

The ability of stopping beta particles depends primarily on the number of electrons in the absorber (*i.e.*, the areal density, which is the number of electrons per cm^2). Hence, the range when expressed as a density thickness (g/cm^2) of the material gives a generic quantifier by which various absorbers can be compared. With the maximum range known, the actual shielding thickness required can be computed [11]:

$$R\ (gm/cm^2) = [R\ (cm)]\ [\rho\ (gm/cm^3)] \quad \ldots\ (3)$$

Where

ρ is the material density.

So, thus the required thickness(x) need to stop all beta particles from ^{90}Sr/^{90}Y according to eq. (3) to generate bremsstrahlung ray in the samples is shown in Table (2):

Table (2): The required thickness(x) need to generate bremsstrahlung ray.

(x)cm	Samples code
0.7	N
0.5	L
0.4	M

Result and discussion

Radiation passing through the material loses its intensity by absorbing it from material and the figures (3,4 and5) show the variation of count with radiation energy for different sample thicknesses for three weight ratio of lead (N,L and M), respectively.

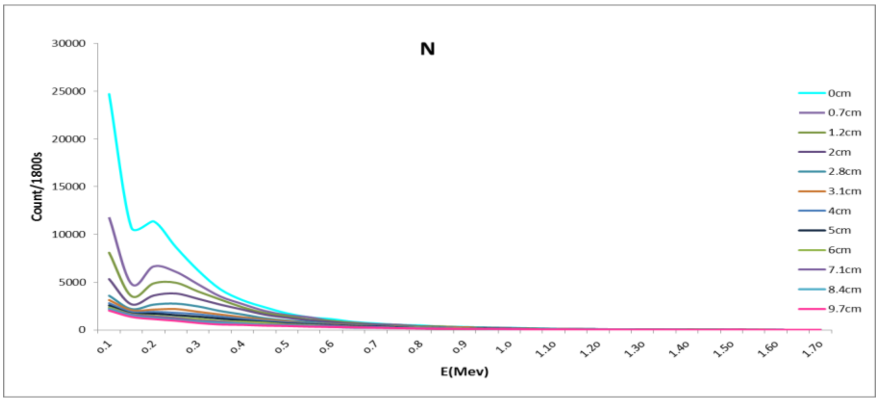

Figure (3): count as afunction of energy in N-composit for different thickness.

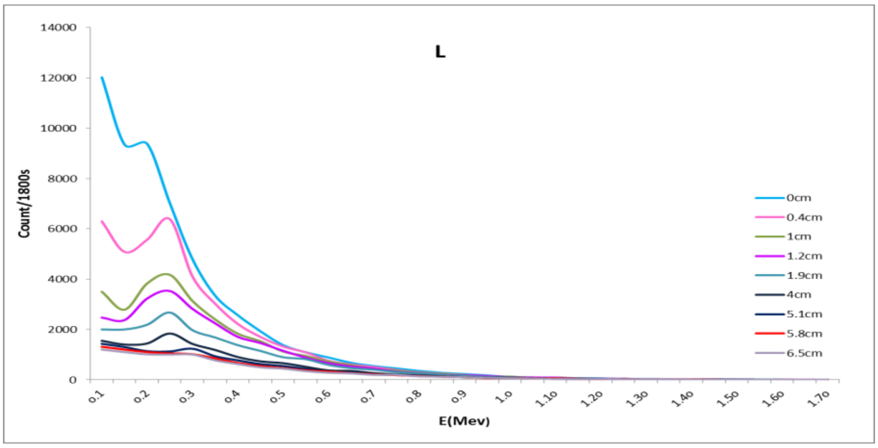

Figure (4): count as a function of energy in L - composit for different thickness.

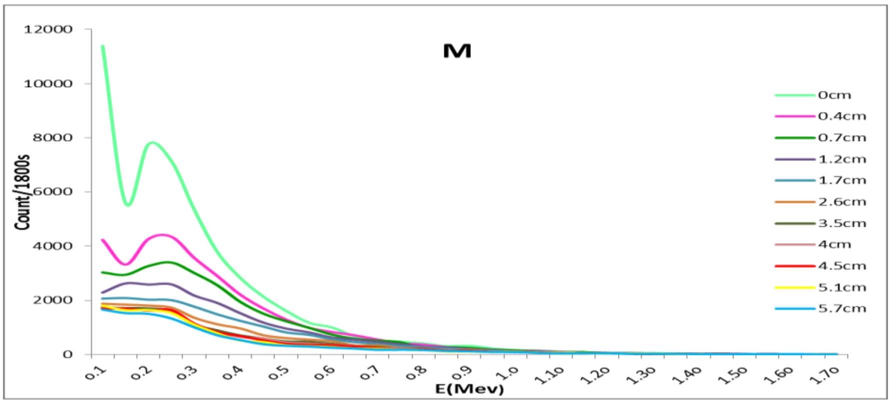

Figure (5): count as a function of energy in M - composite for different thickness.

The figures (3, 4 and5) shows that the intensity of radiation decrease with increasing thickness of samples and also can clarification diference in account in Table (3) with some Selected values of energies for (1.2cm, 5.1cm) in (M) sample Where the count rate decreases with increasing energy until it become a convergent value in all thickness of the sample to highest energies of 0.8MeV.

Table (3): Shows the counts of two different thickness of sample (M).

E(MeV)	0.1	0.3	0.5	0.7	0.9	1.1	1.3	1.5	1.7
Count(1.2cm)	2287	2176	958	463	203	94	28	14	4
Count(5.1cm)	1804	1102	340	208	111	59	34	12	4

Figures (3, 4, and 5) shows that the values of the count rate for M-sample decrease more than other samples with increasing thickness.

Absorption coefficient of samples increases with increase the ratio of lead, while it decreases with increasing energy as shown in figure (6):

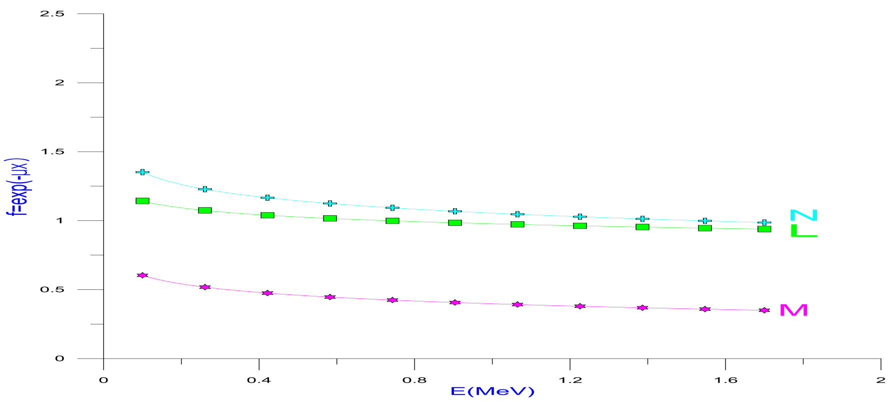

Figure (6): Correction factor of absorption coefficient as a function of energy for different samples.

Figure (6) shows that the absorption of beta radiation does not give a specific range that leads to decreasing the absorption coefficient of beta particles exponationlly as in equation (1). Where the absorption coefficient (μ) of a sample can be evaluated from the linear fitting of [ln (I/I_0)] versus thickness (X) of the sample shown in table (4).

Table (4): The absorption coefficient for samples (N, L, and M).

E(MeV)	μ(cm-1)(N)	μ(cm-1)(L)	μ(cm-1)(M)
0.1	0.214	0.192	0.219
0.15	0.212	0.111	0.154
0.20	0.211	0.178	0.193
0.25	0.223	0.219	0.227
0.30	0.221	0.234	0.263
0.35	0.209	0.224	0.285
0.40	0.187	0.213	0.293
0.45	0.177	0.211	0.283
0.50	0.157	0.18	0.248
0.55	0.146	0.188	0.249
0.60	0.137	0.175	0.227
0.65	0.088	0.153	0.206
0.70	0.122	0.162	0.232
0.75	0.124	0.134	0.181
0.80	0.117	0.093	0.138
0.85	0.125	0.128	0.164
0.90	0.115	0.131	0.152
0.95	0.096	0.133	0.144
1.00	0.100	0.106	0.087
1.05	0.095	0.081	0.128
1.10	0.110	0.103	0.122
1.15	0.993	0.101	0.091
1.20	0.073	0.087	0.091
1.25	0.061	0.083	0.073
1.30	0.108	0.052	0.041
1.35	0.067	0.023	0.010
1.40	0.106	0.043	0.107
1.45	0.089	0.068	0.033
1.50	0.007	0.172	0.027
1.55	0.037	0.139	0.090
1.60	0.133	0.077	0.206
1.65	0.170	0.045	0.960
1.70	0.031	0.008	0.033

And also to prove useful of (M) sample comparing it with the count of pure lead is shown in figure (7).

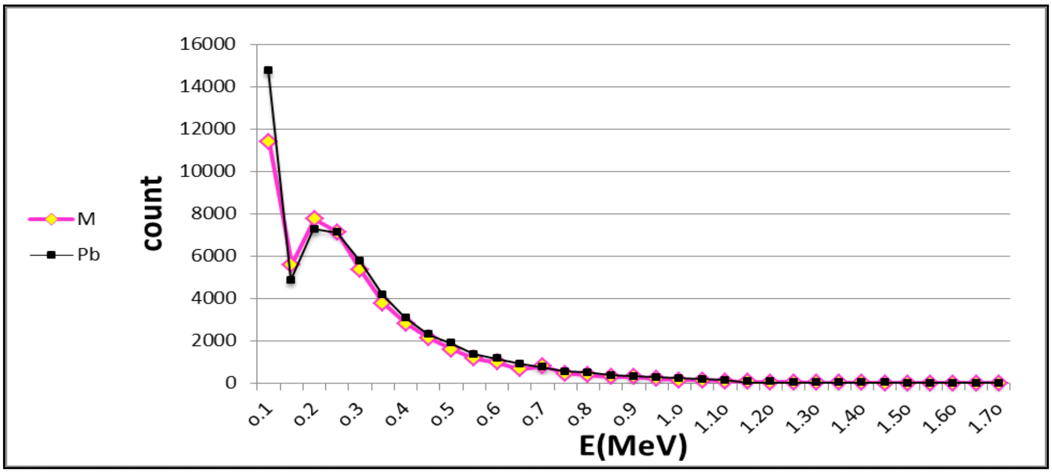

Figure (7): The count rate as a function of energy using pure lead and M sample.

Conclusion

From the results shown one can see that**:-**

1. The samples manufactured in the present work are a good absorbers of negative beta particles and bremsstrahlung radiation.
2. Absorption of bremsstrahulng ray increased by increasing lead ratio
3.Bremsstrahulng can be absorbed by placing (putting) the materials with low atomic number and then materials with high atomic number.
4.The obtained results shows M-sample is a good shiellding for beta source if manufactured by an appropriate thickness.
5.In addition, characterized samples also manufacturer properties such as light weight and ease of manufacturing, transportation and smooth installation and molding to the desired shape can make it attenuation materiales of radiation with a large range in the applications (industrial, medical and environmental).

Future work

1.Tungsten can be used as an absorber for beta particle instead of lead.
2.Exchange epoxy by polystyrene, polyester, styrene-butadiene as a material sample in the blend.
3.Taking different ratios of lead as (30% - 60% - 80%) to prepare another composite material.

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