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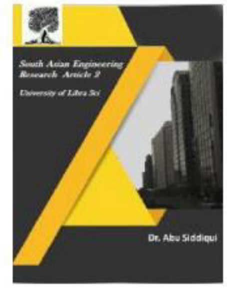

GAMMA RAY AND FTIR STUDIES IN MIXED POLYMER COMPOSITES FOR RADIATION SHIELDING APPLICATION

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Abstract

Gamma ray shielding properties of mixed composites samples containing oxides like lead oxide (PbO), bismuth oxide (Bi_2O_3), tungsten oxide (WO3) with polymer matrix composite panels, doped with different ratios of mixed powder, were produced and characterized by Fourier Transform Infrared Spectroscopy (FTIR). Some of the techniques are used and evaluated practically using XCOM computer software for gamma ray shielding properties. However, gamma ray shielding properties are discussed in terms of various calculated parameters such as half value layer, mean free path and mass attenuation coefficient. The calculated parameters and performance are studied for radiation shielding applications. FTIR studies are undertaken to investigate the various structural groups present in the prepared system. Furthermore, it was observed that the polymer mixed composites samples from 1-7 possess minimum HVL value and maximum mass attenuation coefficient, It has been inferred that addition of mixed composites improve the gamma ray shielding properties for radiation shielding applications.

Keywords: Mixed composites, FTIR Characterization, attenuation coefficient, half value layer.

1. Introduction

Recent advancement of nanotechnology has made nanoscience hot area of research due to their infinite number of advantageous properties. Besides, the focused have been made on gamma ray radiation for different purposes, including nuclear reactor, medicine, industries and nuclear power plant. In recent years transition metal oxide glasses have attracted greatly the attention of many researchers and industries because of their valuable optical and electrical properties. Heavy mixed metal polymer composites are technological importance because of their wider range of their applications. These mixed polymer composites use in various applications including also food, agriculture, medicine, industry and science. Polymer mixed composites containing lead, bismuth, tungsten great importance because it possesses desirable electrical resistivity, low melting points, and high chemical stability over a wider range of concentrations. Furthermore, these polymers fillers play vital role in wide area of research and industrial applications related to radiation shielding applications. In recent time, the study of lead in particular, as one the major essential material former, once it incorporated with certain amount of heavy metal such as lead oxide its properties such as hardness, mechanical strength, transparency and optical properties, drastically change(4, 5). These composites mixed with some fillers density due to its higher bond strength, that make them promising candidate for feature shielding materials.

Usually, concrete are used as conventional shielding materials for protection of gamma radiations but due to certain limitations in the concrete like zero visibility and degradation of their mechanical strength in harsh environmental conditions, researchers requires some alternative method to replace it with another material with mixed composites useful for protection from heavy radiation shielding applications., mechanical strength and non-degradable. Nowadays, mixed composites containing heavy metals becoming promising candidates as a radiation shielding materials. The aim of present work is to investigate radiation shielding properties of some mixed polymer composites and their structural properties using FTIR investigations.

2. Experimental and Theoretical Techniques

All the synthesis chemical reagent of the glass was analytic grade used without further purification. The shielding mixed polymer composites sample was prepared via assisted melt quenching method as followed. A number of composites lead oxide (PbO), bismuth oxide (Bi_2O_3), tungsten oxide (WO3) were thoroughly mixed together. The homogenous mixture was subsequently place in the furnace for a period of 3h at 900 ºC. The melt samples were rapidly cooled to room temperature. The composites sample`s density was calculated using Archimedes principal benzene solution are used as immersion liquid. Furthermore, the molecular structure of the polymer matrix was analyzed using Fourier Transformation Infrared spectrum (FTIR).

The mass attenuation coefficient of the prepared mixed composites samples have been investigated theoretically using Win XCOM computer software at different energies, and compare with standard shielding materials were studied Molar volume (V_m) volume of the mixed samples has been estimated by using the following expression:

$$V_m = \frac{M}{\mu} \quad (1)$$

Where ρ is the density of the sample and M is the molecular weight of the sample. The mass attenuation coefficients calculated using the equation (1)

$$\mu_m = \sum_i^n w_i(\frac{\mu}{\rho}) \quad (2)$$

Where w_i is the weight and (μ/ρ) is the mass attenuation coefficient of the sample. The

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(μ/ρ) values can be taken directly from XCOM software or user-friendly Win XCOM software after substituting the sample composition. The linear attenuation coefficient (in cm-1) is multiplication of μm = (μ/ρ) value and density of the glass. One the easiest technique to determine the effectiveness of material toward the radiation shielding is to employ the idea of half value layer (HVL). This concept was defined by many researchers as the quantity of radiation shielding material needed to reduce the radiation intensity to one-half of the unshielded valve.

$$HVL = \frac{0.693}{\mu} \quad (3)$$

Where μ represent the linear attenuation coefficient and it can be found in the tabular form of radiation shielding parameters. In order to determine the attenuated energy photon in the absorbing medium, the Mean free path (MFP) was estimated as the distance in which the initial photon intensity can be reduced by 1/e factor. Therefore, mean free path (MFP) is considered as the reciprocal of the linear attenuation coefficient.

$$MFP = \frac{1}{\mu} \quad (4)$$

3. Result and Discussion

3.1 Densities and molar volume

The molar volume of the mixed samples was calculated using equation 1. However, Table 1 contains the chemical composites of the prepared mixed samples, densities and molar volume. Furthermore, it was observed that the density of the mixed sample increases with increase of heavy metal content (lead oxide), bismuth, tungsten the molar volume of the glass samples also increases with increase in concentration of these heavy metal oxides. The molar volume clearly shows that the prepared mixed sample`s structure corresponding to higher composition is becoming more open leading the formation of non-bridging oxygen. The molar volume and density the mixed samples corresponding to high compositions increase due to increase of heavy metal mixed contents.

3.2 Mean free path and mass attenuation coefficient

The estimated values of men free path (MFP) for all the mixed samples are given in Table 1. From Table 1 it can be concluded that sample S1 has the lowest mean free path at high energy, which means the rate at which the photon energy is penetrating the sample is less in samples S6. Furthermore, the values of mean free path increase with the increase in the energy of incident Photon12. The glass samples were effectively prepared and its mass attenuation coefficient was evaluated using equation 2, and the results were given in the Table 1, at the energy ranging from 1meV to 100keV. It has clearly observed that to some very extent, the values of mass attenuation are quite very high at low energy value; at this stage, the photoelectric effect is dominant. The mass attenuation coefficient value is evident in the Tables 1, which shows high decease in attaining minimum values at the intermediate energy range. Some photon

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energy move away from the intermediate range of energy are consider as Compton scattering region, the high range of energy corresponding to pair production values of mass attenuation coefficient, at very high energy the value of mass attenuation coefficient become almost constant.

Table 1: Mass Attenuation Coefficients (µm) of mixed polymer Samples

Sample	Mass Attenuation Coefficient (cm2g-1)			
Energy	5.00E+00	1.03E+03	9.34E+02	9.34E+02
S1	1.03E+03	1.34E+02	1.34E+02	1.00E+02
S2	1.03E+03	1.09E+03	1.09E+03	-5.38E+01
S3	1.12E+03	1.13E+03	1.13E+03	-1.75E+01
S4	1.79E+02	1.95E+02	1.95E+02	-1.63E+01
S5	1.88E+02	1.75E+02	1.67E+02	1.28E+01
S6	1.92E+02	1.70E+02	1.59E+02	2.15E+01
S7	2.19E+02	1.97E+02	1.77E+02	2.25E+01

3.3 Half Value Layer and FTIR Analysis

Half Value Layer (HVL) of the prepared mixed samples at different energies was calculated from linear attenuation coefficient using equation 3. The simplest method to investigate the effectiveness of material is to compute its HVL value. It can be observed practically that the HVL that was found with minimum values among the mixed samples is S1, which corresponds to highest mixed composition and filler quantity. Minimum HVL value suggested that this mixed composition is more effective for gamma ray shielding applications. Therefore, the HVL of S1 can be studied with corresponding HVL of the conventional shielding materials.. The FTIR spectral studies (Figure1-7) have been undertaken to investigate various structural groups present in our mixed samples. The peaks in Figure 5 corresponding to wave numbers as shown practically 650.6cm^{-1},683.79cm^{-1},885.05cm^{-1} are assigned to the stretching vibration in the symmetrical of mixed composites. Some peaks are observed at 875.36cm-1 it was shifted strongly to the high wave number indicating presence of all the mixed samples. The peaks that were appear between 650.7 cm^{-1} to 4000.96 cm^{-1} is assigned to the bond of various vibrations. The peak observations as shown in sample 1 to sample 7.

Sample designation	Wt. % of mixed fillers composite	Resin in terms of weight in (gm)	Fillers in terms of weight (gm)	Molar Volume (cm3/mol)
SM1	0	150	0	32.73333
SM2	5	142.5	2.5+2.5+2.5	34.45614
SM3	10	135	5+5+5	36.37032
SM4	15	127.5	7.5+7.5+7.5	38.63099
SM5	20	120	10+10+10	40.91666
SM6	25	112.5	12.5+12.5+12.5	43.64444
SM7	30	105	15+15+5	46.76190

Figure 1: FTIR spectra of electron beam irradiated ISO+0% mixed polymer composites.

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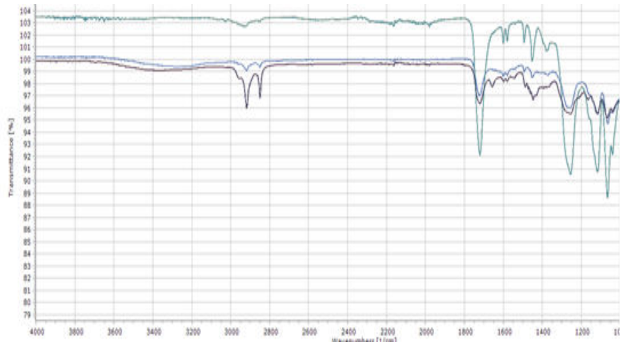

Figure 2: FTIR spectra of electron beam irradiated ISO+5% mixed polymer composites.

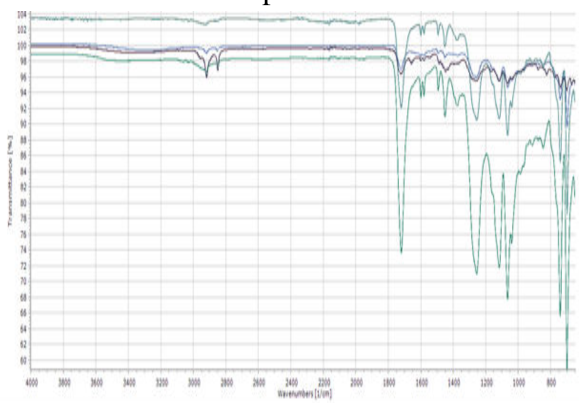

Figure 3: FTIR spectra of electron beam irradiated ISO+10% mixed polymer composites.

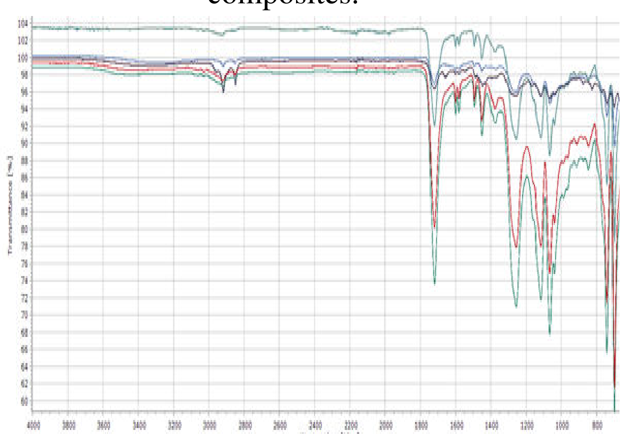

Figure 4: FTIR spectra of electron beam irradiated ISO+15% mixed polymer composites.

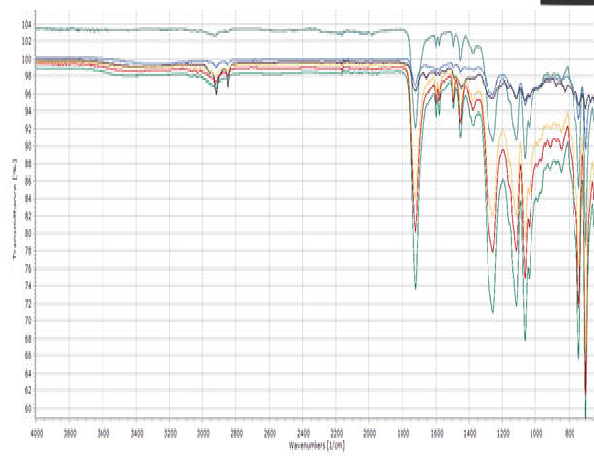

Figure 5: FTIR spectra of electron beam irradiated ISO+20% mixed polymer composites.

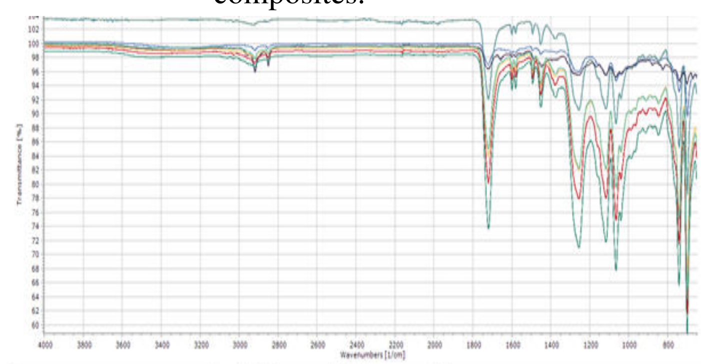

Figure 6: FTIR spectra of electron beam irradiated ISO+25% mixed polymer composites.

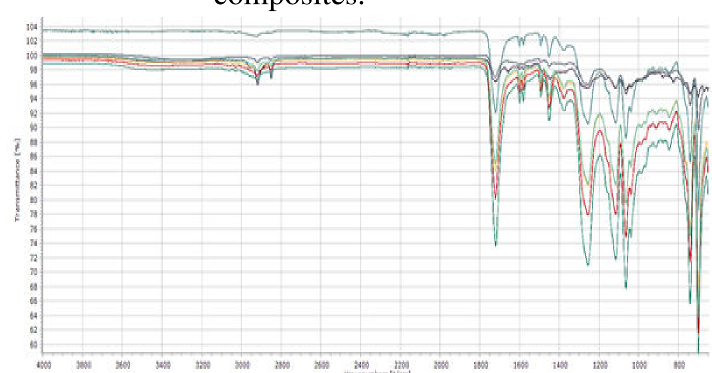

Figure 7: FTIR spectra of electron beam irradiated ISO+30% mixed polymer composites.

4. Conclusions

In this work, it is concluded that mixed composite samples 1-7 has maximum mass attenuation coefficient and minimum HVL value. Furthermore, it is concluded that the attenuation properties improves with increase in mixed polymer composites ratio. The samples containing lead, bismuth, tungsten shown better shielding properties in terms of less HVL value and high mass attenuation coefficient studied practically. FTIR studies indicate the better radiation shielding applications. The influence of heavy mixed metal oxide of all the composites on the structural changes can be observed in the FTIR investigations and characterization. Our findings suggest that mixed composites containing several heavy oxides can serve as good radiation shielding materials as compared to any other composites.

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