Design of Flexible Gamma Ray Shielding Material Composite of Natural Rubber with Coconut Shell/Clay Powder

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Introduction

The development of flexible and light materials that efficiently protect radiation workers and the environment is an area of research with plenty of practical applications. Additional factors involved in selecting an effective shielding material include conformability, cost-effectiveness, weight factor, toxicity, durability, etc. In this regard, polymer composites consisting of a mixture having components of different atomic numbers, incorporated within hydrogenous polymer-matrix with micro or nano scale structures have great potential to be used for radiation shielding[1, 2].

In the present study gamma ray shielding properties of natural rubber (NR) plus coconut shell powder and clay powder composites in the form of sheets were prepared for different thicknesses. The preparation was carried out in such a way that for each specified weight fraction of natural rubber and clay powder, the coconut powder weight fraction was varied, keeping the final thickness the same.By using^{137}Cs as a gamma radiation source, the composites were investigated to determine their gamma ray shielding effect. The measurements have been carried out by using a HPGe detector and an MCA setup attached to a personal computer. For each sample and thickness, three independent 5 hour tests were conducted and average counts (I) were recorded. Average counts without samples placed between the gamma source and detector, were recorded as the initial or reference count (I_0). Values of $ln(I/I_0)$ were then plotted against their corresponding thicknesses (x) and the slope of the plot was calculated[3]. It may be noted that $ln(I/I_0)$ and x are related by:

$$\ln(\frac{I}{I_0}) = -\mu x$$

Thus, μ is the linear attenuation coefficient related to the calculated slope of $ln(I/I_0)$ and x. Mass attenuation coefficient(μ/ρ) ,half value layer (HVL) and mean free path (MFP) have been estimated for all these samples. Here ρ is the density ofthe samples.The basic properties of rubber-coconut shell samples with different weight fraction are listed in Table 1. *CS- Coconut shell, x-thickness, ρ - Density and phr-parts per hundred

TABLE I: The basic properties of rubber-coconut shell with different weight fraction

Sample	CS (in phr)	x (in mm)	ρ (g/cm^3)
CSCLR 0	0	2.5	2.0061
CSCLR 15	15	2.5	2.0337
CSCLR 30	30	2.5	2.0621
CSCLR 45	45	2.5	2.0951
CSCLR 60	60	2.5	2.1556
CSCLR 75	75	2.5	2.2319

Results and Discussion

The values of the average linear attenuation coefficient for the fabricated samples were found to be increasing with the increase of weight fraction of coconut shell from 0 phr to 75 phr, at 0.662 MeV gamma ray energy. The presence of Pb content in the coconut shell

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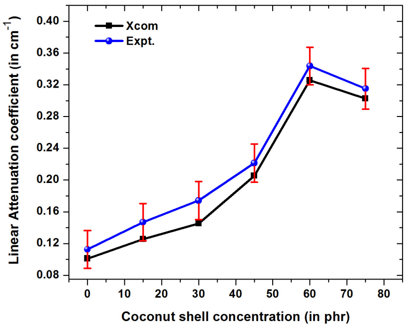

FIG. 1: Variation of linear attenuation coefficient against the coconut shell concentration

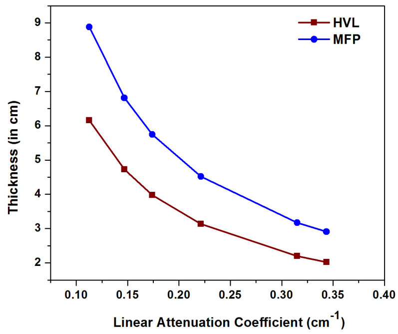

FIG. 2: HVL, MFP vs. the average linear attenuation coefficient for the samples.

powder plays an important role of for the attenuation process. From the EDXRF analysis, it is found that the sample CSCLR 60 (containg 60 phr coconut shell) has 18% of Pb content which has maximum linear attenuation. Sample CSCLR 75 (containing 75 phr coconut shell) has 15% of Pb content. Figure 1 shows the variation of linear attenuation coefficient against the coconut shell concentration. is observed that by adding the coconut shell powder, the volume of void spaces in the rubber is reduced and the mixture will be relatively denser. Further, increasing coconut shell content leads to cracks and holes formation. These cracks and holes reduce the cohesiveness of the rubber matrix and deteriorates its homogeneity.Optimum value has ranged between 60 to 75 phr of coconut shell powder. Figure 2 shows the variation of mean free path and half value layer against the linear attenuation coefficient.

With regards to the mechncical properties of the prepared samples, the tensile modulus at 100% elongation shown in almost linearly decreased with clay and coconut shell powder contents.This behavior could be explained by the fact that as the contents of coconut shell increased, the crosslinking density were is increased. Resulting in greater restriction of the cross-linking joints on the mobility of intercross-linking chains. This effect leads to lesser tensile modulus[4].

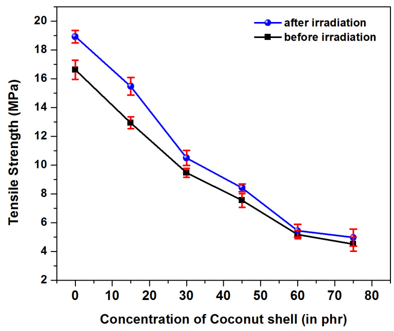

FIG. 3: Tensile strength of composites with addition of coconut shell powder.

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