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A Short Critique on Development and Properties of B_4C Dispersed Epoxy and Rubber Based Irradiation Shielding Materials

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ABSTRACT

The present article deals with the review on the development and the after effect of irradiation exposure on the properties and characteristics of some B_4C polymeric irradiation shielding materials. The smorgasbord of radiations such as alpha, beta, neutron and gamma and their effects not only on biotic but also on a-biotic environments lead to the development of irradiation shielding materials. This article confirms the fabrication of shielding materials that trades off the factor weight without compensating the irradiation shielding ability however possibly by studying material with high thermal neutron absorption and other attenuation factors. One such material is polymers and its allied materials owing to the presence of rich in hydrogen content and the tendency to augment particles within themselves made them suitable for the above mentioned purpose. The details of fabrication and the effects on the mechanical properties are well discussed in this work.

Key words : Attenuation factors, Irradiation Shielding, Polymer Composites, Rubber based composites.

1. INTRODUCTION

Radiation, being a major participant in the electromagnetic spectrum is widely classified into ionizing and non-ionizing radiations. The classification is widely characterized by the interaction of such radiations with the particles, materials and medium as well. The non-ionizing radiation being impotent in ionizing the material which it passes through owing to its low ionizing capability is of less interest among the scientists. On the other hand, the ionizing radiation because of its high ionizing potential ionizes the material which it comes across. Researchers revealed the variety of classification of these radiations ranging from visible light to gamma radiation of the electromagnetic spectrum. Nowadays the demand in developing sustainable materials has improved in order to reduce the threatening degradation of the environment. One such material that is abundant now is recyclable and reusable plastics [1]. Reports suggest the usage of recyclable material for useful potential application saves the characteristics of the soil since landfills and other associated works could be minimized to a considerable extent. The safe accumulation of spent nuclear fissionable fuels without disturbing the environmental characteristics has now become a major keyhole of research. Several researchers have opened the gateway for finding the solution for storing and disposing the spent nuclear fuel possessing harmful radiation such as neutron and gamma radiation. Owing to the deteriorating hazards by these radiations, it is expected that the radiation absorbing and shielding material to have excellent strength, plasticity and excellent neutron absorbing properties for shielding [2-4]. Development of such materials has created great focus among researchers in practical problems [5-7].

EPDM rubber i.e. Ethylene Propylene Diene Monomer comes under the family of synthetic rubber is reported to be applicable widely in nuclear industries as well as domestic applications as sealants and insulating materials respectively [8-9]. However several scientists have reported the usage of EPDM as an embedding material for handling nuclear waste owing to its stability in gamma radiation environment [10]. It is proposed by several researchers that plenty of polymeric matrices affluent in hydrogen content serves the purposes of thermal neutron shielding which is reported because of the tendency of the hydrogen to slow down the neutron particles however lags in flexibility. This makes in the search of flexible polymeric shielding material that serves for the dual purposes like flexibility as well as attenuating the radiation [11-13]. It is also well known that boron carbide particles are a potential replacement for lead based irradiation shielding materials. Boron however natural or enriched is widely suitable to absorb and control the fast accelerated thermally activated neutrons. Since B_4C is

relatively cheap while comparing to other hard metals used for shielding and also possess neutron absorbing cross-section. It is also well known that B_4C being hard is widely used in many of the tribological applications as well [14-16]. Numerous works have reported the consumption of polymeric material dispersed with metallic particles benefiting the irradiation shielding responses. The present article reveals the responses of composites fabricated through wide range of fabrication routes with various polymeric matrices augmented with B_4C particle reinforcements on the mechanical and irradiation shielding properties.

2. EPOXY BASED COMPOSITES

2.1 Epoxy as matrix

With a view to have effective shielding, inclusion of hydrogenous materials in the shielding applications had led to the development of polymeric composites in such sophisticated applications. Epoxy is a well known thermosetting polymer which hardens by inhaling temperature founds to be more beneficial since possessing light weight and the ease at which it can manufactured. The exemplary properties such as excellent dimensional stable behavior, owing to the limited shrinkage, good adhesion strength with a wide range of particle reinforcements, excellent mechanical strength, good resistance to heat and also possession of resistance to chemical attacks as well. Moreover researchers reveal the possession of durability enhancement owing to the presence of aromatic ring in its chemical structure when exposed to gamma and neutron irradiation [17]. Scientists have also reported the retarding to flame characteristics bare by epoxy when augmented with limited reinforcements [18].

2.2 Epoxy with B_4C particles reinforcement

Augmenting B_4C particles with epoxy was reported to increase the tensile property of the test pieces to a considerable extent but addition of the same beyond a threshold limit was reported to reduce the tensile property drastically. On the other hand several reports have showcased the increase in tensile modulus of the test pieces comprising of augmented addition of B_4C. The above fact is a generalized phenomenon to be considered while researching with augmenting B_4C with epoxy [19]. However the trends in irradiation shielding are quite different from that of the mechanical properties.

2.2.1 Attenuation studies

Reports suggested that the superiority of epoxy and B_4C when augmented decreased the neutron flux attenuation with respect to the thickness of the test piece as a function. The results were reported to be comparatively negligible even with the consumption of particles of less size. However the reason reported was nothing but the augmented and yield in the absorbability of the borated sample in connection with the thermal neutron irradiation. The gamma attenuation of the samples borated with B_4C tends to behave much lower when compared with the test samples loaded with lead oxide particles. However the particle dispersion as well as particulate agglomeration plays a vital role in case of yielding not only the shielding property but the mechanical property as well [19-22].

3. RUBBER BASED COMPOSITES

3.1 Rubber as matrix

EDPM rubber being a synthetic rubber and natural rubber find enormous application in the field of irradiation shielding owing to its increase in the composition of hydrogen in their chemical content [23-24]. Scientists suggested the usage of EDPM rubber for some specific shielding applications when added upon with specific filler materials i.e. upon borating, these rubber materials were used for neutron shielding as well as electromagnetic interference shielding as well [25-26]

3.2 Attenuation Studies

The attenuation studies by some researchers have revealed the superiority of EDPM rubber matrix with respect to the content added and as a function of thickness. The study revealed the addition of borated content increased the elastic and in-elastic scattering contained within the sample thereby increasing the thermal neutron shielding. The same has also reported the yield in the mean free path of the borated sample which in turn increased the shielding efficiency [27].

4. CONCLUSION

This short critique paves way for the understanding the irradiation shielding responses of epoxy and natural rubber based polymer matrices dispersed with B_4C and other borated particles. the following were the conclusions derived from the above discussion:

1. The presence of hydrogenated materials will reduce the risk of neutron irradiation by absorbing the fast moving neutron particles thereby increasing the neutron shielding efficiency.
2. Epoxy as mentioned by researchers as a noble matrix material for irradiation shielding responses when augmented with boron rich materials.
3. Rubber, however natural as well as synthetic, has received numerous response among the researchers owing to its chemical composition that facilitate the provision of a hydrogen affluent content end up with good neutron shielding ability.
4. When borated the rubber showcased augmented performance in the case of gamma attenuation but also motivated it in the application wherever flexibility is a major issue.

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