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Effects of γ- Irradiation on High-Density Polyethylene/SiO2 Polymer Nanocomposite Films

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The effects of gamma irradiation on the structural, morphological and thermal properties of high-density polyethylene (HDPE) based nanocomposites (HDPE/%SiO2) are discussed in the work. The main objective and significance of the proposed research is to develop a multifunctional hybrid structure that can provide efficient radiation shielding and at the same time can provide excellent structural properties.
Polymer nanocomposite materials are manufactured commercially for many diverse applications such as isolation materials, aerospace components, automo- biles, etc. In the field of nanotechnology, polymer based nanocomposites have become an important area of current research and development. The addition of inorganic spherical nanoparticles to polymers allows the modification of the polymers physical properties as well as the implementation of new features in the polymer matrix. These composites show unique properties combining the advantages of the inorganic fillers like the rigidity, high thermal stability, and mechanical property with the processability, flexibility, and ductility of the organic polymers [1, 2, 3].
Polymer nano-composite films of high density polyethylene matrix (HDPE+%SiO2) were obtained by thermal pressing (under a pressure of 15 MPa) at a temperature 165 ℃, followed by rapid cooling in water-ice system. As a filler it has been used an amorphous silica dioxide α-SiO2 (Sky Spring Nanomaterials, Inc. Houston, USA) with 20 nm size of spherical particles, specific surface area of S=160 m2/g and density of 2,65 g/sm3 [3]. The nanocomposite films were irradiated by γ-ray radiation. The irradiation was performed at room temperature by g-radiation 60Co isotope source on the facility PX-γ-30 (ANAS Institute of Radiation Problems, Baku, Azerbaijan). The samples were subjected to various irradiation doses from 100 kGy to 500 kGy. The dose rate was 2.7 kGy/h during the irradiation [4]. Small-angle X-ray scattering (SAXS), small-angle neutron scattering (SANS), scanning electron microscopy (SEM), differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) have been implemented to characterize nanoparticles behavior in the matrix of high-density polyethylene (HDPE).
The effects of gamma irradiation on the structural, morphological and thermal properties of this particular composition were systematically investigated and conclusions were drawn.
The nano-SiO2 filler causes strong interfacial interactions into HDPE polymer matrix. The nanoparticles lead to higher crystallization rate of HDPE. The lamellar thickness and the degree of crystallinity increase with increasing the nano-SiO2 filler loading. The degree of crystallinity, and crystallite sizes (both HDPE and the composite) increased with increasing of irradiation dose.
The polymer crystallinity increased as a consequence of the polymer chain alignment due to the crosslinking upon γ- irradiation. The enhancement of β-phases occurred due to the presence of hydrogen bonding that promoted crosslinking in the crystalline region upon gamma irradiation.
SEM results revealed that nano-SiO2 particles aggregates were in general distributed homogeneously. It was found that the nano-SiO2 aggregates are evenly located in the polymer matrix and their surface roughness and fractal character are determined by their initial state in the powders. DSC results showed that the silica nanoparticles decrease the melting temperature of composite but increase the crystallization temperature. Moreover, the structural and thermo-physical analysis showed that the core materials can retain the structural integrity after they are exposed to the highly gamma radiation.
The results obtained for radiation shielding parameters of HDPE/SiO2 nanocomposite films were found to be more promising and efficient for radiation protection against gamma-ray. In summary, our studies suggest that gamma irradiation can be used for improving the functional properties of polymer–ceramic composites, which are of technological importance in various fields.

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