World Academy of Science, Engineering and Technology
International Journal of Health and Medical Engineering
Vol:10, No:01, 2016

Ultra-High Molecular Weight Polyethylene (UHMWPE) for Radiation Dosimetry Applications

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Abstract : Ultra-high molecular weight polyethylene (UHMWPE) is one of the polymers belongs to polyethylene (PE) family having monomer –CH2– and average molecular weight is approximately 3-6 million g/mol. Due its chemical, mechanical, physical and biocompatible properties, it has been extensively used in the field of electrical insulation, medicine, orthopedic, microelectronics, engineering, chemistry and the food industry etc. In order to alter/modify the properties of UHMWPE for particular application of interest, certain various procedures are in practice e.g. treating the material with high energy irradiations like gamma ray, e-beam, and ion bombardment. Radiation treatment of UHMWPE induces free radicals within its matrix, and these free radicals are the precursors of chain scission, chain accumulation, formation of double bonds, molecular emission, crosslinking etc. All the aforementioned physical and chemical processes are mainly responsible for the modification of polymers properties to use them in any particular application of our interest e.g. to fabricate LEDs, optical sensors, antireflective coatings, polymeric optical fibers, and most importantly for radiation dosimetry applications. It is therefore, to check the feasibility of using UHMWPE for radiation dosimetery applications, the compressed sheets of UHMWPE were irradiated at room temperature (~25°C) for total dose values of 30 kGy and 100 kGy, respectively while one were kept un-irradiated as reference. Transmittance data (from 400 nm to 800 nm) of e-beam irradiated UHMWPE and its hybrids were measured by using Muller matrix spectro-polarimeter. As a result significant changes occur in the absorption behavior of irradiated samples. To analyze these (radiation induced) changes in polymer matrix Urbach edge method and modified Tauc's equation has been used. The results reveal that optical activation energy decreases with irradiation. The values of activation energies are 2.85 meV, 2.48 meV, and 2.40 meV for control, 30 kGy, and 100 kGy samples, respectively. Direct and indirect energy band gaps were also found to decrease with irradiation due to variation of C=C unsaturation in clusters. We believe that the reported results would open new horizons for radiation dosimetery applications.

Keywords : electron beam, radiation dosimetry, Tauc's equation, UHMWPE, Urbach method
Conference Title : ICMPRPR 2016 : International Conference on Medical Physics, Radiation Protection and Radiobiology
Conference Location : Zurich, Switzerland
Conference Dates : January 12-13, 2016