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Characterization of UHMWPE Samples by Depolarization index using Mueller Matrix Polarimatery to investigate aging effect.

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ABSTRACT
Biomaterials of synthetic polymer have potential to perform and improve human health in orthopedic and other applications. Due to some outstanding properties of this material use greater than 90% in joints replacement such as knee, hip, ankleand shoulder joints replacement. But long term efficiency in vivo application is limited due to oxidation degradation. In recent research we try to reduce the oxidation degradation with the techniques of gamma irradiation and then compere fresh irradiated samples with aged samples. For said purpose I was fabricated total 8 samples of UHMWPE material and divided in to two groups. Four samples contain in each groups. Irradiate all samples of fresh group with different dose of gamma radiation (control, 30, 65 and 100KGy) respectively. After certain age the other group also irradiate with same quantity of dose radiation. Then it characterized through Muller matrix polarimatery after and before the certain age for comparison and investigating the aging affect. Muller matrix calculus used for calculating the value of depolarization index P_{Δ}.The function of this parameter is wavelength. Between the parameter of$P_{\Delta}$and wavelength plotted the graphs for fresh and aged samples to compere the irradiation effect in both groups of samples. As a result the aged sample which was treated with 100KGy dose of gamma radiation is better from other samples for long term performance in biomedical applications.

Keywords:Depolarization index, gamma irradiation, Muller matrix polarimatery, aged sample

I. INTRODUCTION:

Ultra High Molecular Weight Polyethylene materials (UHMWPE) has some unique properties. Like low coefficient of friction, high wear rate, stiffness and biocompatibility [1]. Due to these outstanding properties this material chose for the implantation in human body. Almost this materials are used 90% in human skeleton joints like hip cup, knee insert and total joints [2]. But there are some drawbacks which make these implants degradable. In which the major one is long term use of implants after insertion in human body. Researchers try to reduce the Oxidation degradation but he not fully understood yet. The method of thermal treatment (annealing or melting) and irradiations are using to enhance crosslinking [3.4]. The first and important motivation of this research work is to recommend a method for reducing the degradation through irradiation techniques [8]. The second step to investigate the effect of aging on UHMWPE material. Different techniques of characterization used to find free radical concentration namely; X-rays diffraction (XRD), electron spin resonance (ESR), FTIR etc. Due to some limitations [9] of these techniques we propose another simple, reliable and cost effective technique which name is 'Mueller Matrix polarimatery, based on polarization property of light to reduce the difficulties.

1.1. Theory:

Coupling of polarized light with un-polarized light describe the term of depolarization index (DI). In polarization optics this term used for finding the degree of polarization of beam. This term was introduce first time in 1985 by Gill and Berbenau in configuration space of Muller matrices [10]. The brief experimental setup for Muller matrices and DI are shown in figure 1.

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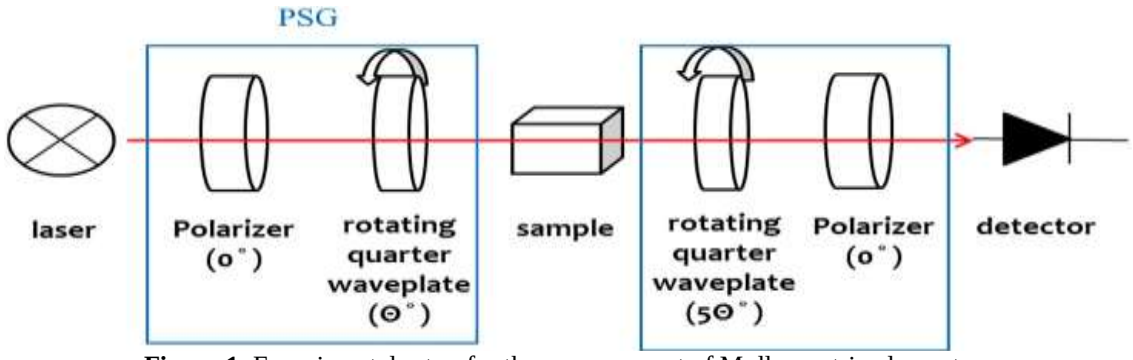

Figure 1. Experimental setup for the measurement of Muller matrix elements.

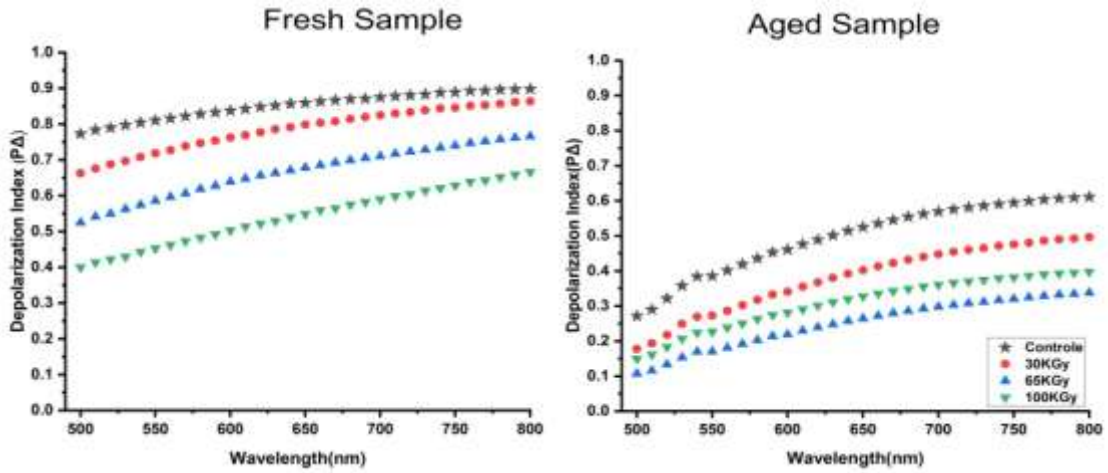

Figure No. 2 Comparison between Fresh and Aged Samples through Depolarization Index (P_Δ).

1.2 Muller matrix

When linearly polarized light interact with medium where Muller matrix (M) explain properties of polarization transformation. Muller matrix relate the incident stock-vector with existing stock-vector. Muller matrix consist of 16 elements each element correspond to a single dimension [13]. This matrix usually analyze with ideal depolarizer along identity matrix. This is very important points for analysis of 16 dimension.

$$I = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} ID = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Seven DOFs are using in 16 DOFs of Muller matrix to explain how different polarization states are depolarized the important parameter degree of polarization (DoP) define as

$$DOP = \frac{\sqrt{S_1^2+S_2^2+S_3^2}}{S_0}, 0 \leq DOP \leq 1$$

(1)

In order to characterize the value of depolarization Index (DI) of Muller matrix. In 1985 Gill present DI as a single matric. The DI is define as when the incident beam of light is polarized and output beam of light is partially polarized the medium is called depolarizing. Mathematically depolarization index can be written as [14]

$$P_\Delta = \sqrt{\frac{1}{3}\left(tr\left(\hat{M}^T\hat{M}\right)-1\right)}$$

(2)

1.3. Literature:

Polarized light used for characterization of Ultra High Molecular Weight Polyethylene (UHMWPE) [12]. Polarized light measure the value of retardance, transmittance, polarizance and linear and circular polarization of light on the wavelength range 400 to 800 nm. Reported result show us

- Due to highly scattering nature UHMWPE increase in linear retardance as compare to circular.
- Show decrease in degree of polarization (DOP) and Depolarization Index (DI) [14].

II. METHODOLOGY

2.1 Material, Sample preparation and irradiation

UHMWPE material in resign purchase from open market having average molecular weight

like 3-6 million g/mole. Furthermore press with 200 bar pressure and holding for 20 min at 160^0C. After the cooling at room temperature i.e. 25^0C. The surface of samples where clean with acetone from dust. All samples are divided in to two groups and labeled with fresh and aged names. Each group having 4 samples which was labeled with name of control, 30, 65 and 100KG. Single sample from both groups are keep in shelf which was labeled with controlled name. Remaining three samples of both groups was irradiated with corresponding dose values of 30, 65 and 100KGy respectively.

2.2 Sample testing

As shown in figs no.1 schematic diagram of experimental setup. This is basically the Muller matrix polarimatery used for measurement of polarimetric properties of medium. For the detail working of this automated polarimatery readers are refer to literature (Ahmad et al., 2013).

III. RESULTS AND DISCUSSION

The value of depolarization index (P_Δ)shown in figure 2 for all samples. From the variation curve we can easily compare fresh and aged samples. Different color and shapes of symbols represent the dose rate which is used for irradiating the samples. Like black color stars symbols represent the control(irradiate) sample, red color represent the sample of 30KGy, Blue color represent 65KGy and green color represent 100KGy respectively. All curves show that the appearing changes in samples due the different rate of irradiation dose. Minimum changes occurred in the sample which is treated with 100KGy dose of gamma radiation. Which was recorded on fresh sample from o.4 to 0.7 (on 500～800nm wavelength) and after aging effect recorded from 0.1 to 0.3 (on 500～800nm wavelength). The difference wasrecorded between the both samples as 0.3 ～ 0.4 as compere to others.Minimum decrease in the value of $P_\Delta$indicated the betterment of sample use for durable biomedical application.

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