Asian Journal of Chemistry; Vol. 28, No. 8 (2016), 1673-1681

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2016.19783

Energy Absorption and Exposure Buildup Factors in Polymers by Nuclear Track Detectors

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Received: 17 December 2015; *Accepted*: 13 February 2016; *Published online*: 30 April 2016; AJC-17872

The photon mass attenuation and mass energy absorption coefficients, energy dependence, effective atomic number, effective electron density and buildup factors are the fundamental quantities required in determining the penetration of X-rays and γ-photons through the material. These parameters have been examined for different polymers by nuclear track detectors. The effective atomic number was found in the range of $6 < Z_{PIeff}$ and $Z_{PEAeff} < 8$ atomic number of their constituent elements for selected polymers. Effective electron density values show similar photon energy dependence to what has been observed for Z_{eff}. The maximum values of energy absorption buildup factor and exposure buildup factor have been observed at 0.08 and 0.1 MeV, respectively. The significant variations in energy absorption buildup factor and exposure buildup factor for polymers have been observed at the moderate energy region. Besides, effect of variations in chemical composition of the given materials has also been observed to the energy absorption buildup factor and exposure buildup factor values. At energies below 0.15 MeV, energy absorption buildup factor and exposure buildup factor values increase with decreasing Z_{eq} of the samples. At 1.5 MeV, where only Compton scattering is the dominant interaction process, values of energy absorption buildup factor and exposure buildup factor seem to be independent of chemical composition of the polymers. It has been concluded that the buildup of photons is less in cellulose nitrate when compared with other materials.

Keywords: Solid state nuclear track detectors, Buildup factors, Effective atomic number, Effective electron density.

INTRODUCTION

The discovery of radiation detectors opened new fields of modern application of solid state nuclear track detectors to high-energy physics, astrophysics, cosmic-ray physics, nuclear fragmentation, exotic particles and many other fields. They are applied in different fields of science and technology mainly due to its simplicity, cost effectiveness and capacity to store permanent records [1]. Nearly all kinds of transparent insulating solids can be used as solid state nuclear track detectors (SSNTDs). Solid state nuclear track detectors are classified into three groups *viz.*, 1-Crystals, 2-Glasses, 3-Polymers.

Compared with inorganic crystalline solid and glasses, polymer detectors are more sensitive. Up to now, CR-39, most sensitive detector in common use, has been the most useful detector material compared with others. Its uses have included radiation risk estimation, particle radiation in space and in the natural environment, the search for magnetic monopoles and the investigation of energetic particles generated by the low energy nuclear reactions, in condensed matter nuclear science, *etc*. Before the discovery of the CR-39 track detector, polycarbonate (PC) foils was widely used as charged particles detectors [2]. Cellulose nitrate is one of the most sensitive nuclear track detector material. Its sensitivity is just less than CR-39. LR-115 is a commercial name of cellulose nitrate detector. LR-115 nuclear track detector for in-air radon activity concentration measurements have been and are still used due to their reliability and low cost [3]. Polyethylene terephthalate (PET) is another commonly used track detector. Polyethylene terephthalate track detector have also been used widely in many fields, such as heavy cosmic-ray analysis [4].

The exposure to low radiations also causes physical and chemical changes in the detector. Some papers [5-8] on the effects of γ-irradiation on the track registration and optical characteristics of some nuclear track detectors have been reported. An article [1] has studied the effective atomic numbers and electronic numbers calculated for total and partial photon interactions for different types of solid state nuclear track detectors.

In the present paper, we purposed to investigate the X and/or γ-radiation interaction with different types of polymeric material used nuclear track detectors in terms of the parameters mass attenuation and energy absorption coefficients, effective atomic number, effective electron density, kinetic energy released per unit mass (kerma) and energy dependence in the wide energy range of 1 keV to 20 MeV as well as the energy

absorption and exposure buildup factors from 0.015 to 15 MeV up to 40 mfp penetration depths.

There are two types of buildup factors: a) the energy absorption buildup factor that is the buildup factor in which the quantity of interest is the absorbed or deposited energy in the interacting material and the detector response function is that of absorption in the interacting material, b) the exposure buildup factor is the buildup factor in which the quantity of interest is the exposure and the detector response function is that of absorption in air [9]. There are different available methods to calculate the buildup factor such as G-P fitting method [10]. Recently, American National Standards ANSI/ANS 6.4.3 has presented the buildup factor data for 23 elements, one compound and two mixtures (*i.e.* air and water) and concrete at energies in the range 0.015-15 MeV up to penetration depths of 40 mean free path by using the G-P method.

CALCULATION METHODS

Total mass attenuation and mass energy absorption coefficient: According to Lambert-Beer law, a parallel beam of mono energetic X-ray and γ-ray photons is attenuated in matter by the following exponential attenuation equation:

$$I = I_0 e^{\left(-\frac{\mu}{\rho}\right)t} \quad (1)$$

where I_0 and I are the incident intensity of photons without attenuation and the attenuated intensity of photons in the sample, respectively, t (g/cm^2) is the areal density of the sample, μ/ρ (cm^2/g) is the total mass attenuation coefficient (TMAC) which is a density independent quantity.

In case of a multi-element material (*i.e.* chemical compound or homogeneous mixture) constituting the sample, the mass attenuation coefficient can be obtained from the coefficients for the constituent elements according to the weighted average

$$\mu/\rho = \sum_i W_i (\mu/\rho)_i \quad (2)$$

where W_i is the proportion by weight of the i^{th} constituent element. Mass attenuation coefficients of polymeric material used nuclear track detectors have been calculated by the WinXCom program. This program provides total cross-sections and attenuation coefficients of elements, compounds or mixtures as well as partial cross-sections for incoherent and coherent scattering, photoelectric absorption and pair production both in the field of nucleus and electrons at energies from 1 keV to 100 GeV.

The mass energy absorption coefficients (MEAC) of the given materials can be obtained from eqn. 2 by substituting the mass energy absorption coefficient for the mass attenuation coefficient. However, it should be mentioned that the eqn. 2 is valid for mass energy absorption under the assumption that the errors in calculating mass energy absorption coefficients are small for photon energies below 20 MeV [11].

Effective atomic number, electron density and energy dependence: The effective atomic numbers of polymeric material used nuclear track detectors have been provided by means of the practical formula:

$$Z_{PIeff} = \frac{\sum_i f_i A_i \left(\frac{\mu}{\rho}\right)_i}{\sum_j f_i \frac{A_j}{Z_j}\left(\frac{\mu}{\rho}\right)_j} \quad (3)$$

where f_i is the fraction by mole of the each constituent element providing that $\sum_i f_i = 1$, A_i is the atomic weight, Z_j is the atomic number, $(\mu/\rho)_i$ is the mass attenuation coefficient. The effective atomic number for photon energy absorption (Z_{PEAeff}) can be obtained from eqn. 3 by substituting the mass energy absorption coefficient for the mass attenuation coefficient.

Also, the effective electron density is expressed by the following relation:

$$N_E = N_A \frac{nZ_{eff}}{\sum_i n_i A_i} = N_A \frac{Z_{eff}}{\langle A \rangle} \text{ (electrons/g)} \quad (4)$$

where $\langle A \rangle$ is the average atomic mass of the material. Thus, using the obtained values of Z_{eff} one can calculate the values of N_E by using the eqn. 4 [12].

The kinetic energy released per unit mass (kerma) is defined as the initial kinetic energy of all secondary charged particles liberated per unit mass at a point of interest by uncharged radiation [13]. To obtain the relationship between kerma and mass energy absorption coefficient, let ψ (J m^{-2}) be the energy fluence of mono-energetic photons passing normally through an area A in an absorber. Keeping in mind the energy transferred to charged particles and the mass in the volume with density ρ being $\psi A \mu_{en} dx$ and $\rho A dx$, respectively, the kerma is calculaded by eqn. 5 [14].

$$K = \frac{\psi A \mu_{en} dx}{\rho A dx} = \psi \left(\frac{\mu_{en}}{\rho}\right) \quad (5)$$

Since the kerma is the product of the energy influence and the mass energy absorption coefficient, kerma of a material relative to air also known as the energy dependence (ED) can be expressed as the ratio between the mass energy absorption coefficient of the used material and the mass energy absorption coefficient of air [12]:

$$\text{Energy dependence} = \frac{\left(\frac{\mu_{en}}{\rho}\right)_{Material}}{\left(\frac{\mu_{en}}{\rho}\right)_{Air}} \quad (6)$$

Energy absorption and exposure buildup factors: To calculate the buildup factors, the G-P fitting parameters were obtained by the method of interpolation from the equivalent atomic number (Z_{eq}). Computations are illustrated step by step as follows: (a) Calculation of the equivalent atomic number, Z_{eq}; (b) Calculation of geometric progression (G-P) fitting parameters (c) Calculation of energy absorption and exposure buildup factors

At the first step, the equivalent atomic number, Z_{eq} for a particular material has been calculated by matching the ratio, $(\mu/\rho)_{Compton}/(\mu/\rho)_{Total}$ of that material at a specific energy with the corresponding ratio of an element at the same energy. Thus,

the Compton partial mass attenuation coefficient, $(\mu/\rho)_{Compton}$ and the total mass attenuation coefficients, $(\mu/\rho)_{Total}$ were obtained for the elements of Z = 4–40 and for the chosen materials in the energy region 0.015-15 MeV, using the WinXCom computer program [15,16] (initially developed as XCOM [17]. For the interpolation of Z_{eq} for which the ratio $(\mu/\rho)_{Compton}/(\mu/\rho)_{Total}$ lies between two successive ratios of elements, the following formula has been employed:

$$Z_{eq} = \frac{Z_1(\log R_2 - \log R) + Z_2(\log R - \log R_1)}{\log R_2 - \log R_1} \quad (7)$$

where Z_1 and Z_2 are the atomic numbers of elements corresponding to the ratios R_1 and R_2, respectively, is the ratio for the chosen building materials at a specific energy.

At the second step, to calculate the G-P fitting parameters a similar interpolation procedure was adopted as in the case of the equivalent atomic number. The G-P fitting parameters for elements were taken from the ANSI/ANS-6.4.3 standard reference database [18], which provides the G-P fitting parameters for elements from beryllium to iron in the energy region 0.015-15 MeV up to 40 mfp.

Finally, these parameters were used to calculate the energy absorption and exposure buildup factors from the G-P fitting formula [10].

$$B(E,X) = 1 + \frac{b-1}{K-1}(K^x - 1) \text{ for } K \neq 1 \quad (8)$$

$$B(E,X) = 1 + (b-1)x \text{ for } K = 1 \quad (9)$$

where,

$$K(E,x) = cx^a + d\frac{\tanh(x/X_k - 2) - \tanh(-2)}{1 - \tanh(-2)} \text{ for } x \leq 40 \text{ mfp} \quad (10)$$

where E is the incident photon energy, x is the penetration depth in mfp, a, b, c, d and X_k are the G-P fitting parameters and b is the value of buildup factor at 1 mfp. The parameter K represents the photon dose multiplication and the change in the shape of the spectrum.

RESULTS AND DISCUSSION

The chemical composition of polymers used in nuclear track detectors are listed in Table-1. The change in effective atomic numbers for photon energy absorption (Z_{PEAeff}) and photon interactions (Z_{PIeff}), electron density and kerma of selected polymers have been shown in graphical form at fixed energy values (Figs. 1-4). Table-2 gives the equivalent atomic numbers of the samples in the energy region of 0.015-15 MeV. The exposure and energy absorption G-P fitting parameters for the polyallydiglcol carbonate ($C_{12}H_{18}O_7$) have been given

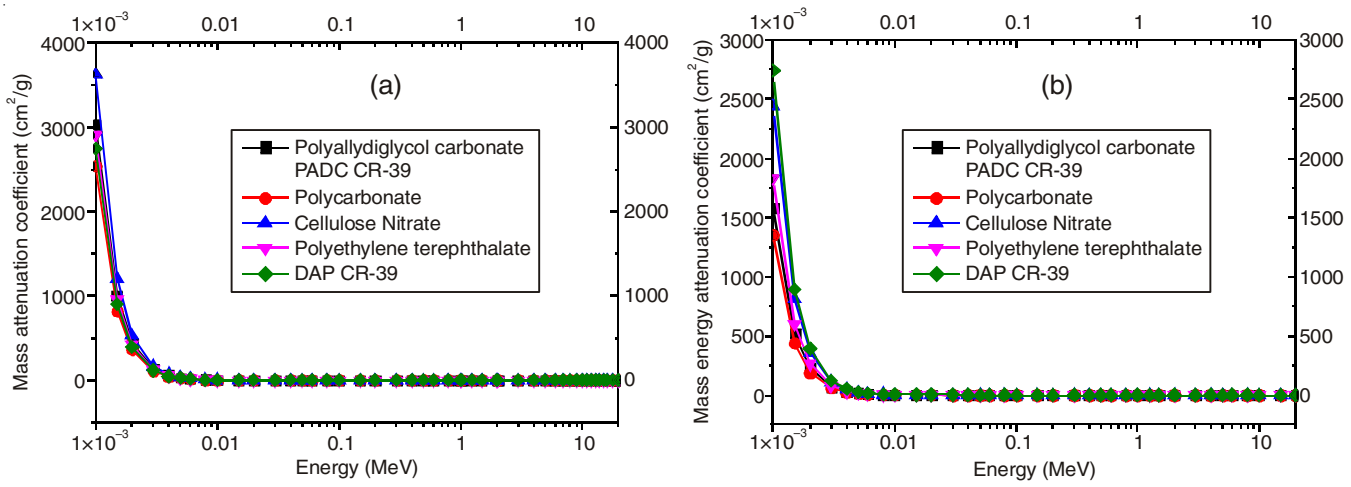


Fig. 1. Mass attenuation (μ/ρ) and mass energy attenuation coefficient (μ_{en}/ρ) of given polymers from 1 keV to 20 MeV

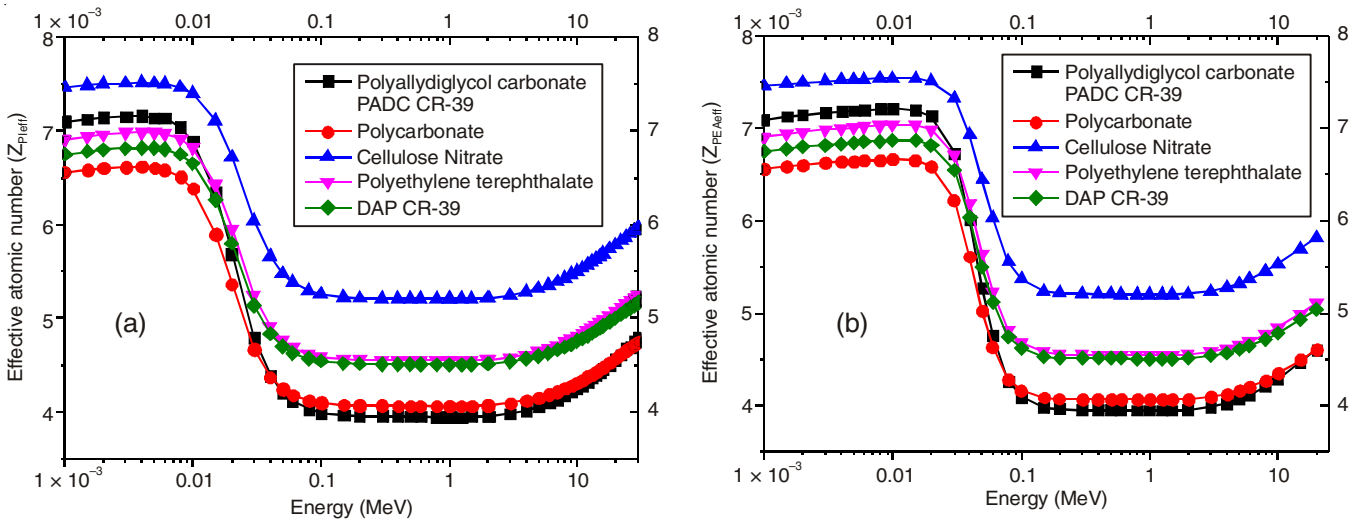


Fig. 2. Effective atomic numbers (Z_{PIeff} and Z_{PEAeff}) of given polymers with photon energy for total photon interaction from 1 keV to 20 MeV

TABLE-1
CHEMICAL FORMULA OF POLYMERS

Name	Chemical formula
Polyallydiglycol carbonate (PADC, CR-39)	$C_{12}H_{18}O_7$
Polycarbonate (PC)	$C_{16}H_{14}O_3$
Cellulose nitrate	$C_6H_8O_9N_2$
Polyethylene terephthalate (PET)	$C_5H_4O_2$
CR-39 DAP	$C_{14}H_{10}O_4$

TABLE-2
EQUIVALENT ATOMIC NUMBERS OF SAMPLES
FOR THE ENERGY RANGE 0.015-15 MeV

Energy (MeV)	Equivalent atomic number				
	PADC	PC	Cellulose nitrate	PET	DAP
0.015	6.74	6.30	7.26	6.67	6.53
0.020	6.76	6.31	7.27	6.68	6.53
0.030	6.77	6.31	7.27	6.68	6.52
0.040	6.78	6.31	7.27	6.68	6.52
0.050	6.78	6.31	7.27	6.68	6.52
0.060	6.79	6.31	7.27	6.69	6.52
0.080	6.79	6.31	7.27	6.69	6.53
0.100	6.80	6.31	7.27	6.69	6.53
0.150	6.80	6.32	7.28	6.70	6.54
0.200	6.80	6.32	7.28	6.70	6.54
0.300	6.81	6.32	7.28	6.70	6.54
0.400	6.81	6.32	7.28	6.71	6.54
0.500	6.81	6.32	7.28	6.71	6.54
0.600	6.82	6.32	7.28	6.71	6.54
0.800	6.82	6.32	7.28	6.71	6.54
1.000	6.82	6.32	7.28	6.71	6.54
1.500	6.19	5.86	6.93	6.26	6.13
2.000	6.16	5.84	6.91	6.25	6.12
3.000	6.16	5.84	6.91	6.24	6.11
4.000	6.15	5.84	6.91	6.24	6.11
5.000	6.15	5.84	6.91	6.24	6.11
6.000	6.15	5.84	6.91	6.24	6.11
8.000	6.15	5.83	6.90	6.24	6.11
10.000	6.15	5.83	6.90	6.24	6.11
15.000	6.15	5.83	6.90	6.24	6.11

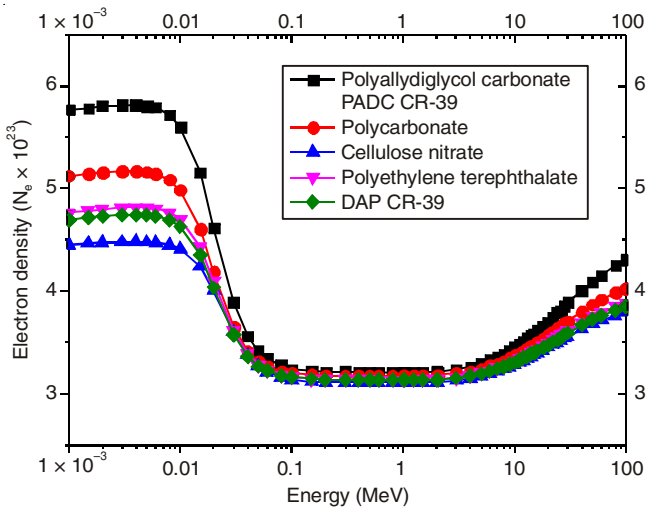


Fig. 3. Variation of electron densitiy (N_e) of given polymers with photon energy

in Table-3. The energy absorption (EABF) and exposure (EBF) buildup factors have been shown in graphical form at fixed energy values (Figs. 5 and 6) as well as at fixed penetration depths (Figs. 7 and 8). Also, EABF and EBF have been shown

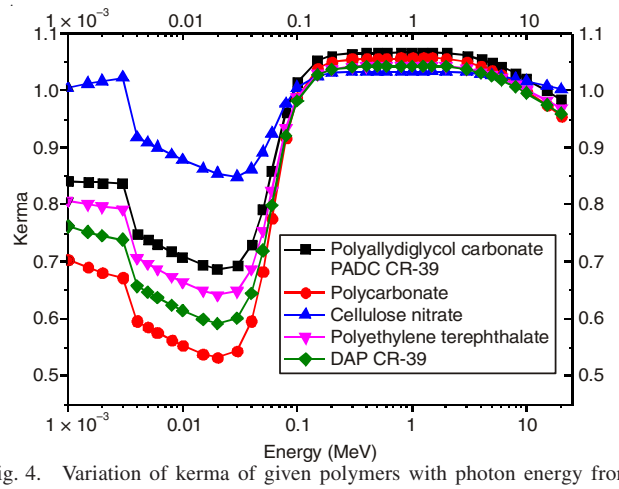


Fig. 4. Variation of kerma of given polymers with photon energy from 1 keV to 20 MeV

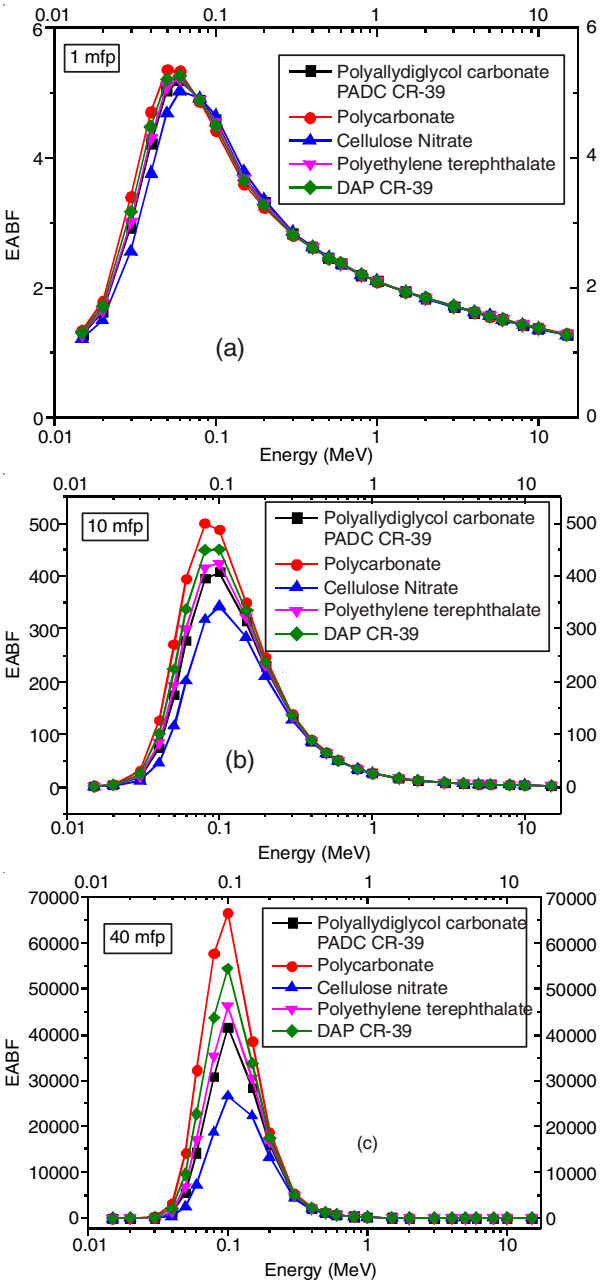
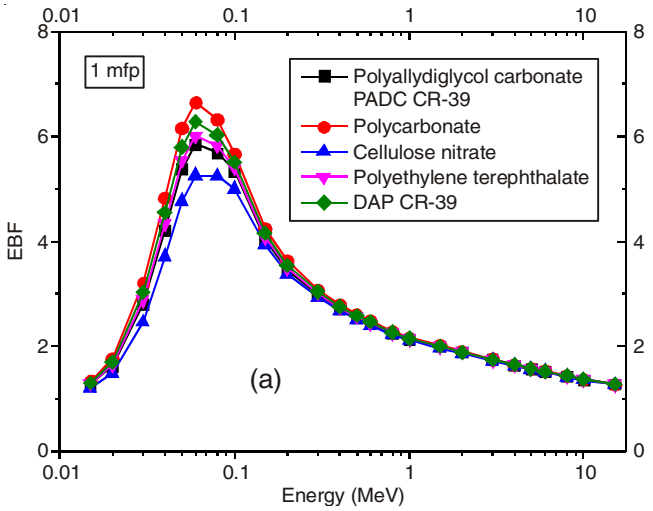
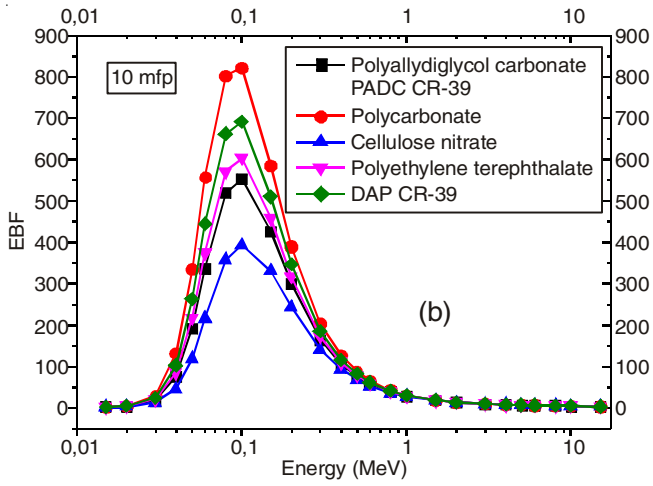


Fig. 5. Energy absorption buildup factor for polymers in the energy region 0.015-15 MeV at 1, 10, 40 mfp

TABLE-3
G-P EXPOSURE AND ENERGY ABSORPTION BUILDUP FACTOR
COEFFICIENTS FOR $C_{12}H_{18}O_7$ IN THE ENERGY RANGE 0.015-15 MeV

Energy (MeV)	EABF					EBF				
	a	b	c	d	Xk	a	b	c	d	Xk
0.015	0.161	1.275	0.495	-0.078	14.534	0.165	1.271	0.490	-0.082	14.280
0.020	0.121	1.637	0.615	-0.059	15.255	0.118	1.619	0.619	-0.058	15.358
0.030	0.035	2.932	0.910	-0.027	15.294	0.036	2.814	0.910	-0.029	15.082
0.040	-0.067	4.212	1.370	0.025	13.863	-0.069	4.222	1.377	0.027	13.650
0.050	-0.122	5.038	1.720	0.052	14.067	-0.125	5.383	1.736	0.054	13.951
0.060	-0.158	5.201	1.993	0.071	13.950	-0.163	5.853	2.027	0.075	13.852
0.080	-0.190	4.903	2.276	0.083	13.700	-0.200	5.693	2.363	0.091	13.523
0.100	-0.188	4.593	2.305	0.078	14.556	-0.200	5.338	2.409	0.087	14.392
0.150	-0.192	3.708	2.334	0.077	14.511	-0.216	4.045	2.529	0.097	14.116
0.200	-0.182	3.330	2.226	0.076	14.794	-0.213	3.460	2.461	0.092	13.643
0.300	-0.169	2.833	2.069	0.067	14.343	-0.185	2.995	2.190	0.079	14.122
0.400	-0.151	2.622	1.903	0.061	14.321	-0.168	2.725	2.015	0.071	13.948
0.500	-0.138	2.461	1.788	0.057	14.457	-0.150	2.559	1.866	0.064	14.140
0.600	-0.123	2.369	1.677	0.049	14.369	-0.137	2.430	1.757	0.058	14.021
0.800	-0.106	2.201	1.547	0.044	14.181	-0.116	2.253	1.599	0.051	13.990
1.000	-0.087	2.104	1.435	0.036	14.630	-0.098	2.135	1.486	0.044	13.937
1.500	-0.060	1.939	1.275	0.027	14.308	-0.067	2.002	1.303	0.031	13.913
2.000	-0.038	1.842	1.169	0.015	14.430	-0.043	1.891	1.189	0.020	13.983
3.000	-0.011	1.714	1.051	0.003	14.183	-0.014	1.746	1.059	0.006	12.309
4.000	0.004	1.626	0.988	-0.003	13.065	0.004	1.649	0.986	-0.007	24.011
5.000	0.015	1.564	0.944	-0.008	14.800	0.017	1.573	0.939	-0.011	14.351
6.000	0.028	1.515	0.906	-0.018	13.121	0.027	1.524	0.907	-0.015	14.054
8.000	0.034	1.430	0.882	-0.017	12.099	0.037	1.437	0.871	-0.032	16.226
10.000	0.040	1.376	0.861	-0.022	14.322	0.041	1.371	0.858	-0.021	12.640
15.000	0.047	1.281	0.838	-0.033	15.769	0.046	1.275	0.841	-0.030	15.234





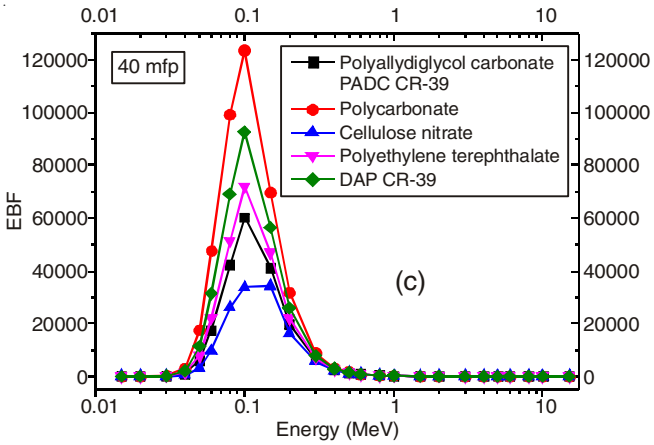


Fig. 6. Exposure buildup factor for polymers in the energy region 0.015-15 MeV at 1, 10, 40 mfp

as a function of weight fractions of C and O in Figs. 9 and 10. The energy dependence Z_{Pleff}, Z_{PEAeff}, kerma, EABF and EBF are discussed in the following paragraphs.

Mass absorption and mass energy absorption coefficients: Calculations of the mass attenuation coefficients of polymers were carried out by the WinXCOM program. The variation of mass absorption coefficient with photon energy at 1 keV to 20 MeV for total photon interaction with coherent for all selected polymers has been shown in Fig. 1(a). From this figure, it is clearly observed that the change in mass absorption coefficient with composition of different chemicals is very large below 10 keV and negligible from 10 keV to 100 MeV. Variation of mass energy absorption coefficients with photon energy (1 keV to 20 MeV) for selected polymers has been shown Fig. 1(b). From this figure, it is observed that

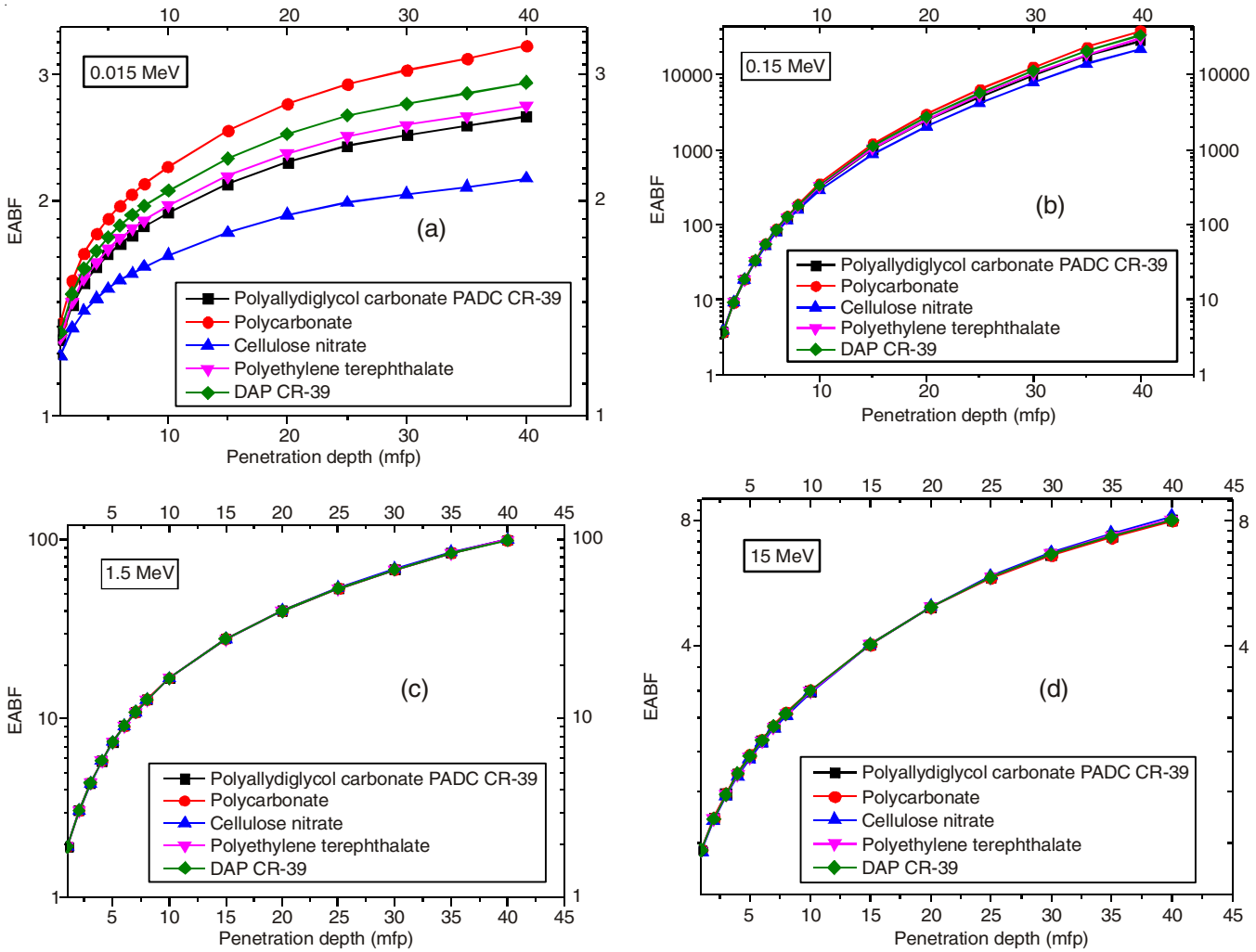


Fig. 7. Energy absorption buildup factor for polymers up to 40 mfp at 0.015, 0.15, 1.5, 15 MeV

initially mass energy absorption coefficient have maximum value which decreases rapidly with increase in incident photon energy for all polymers up to 10 keV. Due to predominant photoelectric absorption (μ_{en}/ρ) and (μ/ρ) show strong incident photon energy dependence in the low energy region. In the high energy region, pair production process in nuclear and electric fields come into importance after certain thresholds above 100 keV are exceeded and hence energy dependence of (μ_{en}/ρ) and (μ/ρ) changes its tilt relative to the moderate energy region.

Effective atomic number: The effective atomic number (Z_{eff}) values of polymers and other complex material are needed to be determined precisely before their applications especially in space physics, plasma physics and industry, cross section studies of absorption, scattering and attenuation of radiation, testing of multi-component and many other radioactive applications. Z_{PIeff} and Z_{PEAeff} for selected polymers were calculated using eqn. 3. The variation of photon interaction and photon energy absorption effective number with incident photon energy has been shown in Fig. 2, respectively. It has been observed that Z_{PIeff} and Z_{PEAeff} of selected polymers remains in the range of $6 < Z_{PIeff}$ and $Z_{PEAeff} < 8$ atomic number of their constituent elements. Z_{PIeff} and Z_{PEAeff} show maximum values initially at 1 keV. Z_{PIeff} and Z_{PEAeff} values remain almost constant up to the incident photon energy of about respectively 10 and 30 keV with the increase incident photon energy, afterwards Z_{PIeff} and Z_{PEAeff} values decrease up to the incident photon energy of about 100 keV. In the moderate energy region (100 keV to 3 MeV), a new Z_{PIeff} and Z_{PEAeff} values become almost constant. On the further side of 3 MeV, Z_{PIeff} and Z_{PEAeff} values show a slow increment with the increase in the incident photon energy. In the lower energy region, photoelectric effect is dominant photon interaction process and cross section for photoelectric absorption depends on atomic number of elements as Z^{4-5}. Therefore maximum values for Z_{PIeff} and Z_{PEAeff} have been observed in the lower energy region. The variation of Z_{PIeff} and Z_{PEAeff} of selected polymers with the incident photon energy are similar due to atomic numbers of its constituent elements are small. However, it is seen that in the transition regions of the partial energy photon interactions, the energy region is shifted between Z_{PIeff} and Z_{PEAeff}. The energy values which effective atomic numbers have maximum values, are different for Z_{PIeff} and Z_{PEAeff}. As for the reason for these differences, as it is known the important part of the Compton scattering radiation leave from the absorbent material. Therefore, Compton scattering contribute significantly to reducing of the radiation beam but contributes very little to the energy absorption.

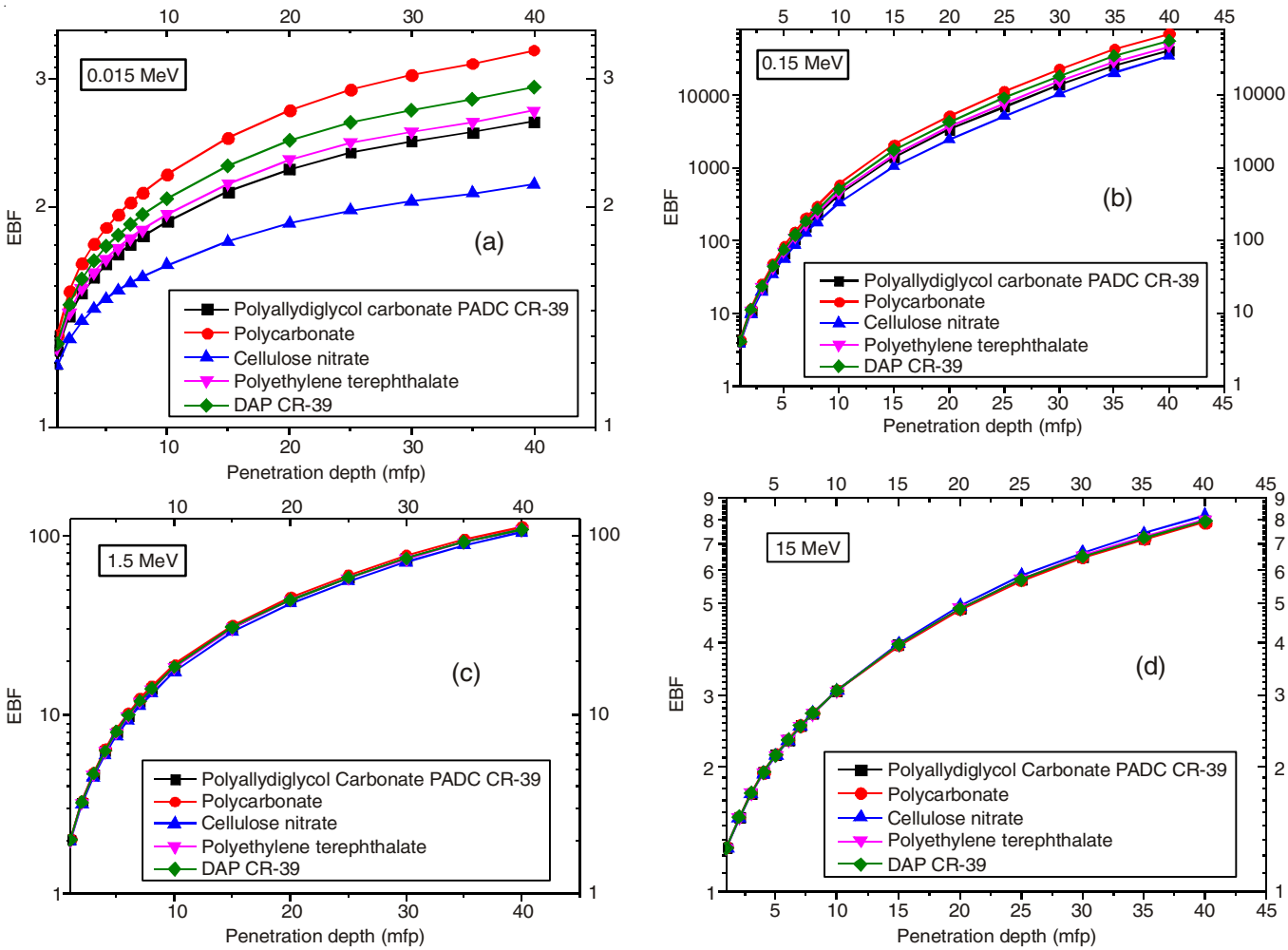


Fig. 8. Exposure buildup factor for polymers up to 40 mfp at 0.015, 0.15, 1.5, 15 MeV

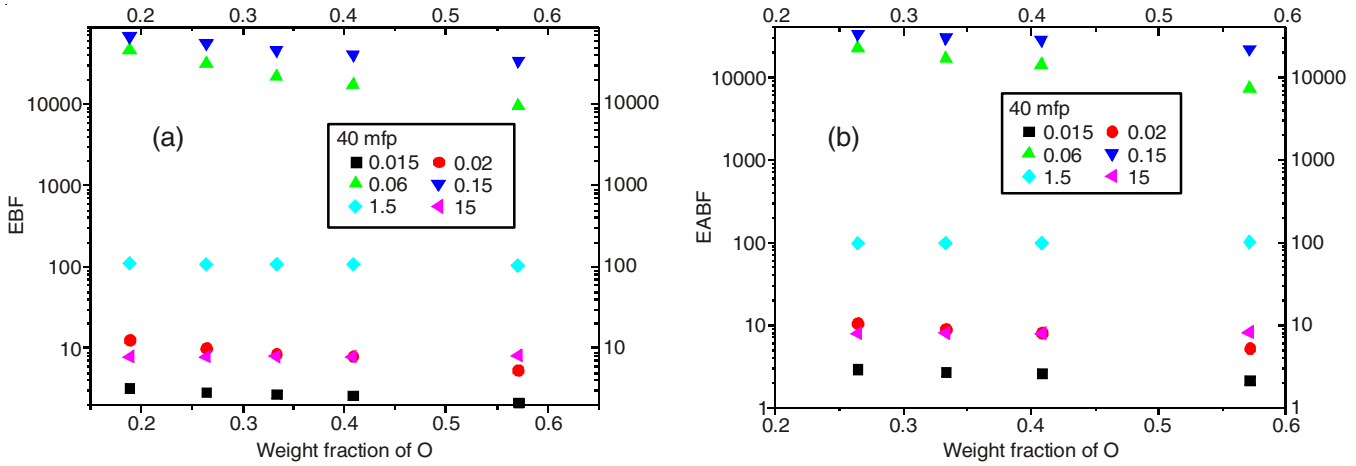


Fig. 9. Energy absorption and exposure buildup factors for polymers as a function of weight fractions of O

According to these differences, the atomic number of the elements increases in the components of the samples, the maximum differences have emerged in the greater energy values. Also, if the quantity of interest is the photon energy absorption, the use of Z_{PEAeff} will be more meaningful in these areas instead of Z_{PIeff}.

Electron density: The number of electrons per unit mass, N_e, has been determined eqn. 4 for the total interactions with coherent and the results is shown in graphically at Fig. 3. The variation N_e in the energy range 1 keV ≤ E ≤ 10 keV and 100 keV ≤ E ≤ 2MeV is almost constant for all the samples. The N_e values show similar photon energy dependence to what has been observed for Z_{eff}.

Kinetic energy released per unit mass: The kinetic energy released in material has been calculated by eqn. 6. The variation of K_a values as a function of energy is shown in Fig. 4. It is clearly seen that kerma depends on the chemical content. Kinetic energy released per unit mass has a discontinuity between 3-4 keV and then slowly decreases with increasing energy up to

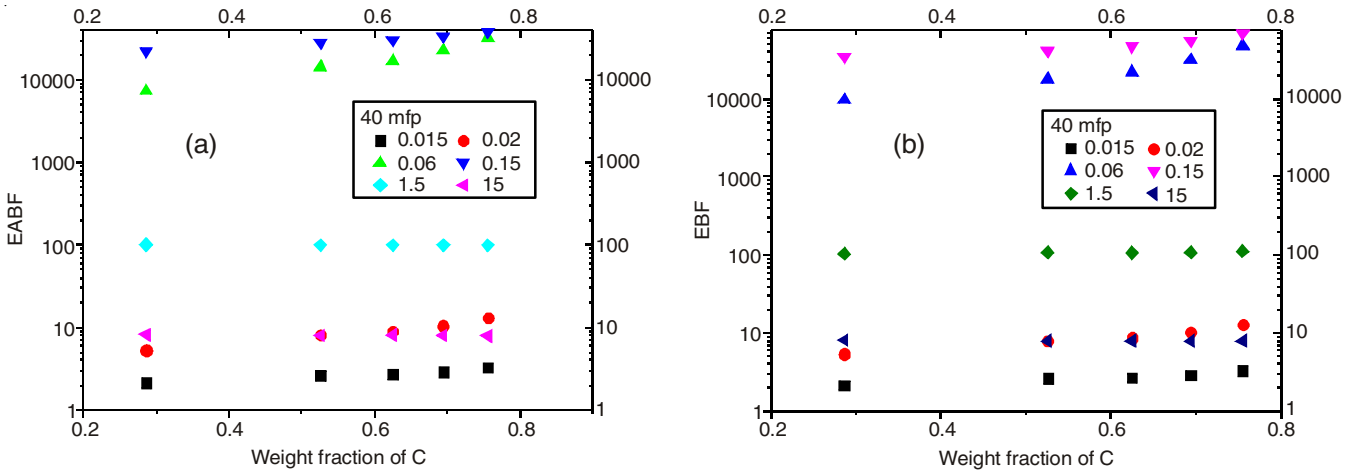


Fig. 10. Energy absorption and exposure buildup factors for polymers as a function of weight fractions of C

about 20 keV. Then there is a sharp rise between 20 and 500 keV. Kinetic energy released per unit mass is constant from 500 keV to 3 MeV and then it slowly decreases with increasing energy. It is also observed that all the samples have a same kerma in the low energy region, photoelectric absorption is dominant and moderate (Compton scattering) energy region.

Energy absorption and exposure buildup factor

Effect of incident photon energy on EABF and EBF: The variation of energy absorption and exposure buildup factors with incident photon energy at some selected penetration depths (1, 10, 40 mfp) for polymers have been shown in Figs. 6 and 7. It has been observed from this figures that for all the selected polymers, buildup factors values are small at lower energies of incident photon besides that higher energies of incident photon and show maximum values in the moderate energy region. In the lower and higher energy region, photoelectric effect and pair production are the predominant process. Hence, they do not exist for a longer period of time resulting in less buildup factor at lower and higher energy regions. Meanwhile the energy of the incident photon increases, Compton scattering process starts dominating. In this process, photons are not completely abolished but only their energies are reduced. They exist for a long time in the material. It results in multiple Compton scattering, which enhance the build-up factors to maximum.

The trend of EABF and EBF against photon energy is almost similar for the selected polymers. The samples have the largest EABF and EBF at 0.1 MeV and 0.08, respectively at 1 mfp. The variations of EABF and EBF with incident photon energy seem to be independent of chemical composition of samples beyond 0.6 MeV. At shallow depths (*i.e.* 1 mfp) (Fig. 6a and Fig. 7a), EABF and EBF decrease as Z_{eq} increases at low energies, namely cellulose nitrate.

Effect of penetration depths on EABF and EBF: The variations of EABF and EBF with penetration depth is shown in Fig. 7 and 8 at some incident photon energies, respectively. Increase in penetration depth results in increase of scattering events in the polymers. Energy absorption buildup factor (EABF) and exposure buildup factor (EBF) of samples increase with increasing penetration depths. For this reason EABF and EBF increase up to large values. The degree of violation of the Lambert-Beer law is less for small penetration depth [19].

Effect of weight fraction on EABF and EBF: Figs. 9 and 10 show the variation of energy absorption and exposure buildup factors with oxygen and carbon weight fractions for some randomly selected energies at a penetration depth of 40 mean free paths. From Fig. 9, it can be concluded that for oxygen weight fraction, at lower energies, below 0.15 MeV, the buildup factors show a decreasing trend, which can be represented by a straight line. At higher energies, above 1.5 MeV, the buildup factor values are independent from changing weight fractions of oxygen. In this case at lower energy, the behaviour of buildup factors are opposite to what has been observed in case of O weight fractions. At higher energies, the behaviour of buildup factors are similar as in previous case of O weight fractions. At energies below 0.15 MeV, EABF and EBF values increase with decreasing Z_{eq} of the samples. This may be due to predomination of photoelectric absorption, which leads to Z_{eq}^{4-5} dependence. At 1.5 MeV, where only Compton scattering is the dominant interaction process, values of EABF and EBF look like to be independent of chemical composition of the polymers.

Conclusion

Our study has been assume to get some information on the mass attenuation coefficients and concerned parameters, effective atomic numbers and electron density for different types of solid state nuclear track detectors. Kinetic energy released per unit mass relative to air of the polymers was also calculated for energy 1 keV to 20 MeV. The G-P fitting method has been used for calculation of energy absorption buildup factors and exposure buildup factors of polymers used nuclear track detectors in the energy range 0.015-15 MeV up to 40 penetration depths. Significant variations in EABF and EBF have been observed for polymers in the intermediate energy region where Compton scattering predominates. At the fixed energy of 1.5 MeV, the variation of EABF with penetration depth appears to be independent of the variations in chemical composition of the polymers. It has been concluded that the buildup of photons is less in cellulose nitrate (LR-115) when compared with other materials. LR-115 and PAD CR-39 are more sensitive to the radiation than other materials in the range

of 0.06 and 6 MeV. The results of the present work should be stimulate research for other detectors.

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