Study of Gamma Absorption Properties of Some Water Soluble Becosule Capsule by Varying Concentration at 511 Kev

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Abstract:-

Linear and Mass attenuation coefficients are two quantities used in the study of gamma rays. Their methods of measurement have been developed by many people for solid and aqueous solutions. But the method developed for aqueous solutions is not complete so we have tried to develop an equation for direct measurement of linear attenuation coefficient of Becosule capsule in aqueous solutions. This method is useful in measuring the absorption coefficient of capsules (Vitamins) without obtaining them in pallet form. Also it verifies the composition specified by the manufacturer, which defines originality of capsule.

Keywords :- Mass and linear attenuation coefficients, Gamma-rays, NaI (Tl) detector, Water and Becosule.

1 Introduction -

Linear and mass attenuation coefficient for gamma rays for different materials and solutions plays an important role in RSID units. There are different measurement techniques to measure them. As technology is developed day by day. The gamma rays are used in many fields, like medicine, food preservation and with their measurement techniques are developed but we find these measurement can be made with still simpler method. Recently Teli et(1997) al has developed the mixture rule and we have modified the rule with simpler approach and is considered for our research work.

This method is developed from single element mass attenuation coefficient of gamma rays to mixtures (solute and solvent). Teli et al.[1-3] measured the linear and mass attenuation coefficient of water soluble salts $MgCl_2$, $6H_2O$, NaCl, KCl series compounds For 0.123 MeV to 1.33 MeV gamma radiation by varying concentration of salt solution. The mixture rule for solutions by taking in to consideration the shrinkage of volume when salt is added to water as suggested by Gerward [5] using the revised technique. Hubbel [6] has calculated mass attenuation coefficient for 92 elements for hydrogen (z=1) to Uranium (z=92) and some compounds from photon energies 1 KeV to 20 MeV. He also tabulated the mass attenuation coefficient of mixture compounds and 92 elements. Pravina P. Pawar et al [7] Studies Gamma ray photon interaction of Cr in the energy range 10keV to 1500keV. Bradley et al (1989) have proposed a sphere transmission method for direct measurement of the energy absorption coefficients for gamma rays by materials in solid form. Recently Singh et al (6) have measured energy absorption coefficient for gamma rays in soil samples by applying Bradley’s technique. Jahagirdar et al (5) have determined narrow beam attenuation coefficients of 320 KeV photon in various high z-materials by using broad beam geometrical configuration.

So for the study of both types of absorption coefficient for gamma rays, for materials in solid and crystal forms by using various techniques as reported above.

In view of importance of the study of gamma attenuation properties of materials and its various applications in science, technology and human health, we wish to study here the absorption properties of material (capsule) in liquid form or those that are soluble in a solvent such as water for checking originality of Becosule. The observations are compared with the theoretical values as calculated from Hubbell's mixture rule and his table.

2 Experimental Arrangement -

The experimental arrangement is as shown in Fig.1 at 511 KeV from Na^{22}. A cylindrical prefix container of internal diameter 2.38 cm was placed below the source at a distance of 1.2 cm by using efficient geometrical arrangement. The gamma rays of 511 KeV from Na^{22} are narrowed by passing through lead holes. The sodium iodide (Thalium) 1.3/4.2 inches crystal is used as the detector connected to 4k multichannel analyzer. The stand is made up of prefix sheet with suitable size; the source and absorber are placed along the axis of the stand and the whole system is enclosed in a lead castle as shown in Fig. 1

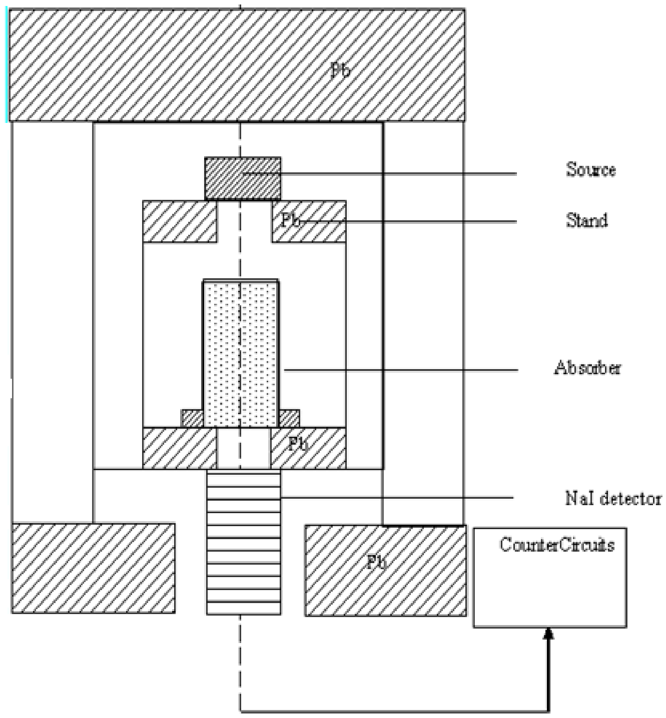

Fig.1 . The experimental arrangement is as shown at energy 511 KeV from Na^{22}

3 Methods and Observations -

The Becosule capsule is weighted by manufacturer and one complete capsule taken in the cylindrical prefix container of internal diameter 2.38 cm. 20 m lit of distilled water was added to dissolve the Becosule. The height of the solution was measured by travelling microscope for changing concentrations. The other quantities measured in the experiment was volume of the capsule V_c (Fixed), V_w volume of water, m_w is the mass of water and m_c mass of Becosule (Capsule) were measured accurately. The volume of Capsule (V_c) and water V_w added together to give total volume (Vs).

The actual volume Vs of the solution is calculated by measuring it's height in the container and by multiplying it by the cross-sectional inner area of the container (πr^2). This procedure is repeated for all the concentrations.

4 Results and Analysis –

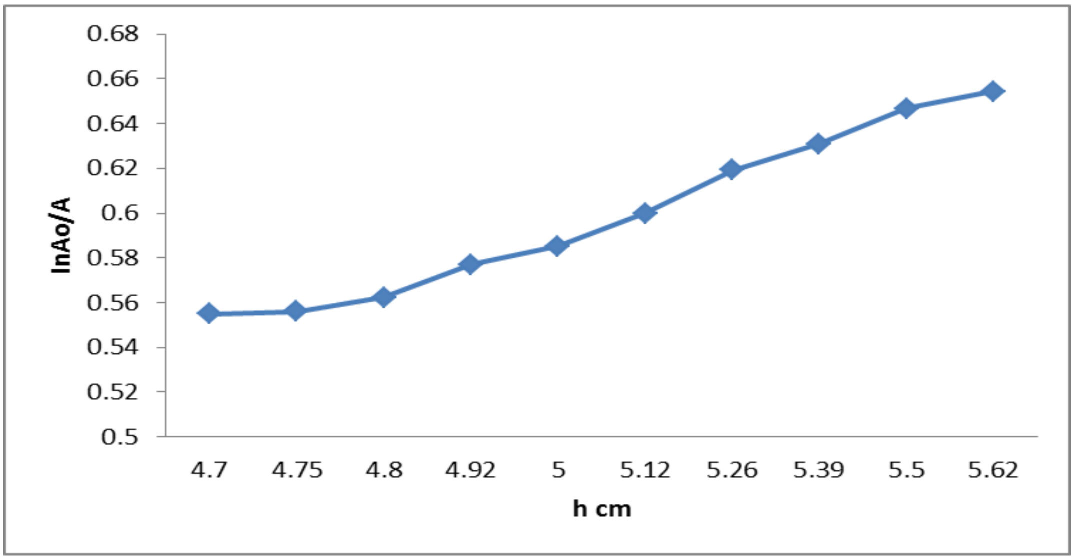

Fig 2. The graph of ln(Ao/A) versus height of liquid column h (cm).

The graph of ln(Ao/A) versus height of liquid column h (cm) as shown in Fig. 2. The observed points are seen to be closely distributed around lines having positive slopes. These lines are obtained by fitting the experimental data by the least square method. Their slope gives the linear coefficient (cm^{-1}) and thus the linearity of the curves with positive slopes suggests the relation.

$$A/A_0=e^{-\mu h} \qquad ....1$$

This indicates the validity of the standard exponential absorption law of gamma rays when they pass through liquid substances

$$A=Ao\ e^{-\mu h} \qquad ....2$$

Where, A_0 and A are the initial and final intensities of interacting photons respectively. The μ (cm-1) is linear attenuation coefficient of the sample and x (cm) is the thickness of a material. The linear attenuation coefficient (μ) of the materials from equation (2) is expressed as

$$\mu = 1/h\ In(Ao/A)$$

We have Hubbel's mixture rule. The mass attenuation coefficient of gamma rays in chemical or any other mixtures of compound is assumed to be depending upon the sum of the cross sections presented by all the atoms in the mixture because the bends are only of the order of few electron volts; there is no significant effect on the Compton, photo or pair interaction. Mass attenuation coefficient for solution is given by.

$$\frac{\mu}{\rho} = \sum_i w_i \left[\frac{\mu}{\rho}\right] \qquad ....3$$

Where ρ is the density and which is depends up on the solution of elements. w_i is the fraction by weight. The effect of shrinkage on the linear attenuation coefficient of a solution is given by Bragg mixture rule which we assume without approximation for aqueous solution of salts, namely

$$\left(\frac{\mu}{\rho}\right)_s = \left[\frac{\mu}{\rho}\right]_w W_w + \left[\frac{\mu}{\rho}\right]_{Ca} W_{Ca} \quad ....4$$

If we use this formula for the proposed work by the following way

$$\left(\frac{\mu}{\rho}\right)_S = \left(\frac{\mu_W}{\rho_W}\right)\times w_W + \left(\frac{\mu_C}{\rho_C}\right)\times w_C + \left(\frac{\mu_{B6}}{\rho_{B6}}\right)\times w_{B6} + \left(\frac{\mu_{B2}}{\rho_{B2}}\right)\times w_{B2} + \left(\frac{\mu_{B3}}{\rho_{B3}}\right)$$

$$\times w_{B3} + \left(\frac{\mu_{FA}}{\rho_{FA}}\right)\times w_{FA} + \left(\frac{\mu_{B1}}{\rho_{B1}}\right)\times w_{B1} + \left(\frac{\mu_B}{\rho_B}\right)\times w_B + \left(\frac{\mu_{B12}}{\rho_{B12}}\right)\times w_{B12} \quad ....5$$

$$\left(\frac{\mu_W}{\rho_W}\right)w_W = 2\left(\frac{\mu_H}{\rho_H}\right)W_H + \left(\frac{\mu_O}{\rho_O}\right)W_O$$ for water

$$\left(\frac{\mu_C}{\rho_C}\right)w_C = 6\left(\frac{\mu_C}{\rho_C}\right)W_C + 8\left(\frac{\mu_H}{\rho_H}\right)W_H + 6\left(\frac{\mu_O}{\rho_O}\right)W_O$$ For vitamin C

$$\left(\frac{\mu_{B6}}{\rho_{B6}}\right)W_{B6} = 8\left(\frac{\mu_C}{\rho_C}\right)w_C + 11\left(\frac{\mu_H}{\rho_H}\right)W_H + \left(\frac{\mu_N}{\rho_N}\right)W_N + 3\left(\frac{\mu_O}{\rho_O}\right)$$ For Vitamin B_6

$$\left(\frac{\mu_{B2}}{\rho_{B2}}\right)w_{B2} = 17\left(\frac{\mu_C}{\rho_C}\right)W_C + 20\left(\frac{\mu_H}{\rho_H}\right)W_H + 4\left(\frac{\mu_N}{\rho_N}\right)W_N + 6\left(\frac{\mu_O}{\rho_O}\right)W_O$$ For vitamin B_2

$$\left(\frac{\mu_{B3}}{\rho_{B3}}\right)w_{B3} = 6\left(\frac{\mu_C}{\rho_C}\right)W_C + 5\left(\frac{\mu_H}{\rho_H}\right)W_H + \left(\frac{\mu_N}{\rho_N}\right)W_N + 2\left(\frac{\mu_O}{\rho_O}\right)W_O$$ For vitamin B_3

$$\left(\frac{\mu_{FA}}{\rho_{FA}}\right)w_{FA} = 19\left(\frac{\mu_C}{\rho_C}\right)W_C + 19\left(\frac{\mu_H}{\rho_H}\right)W_H + 7\left(\frac{\mu_N}{\rho_N}\right)W_N + 6\left(\frac{\mu_O}{\rho_O}\right)W_O$$ For folic Acid

$$\left(\frac{\mu_{B1}}{\rho_{B1}}\right)w_{B1} = 12\left(\frac{\mu_C}{\rho_C}\right)W_C + 17\left(\frac{\mu_H}{\rho_H}\right)W_H + \left(\frac{\mu_N}{\rho_N}\right)W_O + 4\left(\frac{\mu_N}{\rho_N}\right)W_N + \left(\frac{\mu_S}{\rho_S}\right)W_S$$ For Biotin For

$$\left(\frac{\mu_B}{\rho_B}\right)w_B = 10\left(\frac{\mu_C}{\rho_C}\right)W_C + 16\left(\frac{\mu_H}{\rho_H}\right)W_H + 3\left(\frac{\mu_O}{\rho_O}\right)W_O + 2\left(\frac{\mu_N}{\rho_N}\right)W_N + \left(\frac{\mu_S}{\rho_S}\right)W_S$$ Vitamin B_1For

$$\left(\frac{\mu_{B12}}{\rho_{B12}}\right)w_{B12} = 63\left(\frac{\mu_C}{\rho_C}\right)W_C + 88\left(\frac{\mu_H}{\rho_H}\right)W_H + \left(\frac{\mu_{CO}}{\rho_{CO}}\right)W_{CO} + 14\left(\frac{\mu_N}{\rho_N}\right)W_N + 19\left(\frac{\mu_O}{\rho_O}\right)W_O + \left(\frac{\mu_P}{\rho_P}\right)W_P$$ Vitamin B_{12}

For solution of Becosule and water we have,

$$\left(\frac{\mu}{\rho}\right)_S = \left(\frac{\mu_W}{\rho_W}\right)W_W + \left(\frac{\mu_{Ca}}{\rho_{Ca}}\right)W_{Ca} \quad ....6$$

$$\left(\frac{\mu_{Ca}}{\rho_{Ca}}\right) = \left(\frac{\mu_C}{\rho_C} + \frac{\mu_{B1}}{\rho_{B1}} + ...\right)$$

Where $W_{ca} = [W_c + W_{B1} + ...]$

But for homogeneous solution the density is same.

$$\therefore \left(\frac{1}{\rho}\right)_S = \left(\frac{1}{\rho_W}\right)W_W + \left(\frac{1}{\rho_{Ca}}\right)W_{Ca}$$

They can be neglected from above equation so equation 6 becomes.

$$\mu_s = \mu_w \times W_w + \mu_c \times W_c \quad ----------------- 7$$

Table 1 gives the values of μ from eq^n 7 for various concentrations C and theoretical values of (μ/ρ) are calculated by Hubbel[6] mixture rule which is given by

$$\left(\frac{\mu}{\rho}\right) = \Sigma_i W_i \left(\frac{\mu}{\rho}\right)_i$$

Table:-1 Linear attenuation coefficient of Becosules soluble In Water at Gamma ray energy 511 KeV

Sr.no	C=Vw /Vs	h cm	Ao(Sec^{-1})	Ln Ao/A	μ $_{expt.}$(cm^{-1})	μ $_{the}$(cm^{-1})	A (Sec^{-1})
1	0.022483	4.7	47.5656	0.554857	0.118055	0.118152	27.31
2	0.021435	4.75	47.5656	0.555956	0.117043	0.117963	27.28
3	0.020481	4.8	47.5656	0.562207	0.117126	0.117791	27.11
4	0.019608	4.92	47.5656	0.577072	0.117291	0.117634	26.71
5	0.018806	5	47.5656	0.585267	0.117053	0.117489	26.492
6	0.018068	5.12	47.5656	0.599791	0.117147	0.117356	26.11
7	0.017385	5.26	47.5656	0.619127	0.117705	0.117233	25.61
8	0.016752	5.39	47.5656	0.63091	0.117705	0.117119	25.31
9	0.016752	5.5	47.5656	0.64676	0.117593	0.117013	24.912
10	0.015614	5.62	47.5656	0.654457	0.116451	0.116914	24.721

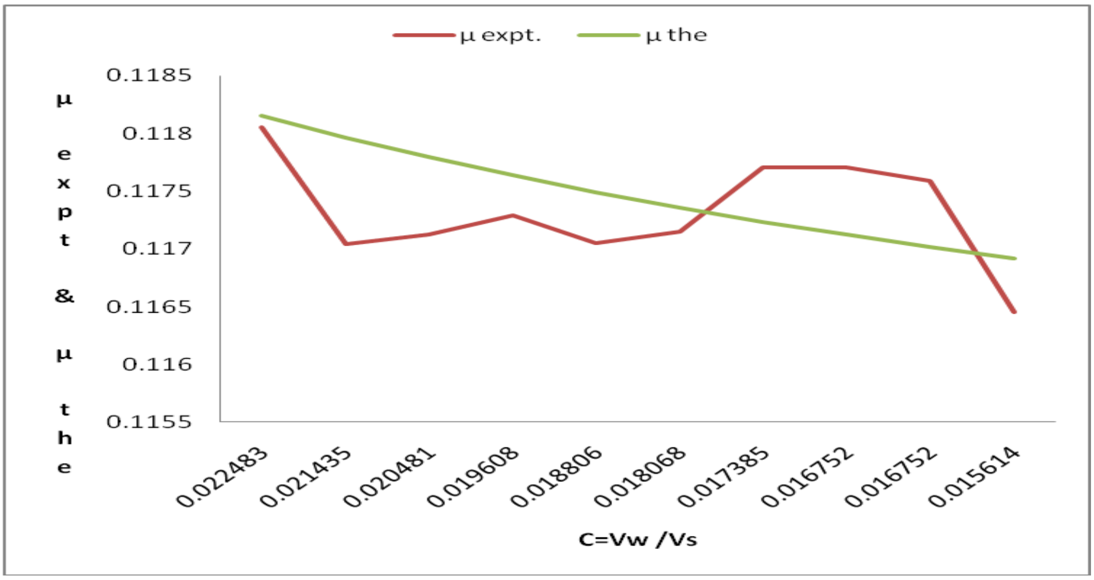

Fig. 3 - Graph of concentration against experimental observations and theoretical values of linear attenuation coefficient of Becosules soluble in Water at Gamma ray energy 511 KeV.

Fig. 3 - shows the graph of concentration against experimental observations and theoretical values obtained from equation 7. The data are fitted on a straight line by the least square method.

The validity of eq^n 7 gives us with a new and alternative method for a solution.

5 Conclusion -

We study linear and mass attenuation of Becosules at 511 KeV. Soluble in water explores the validity of the exponential absorption law for gamma radiation in solution, also as in solids and provide a direct new method for the determination of linear μ_s and mass (μ_s / ρ_s) attenuation coefficients for soluble substance. The results are in good agreement [11-12].

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