# Linear Attenuation Coefficient Methanol Solution of Oxalic Acid by Varying Concentration at 0.511 Mevgamma Energy

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## ABSTRACT

Linear attenuation of 0.511 MeV gamma radiations from methanol by solution of oxalic acidstudied for different concentrations. Mixture rule for theoretical calculation of attenuation coefficient is developed for the solution. Our study explores the validity of the expected exponential absorption law for γ-rays radiations in solution which directly determination of linear attenuation coefficients of soluble compound in methanol. The liquids now a days transparent liquid are playing important role in radiation shield materials for the safety of MHC.

Keywords:- linear attenuation coefficients, Gamma-rays, NaI(Tl) activated Scintillation Detector with 8k multichannel analyzer,oxalic acid as solute and methanol as solvent.

## INTRODUCTION

Linear attenuation coefficient for gamma rays for different materials and solutions plays an important role radiation dosimetry. There are different measurement techniques to measure them. As technology is developed day by day, the gamma rays are used in many fields, like Radiation exposure to cancer, food grains and onion preservation,, Radiation Shielding and with their measurement techniques are developed but we find these measurements can be made with still simpler method. Teli et aland Dongarge S.M. et al has developed the mixture rule and we have used the rule with simpler approach and are considered for our research work.

This method is developed from single element mass attenuation coefficient of gamma rays to mixtures (solute and solvent). Dongarge S.M.(2010-15) extended for the mixture of liquid and liquid materials also. There are various reports on the measurement of these quantities (1-6). Hubbell (3) has developed the rule for calculation of gamma absorption coefficient for mixtures and gave tables of theoretical values for various elements and their mixtures. Teli et al (1994) have measured the attenuation coefficient of 123 KeV gamma radiations by dilute solution of sodium chloride. Dongarge et al (2010) reported the linear attenuation coefficient for measurement of linear attenuation coefficients of gamma rays for Ammonium Sulfate by aqueous solution method 0.511 MeV gamma energy. Recently (7) ZnBr2 is used as liquid radiation shield for mobile hot cell window and shown direct application in viewing window which is usually made of almost radiation shield material for the safety of MCH operators.

So for the study of both types of absorption coefficient for gamma rays has been done for liquids by using various techniques as reported above and the observations are compared with the theoretical values as calculated from Hubbell's mixture rule and his table.

We give here measurements of the attenuation of 0.511 MeV gamma radiations in ethanol soluble oxalic acid for different concentrations.

## MATERIALS (liquid) AND METHODS

### Experimental arrangement:-

The experimental arrangement is as shown in fig. (1) cylindrical prefix container of internal diameter 2.46 cm wasplaced below the source at a distance 1.2 cm and above the detector at 2.2 cm by using efficient geometrical arrangement. The NaI (Tl) crystal is used as the detector connected to 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 the whole system is enclosed in a lead castal.

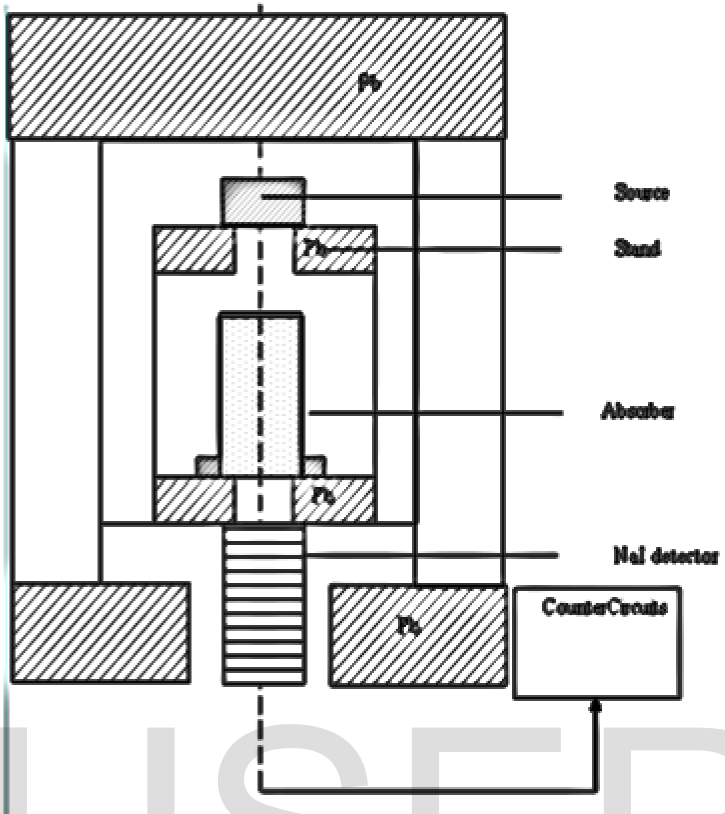

Fig. 1 - Experimental Arrangement

Fig 1: Experimental set up for measurement of gamma absorption coefficient for solution.

## Method of observations:-

First the gamma rays are passed through empty container reaching the detector. The spectrum is obtained for 1800 sec. using MCA which gives plot of channel number Vs counts. We select the interested peak which is smoothed for avoiding the random nature and obtain the peak gross area Ao (The sum of the spread counts which are coming under the peak) this is obtained because in MCA the counts get spread over some energy range around the photo peak. This increases the accuracy of measured solution kept in the container and gamma are passed through it. The concentration varied by adding oxalic acid to fixed volume of methanol. The gamma rays are passed through such solutions and interested peak gross area measured as A 1 , A 2 , …………… A 10. The other quantities measured in the experiment are the volume of oxalic acidand ethanol added together to give total volume . The actual volume V 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 ( $\pi r^2$). This procedure is repeated for all the concentrations we prepared.

## Theoretical development for the experiment

The graph of In (A 0 /A) versus height of liquid column h (cm) is measured. The observed points are seen to be closely distributed around the line having positive slopes. These lines are obtained by fitting the experimental data by the least square method. Their slope gives the linear coefficient and thus the linearity of the curves with positive slopes suggests the relation.

$$\frac{A_0}{A} = e^{-\mu h} \quad ------------ \quad (1)$$

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

$$A = A_0 e^{-\mu h} \quad ------------- \quad (2)$$

We know Hubbell's mixture rule (1982). The mass attenuation coefficient of gamma rays in chemical or any other mixtures of compound is assumed to depend upon the sum of the cross section presented by all the atoms in the mixture because the bonds are only of the order of few electron volts; there have no significant effects on the Compton, photo or pair interaction.

Mass attenuation coefficient for solution is given by.

$$\frac{\mu}{\rho} = \sum_i W_i \left(\frac{\mu}{\rho}\right)_i \quad ------------ \quad (3)$$

Where ρ is the density and which is made up on 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 oxalic acidnamely,

$$\left(\frac{\mu}{\rho}\right)_{sol} = \left(\frac{\mu}{\rho}\right)_{OA} + M_{OA} + \left(\frac{\mu}{\rho}\right)_{MTH} + W_{MTH} \qquad .........(4)$$

When the oxalic acidis dissolved in methanolthen the homogeneous solution forms. If the solution is homogeneous then one can neglect the density from both sides. If we use this formula for the proposed work in the following way then it will be

$$\mu_{\text{solution}} = \mu_{\text{methanol}}\, w_{\text{methanol}} + \mu_{OA} w_{OA} \quad ---------- \quad (5)$$

Table 1 gives the values using equation (5) for various concentration and theoretical values of (μ ethanol ) and (μ oxalic acid )
are calculated by multiplying their densities to (μ/ρ) which is calculated by Hubble mixture rule.

$$\frac{\mu}{\rho} = \sum_i W_i \left(\frac{\mu}{\rho}\right)_i \text{ -------------- } (6)$$

Is used to calculate theoretical $\mu$ (theoretical) given in the table-1

**Solution technique for calculation of linear attenuation coefficient of Ammonium Sulfate**

Using the data the experimental linear attenuation coefficient of the oxalic acid with ethanolsolution ( $\mu$ exp. ) is obtained
from,

$$\left(\mu_{exp}\right) = \frac{1}{h} \ln\left(\frac{A_0}{A}\right) \qquad \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_} (7)$$

Where h is the height of the solution.
The mixture rule for aqueous solution is obtained from equation (5). The equation
(5) is used to obtain theoretical ( $\mu_{th}$ ) and experimental ( $\mu_{exp}$ ) is obtained by equation (7).
exp $\mu$ values are given in the table 1 in 6th column and ( th $\mu$ ) values are given in 7th column and the percent error is obtained by the following equation (8) and is given in 8th column of table 1.

$$\% \text{ error} \quad = \quad \frac{\mu_{the} - \mu_{exp}}{\mu_{the}} \times 100 \text{\_\_\_\_\_\_\_\_\_\_\_\_} (8)$$

$\mu/\rho$ for methanol and oxalic acidis obtained from Hubbell table by multiplying its density we get theoretical $\mu_{the}$ for ethanol and oxalicacid then by using eqn.(5) the $\mu$ is obtained, the results calculated are tabulated in table 1 oxalic acid solution. Eqn (5) is the equation of straight line between $\mu_{exp}$ and concentration in which methanol volume is fixed. The intercept is the attenuation coefficient for the methanol and its slope is the attenuation coefficient difference of both.

If we plot the graphas shown in fig1,from the slope is 0.1689 cm$^{-1}$ and intercept is 0.08248 cm$^{-1}$is the linear attenuation coefficient for theoxalic acidand methanol. We observe fromthe table and graph that, the $\mu_{exp}$and $\mu_{th}$are within the acceptable limit showing very good agreement. The graph of exp $\mu$ (cm-1) versus concentration Vs/V at 0.511MeV gamma ray energy for solution is as shown in fig1.

## CONCLUSION

Our experimental measurement of linear attenuation coefficient of methanol soluble oxalic Acid for different concentrations and estimated from them the attenuation coefficient for pure oxalic acid by using the mixture rule developed by Teli (1998) established the validity and utility of the solution technique. This method is simple and avoids the separate statistical procedure for experiment there by saving time and expenditure. The use of multichannel analyzer has also improved the results as we could replace the counts at the photo peak by the area under it. Further the variation of concentration of solution is made easy by adding methanol to solution without changing the oxalic acid amount in it. This saves the solute quantity and thus further economizes the experiment.

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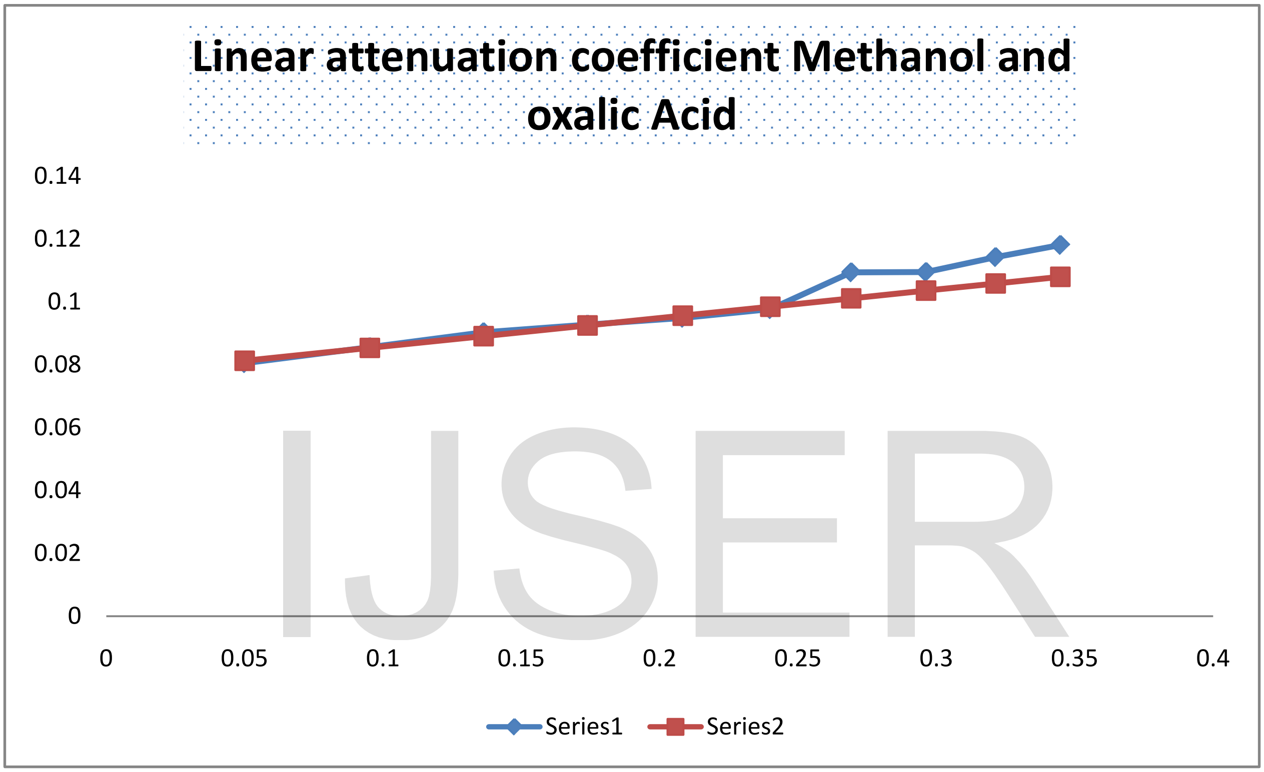

Fig.2 :A plot of linear attenuation coefficient of Methanol and oxalic acid solution by varying concentration.

Table: -1. Linear absorption coefficient of InOxalic Acid and Methanol at Gamma ray energy 0.36 MeV

Ao = 30.438 (Sec$^{-1}$)

| Sr No. | C=V$_g$ /V’ | h cm | A (Sec$^{-1}$) | Ln Ao/A | μ expt. Cm$^{-1}$ | μ$_{th}$. Cm$^{-1}$ | % Error |
|---|---|---|---|---|---|---|---|
| 1. | 0.05 | 2.96 | 23.985 | 0.238273049 | 0.080497652 | 0.08125541 | 0.932563556 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2. | 0.0952381 | 3.16 | 23.224561 | 0.270491301 | 0.085598513 | 0.085351729 | -0.28912778 |
| 3. | 0.136363 | 3.27 | 22.65412 | 0.295359951 | 0.090324144 | 0.089075597 | -1.401671006 |
| 4. | 0.173913 | 3.38 | 22.24587 | 0.31354531 | 0.092764885 | 0.092475757 | -0.312652557 |
| 5. | 0.208333 | 3.49 | 21.8561 | 0.331221625 | 0.09490591 | 0.095592495 | 0.718241585 |
| 6. | 0.24 | 3.58 | 21.456871 | 0.349656763 | 0.097669487 | 0.098459948 | 0.802824926 |
| 7. | 0.2692308 | 3.68 | 20.35214 | 0.402515618 | 0.109379244 | 0.101106803 | -8.18188386 |
| 8. | 0.2962963 | 3.79 | 20.10213 | 0.414875904 | 0.109465938 | 0.103557589 | -5.70053747 |
| 9. | 0.3214286 | 3.88 | 19.5412 | 0.443176627 | 0.11422078 | 0.105833324 | -7.92515601 |
| 10. | 0.3448276 | 3.98 | 19.02458 | 0.469969857 | 0.118082879 | 0.107952108 | -9.38450444 |

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