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# STUDY OF GAMMA ABSORPTION PROPERTIES OF WATER SOLUBLE SULPHATE COMPOUNDS AT DIFFERENT ENERGY LEVELS

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**ABSTRACT**

**Objective:** Linear and Mass attenuation coefficients are two quantities used, their strategies of measurement had been evolved by many peoples for stable and aqueous solutions. we have tried to broaden an equation for direct dimension of linear attenuation coefficient of water soluble sulphates at one of a kind energys. This approach is useful in measuring the absorption coefficient of sulphate without obtaining them in pallet form.

**Materials and Methods:** Water soluble sulphates were collected from study sites. Here we have given Ammonium sulphate($(NH_4)_2SO_4$), Sodium sulphate ($Na_2SO_4$), Copper (II) sulphate( $CuSO_{4x}$), Zinc sulphate( $ZnSo_4$) and water.

**Results:** linear and mass attenuation coefficient of water soluble Sulphate for distinct concentrations and anticipated from them the attenuation coefficient for compound through the use of the aggregate rule developed via Teli (1998) hooked up the validity and utility of the solution technique. This approach is simple and avoids the need of training of pure crystalline compound for experiment there via saving time and expenditure. The version of awareness of answer is made easy by using adding water to solution without changing the compound quantity in it.

**Conclusion:** This saves the compound amount and thus in addition economizes the experiment.

**Keywords**: Linear and mass attenuation coefficients, Gamma-rays, NaI (Tl) detector, sulphates.

## 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 changed 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 measurements can be made with still simpler method. Recently Teli et(1997) [1] al has developed the mixture rule and we have modified the rule with simpler approach and is considered for our research work.

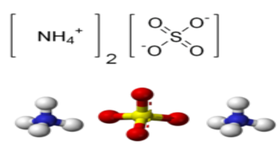
This method is developed from single element mass attenuation coefficient of gamma rays to mixtures (solute and solvent). Teli et al.[2-5] measured the linear and mass attenuation coefficient of water soluble salts $MgCl_2$, $6H_2O$, NaCl, KCl series compounds For 0.123 MeV to 1.33 MeV gamma radiation 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 [6] using the revised technique. Hubbel [7] 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 [8] Studies Gamma ray photon interaction of Cr in the energy range 10keV to 1500keV. Bradley et al (1989) [9] 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 [10] have measured energy absorption coefficient for gamma rays in soil samples by applying Bradley's technique. Jahagirdar et al [11] 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, the view of importance of the study of gamma attenuation properties of materials and its various applications in science, technology and human health.

## SULPHATES

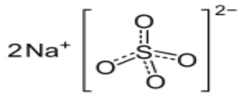
### Ammonium sulphate

Ammonium sulphate; $(NH_4)_2SO_4$, is an inorganic salt that is soluble in water and its molar mass is 132.14 g/mol with some of commercial uses. The most common use is as a soil fertilizer. It carries 21% nitrogen and 24% sulfur. Ammonium sulphate is extremely soluble in water because of its ionic nature, therefore it can "salt out" proteins by means of precipitation. Due to the excessive dielectric constant of water, the dissociated salt ions being cationic ammonium and anionic sulphate are without difficulty solvated inside hydration shells of water molecules. The significance of this substance within the purification of compounds stems from its ability to grow to be extra so hydrated as compared to extraordinarily more nonpolar molecules and so the proper non-polar molecules coalesce and precipitate out of the solution in a concentrated form.



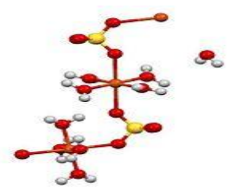
### Sodium sulphate

Sodium sulphate is the inorganic compound with system $Na_2SO_4$ as well as numerous associated hydrates. All bureaucracy are white solids which might be rather soluble in water. With an annual manufacturing of 6 million tonnes, the de-hydrate is a prime commodity chemical product. The crystals had been used as a general purpose laxative, until extra sophisticated options passed off in the 1900s. Sodium sulphate is a regular electrostatically bonded ionic sulphate. The life of free sulphate ions in solution is indicated via the smooth formation of insoluble sulphates while these solutions are dealt with with Ba2+ or Pb2+ salts.



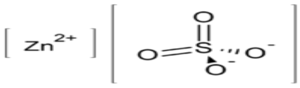
**Copper(II) sulphate**

Copper (II) sulphate, also referred to as copper sulphates are the inorganic compounds with the chemical system $CuSO_{4x}$, where x can variety from zero to 5. The pentahydrate is the most not unusual form. Older names for this compound consist of blue vitriol, bluestone, vitriol of copper, and Roman vitriol. Copper sulphate is produced industrially through treating copper metallic with hot concentrated sulfuric acid or its oxides with dilute sulfuric acid. For laboratory use, copper sulphate is generally purchased. Copper sulphate can also be produced via slowly leaching low grade copper ore in air; bacteria may be used to hasten the process.



**Zinc sulphate**

Zinc sulphate is an inorganic compound soluble in water and nutritional supplement. As a supplement it is used to deal with zinc deficiency and to save you the situation in the ones at excessive risk. Side consequences of extra supplementation may include stomach pain, vomiting, headache, and tiredness. Zinc sulphate is used to supply zinc in animal feeds, fertilizers, toothpaste, and agricultural sprays. Zinc sulphate, like many zinc compounds, can be used to control moss growth on roofs. In medicine it's far used together with oral rehydration therapy (ORT) and an astringent.



**Experimental Arrangement**

The experimental arrangement is as shown in Fig.1 different energys from Na22. 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 sources 137Cs, with one line of energy 0.662 MeV, 60Co with two lines E1=1.17 MeV and E2=1.33 MeVand22Na with two lines, E1=0.511MeV and E2=1.274 MeV,.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

**METHODS AND OBSERVATIONS**

First the gamma rays are passed via empty container achieving the detector. The spectrum is received for 1800 sec. using MCA which gives plot of channel range Vs counts. We select the involved top which is smoothed for averting the random nature and gain the peak gross place Ao (The sum of the spread counts which might be coming under the height) this is acquired due to the fact in MCA the counts get unfold over some energy range around the photograph height. This will increase the accuracy of measured solution kept within the field and gamma rays are passed through it. The attention varied by sulphate compound including to it. The gamma rays are passed via such solutions and interested peak gross location measure d as A1, A2, …… A10 the alternative quantities measured within the experiment are the extent of Sulphate (Vs) and water Vw brought together to offer total quantity (V).

The actual volume V of the solution is calculated by measuring its 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 for gamma energys 0.511,0.662,1.17,1.28,1.33 MeV.

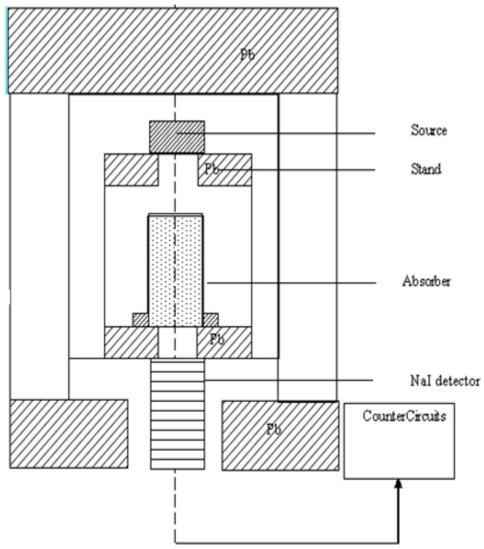



**Fig.1: The experimental arrangement**

**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.

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

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

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

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. 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 h (cm) is the thickness of a material. The linear attenuation coefficient (μ) of the materials from equation (2) is expressed as

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

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.

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

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 alcohol namely,

$$\left(\frac{\mu}{\rho}\right)_{sol} = \left(\frac{\mu}{\rho}\right)_a W_a + \left(\frac{\mu}{\rho}\right)_c W_c \quad \text{----}\ (4)$$

When the Sulphate is dissolved in water then the homogeneous solution is 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

$$\mu_{sol} = \mu_{sul} w_{sul} + \mu_{wat} w_{wat} \quad \text{-----}\ (5)$$

Table 1 gives the values using equation (5) for various concentration and theoretical values of ($\mu_{water}$) and ($\mu_{sulphate}$) are calculated by multiplying their densities to (μ/ρ) which is calculated by Hubble mixture rule.

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

**Solution technique for calculation of linear attenuation coefficient of sulphate.**

Using the data the experimental linear attenuation coefficient of the sulphate solution ($\mu_{exp.}$) is obtained from.

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

Where h is the height of the solution.

**Solution techniques for calculation of mass attenuation coefficient of sulphate.**

The mass ($m_s$) of the sulphate is already weighted using four digit digital balance. Mass of water ($m_w$) is obtained (at room temp.) by multiplying density of water to volume of water. The cross sectional area of the container is measured, and then the experimental mass-attenuation coefficient for sulphate solution is calculated by the formula as

$$\mu/\rho = A/m \ \ \text{In}\ \{A_0/A\} \quad \text{------------}\ (8)$$

Where - m = $m_s + m_w$ mass of solution

A = gross area obtained for the different concentrations of the solution after passing gamma rays through them.

$A_o$ = is the initial gross area of the interested peak of the observed spectrum when gamma rays are passed through the empty container.

The Brags mixture rule for mass attenuation coefficient is given by

$$m\ \{\mu/\rho\} = m\_p\ \{\mu/\rho\} + m\_e\ \{\mu/\rho\}$$

The graph of m {μ/ρ} = A In {$A_0$/A} against mass of water gives a straight line whose intercept gives $m_p\{\mu/\rho\}_p$ and slope gives $\{\mu/\rho\}_e$. The $\{\mu/\rho\}_p$ and $\{\mu/\rho\}_e$ values are calculated for sulphate and water at **0.511, 0.662, 1.17, 1.28, 1.33** MeV gamma ray energies. The measured values are found to be agreeing well with the theoretical values.

The percentage error with respect to theoretical values of mass absorption coefficient of sulphate the formula as follows.

% error =

$$\frac{\{\frac{\mu}{\rho}\}\text{the.} - \{\frac{\mu}{\rho}\}\text{exp}}{\{\frac{\mu}{\rho}\}\text{the}} \times 100 \quad \text{---------}\ (9)$$

**Table: 1 Mass attenuation coefficient of Ammonium sulphate in water For different energys**

| Sr.No | Energy in MeV | μ/ρ exp | μ/ρ the | %error |
|---|---|---|---|---|
| 1 | 0.511 | 0.0905 | 0.09 175 | 0.36239 |
| 2 | 0.662 | 0.08056 | 0.0824 1 | -0.24487 |
| 3 | 1.17 | 0.06 1 96 | 0.06212 | 0.25756 |
| 4 | 1.28 | 0.05996 | 0.05962 | -0.57027 |
| 5 | 1.33 | 0.05732 | 0.05849 | 0.00034 |

**Table2: Mass attenuation coefficient of Sodium sulphate in water For different energys**

| Sr.No | Energy in MeV | μ/ρ exp | μ/ρ the | %error |
|---|---|---|---|---|
| 1 | 0.511 | 0.0857 1 | 0.08542 | -0.3395 |
| 2 | 0.662 | 0.07659 | 0.07679 | 0.26045 |
| 3 | 1.17 | 0.05805 | 0.05808 | 0.05165 |
| 4 | 1.28 | 0.0566 | 0.05549 | -0.00036 |
| 5 | 1.33 | 0.05376 | 0.05442 | 0.21278 |

**Table3: Mass attenuation coefficient of Copper(II) sulphate in water For different energys**

| Sr.No | Energy in MeV | μ/ρ exp | μ/ρ the | %error |
|---|---|---|---|---|
| 1 | 0.511 | 0.08578 | 0.08634 | 0.64859 |
| 2 | 0.662 | 0.07584 | 0.07635 | 0.66797 |
| 3 | 1.17 | 0.05721 | 0.05764 | 0.746 |
| 4 | 1.28 | 0.05561 | 0.055 13 | -0.87066 |
| 5 | 1.33 | 0.05404 | 0.05413 | 0.16626 |

**Table4: Mass attenuation coefficient of Zinc sulphate in water For different energys**

| Sr.No | Energy in MeV | μ/ρ exp | μ/ρ the | %error |
|---|---|---|---|---|
| 1 | 0.511 | 0.08578 | 0.08634 | 0.64859 |
| 2 | 0.662 | 0.07584 | 0.07635 | 0.66797 |
| 3 | 1.17 | 0.05721 | 0.05764 | 0.746 |
| 4 | 1.28 | 0.05561 | 0.055 13 | -0.87066 |
| 5 | 1.33 | 0.05404 | 0.05413 | 0.16626 |

## CONCLUSIONS

Our experimental measurement of linear and mass attenuation coefficient of water soluble Sulphate for distinct concentrations and anticipated from them the attenuation coefficient for compound through the use of the aggregate rule developed via Teli (1998) hooked up the validity and utility of the solution technique. This approach is simple and avoids the need of training of pure crystalline compound for experiment there via saving time and expenditure. The use of multichannel analyzer has also progressed the outcomes as we could replace the counts at the photo peak with the aid of the area beneath it. Further the version of awareness of answer is made easy by using adding water to solution without changing the compound quantity in it. This saves the compound amount and thus in addition economizes the experiment. The effects are in proper agreement (Mitkar S R et al 2012).

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