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Araştırma Makalesi – Research Article

Bazı Potasyum Bileşiklerinin Kütle Soğurma Katsayılarının Ölçülmesi

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ÖZ

Bu çalışmada, bazı potasyum bileşiklerinin (KH_2PO_4, KNO_3, $K_2S_2O_8$, KOH, K_2HPO_4, K_2SO_4, KCl, KIO_3, ve KI) kütle soğurma katsayıları 59,54 keV enerji için Enerji Ayrımlı X-ışını Floresans Spektrometresi (EDXRFS) ve yüksek çözünürlüklü bir Si(Li) dedektör kullanılarak ölçülmüştür. Elde edilen deneysel kütle soğurma katsayıları WinXCom (Windows İşletim Sistemine Uyarlanmış Foton Tesir Kesitleri Veritabanı) ve FFAST (X-Işını Form Faktörü, Soğurma ve Saçılma Tabloları) teorik değerleriyle karşılaştırılmıştır.

Anahtar Kelimeler- Potasyum, EDXRFS, WinXCom, FFAST

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Measurement of Mass Attenuation Coefficients for Some Potassium Compounds

ABSTRACT

In this study, the mass attenuation coefficients of some potassium compounds (KH_2PO_4, KNO_3, $K_2S_2O_8$, KOH, K_2HPO_4, K_2SO_4, KCl, KIO_3, and KI) have been measured by using Energy Dispersive X-ray Fluorescence Spectrometer (EDXRFS) and a high-resolution Si(Li) detector for 59.54 keV energy. Obtained experimental mass attenuation coefficients have been compared with WinXCom (Windows-Photon Cross Sections Database) and FFAST (X-Ray Form Factor, Attenuation and, Scattering Tables) theoretical values.

***Keywords*- Potassium, EDXRFS, WinXCom, FFAST**

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I. INTRODUCTION

The mass attenuation coefficients ($\mu_m = {}^{\mu}/_{\rho}$) of X-and γ-rays are used in radiation physics, radiation dosimetry, biological, medical, agricultural and industrial fields. The mass attenuation coefficient directly gives an idea about the nature of the absorbent material. The mass attenuation coefficient value gives more useful information because it is not dependent on the physical state of the absorbent material. Also, important parameters such as atomic, molecular, electronic cross-sections, effective atomic numbers and, electron densities are determined by measuring the mass attenuation coefficient.

In the literature, accurate values have been sought for the mass attenuation coefficient of many materials. The transmission of gamma-rays for some boron compounds and the trommel sieve waste in the energy range 15.74–40.93 keV have been determined by [1] The mass attenuation coefficients by using gamma radiation at energy 0.662 MeV for different soil samples have been studied by [2]. The atomic parameter for some compounds of Na, Mg, Al, Ca, and Fe has been measured by [3]. The attenuation coefficients and photon interaction cross-sections of human tissues are calculated in good agreement with experimental values [4, 5, 6].

As far as we have known, some potassium compounds (KH_2PO_4, KNO_3, $K_2S_2O_8$, KOH, K_2HPO_4, K_2SO_4, KCl, KIO_3, and KI) have not been measured in the 59.54 keV energy. This study will make an important contribution to the literature in terms of generating the first experimental data.

II. MATERIALS AND METHODS

The experimental setup used in the present work is shown in Figure 1. The experimental setup is formed 100 mCi ^{241}Am a point source and, a high-resolution Si(Li) detector. The spectra were collected in the 1800 s. Target had a diameter of 13 mm. The net counts unattenuated (I_0) and with attenuated (I) were obtained at the same and experimental conditions. A sample spectrum of 59.54 keV γ-rays passed through KIO_3 is shown in Figure 2.

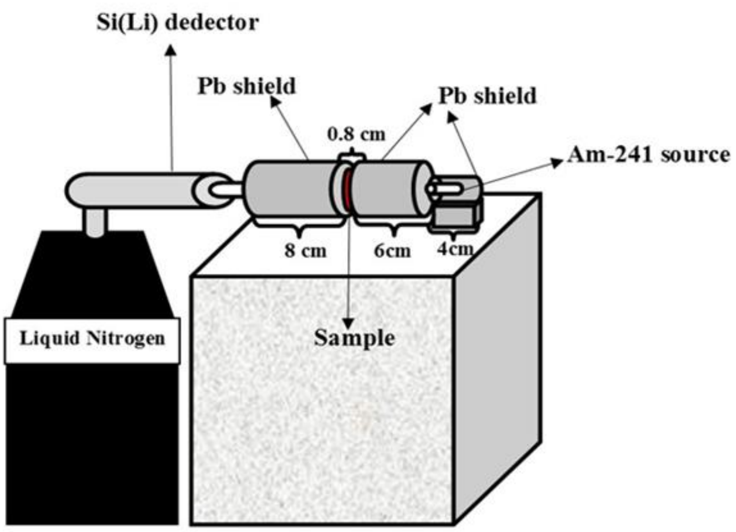

Figure 1. Experimental geometry

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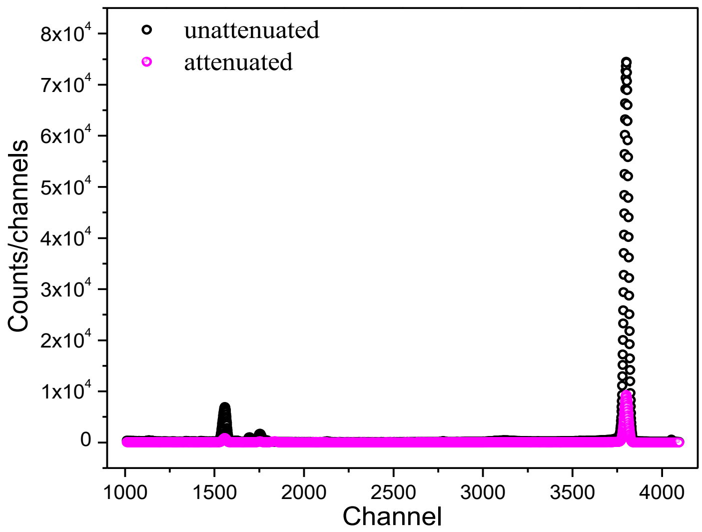

Figure 2. A sample spectrum

The maximum errors in the experimental values were calculated from errors in the incident (I_0) and transmitted (I) intensities and areal density (t) using the formula

$$\Delta\left(\frac{\mu}{\rho}\right) = \frac{1}{t}\sqrt{\left(\frac{\Delta I_0}{I_0}\right)^2 + \left(\frac{\Delta I}{I}\right)^2 + \left(\ln\frac{I_0}{I}\right)^2\left(\frac{\Delta t}{t}\right)^2} \quad (1)$$

where ΔI_0, ΔI and Δt are the errors in the intensities I_0, I and thickness t of the target, respectively. The maximum errors (±σ) in the experimental values are given in Table 1. Also, the relative difference (RD) was calculated by using the following formula equation, and the ratio of Theoretical (T) and Experimental (E) values (T/E) are given in Table 1.

$$Relative\ Difference\ (RD) = \frac{(\mu/\rho_{Theoretical} - \mu/\rho_{Experimental})}{\pm\sigma} \quad (2)$$

To obtain the best experimental mass attenuation coefficients the powder samples have been made for (≈ 0.500; 0.600; 0.700 and, 0.800 g). There are not the FFAST of the mass attenuation coefficients values for 59.54 keV energy. Therefore, FFAST values were obtained by using the interpolation method at 59.54 keV.

III. RESULTS AND DISCUSSION

In this work, the mass attenuation coefficients of some potassium compounds have been measured by using EDXRFS and a Si(Li) detector. Experimental results have been compared with the theoretical results of WinXCom [7-9] and FFAST [10]. Experimental and theoretical results and, the RD and, T/E ratio is given in Table 1.

Table 1. The experimental and theoretical mass attenuation coefficients in the 59.54 keV energy for some potassium compounds

Compounds	$\mu/\rho_{(Exp)}$	$\mu/\rho_{(WinXCom)}$	$\mu/\rho_{(FFAST)}$	$RD_{WinXCom}$	RD_{FFAST}	$T/E_{WinXCom}$	T/E_{FFAST}
$K_2S_2O_8$	0.327 ± 0.014	0.355	0.354	2.000	1.929	1.086	1.083
KNO_3	0.341 ± 0.008	0.340	0.338	-0.125	-0.375	0.997	0.991
KH_2PO_4	0.361 ±0.010	0.341	0.340	-2.000	-2.100	0.945	0.942
K_2HPO_4	0.393 ± 0.014	0.394	0.391	0.071	-0.143	1.003	0.995
K_2SO_4	0.432 ± 0.014	0.405	0.401	-1.929	-2.214	0.938	0.928
KCI	0.499 ±0.010	0.515	0.508	1.600	0.900	1.032	1.018
KOH	0.575 ± 0.013	0.463	0.457	-8.615	-9.077	0.805	0.795
KIO_3	4.043 ± 0.034	4.740	4.671	20.500	18.471	1.172	1.155
KI	6.288 ± 0.013	6.050	5.965	-18.308	-24.846	0.962	0.949

When Table 1 is examined, it is seen that there is a very good agreement between experimental values and theoretical values. But, it is generally seen that experimental values are closer to FFAST values than WinXCom values. Also, WinXCom values are greater than FFAST values. This is because WinXCom based on the mixture rule neglects the effect of the chemical environment and molecular bonds. In addition, chemical, molecular and thermal environments have an effect on the mass attenuation coefficient. In calculations the theoretical value for the isolated atom, the cross-section calculation is taken into account. This leads to the deviation of the experimental mass attenuation coefficient. This deviation is called the invalidity of the mixture rule or the failure of the rule. The invalidity of the mixture rule and its effects have been monitored in some previous studies [11,12].

The presence of heavy elements in compounds with light elements also causes differences between experimental and theoretical mass attenuation coefficients. This is because the photoelectric effect is dominant in the 0.01 MeV-0.05 MeV energy range, where the mass attenuation coefficient is high. When Table 1 is examined, the presence of small atomic number elements in potassium compounds reduces the probability of photon interaction with the atom, while the presence of a heavy element (such as I, iodine), increase the probability of interaction. That is, the heavy element in the compound increases the mass attenuation coefficient. This is due to the predominance of the photoelectric effect for elements with a large atomic number, and the atomic cross-sections are proportional to the mass attenuation coefficient. In this case, it seems that heavy metals will create problems in addition to their own effects on living things, in terms of increasing the probability of radiation interaction.

IV. CONCLUSION

As a result, the mass attenuation coefficients determined for the potassium compounds in our study were measured sensitive experimentally by using narrow-beam geometry. New experimental studies can be made with different compounds, energies, and methods, and the direction of the use of the experimental and theoretical results for these elements and compounds should be further developed through joint studies with different research groups (especially medicine).

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