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Comparison Between Mass Attenuation Coefficient of Metals (Fe, Ag, Sn, Pt, Au, Pb) According to Their Atomic Number

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Abstract

The paper describes the X-ray attenuation in materials according to their atomic number, using six different materials from low atomic number to higher atomic number, Iron (Fe-26) as low atomic number, silver (Ag-47), tin (Sn-50), platinum (Pt-78), gold (Au-79) and lead (Pb-82) as high atomic number. Using the data were taken from the NIST Standard Reference Database 126. From the J. H. Hubbell and S. M. Seltzer work, a table of contents was used. Whereas The mass attenuation coefficient for the above six elements was taken and compared with each other.

1. Introduction

When an X-ray beam incident on an atomic target, two processes may occur; the beam may be absorbed (attenuated) with an ejection of electrons from the atoms, or the beam may be scattered.[1,2] Attenuation is defined as an intensity loss of incident X-rays passing through a matter. The intensity, I0, of a monochromatic beam (X-ray) decreases exponentially:

$$I = I_0 e^{-\mu x} \quad (1)$$

where the linear absorption coefficient, $\mu\ (cm)^{-1}$ represents the average number of absorption and scattering processes that a single photon undergoes through an absorber of thickness x (cm).[3] the mass attenuation coefficient is equal to the linear attenuation coefficient to the density of the element $\mu/\rho\ (cm^2/g)$.

Many experimental measurements to determine the attenuation coefficients in solid materials have been presented [4,5]. The [6,7,8] describe the attenuation coefficient concerning energy range values. And [9] measures the mass attenuation coefficient for (Na, Mg, Al, Ca, and Fe).

The present work is to compare the mass attenuation coefficient for six different elements, at the same X-ray energy value, concerning their atomic numbers

2. Method

NIST X-ray Attenuation Databases[10] were used in work [1], and we used their results in the table of their data to compare the mass attenuation coefficient of the elements Iron (Fe-26) as low atomic number, silver (Ag-47), tin (Sn-50), platinum (Pt-78), gold (Au-79) and lead (Pb-82) as high atomic number, at the same energy value of X-ray 30 KeV. From table 3 of the X-Ray Mass Attenuation Coefficients[1], we get the following data.

3. Data

Table 1. Mass attenuation coefficients for metals with different atomic number

Elements	**Z**	**X-ray Energy (KeV)**	**μ (cm2/g)**
Fe	26	30	8.176
Ag	47	30	36.68
Sn	50	30	41.21
Pt	78	30	26.41
Au	79	30	27.52
Pb	82	30	30.32

4. Discussion

The six elements shown in the above table are chosen to compare the mass attenuation coefficient as a function of the atomic number contained in the medium and high range of atomic number. The attenuation coefficient is directly proportional to the atomic and electronic cross section [11-13], and the atomic cross-section is proportional to the atomic number[9], so there can be said that the attenuation coefficient is proportional to the atomic number of the elements (materials). But if looking at the results shown in table 1, one can see that this was true if compared between Fe, Ag, and Sn, and it was false between Sn and the three other elements Pt, Au, and Pb. The attenuation coefficient for Sn is more significant than that for Fe and Ag, while the atomic number of Sn is greater than the atomic number for Fe and Ag. Still, for Pt, Au, and Pb which have a more significant atomic number than Sn, the attenuation coefficient is less than for Sn. If the comparison will be taken only between the higher atomic number elements Pt, Au and Pb, then one can say that the mass attenuation coefficient is proportional to the atomic number of the element, but this comparision will not be true if taken between these three elements (Pt, Au, and Pb) and Ag, and Sn.

5. Conclusion

X-ray transmission in metals depends on the atomic number of the elements (metals), and the mass attenuation coefficient for six different metals (Fe-26, Ag-47, Sn-50, Pt-78, Au-79, and Pb-82) was compared. The attenuation coefficient is proportional to the atomic number; the data agreed with the first three elements and the second three elements separately, but disagreed if the comparison takes place between Ag and the Pt, Au, and Pb or between these three metals and Sn. For example, the atomic number of Pb is larger than the atomic number of Sn, the attenuation coefficient for Pb is lesser than that for Sn. This comparison will have to take attention to it and is needed to describe the cause of these differences.

Declaration of Competing Interest, The authors declare no conflict of interest.

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