Screening Of Ayurvedic Nano-Medicine (Kasisa Bhasma) by NaI(Tl) X-Ray Detector

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Abstract. Mass Attenuation Coefficient of X-rays have been determined for the ayurvedic Nano-medicine (Kasisa bhasma) of three brands in the X-ray energy range from 17.781 to 44.216 keV by employing good beam transmission geometry using the NaI(Tl) scintillation X-ray detector. The variation in X-ray mass attenuation coefficient (decreasing) with incident photon energy (increasing) was noted. And the XRD analysis confirms the crystalline nature of the nano-medicine with particle size ranging from 38.31 nm (for DKB) and 49.86 nm (for VKB) to 52.75 nm (PKB). Also we observed that, as the sample particle size is increased there is increase in value of mass attenuation coefficient of X-ray, this clearly reflects the mass attenuation coefficient values strongly depends on size of particles of the sample.

Keywords : Nano medicine (Kasisa bhasma), NaI(TI) Detector, X-ray Mass Attenuation Coefficient, XRD

INTRODUCTION

This In present days radiations have became inseparable part of living environment, apart from natural sources of radiation, we have manmade sources like, X-ray machine, NMR, MRI, nuclear reactors, radioisotopes etc., radiations are effectively utilized in various fields such as, Nuclear medicines, industry, defense field etc., as there is increasing use of radiations, it becomes an important and major area of interest to study the interaction of radiations (X-ray or Gamma ray) with matter with material as biological, chemical, and industrial and in common field. For scientific study of interaction of radiation with matter, it needs the thorough characterization and assessment of penetration, scattering and diffusion of X-rays/ Gamma rays with medium. For this there are some parameters in Physics, of which one is the 'mass attenuation coefficient' symbolically denoted as (μ/ρ) has a dimension of area per unit mass i.e cm2/g. Number of literatures reported the experimental as well as theoretical studies regarding mass attenuation coefficient of X-ray or gamma rays from 1 keV to several 100 MeV energy. In addition mass attenuation coefficient value, estimation of absorption and scattering properties of different materials is important for accurate X-ray fluorescent analysis, radiological parameters etc., because it allows choosing a reference sample with attenuation properties identical to those of sample to analyzes [1]. Information of mass attenuation coefficient of samples extends the possibilities of X-ray fluorescence analysis and also seems necessity for obtaining important and useful data. There have been a large number of experimental and theoretical investigations to determine mass attenuation coefficients for complex biological molecules such as carbohydrates, proteins, fats, and oils composed of H, C, N and O elements in varying proportions. In addition mass attenuation coefficient values are used in detailed calculation of photon interaction in different materials such as natural minerals [2], amino acids [3-5], alloys [6] and other materials such as for instance author [7] measured X-ray mass attenuation coefficient at low photon energies (6.400, 8.907, 13.339, keV), in order to calculate the effective atomic number and electron density of dosimetric materials. In one report [8] author used measured coefficients of mass attenuation of X-rays of different energies for calculations of the atomic and electron cross sections and effective atomic and electron numbers in Ti, Ni and their alloys. In literature [9] presented experimental mass attenuation coefficient of saccharides for X-ray range of 8-32 keV, and verified the experimental values with the standard database by WinXcom program. The mass attenuation

coefficient for the medicinal plants have been measured [10,11]. Authors have analyzed the quality of the pharmaceutical drugs by using mass attenuation coefficient values [12]. In the present work for the first time mass attenuation coefficient of nano-medicines were measured available as Ayurvedic drugs known as 'Bhasmas'. Bhasmas are herbo-mineral formulations and very potent drugs in Ayurveda. The variation of mass attenuation coefficient values with the particle sizes is studied by taking the commercial sample of Kasisa bhasma from three different manufacturers (Dhootapapeshwar, Vyas Pharmaceutics, and Patanjali)

Mass Attenuation Coefficient

It is well known that the exponential law determines the narrow beam X-ray mass attenuation coefficient and is expressed as

$$I/Io = \exp [-(\mu/\rho)*(x)] \quad [1]$$

Where I_o and I are the incident intensity of photons without absorber and the attenuated intensity of photons in sample respectively, x is the mass thickness of the sample is obtained by multiplying thickness t by the density ρ i.e., $x=\rho t$ g/cm^2. μ/ρ (in cm^2/g) is the mass attenuation coefficient which is a density independent quantity. The equation (1) can be rewritten as

$$\mu/\rho = x\text{-}1 \ln(I/Io) \quad [2]$$

X-ray Diffraction Study

Powder X-ray Diffraction (XRD) analysis was carried out using Rigaku Ultima-IV X-ray diffractometer with CuK_α radiation (λ=1.54 A°) operating at 30 kV and 20 mA. Diffraction pattern was recorded for the angle two theta (2θ) ranging from 10-80 degree at scanning rate of 4 degree per second. And the particle/crystallite size (d) of the samples were calculated by using Debye Scherer's equation

$$d = (0.9 * \lambda)/(\beta\cos\theta) \quad [3]$$

λ = 1.54 Angstrom unit wavelength of X-ray (CuKα radiation)
β = Full width at half maximum intensity of the peak (Radian)
θ = 2θ/2 (scattering angle in degree).

Experiment

The good beam-geometry experimental arrangement and the procedure adopted for the determination of the mass attenuation coefficient is similar to the one described by us earlier [14] here the Figure 1(a) describes the same Briefly again, photons from a variable energy X-ray source (S) passed through a collimator (C1) and were incident on the specimen (A) in the form of a thin foil/pellet kept normal to the photon beam. The transmitted beam passed through another collimator (C2) and reached a NaI(Tl) X-ray detector (D). The transmitted photon spectrum was recorded using a PC based multichannel analyzer.

The variable energy X-ray source (S) consisted of 10 mCi (370 MBq) ^{241}Am as the primary source of radiation and four different targets (Mo, Ag, Ba and Tb). The 59.65 keV photons from ^{241}Am, was incident on selected targets (Mo, Ag, Ba and Tb) to produce fluorescence X-rays of characteristic energies of target (17.781, 22.581, 32.890 and 44.216 keV respectively). Both incident beam and transmitted beam were collimated to 6 mm dia by 4.0 cm thick lead discs (C1 and C2). The thickness of the collimator was sufficient to reduce the intensity of scattered photons up to 300 keV to a negligible value.

The nano-medicines/samples are bought from different medicine shops/Pharmacies and they are finely grinded with the help of pestle and mortar. The samples of different thickness were prepared by weighed quantity of the finely ground powder was pressed in to 10 mm dia and cylindrical pellet with hydraulic press. The aerial thicknesses of the pellets were calculated using an electronic weighing balance and a traveling microscope. High-purity (99.99 %) metal foils of Mg were used as standard.

A Bicorn make integrated assembly of 25mm dia x 4 mm thick NaI(Tl) scintillator mounted on a photo multiplier tube (PMT) (E) served as X-ray detector. Oxford model PCAP plus single PCI card performed as PMT power supply, pre-amplifier, amplifier, 1k ADC and MCA with control from software package OXWIN MCA.

As established earlier, for a given photon energy, accurate values of attenuation can be obtained by choosing the range of target thickness over 50-2% transmission [13]. The transmitted intensity was obtained by taking the area under the photo peak in the transmitted spectrum. The slope of the linear plot of the logarithm of transmitted intensity versus specimen thickness would yield the attenuation coefficient. Since the detector has a poor energy resolution, the energy corresponding to the measured attenuation coefficient is the weighted average of K_α K_β K_γ energies. The attenuation coefficient at different energies was first determined for standard metal foils and then for the bhasmas. The Intensity of the X-ray was noted without absorber and with absorber for getting the mass attenuation coefficient (μ/ρ) of X-rays by the selected nano-medicine sample. XRD analysis was carried out to estimate the average crystallite size of Kasisa bhasmas.

RESULT AND DISCUSSION

The Table 1 presents the results of mass attenuation coefficient of X-rays for Kasisa bhasma, DKB means Dhootapapeshwar company/brand Kasisa bhasma, VKB- Vyas company/brand Kasisa bhasma, PKB- Patanjali company/brand Kasisa bhasma. And last column in table 1 indicates the average particle size of Kasisa bhasma. From Table 1 and Figure 2(a) we can clearly see that, the mass attenuation coefficient of X-rays is decreasing with increasing energy, and also it seems that there is variation in value of mass attenuation coefficient of X-rays, from one company to other company Kasisa bhasma (nano-medicine), the reason for this variation is as in fig 2(b), is due to changes in particle size of Kasisa bhasma of individual manufacturer this may be attribute to preparation process of individual manufacturer. The XRD patterns of Patanjali brand Kasisa bhasmas is shown in Fig 1 (b) and the nature of the plot represents the crystalline nature of sample, similar peaks were obtained in other two brand also. The two parameter i.e., mass attenuation coefficient, and particle size of the Kasisa bhasma tells the change in quality as well as purity of Kasisa bhasma. And the bhasma selected in the present work from three brands were not found to be same, as per our results.

TABLE 1. X-ray Mass Attenuation Coefficient of nano-medicne Kasisa Bhasma in cm2/g at different energy

Sample Code	Experimental Mass Attenuation Coefficient of X-rays in (μ/ρ) cm^2/g				Crystallite/particle Size in nm
	17.581 keV	**22.581 keV**	**32.890 keV**	**44.216 keV**	
DKB	15.9 ± 0.108	7.9 ± 0.155	2.9 ± 0.1577	1.23 ± 0.009	38.31
VKB	16.45 ±0.247	8.8 ± 0.104	3.59 ± 0.042	1.36 ± 0.008	49.86
PKB	18.44 ±0.516	9.93 ± 0.21	4.01 ± 0.195	1.6 ± 0.047	52.75

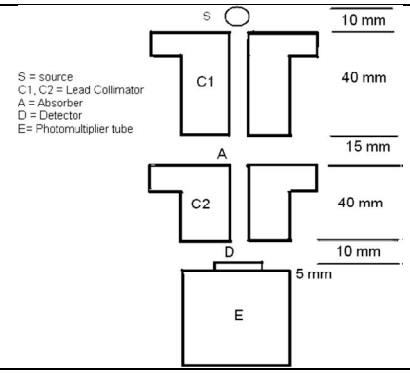

FIGURE 1 a). NaI(Tl) X-ray detector schematic diagram

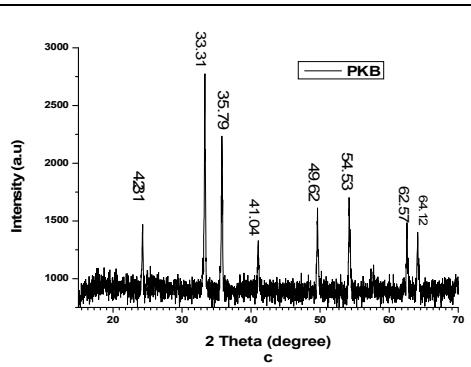

FIGURE 1 b). X-ray Diffractometer Peaks of Kasisa Bhasma(PKB) sample.

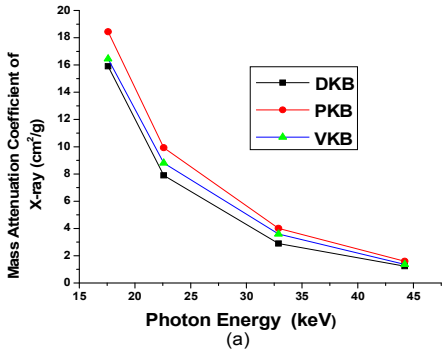

Figure 2 a). Graph showing Variation of Mass Attenuation Coefficient versus X-ray Photon energy.

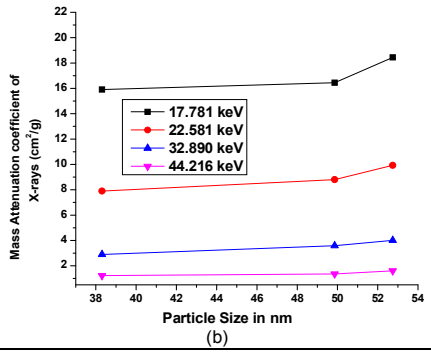

Figure 2 b). Variation of Mass Attenuation Coefficient versus particle size of Kasis Bhasma.

CONCLUSION

From the results of present work X-ray mass attenuation coefficient depends on average size of the particles present in the sample analyzed. And the Nano-medicine or Kasisa bhasma prepared by three manufacturers are different in quality. Thus the non destructive technique like Mass attenuation coefficient and X-ray Diffractometer analysis are very helpful in quality assessment of samples. The data may helpful in further standardization of bhasmas in medicine system and helps to practitioners in prescribing the medicines to the patients based on the size of particles of bhasma. It is worthy to emphasize here that by using the adopted method one can accurately measure μ/ρ for any material even with a low resolution X-ray detector.

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