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Short Communication

Determination of effective atomic number and electron density of chitin by gamma-ray attenuation

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The effective atomic numbers (Z_{eff}) and effective electron density (N_e) of chitin have been calculated using the mass attenuation coefficients (μ/ρ) obtained via XCOM (COMpilation of X-ray Cross Sections) in the photon energy range between 1 keV and 1 GeV. The results were compared with the measured values at the photon energy of 662, 1173 and 1332 keV. Both measured and calculated results were in good agreement.

Key words: Effective atomic number, chitin, effective electron number, COMpilation of X-ray Cross Sections (XCOM).

INTRODUCTION

The chitin is very light, thin and elastic materials. It can easily be used by insect and nowadays it is used in various fields, such as cosmetics, medical materials for human health, and food additives. This structure protects insect from the inconvenient climate condition. The photon interaction with the matter depends on the incoming photon energy (Woods, 1982) and the atomic number Z of the shielding material (Akkurt et al., 2005). This interaction can be represented by some quantity such as mass attenuation coefficients (μ/ρ), effective atomic number (Z_{eff}) and effective electron density (Ne). The mass attenuation coefficient is a measure of the average number of interactions between incident photons and matter, that occur in a given mass-per-unit area thickness of the substance encountered (Woods, 1982). In composite materials, a single number can not represent the atomic number as in the case of an element. This number is defined as the “effective atomic number” and it is a convenient parameter for evaluation of photon interaction with a medium (Hine, 1952). The other important quantity- called “the effective electron number or electron density”- is defined as the electrons per unit mass of the absorber (Shivalinge et al., 2005).

Several works have been carried out on the mass attenuation coefficients (μ/ρ), effective atomic number (Z_{eff}) and effective electron density (Ne) for different types of materials (Akkurt et al., 2004; Akkurt et al., 2005; Icelli et al., 2005; Guru, 1998; El-Kateb et al., 2000; Murty et al., 2000). On the other hand, some works have also been performed on different properties of chitin. Byung-Moo et al. (2004) have investigated electrospinning conditions of chitin. The chemical and structural changes according to the deacetylation were systematically investigated in same work. Akkurt et al. (2007) have investigated radiation shielding properties of the chitin.

In this work, the mass attenuation coefficients (μ/ρ), effective atomic number (Z_{eff}) and effective electron density (Ne) were calculated. The calculated results were compared with the experimental measurement.

MATERIALS AND METHODS

Mass attenuation coefficients

The mass attenuation coefficients (μ/ρ)) were calculated using the computer code “XCOM” (Berger et al., 1987) at photon energies in the range between 1 keV and 1 GeV. The XCOM input data was prepared by combining previously existing data bases for interaction cross sections, the chemical composition, and the density of chitin (ρ). Mass attenuation coefficients (μ/ρ)) were obtained by dividing the measured linear attenuation coeffeceint on density. The linear attenuation coefficients (μ)) , was determined by measuring the transmission of γ-rays through a target of known thickness of chitin. The measurement had been performed using a gamma ray spectrometer of 3”×3” NaI(Tl) detector with the Multi Channel Analyser (MCA) (Akkurt et al., 2010; Akkurt, 2007). The spectrometer communicates with the PC by Genie200 software. ^{137}Cs and ^{60}Co sources were used which emit energies of 662, 1173 and 1332 keV respectively. Gamma ray spectrum is shown in Figure 1 where two sharp peak related to 1773 and 1332 keV gamma rays can be clearly seen. From the transmitted (N) and the incident photon (N_o) for a thickness (*x*) of the absorber, the linear

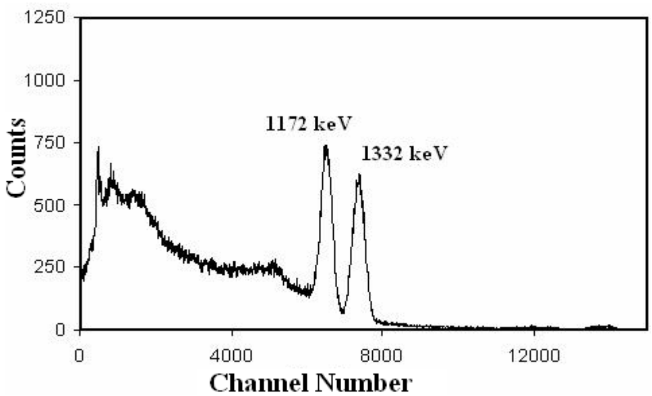

Figure 1. Gamma ray spectrum obtained from ^{60}Co source.

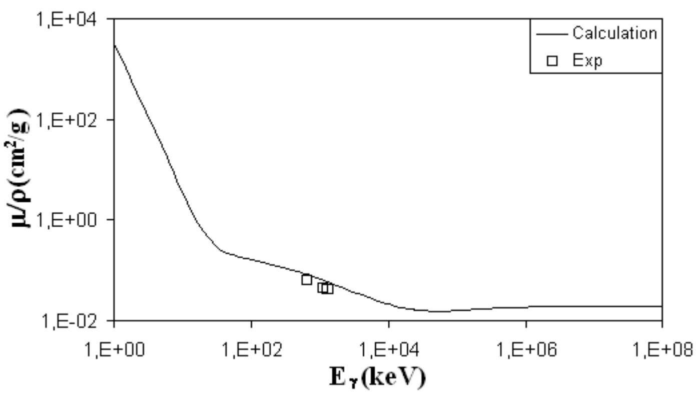

Figure 2. Mass attenuation coefficients of chitin as a function of photon energies (Akkurt et al., 2007).

attenuation coefficients (μ) can be given by the following expression:

$$\mu = \frac{1}{x} In \frac{N_0}{N} \qquad (1)$$

Effective atomic number

The effective atomic number (Z_{eff}) of a material consisting of different elements can be obtained by the relation (Guru et al., 1998):

$$Z_{eff} = \frac{\sigma_a}{\sigma_{el}} \qquad (2)$$

where σ_a and σ_{el} represent total atomic cross section and total electric cross section, respectively. The total atomic cross section (σ_a) can be obtained via the total mass attenuation coefficients (Guru et al., 1998)

$$\sigma_a = \frac{1}{N} \frac{(\mu/\rho)_{chitin}}{\sum_i \frac{w_i}{A_i}} \qquad (3)$$

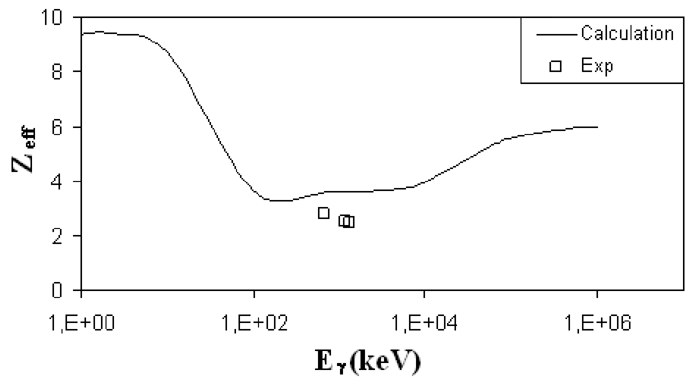

Figure 3. Effective atomic number as a function of photon energy.

where μ/ρ is total mass attenuation coefficients, N is the Avogadro's number, A_i and w_i are atomic weights (in gram) and fractional weights of the constituent of chitin, respectively. The total electric cross section σ_{el} can be obtained by the formula of

$$\sigma_{el} = \frac{1}{N} \sum_i \frac{f_i A_i}{Z_i} \left(\frac{\mu}{\rho}\right)_i \qquad (4)$$

where f_i is ratio of the number of atoms of element i to the total number of atoms of all elements in the composite material, Z_i is the atomic number of the i^{th} elements in a molecule, and $(\mu/\rho)_i$ is the total mass attenuation coefficients of the i^{th} element in molecule.

Effective electron density

The effective electron density (Ne) has been calculated using the following expression

$$N_e = \frac{(\mu/\rho)_{chitin}}{\sigma_{el}} \qquad (5)$$

where μ/ρ total mass attenuation coefficients of alloy and σ_{el} is the electronic cross section.

RESULTS

The mass attenuation coefficients have been calculated at the photon energies between 1 keV and 100 GeV. Both calculated and measured results are displayed in Figure 2 mass attenuation coefficients decrease with the increase in photon energies. This is because the interaction mechanism of photons with the matter is different for different photon energy (Akkurt et al., 2004). Using the mass attenuation coefficient (Akkurt et al., 2007), the effective atomic numbers (Z_{eff}) for chitin at photon energies in the range between 1 keV to 1 GeV have been calculated and the results have been displayed in Figure 3 as a function of photon energies. The calculated and the measured mass attenuation co-

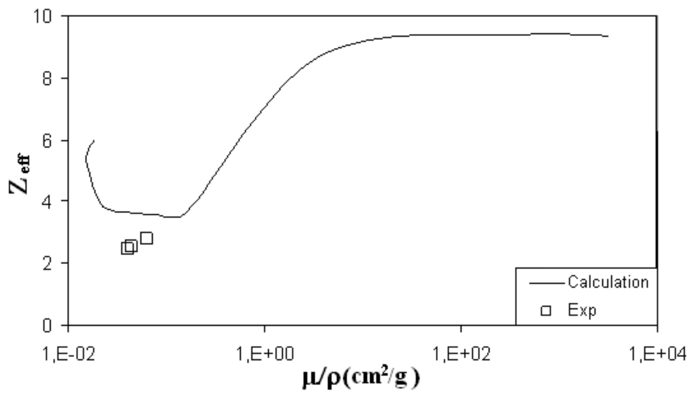

Figure 4. Effective atomic number as a function of the mass attenuation coefficients.

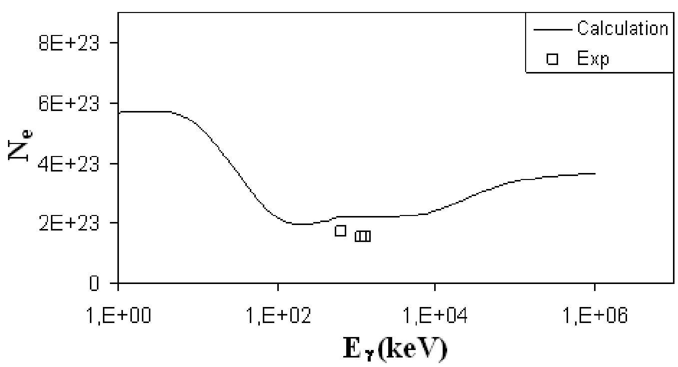

Figure 5. Effective electron number as a function of photon energy.

efficients versus effective atomic number of chitin have been displayed in Figure 4.

The calculated and measured effective electron density as a function of photon energy is shown in Figure 5.

It can be noticed in Figures 2 to 5 that experimental and calculated results are in a good agreement.

DISCUSSION

It can be concluded from both calculated and measured results that the mass attenuation coefficients, the effective atomic and electron density depend on incoming photon energies and compounds of the materials.

REFERENCES

Akkurt I, Akyıldırım H, Mavi B, Kilincarslan S, Basyigit C (2010). Radiation shielding Measurement of the concrete containing zeolite. Rad. Meas., 45: 827-830.

Akkurt I (2007). Effective Atomic Numbers for Fe-Mn alloy Using Transmission Experiment. Chin. Phys. Lett., 24-10: 2812.

Akkurt I, Basyiğit C, Kilincarslan S (2004). The photon attenuation coefficients of barite,marble and limra. Ann. Nucl. Energy, 31: 577.

Akkurt I, Basyiğit C, Kilincarslan S, Mavi B (2005). The Shielding of γ-rays by Concretes Produced with Barite. Prog. Nucl. Energy, 46: 1-11.

Akkurt I, Mavi B, Celebi C, Akyıldırım H (2007). Kitin: böceklerı radyasyondan koruyan zırh. Turkish Physical Society 24th Physics conference.

Akkurt I, Mavi B, Akkurt A, Basyigit C, Kilincarslan S, Yalim HA (2005). Study on *Z* dependence of partial and total mass attenuation coefficients. J. Quantitative Spect. Rad. Trans., 94(3-4): 379-385.

Byung-Moo M, Sung Won L, Jung Nam L, Young Y, Taek Seung L, Pil Hyun K, Won Ho P (2004). Chitin and chitosan nanofibers: electrospinning of chitin and deacetylation of chitin nanofibers. Polymer, 45: 7137–7142.

El-Kateb AH, Rizk RAM, Abdul-Kader AM (2000). Determination of atomic cross-sections and effective atomic numbers for some alloys. Ann. Nucl. Energy, 27: 1333-1343.

Guru Prasad S, Parthasaradhi K, Bloomer WD (1998). Effective atomic numbers for photo absorption in alloys in the energy region of absorption edges. Rad. Phys. Chem., 53:449-453.

Hine GJ (1952). Use wildcard to add more than one file at a time. Phys. Rev., 85: 752.

Icelli O, Erzeneoglu S, Karahan IH, Cankaya G (2005). Effective atomic numbers for CoCuNi alloys using transmission experiments. J. Quantitative Spect. Rad. Trans., 91: 485-491.

Murty VRK, Winkoun DP, Devan KRS, (2000). Effective atomic numbers for W/Cu alloy using transmission experiments. Appl. Rad. Isotops, 53: 945-948.

Shivalinge G, Krishnaveni S, and Ramakrishna G (2005). Studies on effective atomic numbers and electron densities in amino acids and sugars in the energy range 30–1333 keV. Nucl. Inst. Met. in Phys. Res. B: 239- 4:361-369.

Woods J (1982). Computational Methods in Reactor Shielding, Pergamon Press., New York.