Isomeric and ground state energy level measurements of natural tellurium isotopes via (γ,n) reaction

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Isomeric and ground state energy level measurements of natural tellurium isotopes via (γ,n) reaction

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Abstract. We have planned to measure isomeric and ground state energy levels in ^{120}Te(γ,n)^{119m,g}Te, ^{122}Te(γ,n)^{121m,g}Te, ^{128}Te(γ,n)^{127m,g}Te, ^{130}Te(γ,n)^{129m,g}Te photonuclear reactions of natural tellurium induced by bremsstrahlung photons with end-point energy at 18 MeV. The sample was irradiated in the clinical linear electron accelerator (Philips SLi-25) at Akdeniz University Hospital. The gamma spectrum of the tellurium sample was measured using HP(Ge) semiconductor detector (ORTEC) and multi channel analyzer. We used both MAESTRO (ORTEC) and home made root based gui program (Theia) for data analyzing. The obtained experimental data values are compared with NUDAT energy values.

Keywords: isomeric state, ground state, energy level

1. Introduction

There are many nuclear reactions that populate both the ground state and the metastable(isomeric) state of daughter nucleus. Isomeric activities can be induced in many stable nuclides that occur in the region of closed nuclear shells, by gamma activation [1-4]. Gamma activation excites the target nucleus from the ground state to one of its activation energy levels above the metastable isomeric state [5].

The investigation of the properties of excited states in a nuclear reaction such as the energy and spin distributions, the probability of excitation, and different decay modes allow one to acquire important information about interaction mechanism. It is particularly efficient when the excited states last for a adequately long period of time as the isomeric and ground state. It is well known that in the same experimental conditions the isomeric and ground states are formed simultaneously during nuclear reaction process. For this reason, isomeric ratio studies have gained importance from past to the present [1-8]. Today, the isomeric ratios can be determined with high accuracy benefiting from

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developed experimental measurement equipments and theoretical models. But in the isomeric ratio studies, the determination of ground state and isomeric state energy levels will improve the accuracy of this studies.

The aim of this work, is to determine the isomeric and ground state energy levels of natural tellurium induced by bremsstrahlung photons with end-point energy at 18 MeV. The nuclear reactions considered in this investigation are ^{120}Te(γ,n)^{119m,g}Te, ^{122}Te(γ,n)^{121m,g}Te, ^{128}Te(γ,n)^{127m,g}Te, ^{130}Te(γ,n)^{129m,g}Te photonuclear reactions.

2. Experimental Technique

In our experiment, we used the photo activation technique. Research was performed with the use of bremmstrahlung beam obtained from a clinical linear electron accelerator (cLinac), Philips SLi-25, at the Akdeniz University Hospital.

The cLINAC which is used as the source of bremsthralung photons for phohonucelar reactions is a standard and up-to-date Elekta TM Synergy TM accelerator, SLi-25 [9]. The accelerator's primary electron beam is generated by a gun with an energy of 50 keV. After that the electrons are accelerated in a copper cavity by a 3 GHz (2856MHz to be exact) radio-frequency with peak power of about 5 MW [10]. For an electron energy of about 10 MeV, the typical average electron current is about 300 μA. Figure 1 shows the schematic view of cLinac.

In this experiment, we used 0.7 g of natural tellurium, which is obtained from Sigma-Aldrich Laboratory, with purity of 99.99% in small ore pieces. The sample was irradiated for 50 minutes at 18 MeV end-point energy.

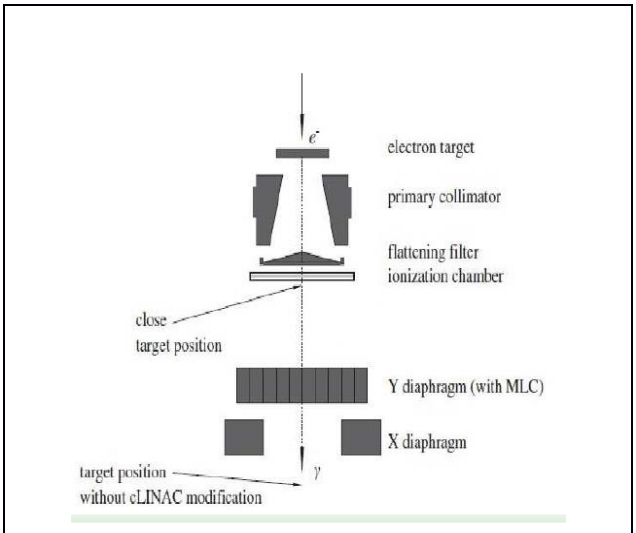

Figure 1. Schematic view of the photon beam production at the cLinac

The sample was placed coaxially at 6 cm distance from the High-Purity Germanium (HPGe) detector. Multi spectrum scaling technique is used to collect gamma-ray spectrum with 5 min cooling time and sampling times were adjusted to 3s, 30s, 180s and 900s to sum up to 20 h counting time. Except for the last time interval 200 cumulative spectrums were recorded to be able to correct spectrums due to different half-lives. The detector used was a p-type, coaxial, electrically cooled, HPGe gamma-ray spectrometer AMATEK- ORTEC (GEM40P4-83) 40% relative efficiency. It is connected to a NIM

consisting of ORTEC bias supply, 672 spectroscopy amplifier, 927 multi-channel analyzer and a computer. For detector energy calibration, a mixed calibration source supplied by the Çekmece nuclear Research and Training Center emitting gamma rays in the energy range between 47 and 1836 keV was used.

2.1. Gamma-Ray Spectra Calculations

Throughout the data acquisition period Maestro software was used to acquire and analyse the data for consistency. After data acquisition, a home made ROOT (Root 5.26.00) [11] based graphical user interface program named as "Theia" is used to analyse photo peaks and for calculation of the peak parameters (figure 2 and figure 3) Theia designed to enable methodological access to some desired futures of ROOT in a simpler manner while providing Compton background correction for all photo peaks which are assumed to be in Gaussian form.

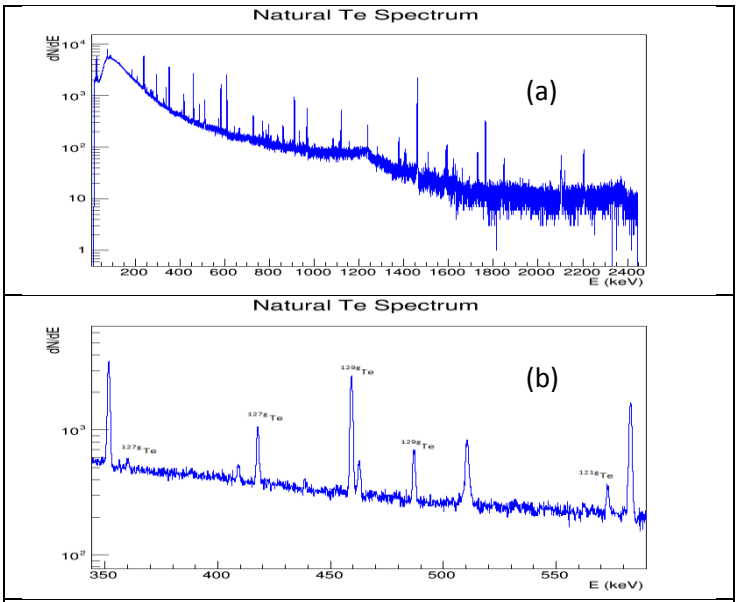

Figure 2. Full energy range spectrum of natural Tellurium (γ,n) reaction (a) and the photopeaks of the analyzed region (b)

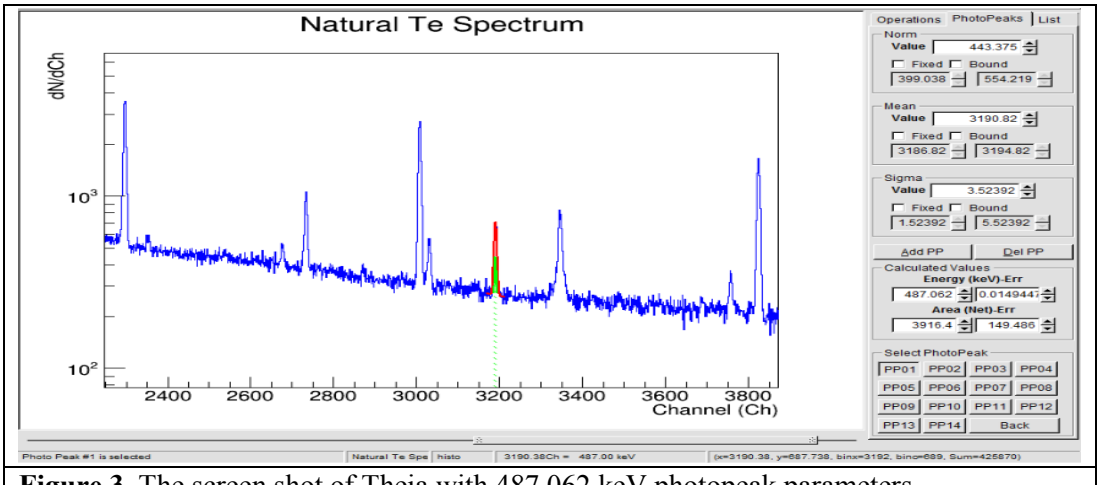

Figure 3. The screen shot of Theia with 487.062 keV photopeak parameters

3. Conclusion

The obtained experimental data values are compared with NUDAT energy values (table 2). As seen, gamma energy values which was determined by analysis programs Theia and Maestro. Calculated values by both software are very close to NUDAT energy values. All of the planned isotopes could not be determined because only the results of 20 h count could be reached. Our study continues to determine gamma energy levels and half-life of the long half-life isotopes.

Table 2. Analysis result of irradiated natural tellurium spectrum

Reaction Product	Spin	Half Life	Reac.Threshold (MeV)	Gamma Energy (keV) (Err)	Gamma İnt(%)(Err)	Theia Energy (keV)(Err)	Energy Maestro (keV)(Err)
^{121g}Te	$1^{+}/2$	16.8 d	17.29	573.139(0.011)	80.4(0.22)	572.89 (0.04)	572.95 (0.15)
^{129g}Te	3+/2	69.5 min	8.39	459.60(0.05)	7.70(0.06)	459.272 (0.159)	459.33 (0.15)
				487.39(0.05)	1.42(0.10)	487.062 (0.015)	487.24 (0.15)
^{127g}Te	3+/2	9.35 h	8.75	360.30(0.1)	0.135(0.14)	360.054 (0.072)	360.19 (0.15)
				417.90(0.1)	0.99(0.14)	417.712 (0.012)	417.58 (0.15)

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