CO11-1 **Coherent Terahertz Spectroscopy of Bile Acids by L-Band LINAC**

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INTRODUCTION: THz time domain spectroscopy (THz-TDS) using THz pulses generated by femto-second laser is the mainly used method in THz spectroscopy. Moreover, coherent THz wave [1,2] recently attracts the attentions by the development of free electron laser. Although coherent THz wave is also the useful, the study about an application of coherent THz wave hardly develops. In this study, we examined the characteristics and usefulness of coherent THz wave, and applied it to the analysis of natural materials, bile acids.

EXPERIMENTS: Coherent THz wave was obtained from the transition radiation generated by L-band linear accelerator in Kyoto University Research Reactor Institute. The absorption spectra were measured as time-domain signal by the composite type liquid-helium-cooled silicon bolometers after through Martin-Puplett type interferometer and sample. By Fourier transforming the time-domain signal, the amplitude spectra were obtained.

RESULTS: Bile acids are one group of the important natural compounds, relating to processing of dietary fat. THz spectra of some kinds of bile acids were measured by using coherent THz wave. The spectra were remarkably different between sodium salt and sodium free form of cholic acid as shown in Figs. 1 and 2. Mid-infrared spectroscopy suggested that the peaks in the dashed circles are the vibration mode of C=O group. Such peak shift in sodium salt was observed in the THz spectra of deoxycholic acid. We, now, try to explain the reason of the peak shift effect of sodium in THz spectra by quantum chemical calculations.

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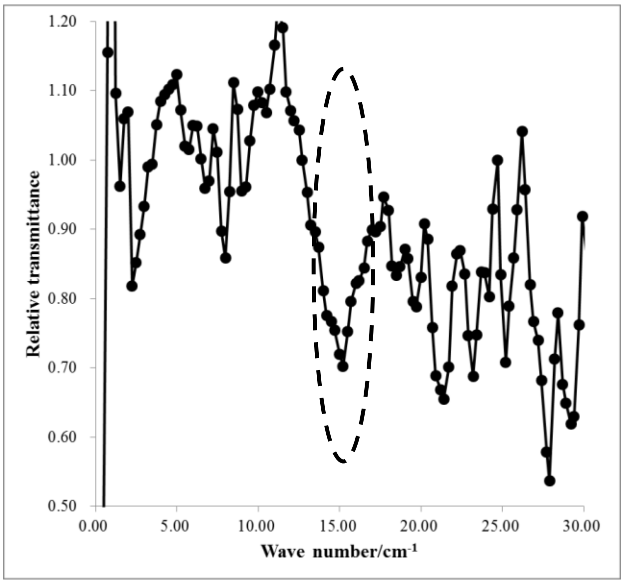

Fig. 1. THz spectrum of cholic acid (sodium free form)

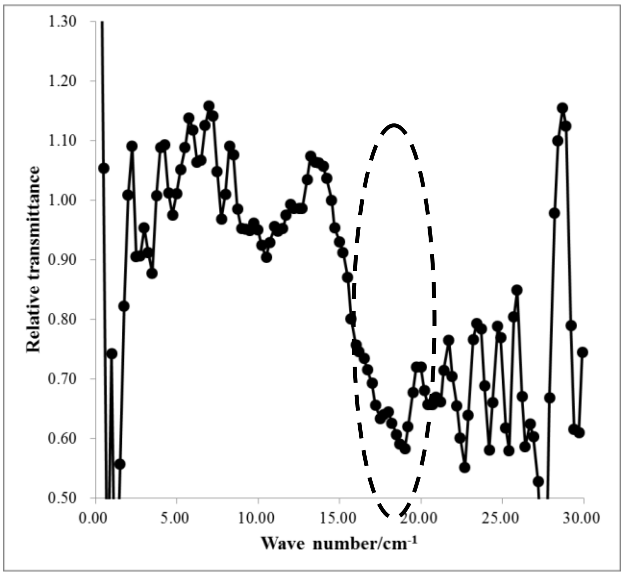

Fig. 2. THz spectrum of sodium cholate (sodium salt)

採択課題番号 23001 L-バンド LINAC を用いた胆汁酸の TH z 分光 共同通常
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CO11-2 **Evaluation and Verification of Photon Irradiation Field at KURRI-LINAC**

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INTRODUCTION: At the KURRI-LINAC, the acceleration energy of electrons can be varied from 6 to 46 MeV by regulation of microwave power [1-2]. Thus the flexibility of bremsstrahlung irradiation has increased. The spectrum of bremsstrahlung has been investigated by comparing results from Monte Carlo simulation and foil activation.

EXPERIMENTS: The foil activation was conducted with high-energy photons produced by electron irradiation of lead sheets water-cooled in an aluminum container. A gold foil was placed behind the lead sheets in the electron beam line and irradiated with changing sheet thickness ranging from 1 to 32 mm. The energy spectrum of incident photon beam into the gold foil was simulated by Electron Gamma Shower (EGS5) Monte Carlo code. Both results of gold foil activation and EGS5 can be connected with activation equation. The activation equation, if irradiation time is sufficient short, can be expressed as

$$\frac{A}{N\lambda t_i \cdot ne} = \int \sigma(E)\cdot\varphi_g(E)dE$$

where A, λ, and σ are produced activity, the decay constant and the production cross-section of Au-196, respectively, and N, t_i, ne and φ_g are the number of gold atom, irradiation time, the number of incident electron and the flux of photon per electron irradiated, respectively. The number of incident electron (ne) can be obtained by multiplying 6.24×10^{18} to average electron beam current. The value of the left and right member of the equation were obtained from results of Au foil activation and EGS5, respectively and defined here as activation rate.

RESULTS: The bremsstrahlung energy spectra simulated by EGS5 show continuous spectra and their flux is decreased with energy (Fig.1). The most effective photon production was obtained at the lead thickness of 2 mm. Fig.2 shows the cross-section of Au-197 (γ, n) Au-196 [3] averaged in each energy bin used in EGS5. Fig.3 shows activation rate from the EGS5 simulation and the gold foil activation. Both values agreed well with each other for lead thickness more than 8 mm. Further study is required to elucidate discrepancies for thinner lead sheets.

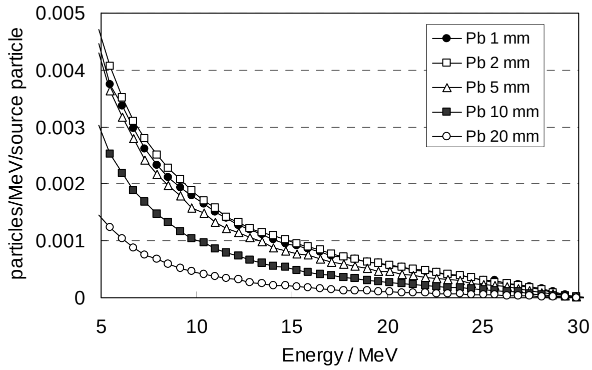

Fig.1. Bremsstrahlung spectra generated by 30 MeV electrons

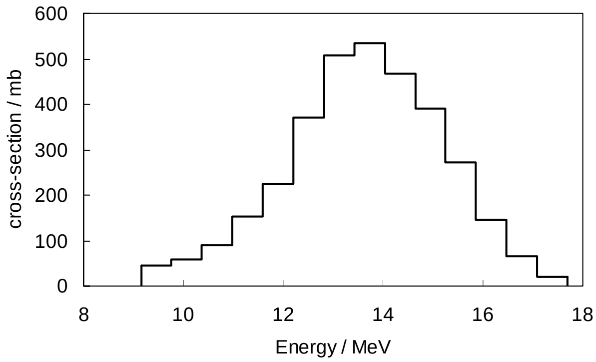

Fig.2. Average cross-section of photonuclear reaction from Au-197 to Au-196

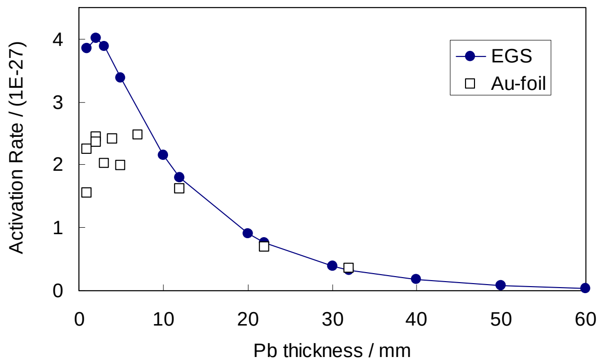

Fig.3. Comparison of activation rate evaluated from EGS5 and foil activation

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採択課題番号 23004　　　光子照射による汚染土壌の回復の検討
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CO11-3 Developments of Coherent Synchrotron Radiations for Terahertz-wave Spectrophotometry by Compton Backscattering Using KURRI-LINAC

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INTRODUCTION: We have studied terahertz-wave spectrophotometry by Compton backscattering (THz-SCB) using an L-band electron linear accelerator at the Kyoto University Research Reactor Institute (KURRI-LINAC) [1, 2]. When a coherent synchrotron radiation is used as a light source of the THz-SCB, the energy of the synchrotron radiation is much lower than that of the Compton backscattered photons. Then, we developed coherent synchrotron radiations with a pair of bending magnets comprised of permanent magnets. Yield of the Compton backscattered photon increases as a cross-section of an electron beam becomes small. We also conducted measurements of electron-beam emittances by a Q-scan method with using new quadrupole magnets, which installed in the KURRI-LINAC.

EXPERIMENTS: We used two bending magnets comprised of permanent magnets, which has a gap of 40 mm and magnetic field of 0.16 T. The length of the magnet was 55 mm. Figure 1 shows a photograph which illustrates the location of the bending magnets. The electron beam passes through the center of the bending magnets from the left side in a vacuum chamber and is released in the atmosphere. When a distance between the two bending magnets is set to be 295 mm, the electron beam with the energy of 32 MeV moves to a distance of 40 mm in parallel. There is a magnetic-filed-free space between the bending magnets. A synchrotron radiation, which was emitted on an axis of the electron-beam trajectory in the space, was transformed to an experimental room. A spectrum of the synchrotron radiation from the bending magnets was measured by a Marin-Pupplett interferometer with a high-sensitivity Si bolometer. We observed a coherent synchrotron radiation whose intensity was approximately one-thirtieth of intensity of the coherent transition radiation developed in KURRI-LINAC. A wavelength of a peak power of the coherent synchrotron radiation was approximately 3 mm, so that it shifted in the longer wavelength direction compared with that of the coherent transition radiation. A wavelength at which a spectrum of the Compton backscattered photon had a maximum was calculated to be approximately 190 nm for the electron-beam energy of 32 MeV. We should set it to be 300 nm due to sensitivity of a detector for the Compton backscattered photon. Therefore, it was noted that optimum electron-beam energy for the THz-SCB in the KURRI-LINAC was approximately 25 MeV.

Fig. 1. Photograph of two bending magnets comprised of permanent magnets.

Recently, to focus the electron beam at an Al foil target in coherent transition radiation experiments, a doublet of quadrupole magnets was installed after the accelerator tubes in the KURRI-LINAC. We measured the electron-beam emittances by a Q-scan method with using the new quadrupole magnets. An Al board was set just after a Ti window which located at the end of the linac. It inclined 45 degrees for electron beam. A transition radiation caused at the Al board was imaged at an optical fiber on a two-dimension translation stage. The transition radiation was transported by the optical fiber to the experimental room, and its intensity was measured by a photomultiplier. Normalized emittance was calculated by the electron-beam size while changing magnetic field of a quadrupole magnet. It was clarified that the normalized emittance was 4.97×10^{-4} m·rad in the horizontal direction and 3.52×10^{-4} m·rad in the vertical direction. Then, the electron-beam size at a collision point of the Compton backscattering will be less than 5 mm in THz-SCB experiments.

CONCLUSIONS: We achieved to develop a coherent synchrotron radiation using two bending magnets comprised of permanent magnets. A spectrum of the coherent synchrotron radiation was measured, and a wavelength of its peak power was approximately 3 mm at the electron-beam energy of 32 MeV. It was found that the appropriate beam energy for THz-SCB experiments was approximately 25 MeV in the KURRI-LINAC. Moreover, we measured an electron-beam emittance by a Q-scan method with using new quadrupole magnets. The electron-beam size at a collision point of the Compton backscattering will be less than 5 mm in THz-SCB experiments. We will conduct THz-SCB experiments using the developing coherent synchrotron radiation.

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採択課題番号 23069　コヒーレント放射を用いたテラヘルツ波電子線分光法の研究　　　共同通常
（産総研）清　紀弘（京大・原子炉）高橋 俊晴