Development of Cosmic X-ray Polarimeter with Capillary Plate

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Measurements of X-ray polarization provide us with a new probe for the study of the emission mechanism of γ-ray burst (GRB), the structure of black hole candidates and active galactic nuclei (AGN), and the structure of magnetic fields around pulsars and of synchrotron nebulae. The development of polarimeter with higher sensitivity than currently available is necessary for the systematic observation of polarized X-rays from stellar objects.

Since directions of K-shell photoelectrons emitted by photoabsorption depend on the electric vector of incident X-rays, the degree of X-ray polarization can be measured by detecting the emission directions of the photoelectrons. For accurate detection of the direction, it is essential to obtain image of a photoelectron track and hence the polarimeter of employing the photoabsorption effect simultaneously has the capability of X-ray imaging.

For this purpose, we have been developing an optical imaging capillary gas proportional counter, which consists of the capillary gas proportional counter (CGPC) and an optical system with an image-intensified CCD camera (I.I.CCD). The image of photoelectron track is obtained by the I.I.CCD using light signals of CGPC, and the energy and the timing of incident X-rays are measured using the charge signal from the anode of the capillary plate.

The performance of the optical imaging CGPC was investigated by using a highly polarized (>93%) X-ray beam at the BL38B1 beamline of the SPring-8. The experimental arrangement is shown in Fig.1. X-ray in the energy of 20 keV were focused on the center of the CGPC with the beam of 200 μm x 200 μm.

Fig.2 a) shows an X-ray image obtained by the optical imaging CGPC. This image was accumulated with the exposure time of 20 sec in the I.I.CCD. The X-rays corresponding to the image was estimated to 560 counts. The electric vector of incident polarized X-rays are directed to the X-axis in this figure. Fig. 2 b) and c) are projected position distributions to the X-axis and the Y-axis, respectively. The least squares fitted curves with a function of Lorenzian and constant are also shown in Fig. 2 b) and c). The FWHMs for the X-axis and Y-axis projection were 1.7 mm and 1.4 mm, respectively. The image and the difference of the width between the position distributions indicate that the image are formed by photoelectrons from 20 keV polarized X-rays.

For precise evaluation of the performance of the optical imaging CGPC as an X-ray polarimeter, we are currently investigating the structures of 20 keV X-ray photoelectron tracks for event by event.

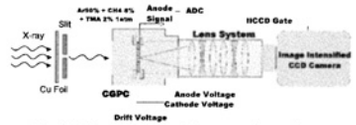

Fig.1 Schematic view of the experimental setup.

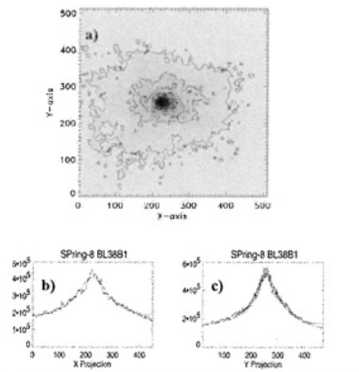

Fig.2 a) 20 keV polarized X-ray image obtained by an optical imaging CGPC . b) and c) are projected position distributions to the X-axis and Y-axis, respectively.

Crystallization and preliminary X-ray diffraction analysis of O-acetylserine sulfhydrylase from Aeropyrum pernix K1

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Indroduction

Aeropyrum pernix K1 is the hyperthermophilic archaea with an optimal growth temperature at 363 K to 368 K (Sako et al., 1996). The product of the gene (APE1586) encoding OASS from A. pernix consists of 389 amino acids with the subunit molecular mass of 42 kDa (Kawarabayashi et al., 1999). We have recently started to discover the physiological meaning of OASS with respect to L-cysteine biosynthesis in the A. pernix cells. Structural information for OASS from A. pernix may useful to understand the function of the enzyme and the mechanism of the novel thermostability of the enzyme. We report here the crystallization and preliminary X-ray diffraction analysis of recombinant OASS from A. pernix.

Experimental

For X-ray data collection, a crystal was immersed in reservoir solution containing an additional 10%(v/v) glycerol as cryoprotectant. The crystal was picked up with a loop and then flash-frozen in a stream of nitrogen gas cooled to 100 K. Diffraction data were collected at 100 K with an ADSC Quantum 4R CCD detector at the wavelength of 1.0 Å at the BL38 experimental station of the Japan Synchrotron Radiation Research Institute (Harima, Japan). The crystal-to-detector distance was set to 200 mm. The crystal was rotated 180° with an oscillation angle of 0.5° per frame. An exposure time of the crystal to an X-ray was 15 s per frame. Diffraction data were processed using MOSFLM.

Results

Result of data collection and processing revealed that the crystal belonged to space group $P4212$, $P\,41212$, $P\,42212$, or $P\,43212$. The unit-cell parameters were $a=b=74.5$, and $c=276.0$ Å. The presence of two subunits of A. pernix OASS in the asymmetric unit gives a crystal volume per protein mass (V_M) of 2.29 $Å^3Da^{-1}$ and a solvent content of 48% (v/v) (Matthews, 1968). The statistics of data collection are summarized in Table 1. A data set was collected to 2.25 Å. It consists of 244 453 measurements and of 32 116 unique reflections, An overall Rmerge was 6.2 % and an overall I/s(I) was 11.2. The data set has completeness of 85.7%. The outermost shell of data between 2.37 and 2.25 Å has completeness of 80.2%.

Table 1

Values in parentheses correspond to the outer resolution shell.

Space group	$P42_12$, $P\,4_1$
Unit-cell parameters (Å)	$a=b=74.5$,
Matthews coefficient ($Å^3Da^{-1}$)	2.29, two su
Solvent content (%)	46
Resolution range (Å)	∞-2.25 (2.3
Number of observed reflections	244453
Total number of unique reflections	32116
Average $I/\sigma(I)$	11.2 (2.9)
$Rmerge^{\dagger}$ (%)	6.2 (28.2)
Completeness (%)	85.7 (80.2)

† *Rmerge* =

References

Sako, Y., Nomura, N., Uchida, A., Ishida, Y., Morii, H., Koga, Y., Hoaki, T. & Maruyama, T. (1996). Int. J. Syst. Bacteriol. 46, 1070-1077.