X-ray Solution Scattering of Biological Supramolecules on an Undulator Radiation Source

Yoji INOKO(0003050)*1), Tetsuro FUJISAWA(0000327)2), Naoto YAGI(0001129)3), Mikio KATAOKA(0003059)4)

1)Division of Biophysical Engineering, Graduated School of Engineering Science, Osaka University, Toyonaka, Osaka 560-8531, Japan
2)The Institute of Physical and Chemical Research(RIKEN), Sayou-gun, Hyogo 679-5143, Japan
3)Japan Synchrotron Radiation Research Institute(JASRI), Sayou-gun, Hyogo 679-5198, Japan
4)Nara Institute of Science and Technology, Ikoma, Nara 630-0101, Japan

1. Introduction

X-ray scattering study of biological supramolecules in solution generally requires high quality scattering data over the range of very small to medium angles. The small-angle X-ray scattering (SAXS) station of the RIKEN beamlinel for structure biology (BL45XU) is well suited for such scattering experiments, since the station, at present, provides a very small size ($400\times600\mu m^2$) of focused undulator beam with rather high flux ($\sim3\times10^{11}$photons/s) on the sample. The present study has been carried out with intention of evaluating the current status of the RIKEN SAXS station and for its further improvements toward a SAXS facility with high spatial resolution.

2. Experiments

Apoferritin, prepared from horse spleen ferritin, was used for the purpose of this study. The scattering from 1% solutions of apoferritin was measured at two different sample-to-detector distances of 2 and 0.5m using 12.1keV X-rays(λ=1.02Å). To avoid radiation damage, the samples were made to flow in a cell having a 3mm path length at a rate of 1-2ml/min. The scattering patterns were cyclically recorded at appropriate time intervals on an X-ray image intensifier coupled with a cooled CCD camera. The data acquisition time in one cycle was 1sec in most cases. A set of two-dimensional data collected at each measurement was accumulated and circularly averaged.

3. Results and Discussion

Apoferritin is a protein composed of 24 nearly identical subunits of an average molecular weight of 19,800 and has an approximately spherical shell structure. The scattering curve of apoferritin measured at a 0.5m camera length is shown in Fig.1, together with another experimental curve taken using the SAXS equipment at bending magnet beamline 10C of the Photon Factory (PF) and theoretical one. The scattering data obtained at SPring-8 reveals an extremely smooth profile compared with that at PF. In the inset, the profile of SPring-8 is vertically expanded to clarify its fine structure at higher angles. Successive peaks up to the 8th order are observable and well coincide in position with those of the profile of a hollow sphere model. These results demonstrate that the use of an area detector combined with an undulator beam is powerful and essential for recording weak scattering from solutions. On the other hand, the depths of the minima in the profile of SPring-8 are shallower than with those of PF, suggesting a smearing of image arising from the characteristics of the area detector. In order to determine the small-angle scattering resolution, the samples were measured at a 2m camera length. The obtained data reveals that the smallest angle of the scattering region available for the Guinier approximation is $S(=2\sin\theta/\lambda)=8\times10^{-4}$Å^{-1}(~1200Å in real space). This resolution is slightly superior to those of other SAXS facilities.

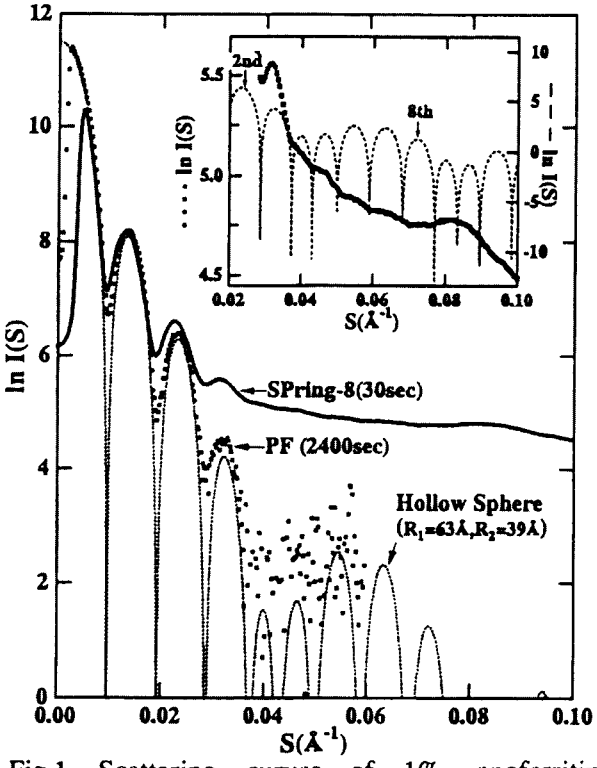

Fig.1 Scattering curves of 1% apoferritin solutions and theoretical curve of a hollow sphere. The inset shows an expansion of the profile taken at SPring-8.