T529 The Measurements of Electronic X rays Correlated with Pionic X rays

Our group has been studying a pion capture process in molecules, especially in hydrogen compounds, in the liquid and gas phases. We have already revealed that the valence electrons and chemical structure influence the pion capture and transfer processes [1-4]. When pions are captured in atoms or molecules, the pions are in high excited states at first, and then cascade to lower states by emitting pionic X rays (□X rays) or Auger electrons. In the latter case, electronic X rays (eX rays) are also emitted. In the present study, we examined the correlation between the eX rays and particular □X rays to understand the pion capture mechanism microscopically.

The measurements were performed at □□-channel of KEK-PS. In this experiment, we constructed a new measuring system consisting of three Ge detectors, which allowed us to take correlation spectra of eX and □X rays in a lower energy region and more effectively. We measured these X rays for Zn, Mo, Ag, Sn and Ta metals and Zn, Mo and Sn oxides. The typical pion beam intensity was about $1x10^4$ □- per pulse.

The eX rays observed in the spectra are classified into two types. Some are the characteristic eX rays of target (atomic number Z) atoms emitted as a result of their ionization by the pion beam, and the others are attributed to those triggered by the Auger processes in the pionic cascade. Due to strong screening effect, the eX-ray energies of pionic atoms are close to the characteristic eX rays of Z－1 atom, and they are shifted to a high-energy side. We show Z dependence of the energy shift in Fig.1. With the present apparatus and counting statistics, it is difficult to identify the pion transition state in correlating with these X rays.

Atomic and molecular states after the pion capture were also studied from the relation between eX rays and □X rays emitted in the pion capture process. In this purpose, we extracted eX ray signals correlated with □X ray from the obtained spectra and then examined the difference in the fine structure of KX rays (the ratio of K□ to K□ X rays) between Sn and Sn oxide. However, as shown in Fig.2, the number of correlated events is too small to discuss on the difference quantitatively.

We are now developing a vacuum chamber for efficient detection of extremely low-energy X rays, and improving the geometrical arrangement of the setup.

References

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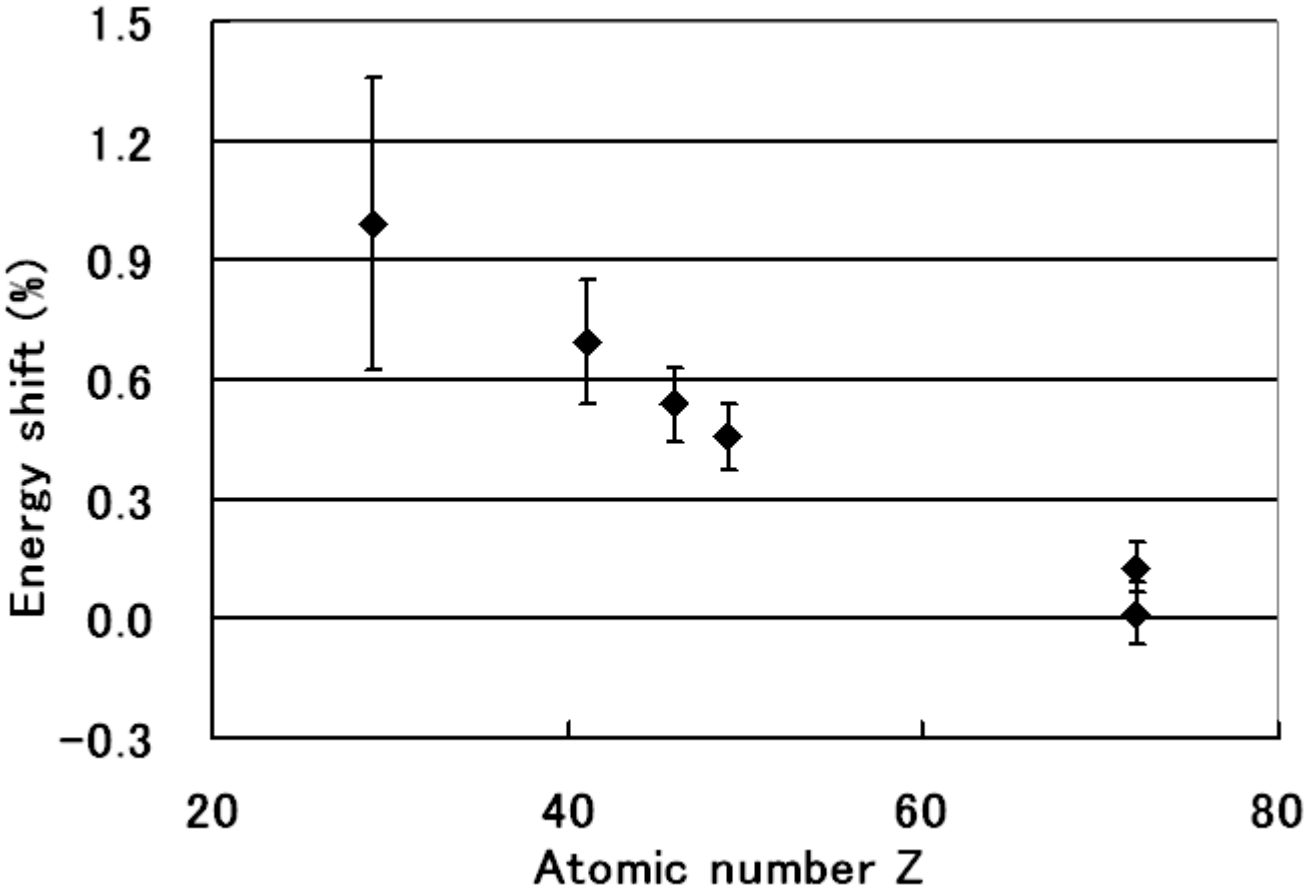
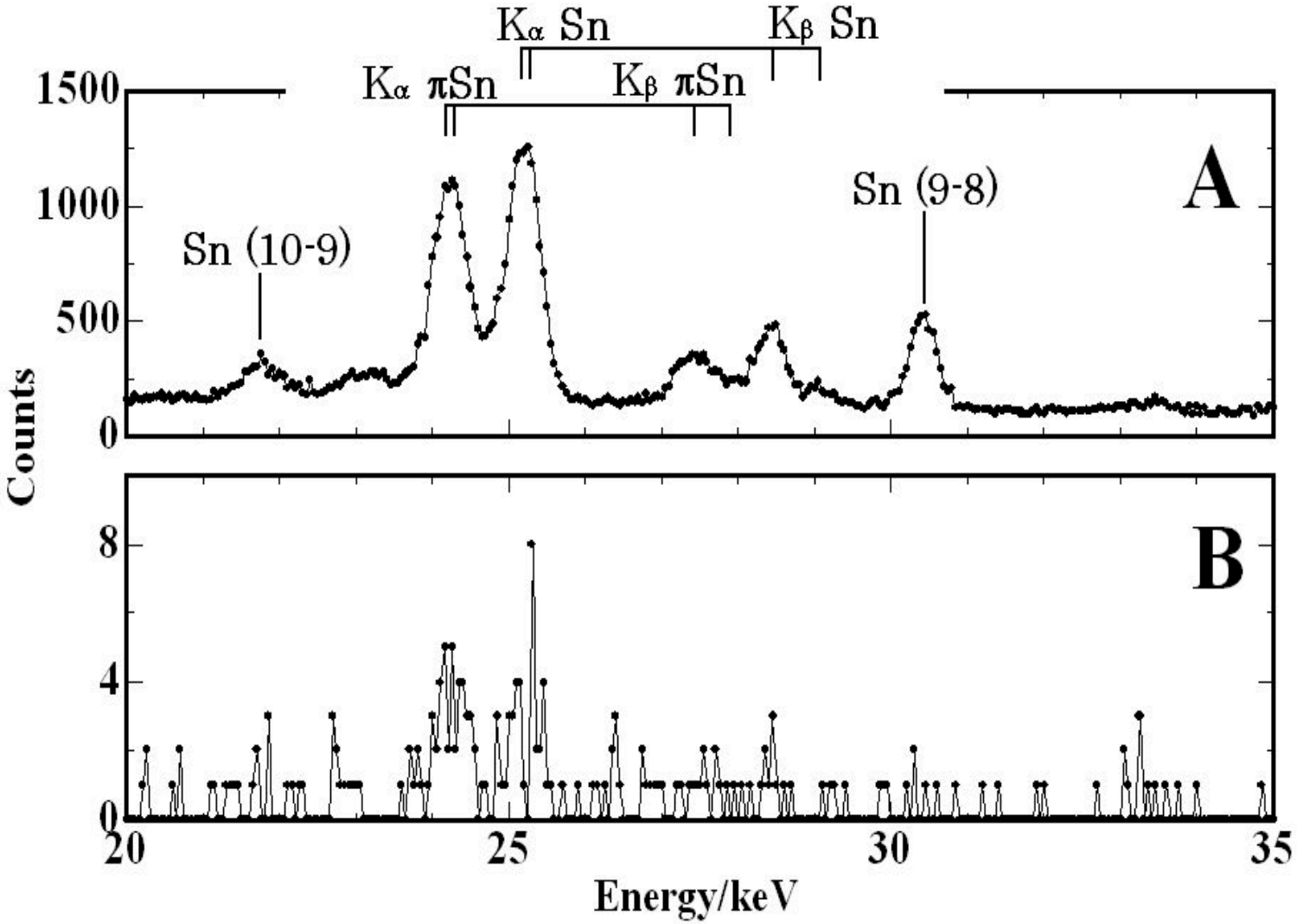
Figure Captions

Fig.1
Atomic-number dependence of the energy shift of K□ ray.
The vertical axis shows the difference in the energy of eX rays between Z－1 and Z atom divided by the eX ray energy of Z－1 atom. As the atomic number Z is larger, the ratio of energy shift becomes smaller.

Fig.2
Observed photo spectrum in the electronic X-ray region for a Sn target.
Spectrum A is a single spectrum, and spectrum B shows coincidence events with(6-5) □X ray. The numbers in parentheses indicate the main quantum-number transition of the pion deexcitation


1.5
1.2
0.9
0.6
0.3
0.0
−0.3
Energy shift (%)
20
40
60
80
Atomic number Z


Kα Sn
Kβ Sn
Kα πSn
Kβ πSn
Sn (10-9)
Sn (9-8)
A
B
Counts
1500
1000
500
0
8
4
0
20
25
30
35
Energy/keV