

Soft X-ray Photochemistry

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1. Introduction

The soft X-ray photochemistry beamline is a public beamline designed for the study of soft X-ray interaction with matter and consequent atomic and molecular processes, both in the gas phase and on solid surfaces. A detailed description of the whole system has been given in the preceding Annual Report [1] as well as in a journal.[2]. In the present report, a brief description is given of its current status (section 2), its capabilities (section 3), and the result of an off-line performance test carried out for the reflectron-type time-of-flight mass spectrometer (section 4).

2. Current Status

The construction of the beamline elements, except the monochromator and related deflecting/focusing optics, has been completed in the factory during this fiscal year and the main part of them has just been installed in the experiment hall of the SPring-8. As to the monochromator and related optics, unavoidable situation forced their installation to be delayed until the end of November, 1998. Meanwhile, an intensive discussion continued throughout this fiscal year on the preferred type of the monochromator. This finally led us to the adoption of a constant deviation angle type of monochromator with three interchangeable plane varied line space gratings (VLSGs) combined with two interchangeable spherical mirrors. Using the tangential focusing of the mirrors, this combination allows the use of it over the photon energy range of 0.15-2.0 keV. A ray-tracing calculation showed that the maximum resolution attainable with this monochromator is as high as 70,000 [with entrance and exit slit widths of 10 μ m and 2

μ m, respectively] if there are no slope errors of the gratings and mirrors, but that the resolution is critically reduced by such slope errors.

3. Capabilities of the Apparatus

Main part of the experimental station, shown in Fig. 1, consists of three chambers: a main chamber to house or attach all analyzers, a chamber for main pumping, and a chamber for differential pumping. The last chamber also serves as an optical filter chamber for order sorting (not shown in Fig. 1). A reflectron-type time-of-flight mass spectrometer (RTOF) and a cylindrical mirror electron energy analyzer (CMA) are attached to the main chamber in a direction perpendicular to the incident photon beam and opposite to each other. This arrangement allows coincidence measurements between energy analyzed photoelectron/Auger electron and mass analyzed photoion (PEPICO/AEPICO). Alternatively, the CMA can be attached to the main chamber at another position downstream along the photon beam. At this position a hemispherical electron/ion energy analyzer is set on a turn table inside the chamber. The turn table allows the rotation of the analyzer around the photon beam axis. Thus, with this arrangement, the measurements of photoelectron/Auger electron-photoelectron coincidence (PEPECO/AEPECO) and photoelectron/Auger electron-photoion coincidence (PEPICO/AEPICO) are possible with additional capability of measuring angular correlation between these two coincident particles. The main chamber, together with all analyzers, can also be rotated around the photon beam axis through an angle of 130° without deteriorating the ultrahigh vacuum of the system. These two independent rotation mechanisms allow the high resolution angle resolved studies of photoelectron/Auger electron spectroscopy, time-of-flight mass spectrometry, PEPICO and PIPICO spectroscopy, and angular correlation measurements.

4. The Performance of the RTOF Mass Spectrometer

The performance of the reflectron-type time-of-flight mass spectrometer (RTOF)

of our own design has been examined using synchrotron radiation from other facility (UVSOR). Several gaseous samples were ionized at various photon energies to test its resolution. Figure 2 shows a mass spectrum of benzonitril produced by nitrogen 1s excitation to the bound π^* orbital. Six groups of peaks are seen with regular spacing, each corresponding to the $C_nH_m^+$ group of ions with successive carbon number $n=1$ to 6. The resolution is found to be satisfactory for the intended research subjects [2], indicating that the mass number difference by one is clearly resolved in this whole range. (The highest peak in the $C_2H_m^+$ group is a composite of the $C_2H_2^+$ and CN^+ fragments.)

References

- [1] A. Hiraya, E. Ishiguro, K. Ueda, I. H. Suzuki, T. Ibuki, and I. Koyano, Spring-8 Annual Report 1996, pp71-72 (1996)
- [2] I. Koyano, M. Okuyama, E. Ishiguro, A. Hiraya, H. Ohashi, T. Kanashima, K. Ueda, I. H. Suzuki, T. Ibuki, J. Synchrotron Rad., (1998) in press.

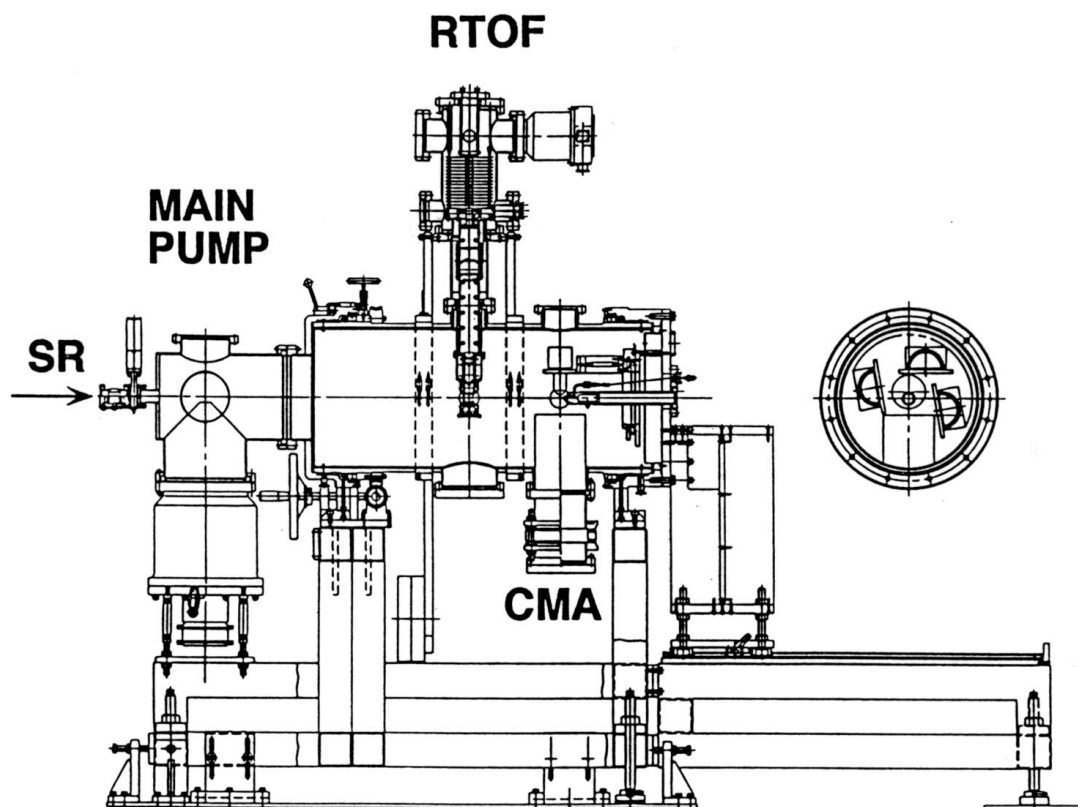


Fig. 1 Main part of the apparatus at the Soft X-ray Photochemistry station.

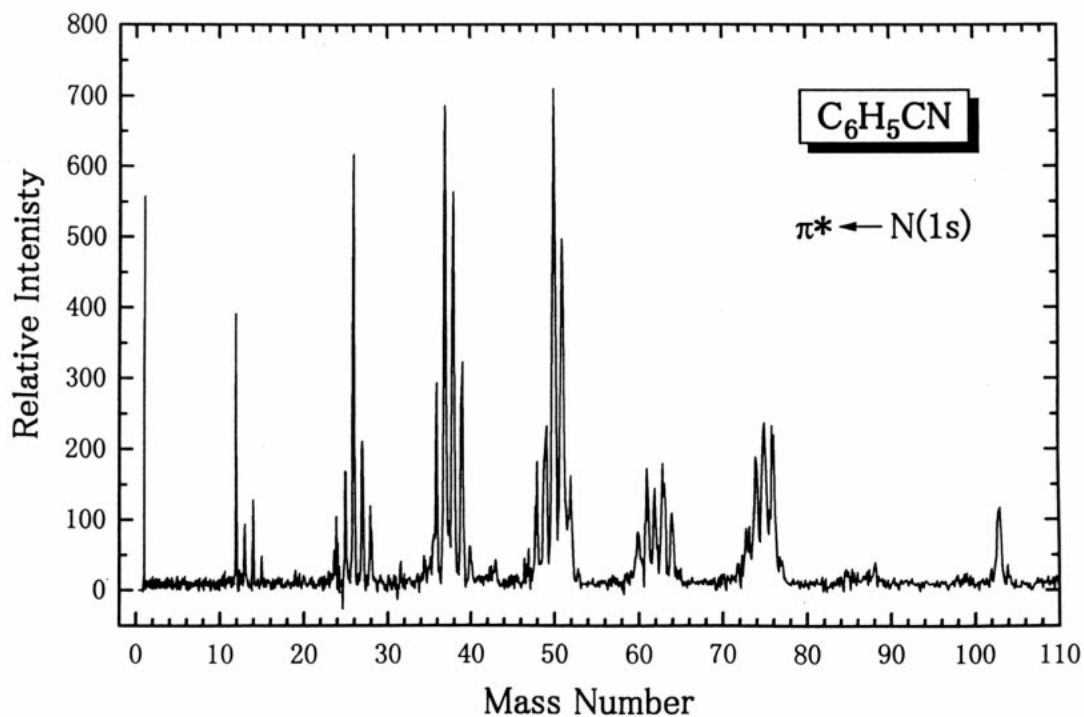


Fig. 2 Time-of-flight mass spectrum of benzonitril by $N(1s) \rightarrow \pi^*$ excitation, showing the performance of the RTOF mass spectrometer.