Dissociative Photoionization Studies of Fullerenes and Carbon Nanotubes and Their Application to Dye-Sensitized Solar Cells

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We have studied the mechanisms and kinetics of dissociative photoionization of fullerenes by means of the velocity map imaging spectroscopy. We now intend to apply the above gas phase spectroscopy to functional materials such as carbon nanotubes (CNTs). Additionally we apply the CNT and fullerene derivatives to a catalytic counter electrode (CE) in dye-sensitized solar cells (DSSCs).

1. Mass Resolved Velocity Map Imaging of Doubly Charged Photofragments from C_{60} and C_{70}

We have obtained 2D velocity images of the fragments from C_{60}[1)] and C_{70} with improved resolution. The 2D velocity images of fragments were found to be convolutions of isotropic center-of-mass velocity acquired by the C_2 emission and anisotropic velocity of C_{60} in the parent molecular beam.

2. Gas Phase Spectroscopy of CNTs

We built a vacuum apparatus for the gas phase spectroscopy of CNTs. With the apparatus we will perform experiments using the fullerenes and then improve the chamber to achieve experiments using CNTs.

3. Development of the Counter Electrodes Using CNTs and Fullerene Derivatives and Evaluation of Their Feasibility for DSSCs

To improve efficiency, lifetime and cost of the DSSC, materials to make the CE need to be reconsidered. We prepared the CEs using commercial CNT aqueous dispersions and succeeded in fabricating DSSC cells which showed reasonable efficiency. We have started to make CEs using sulfonated fullerenes. We produced Langmuir-Blodgett (LB) films of the sulfonated fullerenes on glass substrates. We will evaluate the feasibility of the LB films for the DSSCs.

Reference

1) H. Katayanagi and K. Mitsuke, *Bull. Chem. Soc. Jpn.* **88**, 857–861 (2015).

Soft X-Ray Spectro-Microscopy for *In-Situ* Chemical Imaging

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A scanning X-ray transmission microscopy (STXM) is a powerful tool[1)] for *in-situ* chemical imaging. In the present work, we have developed a humidity control sample cell for the chemical and morphological analysis of a fuel cell under the working condition, such as high temperature and high humidity. The sample cell is consisted of two silicon nitride windows with 100 nm thickness and a chamber. A small sensor (SHT7x, Sensirion AG) is placed near the sample in the chamber to monitor the humidity and the temperature. The chamber is equipped with three gas ports and the humidity of the sample can be controlled by flowing dry or humid helium gas in the sample cell.

With changing the humidity inside the sample cell from 8 to 83% at room temperature, a thin section (thickness of 100 nm) of the fuel cell has been observed. The optical density images of a porous polymer electrode of the fuel cell are shown in Figure 1. These images were acquired by using the photon energy at 285.5 eV and the dwell time per a pixel was 10 ms. In a high humidity condition, the area of the polymers (shown as white color) increases and the voids (shown in dark color) decreases. This result implies that the porous polymers are swelled by absorbing the water vapor.

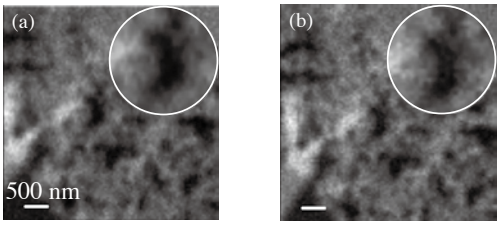

Figure 1. OD images of the electrode at the humidity of (a) 8% and (b) 83%. Inset images are blowup of the same area.

Reference

1) T. Ohigashi, H. Arai, T. Araki, N. Kondo, E. Shigemasa, A. Ito, N. Kosugi and M. Katoh, *J. Phys.: Conf. Ser.* **463**, 012006 (2013).