Characterization of Carbon Nanocoil-supported Pd-Ru-Pt Alloy Electrocatalysts Used for DMFCs by XANES/EXAFS Spectroscopy

Kuen-Song Lin (林錕松)[1], Jyh-Fu Lee (李志甫)[2], Ding-Gao Liu (劉定國)[2], Mau-Tsu Tang (湯茂竹)[2], and Yao-Wen Yang (楊耀文)[2]

[1]Department of Chemical Engineering & Materials Science, Yuan-Ze University, Chungli, Taiwan
[2]National Synchrotron Radiation Research Center, Hsinchu, Taiwan

Recently, direct methanol fuel cell (DMFCs), which directly use methanol as fuel, have been investigated intensively because of their numerous advantages that include high energy density, low operating temperatures, ease of handling a liquid, and their possible applications to micro- fuel cells in the future. The performance and stability of low-temperature fuel cells such as DMFCs are known to be strongly dependent on the carbon support used, as well as the catalytically active species.

Carbon nanomaterials have the essential properties of electronic conductivity, corrosion resistance, surface properties, and the low cost required for the commercialization of fuel cells. These nanostructured carbon materials such as carbon nanocoils (CNCs) exhibit many interesting characteristics and have been applied extensively in various areas, including electronic devices, and electrode materials.

The characterization of Pd-Ru-Pt tri-metallics is a good choice to undergo absorption experiments because of the large separation in energy edges of the two metals. Investigations on the dispersion and interaction of the Pd, Ru, and Pt atoms seems to be very important in the electrocatalytic performance of Pd-Ru-Pt alloy catalysts supported on newly synthesized carbon nanocoil materials.The EXAFS and XANES spectra of the Pd-Ru-Pt alloy catalysts supported on carbon nanocoil materials were measured at the BL01C1 (SWLS) beamline at the NSRRC of Taiwan. The electron storage ring were operated with an energy of 1.5 GeV and a current of 100-200 mA. A Si DCM was used for providing highly monochromatized photon beams with energies of 5 to 30 keV and resolving power (E/ΔE) of up to 7000. Data were collected in fluorescence or transmission mode with a Lytle ionization detector for the Pd (24350 eV) or Ru (22117 eV) K edges and Pt (11564 eV) L(III) edges experiments at room temperature.

Since the valency and fine structure of Pd atom in the Pd-Ru-Pt alloy catalysts supported on carbon nanocoil have not been well studied, therefore the catalytic redox mechanisms effected by the Pd-Ru-Pt alloy catalysts supported on carbon nanocoil may be determined by using XANES and EXAFS spectra. The Pd EXAFS spectra indicating the Pd species with Pd-Pd bond distances of 2.76 Å were found in Figure 1. Coordination numbers of the Pd species from Pd EXAFS spectra were 12.1. These results may also offer a further explanation of how the interaction bonding or redox reaction in the synthesis for Pd-Ru-Pt alloy catalysts supported on carbon nanocoil materials. Combined with the experiments, it may provide the understanding of the fine structures or oxidation states of fresh and used Pd-Ru-Pt alloy catalysts supported on carbon nanocoil materials under DMFCs electrochemical performance. By using the EXAFS spectra, the results of fine structures or bonding lengths might provide the originals of interactions between the carbon nanocoil supports and Pd-Ru-Pt alloy catalysts.

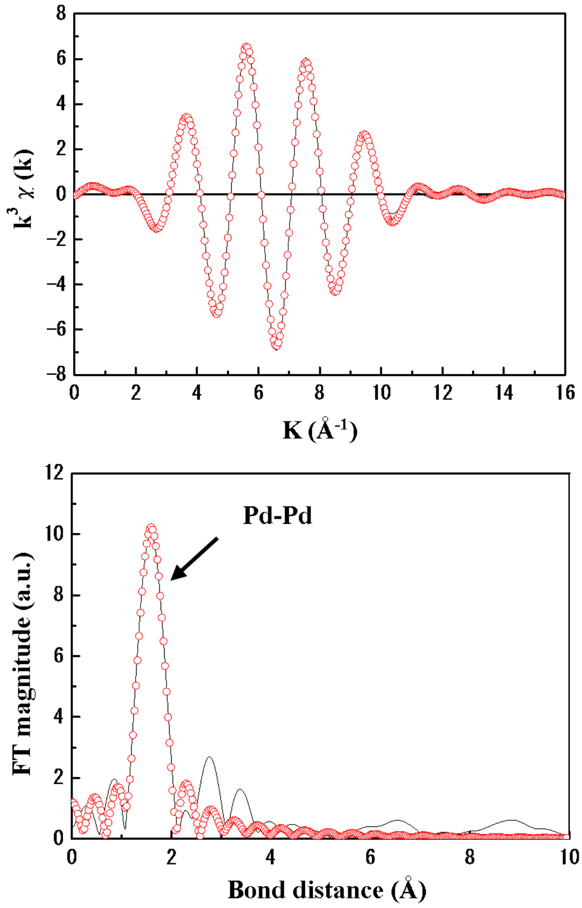

Figure 1 (a) Pd K-edge EXAFS oscillation $k^3\chi$(k) and (b) Fourier transform (FT) of the Pd (Pd metals) K-edge EXAFS of the Pd-Ru-Pt alloy catalysts supported on carbon nanocoil materials. The best fitting of the EXAFS spectra are expressed by the dotted lines.