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Photoemission Spectroscopy of C_{70} Fullerene-Peapod

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Introduction

A single-walled carbon nanotube (SWCNT) encapsulating C_{70} fullerenes, has attracted much attention because of its nanoscale structure, which has the potential to drastically change the electronic properties of SWCNTs and C_{70} fullerenes. The band calculation was performed by Otani *et al.* [1]; it is expected that the lowest unoccupied states (LU) and the highest occupied states (HO) of the C_{70} fullerene encapsulated in SWCNT are different from those in an isolated C_{70} molecule because of the orbital mixing between the nearly-free-electron states of SWNTs and the π orbitals of C_{70} fullerenes. In this study, we have measured the photoemission spectra of SWCNT and C_{70} fullerene peapod (C_{70} PPD) samples.

Experimental

The photoemission experiments were performed using synchrotron radiation at the beam line BL-11D of the Photon Factory, High Energy Accelerator Research Organization (KEK). The instrumental resolution was 50 meV. SWCNT samples were prepared by the laser vaporization method [2, 3]. The mean diameter of SWCNTs in C_{70} PPD sample is 1.4 nm.

Results and Discussion

Figure 1 shows the photoemission spectrum of the C_{70} PPD sample measured at $h\nu$= 65 eV. The photoemission spectrum of the C_{70} PPD is, as a whole, similar to that of the SWCNT [2, 3].

The spectrum of the C_{70} fullerenes (C_{70} pea) inside the SWCNT was obtained by subtracting the empty SWCNT spectrum from the C_{70} PPD spectrum and is shown in the figure. The overall spectral features are very similar to those of the C_{70} solid spectrum. The peaks in the binding energy region between 3 eV and E_F correspond mostly to the π band structures of C_{70} fullerenes. The peak at the binding energy of 2.8 eV is due to the highest occupied state (HO). The structures at the binding energies above 8 eV correspond mostly to the σ band. The several peaks in the binding energy region between 3 eV and 8 eV are due to the mixture of the π and σ bands.

As shown in the figure, the HO peak position is nearly equal to the corresponding peak position in the C_{70} solid spectrum. According to the theoretical calculation performed by Otani *et al.* [1], the LU states of the C_{70} fullerene shift downward compared with those of an isolated C_{70} fullerene. If such a shift occurs, it is expected that the HO states shift downward compared with those of a C_{70} solid. For the present C_{70} PPD sample, however, the energy shift of HO states cannot be observed. It is concluded that the electronic states of C_{70} fullerenes inside SWCNT are very similar to those of a C_{70} solid.

References

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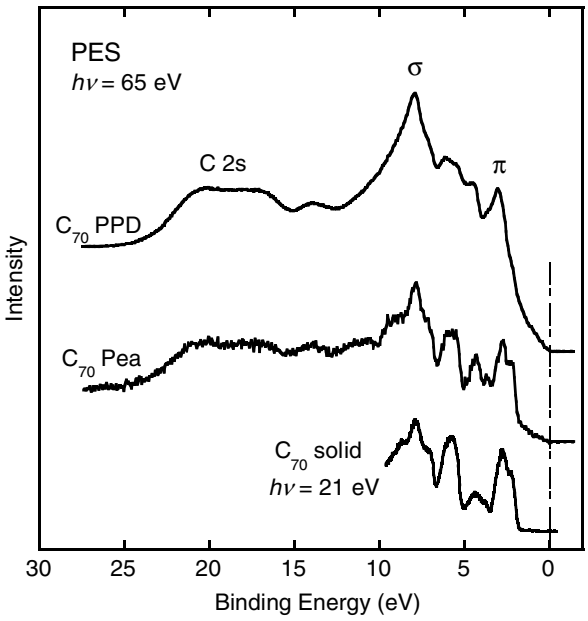

Figure 1: Photoemission spectra of the C_{70} peapod sample (C_{70} PPD), C_{70} fullerenes in SWCNTs (C_{70} Pea) and C_{70} solid.

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