Hydrogenation of C_{60} deposited on a substrate under low temperature condition

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Synopsis We performed experiments for hydrogenation of C_{60} at ~300 K and low temperatures through an infrared absorption spectroscopy. Absorption bands corresponding to CH stretching of hydrogenated C_{60} were observed at both ~300 K and low temperatures.

Observations of the infrared transitions of C_{60} evidently indicated that fullerenes exist in the interstellar matter (ISM) [1, 2]. Fullerenes were also found in H-rich astrophysical circumstances. [2] This implies that hydrogenated fullerenes widely distribute in the ISM and thus laboratory spectroscopic investigations of those hydrogenated species have been performed for identifications of them in space [3]. However, hydrogenated fullerenes may lose hydrogen through photolysis by ultraviolet radiation [4]. On the other hand, since C_{60} is substantially stable and hard to be dissociated, C_{60} might exist in lower-temperature astrophysical environments than those where C_{60} is generated. We performed experiments for hydrogenation of C_{60} under low temperature conditions through infrared (IR) absorption spectroscopy to investigate the hydrogenation reactions in such conditions.

Our apparatus mainly consists of an ultra-high vacuum reaction chamber, a hydrogen atomic source, a Fourier transform infrared spectrometer, and an effusive cell. The details of the apparatus were described in the previous paper [5]. An aluminum (Al) substrate is mounted in the reaction chamber. Its temperature is controlled from ~10 K to ~300 K. C_{60} vapor was deposited onto the Al substrate. H atoms were generated in micro-wave induced plasma and transferred into the reaction chamber via a temperature-controlled pipe which determined the translational temperature of H atoms. We performed two type experiments: i) H atoms and C_{60} were codeposited onto the substrate. ii) H atoms were deposited onto a thin solid of C_{60} predeposited. Temperature conditions were: i) the substrate was at ~10 K while the transfer pipe of H atoms was at ~100 K and ii) both the substrate and the transfer pipe were kept at ~300 K. The latter was a comparison experiment to that under the low temperature condition.

Figure 1 shows the observed IR absorption spectrum of CH stretching band for codeposition at ~300 K. A broad band with four small peak structures are seen in the region of CH stretching band from ~2750 to ~3050 cm^{-1}.

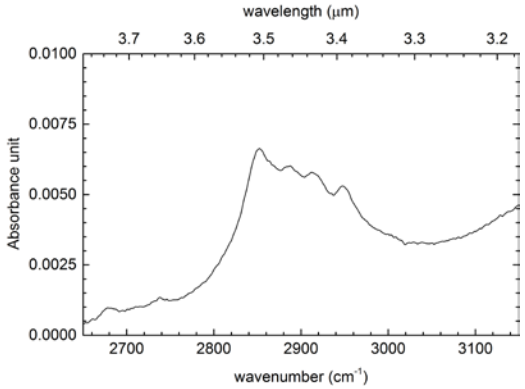

Figure 1. Observed IR absorption spectrum for CH stretching band in the case of codeposition at ~300K.

In the case of exposure of H atoms onto C_{60} solid, absorption bands corresponding to CH stretching were observed at both ~300 K and low temperatures (~10 K substrate). This implies that the reaction barrier of hydrogenation is very low, which is consistent with recent theoretical calculation [6]. The band widths seem to become wider towards high wavenumber side at ~300 K than the low temperature condition. Further details will be discussed at the conference.

References

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