Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

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Version of record first published: 24 Sep 2006

To cite this article: Hai-Ning Cui, Eung Ryul Kim & Haiwon Lee (2001): Photoluminescence of Aggregated C_{60} in Nano-Size at Room Temperature, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 371:1, 333-336

To link to this article: http://dx.doi.org/10.1080/10587250108024754

Mol. Cryst. and Liq. Cryst., 2001, Vol. 371, pp. 333-336

Photoluminescence of Aggregated C_{60} in Nano-Size at Room Temperature

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When the aggregation of C_{60} is arranged in mono-dispersed state on the ITO substrate, the photoluminescence (PL) spectra are observed clearly. These emission peaks are attributed to recombination of self – trapped excitons, the zero-phonon exciton (R_0) and its phonon replicas.

Key words: fullerene; UV-vis spectra; photoluminescence

INTRODUCTION

Photoluminescence (PL) and UV-vis spectroscopy are ones of the most powerful tools to investigate the properties of isolated C_{60}, C_{60} compounds and crystalline C_{60} . Many groups have studied the PL properties of C_{60} molecules in solution [1, 2] and solid in different morphologies such as single crystal [3], films and polycrystalline powder [4-6]. It has been reported that there is only weak or no luminescence of C_{60} in solution and solid state at room

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temperature [7,8]. In this paper we prepared some solid state C_{60} on the indium tin oxide (ITO) substrate, which exhibits room-temperature fluorescence spectra.

EXPERIMENTAL SECTION

Gold grade C_{60} was obtained from Hoechst (Germany).1,2-Dichloro-benzene (DCB) and ITO-glass was purchased from Sigma-Aldrich and Corning Company, respectively. The C_{60} solution (0.1 mg/ml) was dropped onto substrate and aggregated C_{60} was formed after drying at room temperature for 48 hours. The PL synchronous spectra were obtained using a spectrofluorometer (ISS -PC1).

RESULTS AND DISCUSSION

Figure 1 shows the synchronous spectrum of the C_{60}. These peak positions and some values of references are shown in Table 1. The strong PL band of 616 nm originate from C_{60}'s electron transition under the state

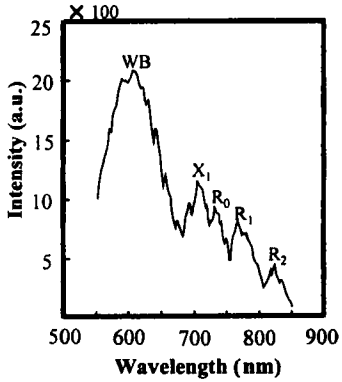

FIGURE 1 The synchronous spectrum of C_{60} photoluminescence.

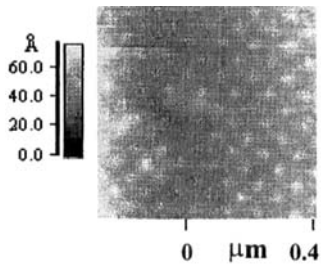

FIGURE 2 AFM micrograph of nano aggregation state of C_{60}

called Zero-phonon line (R_0) at 720~738 nm is attributed to an exciton-polaron recombination (or self-trapped emission) [9, 10]. The exciton

complex derives a strong electron-vibration coupling on the C_{60} cluster, but only very weak R_0 peaks are observed in Fig. 1. It means that there are few C_{60} clusters. The AFM results support that C_{60} molecules are dispersed in nano-size as shown in Fig. 2. According to the ref.11, the emitting bands R_1(765 nm), R_2(827 nm) and R_3(873 nm) are attributed to phonon replicas of the R_0, respectively. The peak X_1 is attributed to the transition of t_{1u} and h_u levels corresponding to surface which is related exciton states and connected to the lattice distortions of the grains. The electronic

Table 1. PL spectra at various substrates

Substrate.	Temp /K	WB /nm	X_1/ nm	R_0/ nm	R_1/ Nm	R_2/ Nm	R_3/ nm	Reference
GaSe	15		700	738	765	827	873	[11]
Au	15		720	729	752	800		[11]
Doped Al_2O_3	320	619		690				[8]
Quartz	270			727			841	[9]
Silicon	10 ~ 320			727				[12]
ITO	320	618	708	728	779	827		This work

hybridization occurs between C_{60} and the substrate. Our spectrum looked like the combination or overlap effect of wide band (520 nm ~ 750 nm) of ref. 8 [8] and R_1, R_3 narrow emission peaks of ref.11 [11]. In Table 1 all the peak positions are of a little different.

The shift of the emission peaks is due to electron transition of the C_{60}^+ or C_{60}^{+n}, because the distance between h_u and t_{1u} increased due to the ionization. While the interface of the C_{60} on oxide surfaces changed, the oxygen dangling bonds also changed. Capozzi and co-workers [9] reported the positions of R_1 and R_2 bands shifted to longer wavelength. The ratio values of R_0/R_2 and R_0/R_2 become small eventually while the temperature increases from 10 K up to 270 K. Table 1 clearly shows that our results are similar to the characteristics at the high temperature condition.In our experiments, no PL spectra were observed with pure C_{60}

powder, C_{60} solution (0.1 and 2 mg/ml) and thin film on quartz, but the synchronous spectra of PL were observed in the form of aggregated C_{60} on ITO substrate under the same conditions due to the slow deposition rate of solid C_{60}[11] and lattice matching property between C_{60} and substrate[11]. Nearly mono-dispersed C_{60} aggregation of C_{60} can decrease non-radiative recombination. Xenon Arc lamp instead of laser as a excitation light source can help obtaining synchronous spectra.

CONCLUSION

Mono-dispersed state of C_{60} was prepared on the ITO substrate, and its photoluminescence spectra are attributed to recombination of self – trapped excitons, the zero-phonon exciton and its phonon replicas.

ACKNOWLEDGEMENT

This work was partially supported by a program of National Research Laboratory, the Ministry of Science and Technology (Grant Number : 99-N-NL-01-C-103) .

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