Application of Green-Emitting Carbon Dot-Based Films to Luminescent Solar Concentrator

Keio Univ., ○Yunxiang Liu, Yoshiki Iso, Tetsuhiko Isobe
E-mail: iso@applc.keio.ac.jp, isobe@applc.keio.ac.jp

Introduction In this study, carbon dots (CDs) were synthesized by dehydrogenation polymerization of *p*-phenylenediamine (*p*-PD) [1]. Furthermore, the films consisting of the CDs and ethylene vinyl acetate (EVA) copolymer were fabricated and applied to a luminescent solar concentrator (LSC).

Experimental *p*-PD was added to diphenyl ether. The mixture was refluxed at 250 °C for 2 h under ambient air. The resulting CDs were washed with hexane and collected by centrifugation. The CDs were purified by silica gel column chromatography using a mixture of dichloromethane and methanol as the eluent and collected by evaporation. The purified CDs were dispersed in EVA copolymer chloroform solutions. The dispersions were poured into Petri dishes and dried to obtain CDs@EVA films with different CD concentrations and film thicknesses. EVA film without CDs were also fabricated. These films were attached to the device (Fig. 1) to evaluate LSC performance.

Results & Discussion Fig. 2 shows photographs of a typical CDs@EVA film which was transparent yellow under white light and exhibited green luminescence under 365 nm UV light. As shown in Fig. 3, the absorption peak was observed at 468 nm due to the HOMO-LUMO transition of the π-conjugated system. As also shown in Fig. 3, the excitation and emission peaks corresponding to the HOMO-LUMO transition were observed at 490 nm and 540 nm, respectively. As shown in Fig. 4, the photoluminescence quantum yield (PLQY) decreased with increasing CD concentration and film thickness. This is due to reabsorption of emission caused by the overlap between the absorption and emission spectra. The highest PLQY was 55% at 0.05 wt% CD concentration and 137±11 μm thickness. Fig. 5 shows current–voltage (*I*–*V*) curves measured under AM1.5G simulated solar light. Attaching CDs@EVA film with 0.05 wt% CD concentration and 369±7 μm thickness to the LSC device resulted in the largest short-circuit current (I_{sc}), and thus the largest photoelectric conversion efficiency (η). The spectral sensitivity of the LSC device confirmed that the increased I_{sc} and η are attributed to green luminescence from the absorption of UV and blue light.

Reference [1] R. Sato, Y. Iso, T. Isobe, *Langmuir*, **35**, 15257 (2019).

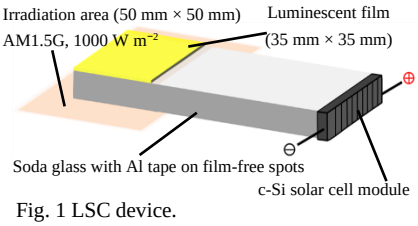

Fig. 1 LSC device.

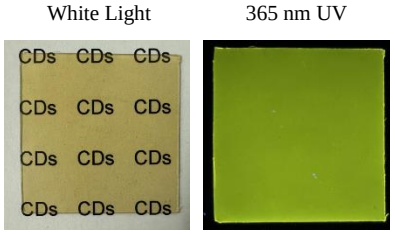

Fig. 2 Photographs of CDs@EVA film with 0.05 wt% CD concentration and 369±7 μm thickness.

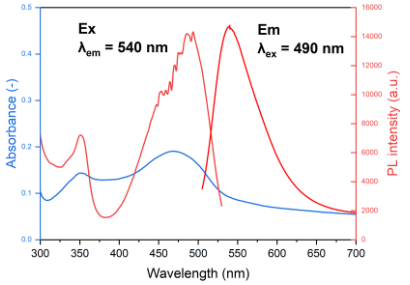

Fig. 3 Absorption, excitation, and emission spectra of CDs@EVA film with 0.05 wt% CD concentration and 369±7 μm thickness.

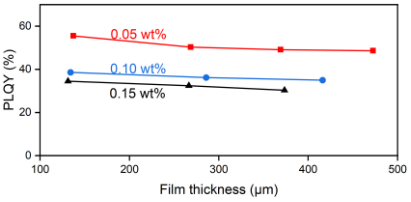

Fig. 4 Change in PLQY of CDs@EVA films with film thickness.

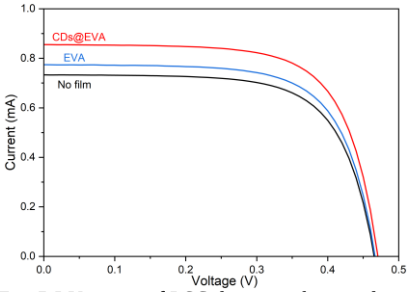

Fig. 5 *I*-*V* curves of LSC device without and with EVA and CDs@EVA films with 0.05 wt% CD concentration and 369±7 μm thickness.