전기발광 고분자의 이광자흡수특성: 광발광 및 광전도 특성

Two photon absorption of electroluminescent polymer: Photoluminescence and photoconductivity studies

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Electroluminescent polymers have attracted considerable attention due to possible applications as large-area light-emitting displays. There have been many efforts to improve the electroluminescent efficiency. To design the polymer with high efficiency, it is necessary to understand the luminescent mechanism.

In this report, we have investigated two-photon absorption(2PA) characteristics of highly efficient electroluminescent polymer using various techniques such as nonlinear transmission, 2PA-induced photoluminescence(2PA-PL) and 2PA-induced photoconductivity(2PA-PC). The sample was a poly (phenylenevinylene) derivative with an alkoxy and carbazole groups as pendant (CzEh-PPV).

To find the origin of the 2PA, we measured 2PE and 1PE spectra. The 2PE spectra were obtained with the optical parametric oscillator(OPO) pumped with the third harmonics of a nanosecond neodymium-doped yttrium-aluminum-garnet(Nd-YAG) laser and the 1PE spectra were acquired using a xenon lamp and a monochromator. The detection wavelength was fixed near the maximum photoluminescence position. The excitation wavelengths were varied in the absorptive region. To obtain the 2PA coefficients, we measured the photoluminescence spectra after two- and one-photon absorption. Recordings of the PL spectra were performed using a spectrophotometer. The excitation wavelengths were 840 nm and 420 nm for 2PA-PL and 1PA-PL, respectively. To find the nature of the species induced by 2PA, we measured 2PA-PC. The excitation source is a fs-laser with the wavelength of 800 nm, the pulse width of 150 fs and the repetition rate of 1 kHz.

Shown in Fig. 1 are the photoluminescence spectra after two- and one-photon absorption. The 2PA-PL spectra are similar to 1PA-PL spectra. The photoluminescence spectra show the spectroscopic features that can be resolved to two peaks. By comparing this spectra with the PL spectra of Rhodamine 6G, we obtained the 2PA coefficient. Figure 2 shows 2PE spectrum. Two-photon excitation spectrum shows two bands. Meanwhile, one-photon excitation spectrum has three broad bands: E1, E2, and E3. The E1 band has two peaks at 430nm and 456nm and E2 band shows two peaks at 328nm and 341nm. Compared these bands with those of PPV and carbazole, the E1 band is thought to be due to photoluminescences by excitation of the phenylenevinylene unit in the main chain and the E2 band to photoluminescence by excitation of the carbazole unit in the side chain. A new band(E3) appears around 372nm and its origin is not yet clearly understood. The 2PE of CzEh-PPV shows the two-photon transition($1A_g \rightarrow nA_g$) that is shifted to the blue side when compared with the one-photon transition($1A_g \rightarrow 1B_u$). Comparing two-photon excitation spectra with one-photon excitation spectra, we found that two- and one-photon transitions satisfy different selection rules.

Shown in Figure 3-(a) is the time-resolved 2PA-PC signal generated by a 150 fs pulse at 800 nm from a Ti:sapphire laser. This PC signal is an evidence that the species induced by 2PA are the charged carriers. The double-logarithmic plot of signal represents a dispersive transport. From the transit time at the knee of the curve, we obtained the mobility of $9.5\times10^{-6}cm^2/V\cdot s$. We assumed that this mobility is that of the hole among the charge carriers generated by 2PA. Figure 3-(b) is the electric field dependence of the peak transient PC that shows an increase of the photocurrent with a increase of the applied electric field. This is because the dirift current override the diffusion current under the high field condition.

In conclusion, it was found that the two- and one-photon transitions satisfy the different selection rules. The CzEh-PPV showed the two-photon transition that was shifted to the blue side when compared with the one-photon transition. At 840 nm, 2PA coefficients of CzEh-PPV are measured to be 4.4×10^{-49} cm^4s, respectively. We found that the excited species induced by 2PA are the charged carriers. The mobility of the hole generated by 2PA is $9.5\times10^{-6}cm^2/V\cdot s$.

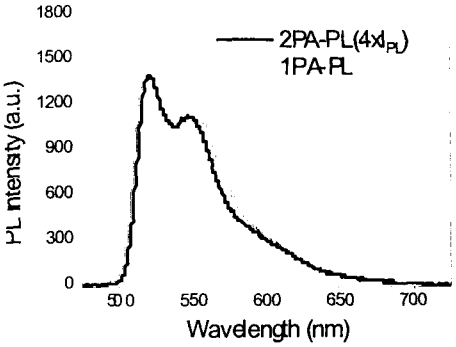


Figure 1. Photoluminescence spectra after two- and one-photon absorption.

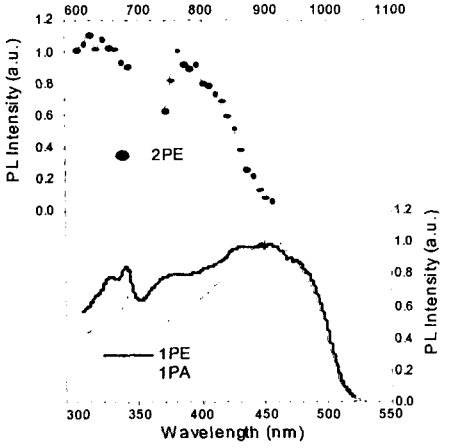
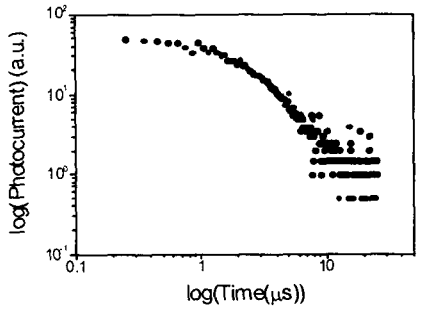
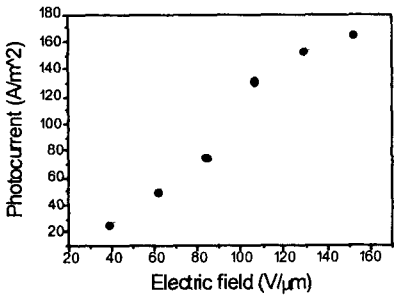


Figure 2. Two- and one-photon excitation spectra. Also, one-photon absorption spectra are shown.



(a)



(b)

Figure 3. Time-resolved 2PA-PC signal (a) generated by a 150 fs pulse at 800 nm from a Ti:sapphire laser and the electric field dependence of the peak transient PC (b).