Spectroscopic approach to photo-degradation process of PTB7-Th Polymer

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Abstract

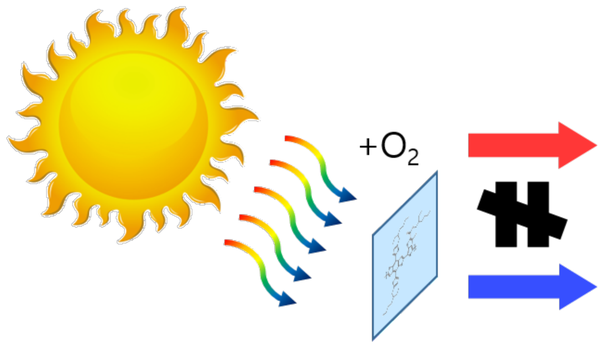

Figure 1. Wavelength dependence of photo-degradation process

Organic photovoltaics composed of conducting copolymer and fullerenes have many advantages compare to silicon based solar cell such as low-cost, light-weight, solubility, flexibility etc. However, there are obstacles to use OPV in daily basis. Because conducting polymer easily goes degradation process in ambient condition and results in sunlight absorption decrease which drops the device performance. To prevent the degradation process, first, we need to know properties of the process. In this work we use various actinic source(640nm, 532nm, 473nm) to proceed degradation process and observe Raman spectrum and photoluminescence spectrum. Raman spectrum does not show significant difference between actinic sources. But photoluminescence spectrum changes significantly when varying degradation light wavelength. Interestingly, 640nm and 532nm radiation make polymer degradation in the same way but 473nm does not. It can be explained by absorbance spectrum. I hope our findings provide insight into the degradation mechanism of conjugated copolymer and dedicate to progress in OPV devices

Introduction

• Sample information

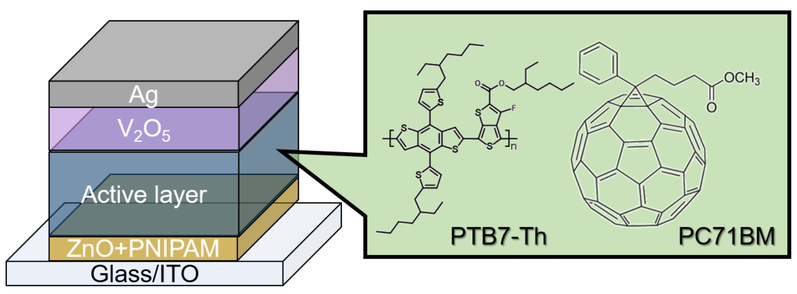

Figure 2. OPV structure and component of active layer

Active layer consist of PTB7-Th polymer and PC71BM blend. PTB7-Th polymer which absorbs sunlight easily ruined by light and air. To prevent degradation process we need to know how the process undergoes.

• Singlet oxygen

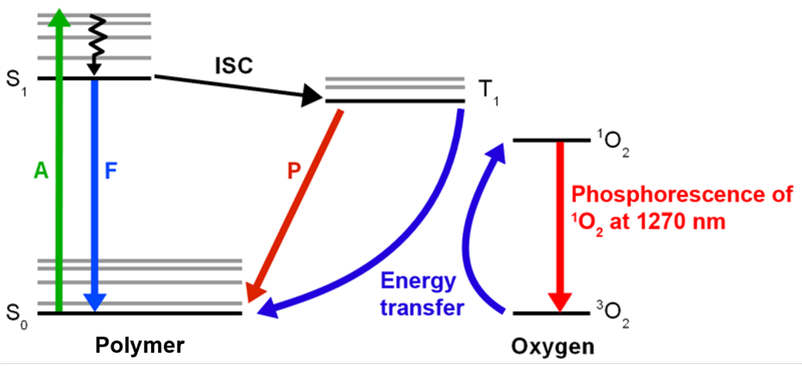

Figure 3. The Joblonski diagram for optical excitation of the copolymer

When the polymer excited by sunlight, some of them go to triplet state. This energy can transfer to oxygen and excite oxygen to create singlet oxygen. After singlet oxygen created, this oxygen attacks polymer to proceed degradation process

Experiment setup

• Home-built Raman setup

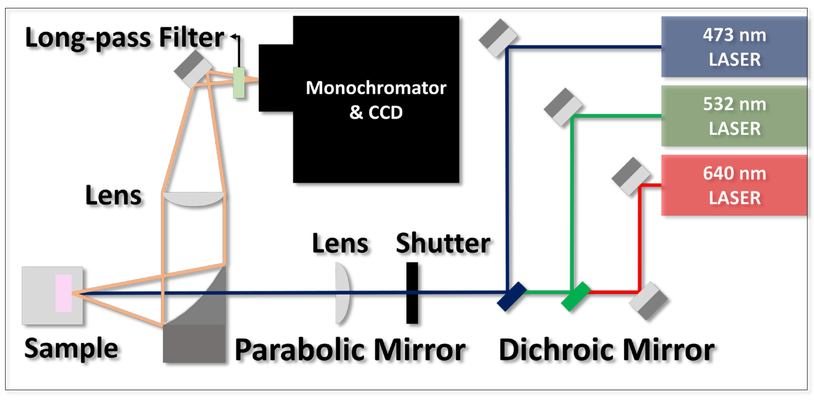

Figure 4. Home built Backscattering Raman Spectroscopy scheme

Result

• Degradation without oxygen

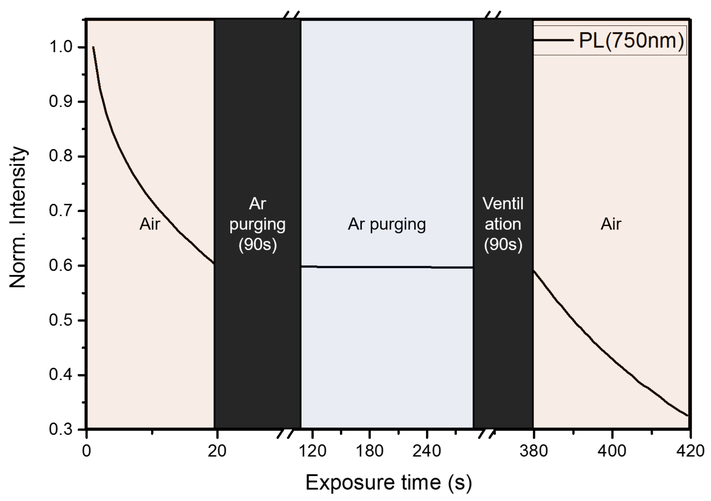

Figure 5. PL change under ambient air and Ar

Above figure represent that oxygen plays a key role in degradation process. I recorded photo luminescence spectrum using 532nm laser for degradation and probe. Then, I plotted 750nm value of the spectrum. At first 20 s PL value decreases because of the degradation process then, turn off the light and fill Ar gas to eliminate oxygen around sample. This process takes 90s then, take PL spectrum again. And I take PL spectrum once a minute. Interestingly if there isn't oxygen, PL spectrum doesn't change. After 5 min, I open the purging box and fill ambient air into box. Then, take PL spectrum and it goes to decrease again.

• Raman spectrum change

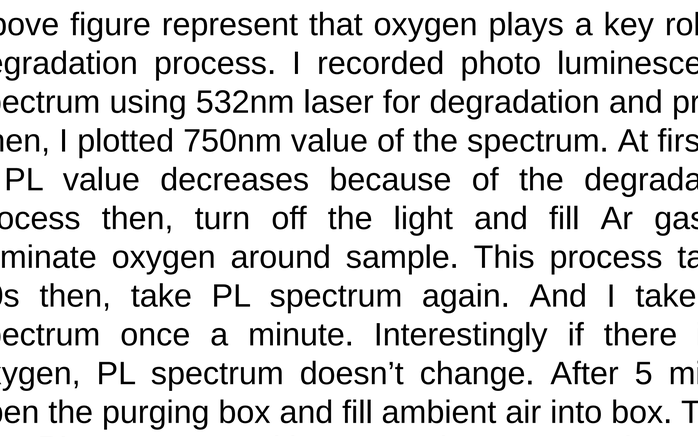

Figure 6. Raman spectrum change varying actinic source

These Raman spectrum were recorded using 532nm laser for probe and varying actinic source. (actinic source is written above each spectra) Legend shows exposure time of actinic source. Baseline was subtracted by non-linear fitting. As time increases, 1400cm^{-1} to 1600cm^{-1} peaks decrease because of structure breakage. And increase of 1650 cm^{-1} peak indicate that formation of C=O peak.

Discussion

• PL spectrum change

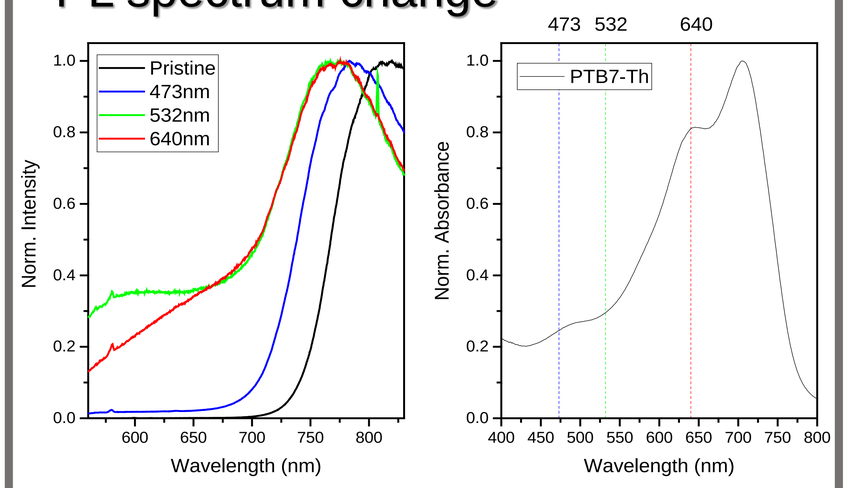

Figure 7. PL change under degradation process and absorbance spectra

Left figure shows photoluminescence spectrum varying actinic source. Legend represents actinic source. All spectrum were recorded using 532 nm probe. Each of spectra was taken after 5 min illumination with same power by actinic source. To show shift of fluorescence at glance, each spectra were normalized to maximum. Right figure shows absorbance spectrum of pristine PTB7-Th film. There are 3 absorption band in the spectrum. 473 nm excite high energy band and 532nm, 640nm excite low energy band. Absorbance of 473nm is similar to 532nm and 640 nm absorbance is 3 times higher than others. Come back to PL spectrum, blue shift of fluorescence means shorten chain length. Excitation of low energy band shows a little shift of fluorescence and amount of chain scission is low. In contrast excitation of high energy band shows much shift of fluorescence and we can see fluorescence of shorter chain length.

Conclusion

Photo-degradation process of PTB7-Th polymer is dominant by oxygen. But according to our research, wavelength plays a role in degradation process. It means specific wavelength can ruin polymer efficiently.

Acknowledgment

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