doi:10.1017/S1431927620021388
Microsc. Microanal. 26 (Suppl 2), 2020

Morphological Characterization of Polymer Blends: Impact of Side Chain Modification

Washat Ware, Antony Devita, Tia Wright, Shubo Han and Bhoj Gautam

Fayetteville State University, Fayetteville, North Carolina, United States

Conjugated polymers and small molecules have been intensively studied due to their unique electronic and optical properties. Relatively easy and inexpensive fabrication, light weight, mechanical flexibility and non-toxic processing methods open broad prospects for their applications in solar cells[1, 2]. Power conversion efficiency of about 16% [3] has been achieved in these solar cells. Significant focus of research efforts involve develop new materials or to advance processing systems to increase the power conversion efficiency (PCE)[4, 5]. Currently, there remains a question whether the processing based on the non-halogenated solvents, called "green solvents"[6], is possible on an industrial-scale. The sustainable manufacturing of these organic electronics, because of the organic solvents used, still pose serious health problems and a harmful environmental impact. Here, we studied the morphology of the "green solvents" processed polymer blend and compared with the blend processed with "halogenated solvent" to explore the reasons for the difference in charge generation efficiency in polymer solar cells based on aliphatic side chain and oligoethylene glycol (OEG) side chain[7]. The performance of the highly efficient PPDT2FBT:PCBM [8]system with 9.2% power conversion efficiency is degraded significantly to 1.4% when PCBO12 is blended with a OEG version of a polymer namely PPDT2FBT-A[9], that has only a minor side-chain modification. We employed Atomic Force Microscopy to investigate the impact of side chain on morphology of these polymer blends.

The donor polymer PPDT2FBT-A and PCBO12 acceptor were dissolved in 88:12 (v/v) ethanol/water mixture. The concentration of blend solution of PPDT2FBT-A:PCBO12 (1:2.5 w/w) was 5 mg/ml. Blend solution (5mg/ml) of PPDT2FBT:PCBM (1:1.5 w/w) was prepared by dissolving in chlorobenzene. Both blend solutions were stirred at 90^0 C for 5 hours. The glass substrates were cleaned ultrasonically using deionized water, acetone, and isopropanol for 15 min per cleaning solvent before spin casting. Blend films were prepared by spin casting the solution on glass substrates at 1000 rpm for 60 s to yield the active layer thickness of ~100 nm.

Figure 1 (a, b) shows the atomic force microscopy topography image of PPDT2FBT:PCBM and PPDT2FBT-A:PCBO12 blends. We observed the roughness of 12 nm in PPDT2FBT:PCBM blend from polymer with aliphatic sidechain in contrast to 120 roughness in OEG based polymer blend PPDT2FBT-A:PCBO12. We also observed the smooth phase separation with inter-penetrating mesh-like networks in former blend as shown in Figure 2 (a, b). Our results indicate that the difference in performance of these solar cells is due to the differences in charge generation and transport resulted from morphological variation.

Corresponding Author: *bgautam@uncfsu.edu

This work was supported by NSF PREM (DMR 1827731), NSF RIA (HRD 1900998) and NSF (ECCS-1900837). Prof. Bumjoon Kim from Korea Advanced Institute of Science Technology and Han Young Woo from Korea University are acknowledged for supplying donor polymers and acceptors.

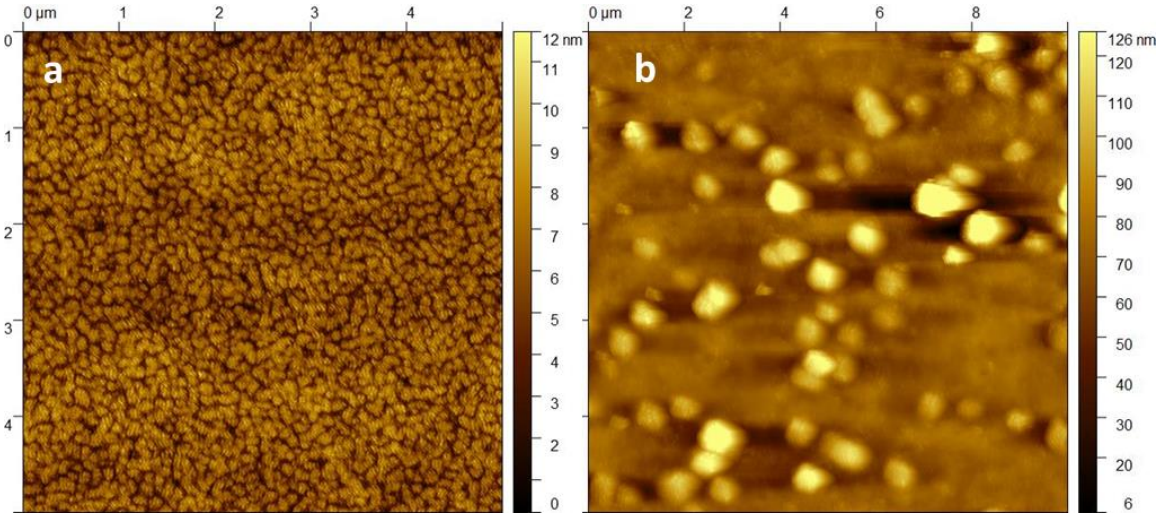

Figure 1. Atomic force microscopy topography image of (a) PPDT2FBT:PC61BM and (b) PPDT2FBT-A:PCBO12 blend.

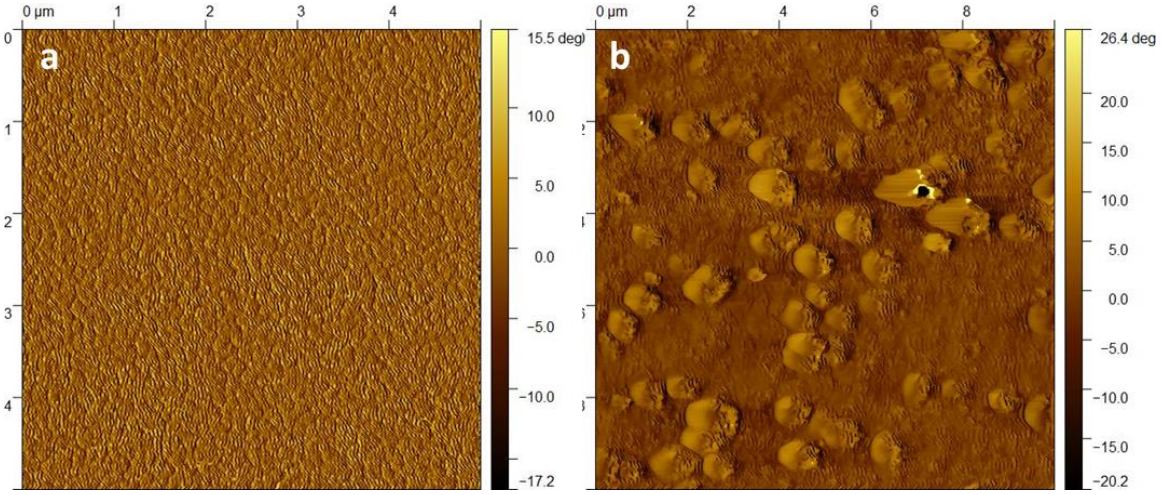

Figure 2. Atomic force microscopy phase image of (a) PPDT2FBT:PC61BM and (b) PPDT2FBT-A:PCBO12 blend.

References

[1] L. Tanet, et. al., Adv. Sci., **6** (2019) 1801180.
[2] S. Venkatesan, et. al., Energy Technol., **2** (2014) 269-274.
[3] Y. Cui, et. al., Nat. Commun., **10** (2019) 2515.
[4] K. Li, et. al., Adv. Energy Mater., **9** (2019) 1901728.
[5] J et. al., Nat. Energy, **1** (2016) 1-7.
[6] Z. Chen, et. al., ACS Appl. Poly. Mater., **1** (2019) 804-814.
[7] Y. Kim, et. al., Chem. Mater., **30** (2018) 5663-5672.
[8] T. Nguyen, et. al., Energy Environ. Sci., **7** (2014) 3040-3051.
[9] C. Lee, et. al., Adv. Energy Mater., **8** (2018) 1870149.

https://doi.org/10.1017/S1431927620021388 Published online by Cambridge University Press