Immerse Precipitation as an Efficient Protocol to Optimize Morphology and Performance of Organic Solar Cells

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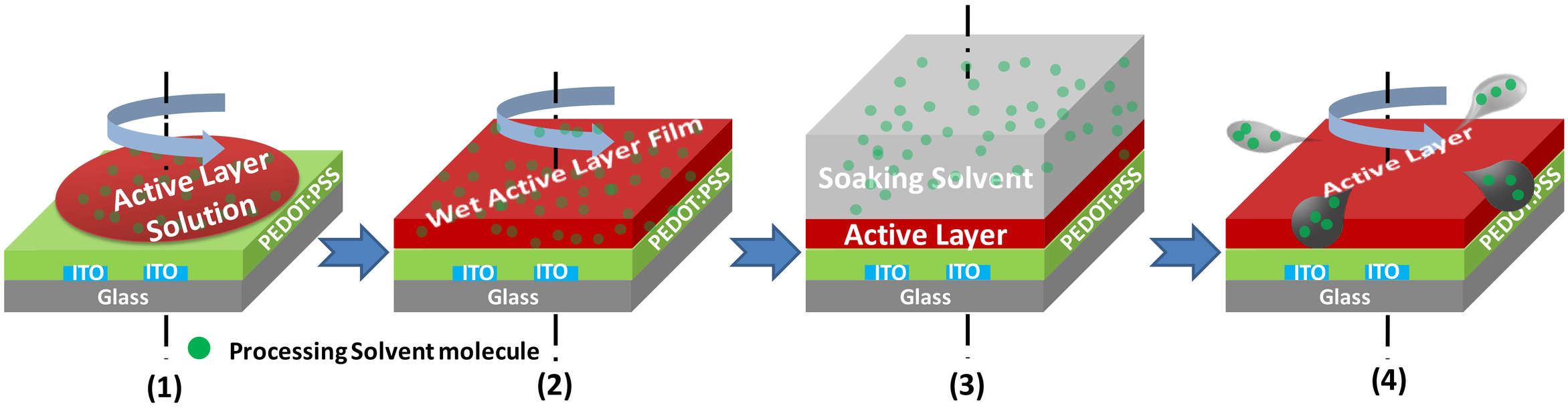
Here, we demonstrate a effective protocol for morphology control and device optimization. With this procedure, controlled morphology and optimized device performance were obtained.

A. The so-called “immerse precipitation” procedure (I.P. for short) goes as follow:



Scheme 1. (1). active layer solution was spin-casted onto glass/ITO/PEDOT:PSS substrates; (2). the wet active layer film containing certain amount of processing solvents were formed by spin-coating; (3) soaking solvent, which was selectively soluble for the processing solvent but the active layer materials (donors or acceptors), was dropped onto the wet active layer film. Immediately the solvent in the wet active layer film is absorbed by the soaking solvent and the dried active layer is formed. (4). after a few seconds, the soaking solvent which contain processing solvents is removed by spinning at high speed.

B. Device performance.

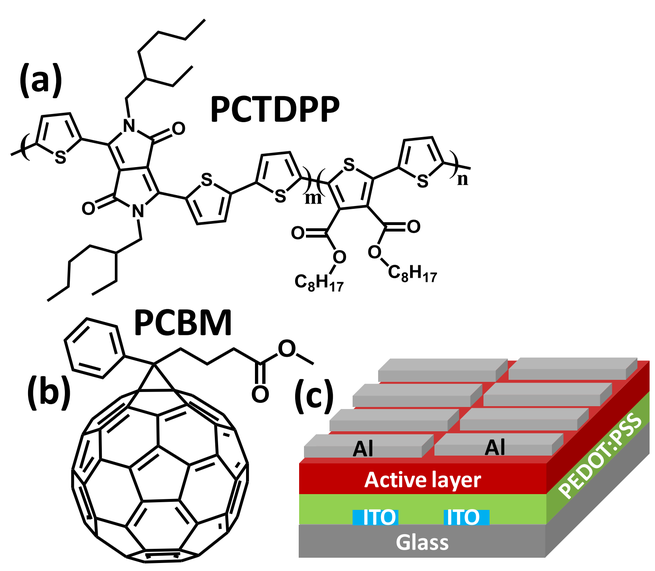


Figure 1. Molecular structure of active layer materials: (a) PCTDPP, (b) PCBM, and (c) device structure

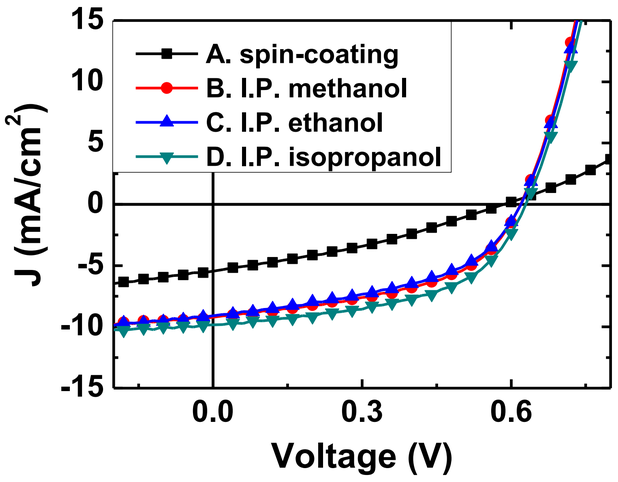


Figure 2. I-V characteristic of device processed using different procedures: Device A, traditional spin-coating, B, immerse precipitation by methanol, C, immerse precipitation by ethanol, D, immerse precipitation by isopropanol. As shown, the devices with immerse precipitation show much better performance compared to those with traditional spin-coating.

Table I detailed device parameters for device A, B, C, and D.

Device	Soaking solvent	Device parameters			
		J_{SC} mA/cm^2	V_{OC} V	PCE %	FF
A	Spin dry	5.6	0.58	1.04	0.32
B	methanol	9.2	0.62	2.8	0.49
C	ethanol	8.8	0.62	2.56	0.47
D	isopropanol	10.2	0.62	3.2	0.51

C. Active layer morphology.

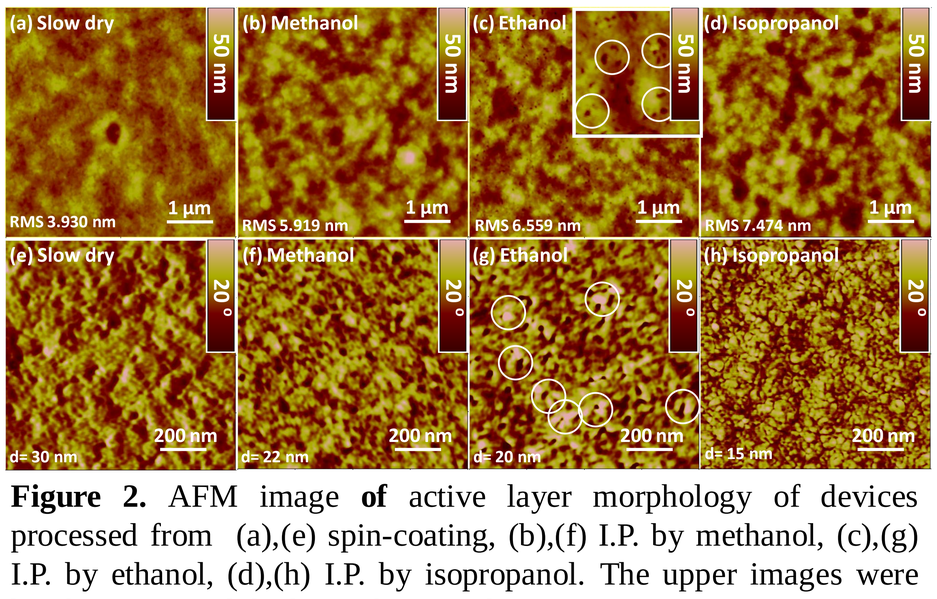


Figure 2. AFM image **of** active layer morphology of devices processed from (a),(e) spin-coating, (b),(f) I.P. by methanol, (c),(g) I.P. by ethanol, (d),(h) I.P. by isopropanol. The upper images were height image and the beneath were phase images.

D. Absorption.

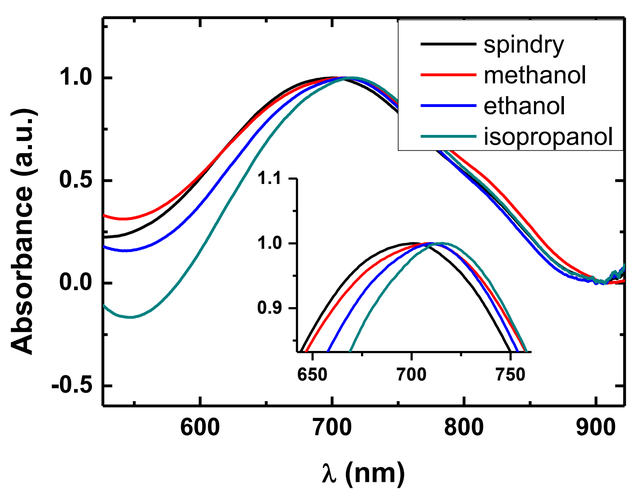


Figure 2. Absorption of device processed from spin-coating and I.P. by different soaking solvents. Red-shift were observed.

E. Conclusion.

We developed a novel immerse precipitation processing protocol for device preparation, where the wet active layer was solidified by immersing into soaking solvent, which is selectively soluble for the processing solvents but hardly soluble for active layer materials. And we demonstrate it is a promising method for morphology control and device optimization in OSCs.

F. Acknowledgment.

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G. Reference.

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[2] Hu, X.; Zuo, L.; Fu, W.; Larsen-Olsen, T. T.; Helgesen, M.; Bundgaard, E.; Hagemann, O.; Shi, M.; Krebs, F. C.; Chen, H. J. Mater. Chem. 2012, 22, 15710.