Low-cost and green fabrication of polymer solar cell active layers by push-coating

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Recent studies clearly demonstrate that the power conversion efficiencies (PCEs) of polymer solar cells (PSCs) can now overcome the milestone value of 10%.[1] This renewable energy technology is often regarded as a low-cost alternative to silicon and other inorganic solar cells. However, the price of the newly introduced materials for efficient PSC fabrication can be as high as 10 USD/mg. Furthermore, spin-coating is commonly used as the thin film deposition method for active layer fabrication from chlorinated solvents. Consequently, large amounts of active material and hazardous chlorinated solvent wastes are generated as the solution is ejected out of the substrate by centrifugal forces during spin-coating. As a result, alternative thin film deposition techniques which employ non-hazardous solvents (e.g., water-based suspensions)[2] and/or reduce the amount of active material wastes (e.g., spray-coating) have been developed.

Here, we present our study on the push-coating technique which enables to easily recycle the small amount of employed hazardous solvent and virtually generates no active material waste. When a thick polydimethylsiloxane (PDMS) film is placed on top of a few µl of active layer solution, the solution spreads through capillary forces and forms a uniform wet film. The solvent then slowly diffuses and gets trapped into PDMS. The solvent swollen PDMS can then be easily removed from the surface of dried thin film with enhanced crystallinity without damaging their surface and the trapped solvent can be recycled.[3]

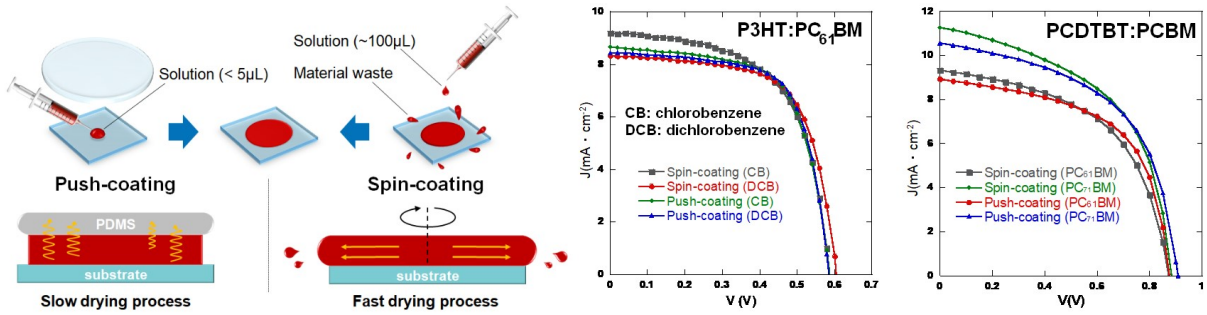

Figure. *Schematic representation and J-V characteristics of PSCs prepared using spin-coating and push-coating*

Using two of the most widely employed conjugated polymers for PSC fabrication, namely, P3HT and PCDTBT, we demonstrate that similar or higher PCEs than spin-coated PSCs can be obtained in push-coated PSCs while using 20 to 50 times less hazardous solvent and active material. In particular, using 2 µl of PCDTBT:$PC_{71}BM$ solution in dichlorobenzene, we fabricated inverted push-coated devices with an average PCE of 5.2%. Push-coating can virtually be applied to any PSC active layer and therefore opens the path to extremely low-cost and green fabrication of efficient sustainable energy devices.

[1] V. Vohra *et al. Nature Photonics 9*, 403-408 (**2015**)
[2] S. Zappia *et al. Advanced Sustainable Systems* (*in press*)
[3] V. Vohra *et al. ACS Applied Materials & Interfaces 9*, 25434–25444 (**2017**)