SYNTHESIS, CHARACTERIZATION AND APPLICATION OF NOVEL FULLERENE DERIVATIVES IN PEROVSKITE SOLAR CELLS

Kasjan Misztal, Konrad Wojciechowski, Rosinda Fuentes Pineda

Saule Research Institute Foundation, Wroclaw, Poland

Perovskite Solar Cells (PSC) gained a lot of interest in the photovoltaic community due to the surprising and rapid improvement in power conversion efficiency from the mere 3.8% in 2009 to 23.7% in 2018 [1]. Maybe one of the key early discoveries in perovskite research was demonstrated ambipolar character of perovskite semiconductor. This allowed large versatility in possible architectures, designs and available materials for processing perovskite solar cells. P-i-n architecture, where perovskite material is sandwiched between hole selective material (processed bedore perovskite) and electron selective material (processed on top of perovskite layer) has several advantages, including lower hysteresis, potentially superior stability [2], facile processing. Charge transporting layers are crucial for extraction of electrons and holes, which are generated inside the perovskite layer and transported towards respective contacts. Strict requirements regarding facile layer formation at low temperatures are extremely important for Electron Transporting Material (ETM) which is deposited on top of perovskite layer in p-i-n architecture. One of the most commonly used materials is PCBM (phenyl-C61-butyric acid methyl ester). [3] Despite high efficiencies of solar cells achieved with this material, it possess certain drawbacks, including poor film formation, high synthesis cost, non-ideal electronic contact with perovskite and limited possibility to tune its properties by chemical synthesis. Therefore, there is a growing interest in developing novel materials which possess all the advantages of native PCBM and at the same time can overcome the drawbacks. Already existing alternatives include fullerene-indene adducts. [4] Researchers proved that these molecules exhibit better properties in case of electronic contact, wettability and overall power conversion efficiency of respective solar cells. [5] However, these molecules are limited in terms of possible modifications via synthetic approach. The new solution enabling the synthesis of novel indenes [6] was adopted and series of fullerene adducts was synthesized, tested and evaluated after integration in PSCs.

Acknowledgments: The authors are grateful to the National Science Centre (Poland) for the NCN Opus grant no. UMO-2016/23/B/ST5/02861.

---

[1] https://www.nrel.gov/pv/assets/images/efficiency-chart.png

[2] Saliba, M.; Stolterfoht, M.; Wolff, C. M.; Neher, D.; Abate, A. Measuring Aging Stability of Perovskite Solar Cells. Joule 2018, 2, 1019−1024

[3] Luo, D. ; Yang, W. ; Wang, Z. ; Sadhanala, A. ; Hu, Q. ; Su, R. ; Shivanna, R. ; Trindade, G. F. ; Watts, J. F. ; Xu, Z. ; Liu, T. ; Chen, K. ; Ye, F. ; Wu, P. ; Zhao, L. ; Wu, J. ; Tu, Y. ; Zhang, Y. ; Yang, X. ; Zhang, W.; Friend, R. H. ; Gong, Q. ; J. Snaith, H. ; Zhu, R., Enhanced photovoltage for inverted planar heterojunction perovskite solar cells Science, 2018, 360, 1442-1446

[4] Sieval, A. B., Treat, N. D., Rozema, D., Hummelen, J. C., Stingelin, N., Diels–Alders adducts of C60 and esters of 3-(1-indenyl)-propionic acid: alternatives for [60]PCBM in polymer:fullerene solar cells, Chem.Comm. 2015, 51, 8126-8129.

[5] Gil-Escrig, L., Momblona, C., Sessolo, M., Bolink, H. J., Fullerene imposed high open-circuit voltage in efficient perovskite based solar cells, J. Mater. Chem. A 2016, 4, 3667-3672.

[6] Jana, A., Misztal, K., Żak, A., Grela, K., Synthesis of Selectively Substituted or Deuterated Indenes via Sequential Pd and Ru Catalysis, J. Org. Chem. 2017, 82 (8), 4226–4234.