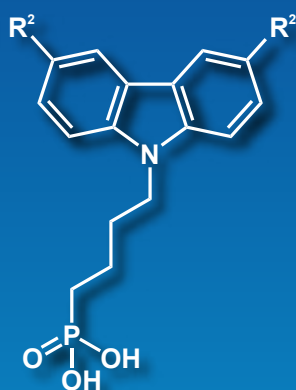


For Highly Efficient Solar Cells, Hole-Selective, Self-Assembled Monolayer (SAM)-Forming Agents



2PACz series



4PACz series

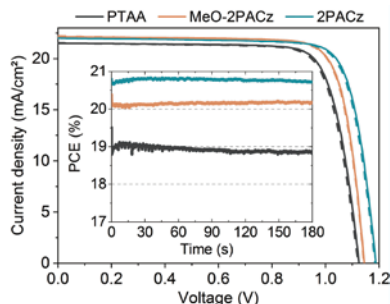
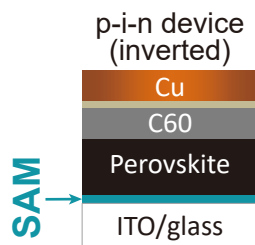
R ¹	Product Name	Size	Product No.
H	2PACz	500mg	[C3663]
MeO	MeO-2PACz	500mg	[D5798]
Me	Me-2PACz	500mg	[M3477]
Br	Br-2PACz	500mg	[B6391]

R ²	Product Name	Size	Product No.
H	4PACz	500mg	[P2995]
MeO	MeO-4PACz	500mg	[M3549]
Me	Me-4PACz	500mg	[M3359]
Br	Br-4PACz	500mg	[B6445]

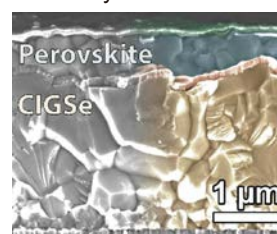
Advantages

- Enable efficient, versatile and stable solar cell devices without additives, interlayers or dopants
- Self-assembly leads to conformal coverage of oxide surfaces (including textured)
- Simple, scalable and extremely cost-effective processing

Application



Efficiency on 1 cm² = 23.26%



SAM
oxide

World-record CIGSe/perovskite tandem enabled by conformal SAM

Stabilized power conversion efficiencies of PSC and OPV with self-assembled monolayer (SAM):

SAM	CsMAFA	MAFA	Co-evaporated MAPbI ₃	Slot-die coated MAPbI ₃	CIGSe/CsMAFA tandem	Silicon/CsMAFA tandem	OPV Ternary BHJ
2PACz	20.8% ¹⁾	21.1% ¹⁾	-	20.8% ⁵⁾	-	27.36% ³⁾	18.03% ⁴⁾
MeO-2PACz	20.2% ¹⁾	21.1% ¹⁾	20.6% ²⁾	-	23.26%, certified ¹⁾	28.60% ³⁾	-
Me-4PACz	20.8% ³⁾	-	-	-	24.16% certified ⁶⁾	29.15%, certified ³⁾	-
Br-2PACz	-	-	-	-	-	-	18.4% ⁷⁾

(CsMAFA = Cs_{0.05}(MA_{0.17}FA_{0.83})_{0.95}Pb(I_{0.83}Br_{0.17})₃, MAFA = MA_{0.05}FA_{0.95}Pb(I_{0.95}Br_{0.05})₃, Cs = cesium, MA = methylammonium, FA = formamidinium, CIGSe = copper indium gallium selenide)

* These data are from References below:

- 1) A. Al-Ashouri, A. Magomedov, V. Getautis, S. Albrecht, *et al.*, *Energy Environ. Sci.* **2019**, 12, 3356. <https://doi.org/10.1039/C9EE02268F>
- 2) M. Roß, S. Albrecht, *et al.*, *ACS Appl. Mater. Interfaces* **2020**, 12, 39261. <https://doi.org/10.1021/acsami.0c10898>
- 3) A. Al-Ashouri, A. Magomedov, V. Getautis, S. Albrecht, *et al.*, *Science* **2020**, 370, 1300. <https://doi.org/10.1126/science.abd4016>
- 4) Y. Firdaus, T. D. Anthopoulos, *et al.*, *ACS Energy Lett.* **2020**, 5, 2935. <https://doi.org/10.1021/acsenrgylett.0c01421>
- 5) J. Li, A. Abate, E. Unger, *et al.*, *Adv. Energy Mater.* **2021**, 11, 2003460. <https://doi.org/10.1002/aenm.202003460>
- 6) NREL Best Research-Cell Efficiency Chart <https://www.nrel.gov/pv/cell-efficiency.html>
- 7) Y. Lin, A. Magomedov, V. Getautis, T. D. Anthopoulos, *et al.*, *ChemSusChem* **2021**, 14, 3569. <https://doi.org/10.1002/cssc.202100707>

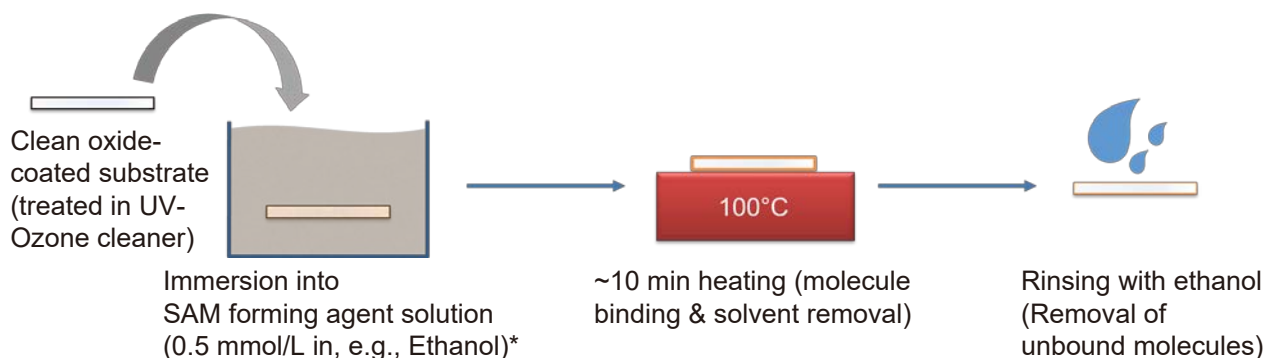
The 2PACz and 4PACz series are covered by a joint patent pending (PCT/EP2019/060586) of Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Germany and Kaunas University of Technology, Lithuania. TCI has been granted the right to manufacture and sell these materials.

For Highly Efficient Solar Cells, Hole-Selective, Self-Assembled Monolayer (SAM)-Forming Agents

Processing

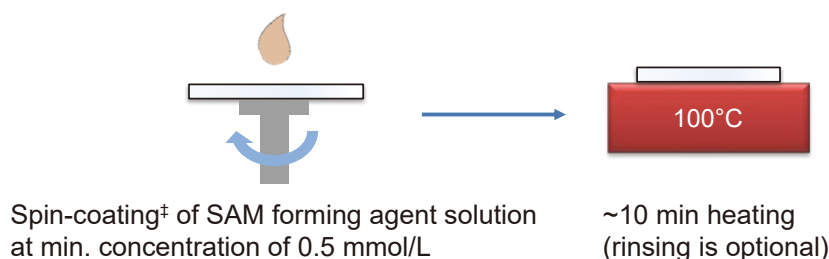
Method 1: Dip coating

suitable for large-area coating and textured substrates



Method 2: Spin coating

suitable for fast research & optimization



* The minimum needed dipping time can vary from minutes to hours. After some further testing with 2PACz, researchers found more reproducible results with rather 0.5 mmol/L and 5 min dipping. Note that optimal concentration and dipping time may vary depending on the used substrate oxide and pre-treatment.

- The SAM forming agents can be processed within wide processing windows with higher reproducibility than current standard hole transport materials (like PTAA). The substrates (e.g. ITO) have to be clean and activated by, for example, UV-Ozone treatment.
- The SAM forming agent powders were usually dissolved in ethanol or isopropanol (1 mmol/L $\approx$ 0.3 mg/mL), MeO-2PACz powder was stored in air, while 2PACz and Me-4PACz were stored in a nitrogen gas-filled glovebox.

[‡]For more details, see supplementary information of the following reference.

A. Al-Ashouri, A. Magomedov, V. Getautis, S. Albrecht, *et al.*, *Energy Environ. Sci.* **2019**, 12, 3356. <https://doi.org/10.1039/C9EE02268F>

*These data are provided by Prof. Steve Albrecht and Prof. Vytautas Getautis.

For further information please refer to our website at www.TCIchemicals.com. >>> TCI solar cell

Ordering and Customer Service

TCI AMERICA

Tel : 800-423-8616 / 503-283-1681
Fax : 888-520-1075 / 503-283-1987
E-mail : Sales-US@TCIchemicals.com

TCI EUROPE N.V.

Tel : +32 (0)3 735 07 00
Fax : +32 (0)3 735 07 01
E-mail : Sales-EU@TCIchemicals.com

TCI Deutschland GmbH

Tel : +49 (0)6196 64053-00
Fax : +49 (0)6196 64053-01
E-mail : Sales-DE@TCIchemicals.com

Tokyo Chemical Industry UK Ltd.

Tel : +44 (0)1865 78 45 60
E-mail : Sales-UK@TCIchemicals.com

TCI Chemicals (India) Pvt. Ltd.

Tel : 1800 425 7889 / 044-2262 0909
E-mail : Sales-IN@TCIchemicals.com

梯希爱(上海)化成工业发展有限公司

Tel : 800-988-0390 / 021-67121386
Fax : 021-6712-1385
E-mail : Sales-CN@TCIchemicals.com

TOKYO CHEMICAL INDUSTRY CO., LTD.

Tel : +81 (0)3-5640-8878
E-mail : globalbusiness@TCIchemicals.com

Availability, price or specification of the listed products are subject to change without prior notice. Reproduction forbidden without the prior written consent of Tokyo Chemical Industry Co., Ltd.