MATERIALS

Perovskite's Guide Book

TCI · SEJIN CI

Three Advantages of TCI's Perovskite-Related Products

High Purity

We can provide high purity PbX_2 (X = I, Br, Cl) as well as organic onium salts with low water content (eg. MAI, FAI, etc). High purity and low water materials can enhance the perovskite solar cell performance such as efficiency and stability. Highly pure PbX_2 shows good solubility in polar organic solvents to be appropriate for solution processable device fabrication of the perovskite solar cell.

Product Variety

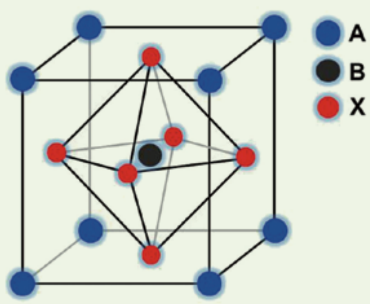
We can provide various PbX_2 (X = I, Br, Cl) and organic onium salts. A mixed cation perovskite where the A site includes some cations, enables the perovskite solar cell to be efficient and stable.

Scale -Up

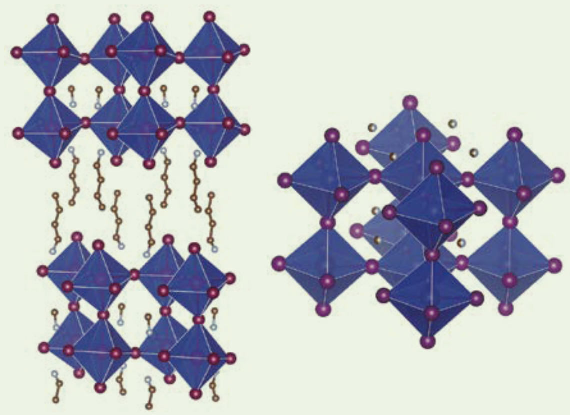
We can provide various PbX_2 (X = I, Br, Cl) and some dominant organic onium salts in bulk scale. Our bulk production enables the perovskite solar cell to be low cost and large area.

Organic-Inorganic Perovskite Precursors

"Perovskite" originates from the mineral name of calcium titanate ($CaTiO_3$) and the compounds with formula of ABX_3 generally belong to a perovskite-type compound, where the A is a divalent and B is a tetravalent metal ion. A perovskite with cubic or orthorhombic phases shows ferroelectricity, for instance, barium titanate ($BaTiO_3$) is a ferroelectric or piezoelectric material. High temperature superconductive oxides with a unit of copper oxide are obtained from all perovskite compounds. These perovskite compounds consist of metal ions and oxygen atoms, and are manufactured by a physical procedure (eg. sintering method). Modification of the metal ion and a changing ratio of the metal ion components can drastically control physical properties of the perovskite. In addition to the oxide perovskites, halide-based perovskites are also well known.



On the other hand, one can replace the cationic component with an organic ammonium at the A site. In this case, a chemical method can provide a perovskite compound. This perovskite compound is called an "organic-inorganic perovskite compound", because it contains an organic component. A metal ion component usually involves tin or lead. This perovskite compound has the general formula $[(RNH_3)_mMXn]$, in which modifications of metal (M), halide (X) and organic groups (R) precisely control physical properties. Among them, the tin perovskite is relatively better for electrical conduction, and the lead one is better for optical properties. A chemical modification of the halide controls band gap. Selection of organic onium halide, metal halide and their mixing ratio changes the component ratio of the halide. The organic groups are selected from methyl, long alkyls, phenyl, benzyl, phenethyl and so on. Diversity of these organic groups allows controlling the structure of a perovskite compound. For instance, a perovskite compound with R = methyl provides $[(MeNH_3)MX_3]$ having a three-dimensional cubic perovskite structure. A perovskite compound with R = C_nH_{2n+1} ($n \geq 2$) provides a two-dimensional perovskite layer and the length of alkyl group can control the inter-layer distance.



An application of an organic-inorganic perovskite is a perovskite solar cell. This solar cell can usually be fabricated by the three-dimensional cubic perovskite $[(MeNH_3)MX_3]$. Doping effects of formamidinium and cesium cations to the A site were also investigated for the perovskite solar cell research. Wakamiya *et al.* recently developed a ready-to-use perovskite precursor, $MeNH_3I/PbI_2$-DMF complex, enabling us to fabricate a well-uniformed crystalline film by a solution method. Research on the perovskite solar cell recently received much attention. Power conversion efficiency of this solar cell is more than those of organic photovoltaics (OPV) and dye-sensitized solar cells (DSSC), and the device can be fabricated by a solution method at low cost.

n-i-p type Conventional Type

Au

Hole Transport Layer

- **B5672** TOP-HTM-α1
- **T3722** TOP-HTM-α2
- **T3672** Spiro-MeOTAD
- **P2513** P3HT (regioregular)
- B4682 4,4'-Bis[4-(di-p-tolylamino)styryl]biphenyl
- D5155 H101

Perovskite Materials

Perov. Material

BX_2 Site

- **L0279** **Lead(II) Iodide** (99.99%, trace metals basis)
- **L0288** **Lead(II) Bromide**
- **L0346** **Lead(II) Bromide** (Low water content)
- **L0291** **Lead(II) Chloride** (purified by sublimation)
- **L0292** **Lead(II) Chloride**
- **L0315** **Lead(II) Acetate**
- **T3449** **Tin(II) Iodide**
- **T3573** **Tin(II) Bromide**
- **T3570** **Tin(II) Chloride**

ABX_3

- C3570 Cesium Lead Triiodide (Low water content)
- C3569 Cesium Lead Tribromide (Low water content)

AX Site

- **F1263** **Formamidine Hydroiodide** (99.99%, trace metals basis)
- **F0974** **Formamidine Hydroiodide** (Low water content)
- F1244 Formamidine Hydrobromide (99.99%, trace metals basis)
- F0973 Formamidine Hydrobromide (Low water content)
- F0103 Formamidine Hydrochloride
- C2205 Cesium Iodide
- C2202 Cesium Bromide
- C2203 Cesium Chloride

Anti-solvent

- C1948 Chlorobenzene
- D3479 Diethyl Ether Anhydrous (stabilized with BHT)

Solvent

- D0939 N,N-Dimethylformamide [for Spectrophotometry]
- D0722 N,N-Dimethylformamide
- D5293 Dimethyl Sulfoxide [for Spectrophotometry]
- D0798 Dimethyl Sulfoxide

Au

Electron Transport Layer

TCO

TCO Etching

- Z0015 Zinc Powder
- H1202 Hydrochloric Acid(1mol/L)
- H1203 Hydrochloric Acid(2mol/L)

Glass

p-i-n type Inverted Type

Au

Electron Transport Layer

- **M2088** [6,6]-Phenyl-C61-butyric Acid Methyl Ester
- **P2682** [6,6]-Phenyl-C61-butyric Acid Methyl Ester (for organic electronics)
- **B4576** Bis-PCBM (mixture of isomers)
- **M2550** [6,6]-Phenyl-C71-butyric Acid Methyl Ester (mixture of isomers)
- **P2683** [6,6]-Phenyl-C71-butyric Acid Methyl Ester (mixture of isomers) (for organic electronics)
- **B1641** Fullerene C60 (pure)
- **B1694** Fullerene C70
- **P2744** N-Phenyl-2-hexyl[60]fulleropyrrolidine
- **D5757** N,2-Diphenyl[60]fulleropyrrolidine (contains 5% Hexane at maximum)
- **B2694** Bathocuproine (purified by sublimation)
- **D0711** Bathocuproine

Perovskite Materials

Perov. Material

BX_2 Site

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- **L0288** **Lead(II) Bromide**
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- **T3573** **Tin(II) Bromide**
- **T3570** **Tin(II) Chloride**

ABX_3

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- **C3569** Cesium Lead Tribromide (Low water content)

Anti-solvent

- **C1948** Chlorobenzene
- **D3479** Diethyl Ether Anhydrous (stabilized with BHT)

AX Site

- **F1263** **Formamidine Hydroiodide** (99.99%, trace metals basis)
- **F0974** **Formamidine Hydroiodide** (Low water content)
- **F1244** Formamidine Hydrobromide (99.99%, trace metals basis)
- **F0973** Formamidine Hydrobromide (Low water content)
- **F0103** Formamidine Hydrochloride
- **C2205** Cesium Iodide
- **C2202** Cesium Bromide
- **C2203** Cesium Chloride

Solvent

- **D0939** N,N-Dimethylformamide [for Spectrophotometry]
- **D0722** N,N-Dimethylformamide
- **D5293** Dimethyl Sulfoxide [for Spectrophotometry]
- **D0798** Dimethyl Sulfoxide

Au

Hole Transport Layer

- **D5798** MeO-2PACz
- **M3359** Me-4PACz
- **M3477** Me-2PACz
- **B6391** Br-2PACz
- **P2995** 4PACz
- **M3549** MeO-4PACz
- **B6445** Br-4PACz
- **P2524** Pentacene (99.999%, trace metals basis)
- **B2080** 1,4-Bis[4-(di-p-tolylamino)styryl]benzene
- **B4682** 4,4'-Bis[4-(di-p-tolylamino)styryl]biphenyl

TCO

TCO Etching

- **Z0015** Zinc Powder
- **H1202** Hydrochloric Acid(1mol/L)
- **H1203** Hydrochloric Acid(2mol/L)

Glass

Perovskite Precursor for Solar Cell Purified Lead(II) Iodide

Advantages

- PbI_2 [L0279] with extremely low water content for preparing a concentrated clear DMF solution.
- Fabricates efficient perovskite solar cell devices (PCE > 10%) with high reproducibility.

Comparison of an existing product and PbI_2 [L0279]

PbI_2 [L0279]

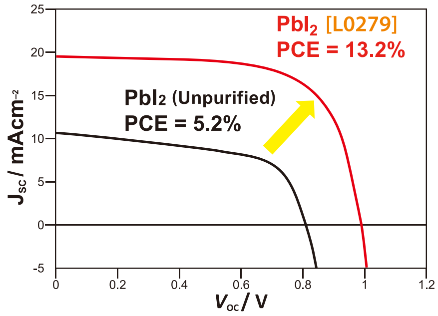
Cryst. solid

DMF soln.
(Clear, 1M)

An exist. product

DMF soln.
(Cloudy)

PCE



References A. Wakamiya, M. Endo, Y. Murata, Patent, Appl. No. JP2015-138822; A. Wakamiya, S. Hayase, Y. Murata, *Chem. Lett.* **2014**, *43*, 711.

PbI_2 [L0279] contributed efficient, stable and large area perovskite solar cells

PSC device system	PCE	Active area size	Stability and condition	Reference
$(FAPbI_3)_{0.85}(MAPbI_3)_{0.15}$ PTAA, SnO_2, ALD method	20%	0.16 cm^2	90 days, RH 20% in dark, uncapsulated	Lee, Nazeeruddin *et al., Adv. Sci.* **2018**, 1800130.
$(Rb/Cs/MA/FA)PbI_3$ Spiro-OMeTAD, TiO_2	19%	0.5 cm^2	500 H, 85 deg-C, under full solar illumination, polymer coated	Gratzel *et al., Science* **2016**, *354*, 206.
$BA_{0.05}(FA_{0.83}Cs_{0.17})Pb(I_{0.8}Br_{0.2})_3$ Spiro-OMeTAD, PCBM, SnO_2	17.5%	0.0919 cm^{-2}	1000 H in air, 4000 H in encapsulated	Snaith *et al., Nat. Energy* **2017**, *2*, 17135.
$FA_{0.98}Cs_{0.02}PbI_3$ Spiro-OMeTAD, SnO_2, Adduct approach	19.34%	0.1 cm^2	-	Yang *et al., J. Am. Chem. Soc.* **2018**, *140*, 6317.
$MAPbI_3$ Spiro-OMeTAD, PMMA, TiO_2	19.9%	0.1 cm^2	40 days, RH 40% in dark	Wakamiya, Matsuda *et al., Adv. Mater. Interfaces* **2018**, *5*, 1701256.
$FA_{0.5}MA_{0.5}Sn_{0.5}Pb_{0.5}I_3$ PEDOT:PSS, PCBM, C_{60}, BCP	17.6%	0.1 cm^2	-	Kapil, Segawa, Hayase *et al., Nano Lett.* **2018**, *18*, 3600.
$(FAPbI_3)_{0.85}(MAPbI_3)_{0.15}$ Spiro-OMeTAD, SnO_2, ALD method	18%	0.16 cm^2	30 days, uncapsulated, in dry air	Baena, Hagfelt *et al., Energy Environ. Sci.* **2015**, *8*, 2928.
$(FAPbI_3)_{0.83}(MAPbI_3)_{0.17}$ NiO, PCBM, SnO_2/ZTO, ALD method, with Si tandem	23.6%	1 cm^2	1000 H, 85 deg-C, RH 85%	McGehee *et al., Nat. Energy* **2017**, *2*, 17009.
$(5\text{-}AVA)_x(MA)_{1-x}PbI_3$ TiO_2/ZnO_2/Carbon, Monolithic solar module	10.74%	70 cm^2	2000 H, 25-30 deg-C, RH 65-70%	Mhaisalkar *et al., Energy Environ. Sci.* **2016**, *9*, 3687.

Lead(II) Iodide [for Perovskite precursor] (99.99%, trace metal basis) 1g / 5g / 25g / 100g / 1kg [L0279]

These products were commercialized by collaboration with Prof. Atsushi Wakamiya.

High Purity Perovskite Precursor
Purified Lead(II) Bromide

Advantages

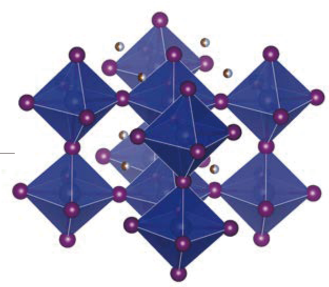
- **Water content <100 ppm**
- **Purity >99.8% (trace metal basis)**
- **Provides clear DMF solution**

Applications

Syntheses and applications of lead perovskite

$PbBr_2$ + MAX / FAX / CsX / etc. →

(X = Cl, Br, I)



Perovskite material

- √ **Solar cell device**
- √ **Light emitting device**
- √ **Laser device**

Lead(II) Bromide (Low water content) [for Perovskite precursor] 1g / 5g [L0346]

Related Products

Lead(II) Iodide (99.99%, trace metals basis) [for Perovskite precursor]	1g / 5g / 25g / 100g / 1kg	[L0279]
Lead(II) Bromide [for Perovskite precursor]	1g / 5g / 25g	[L0288]
Lead(II) Chloride (purified by sublimation) [for Perovskite precursor]	1g / 5g	[L0291]
Lead(II) Chloride [for Perovskite precursor]	1g / 5g / 25g	[L0292]

Perovskite Precursor
Lead Acetate Anhydrous

$Pb(OAc)_2$

Lead(II) Acetate
[for Perovskite precursor]
1g / 5g /25g
[L0315]

Advantages

- **Enables fast crystal growth of perovskites**
- **Provides ultrasmooth and pin-hole free perovskite film**
- **Fabricates perovskite device under anhydrous conditions**

Application for Perovskite Solar Cells (PSC)

Proposed formation mechanism of $CH_3NH_3PbI_3$ from $Pb(OAc)_2$ 1)

$$Pb(OAc)_2 + 3CH_3NH_3I \quad CH_3NH_3PbI_3 + 2CH_3NH_3(OAc)$$

[L0315]

Perovskite

$$2CH_3NH_3(OAc) \rightleftarrows 2CH_3NH_2 + 2AcOH$$

References PSC research data based on lead acetate precursor

1) PCE >10%: E. Mas-Marzá, I. Mora-Sero, *et al., J. Mater. Chem. A* **2015**, *3*, 9194.
2) PCE >17%: T. Singh, T. Miyasaka, *Chem. Commun*. **2016**, *52*, 4784.
3) PCE 14%: H. J. Snaith, *et al., Nat. Commun*. **2015**, *6*, 6142.
4) PCE >18%: T. P. Russell, H. J. Snaith, R. Zhu, Q. Gong, *et al., Adv. Funct. Mater.* **2016**, *26*, 3508.
5) PCE >13%: W. Qiu, H. J. Snaith, P. Heremans, *et al., Energy Environ. Sci.* **2016**, *9*, 484.
6) PCE >14%: M.-F. Lo, C.-S. Lee, *et al., ACS Appl. Mater. Interfaces* **2015**, *7*, 23110.

Related Products

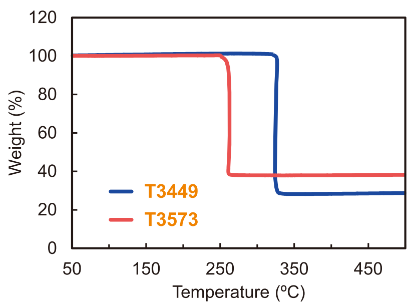
Lead(II) Iodide (99.99%, trace metals basis) [for Perovskite precursor]	1g / 5g / 25g / 100g / 1kg	[L0279]
Lead(II) Bromide [for Perovskite precursor]	1g / 5g / 25g	[L0288]
Lead(II) Chloride (purified by sublimation) [for Perovskite precursor]	1g / 5g	[L0291]
Lead(II) Chloride [for Perovskite precursor]	1g / 5g / 25g	[L0292]
Formamidine Hydroiodide (Water < 100 ppm) (= FAI)	1g / 5g / 25g	[F0974]

Perovskite Precursors
Tin(II) Iodide, Tin(II) Bromide

SnI_2	$SnBr_2$
Tin(II) Iodide	**Tin(II) Bromide**
[for Perovskite precursor]	[for Perovskite precursor]
1g / 5g	1g / 5g
[T3449]	[T3573]

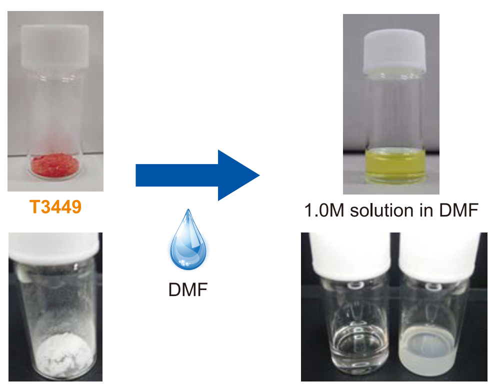
Advantages

- **High purity crystalline solids**
- **Extremely low Sn(IV) content**
- **Provide clear DMF solutions**
- **Low water content (T3449 : Water < 100 ppm)**



Thermogravimetric (TG) analysis of T3449 and T3573

- T3449 exhibits no mass loss at *ca.* 150 ºC indicating absence of SnI_4
- Single mass drop based on SnI_2 or $SnBr_2$



T3573

1.0M solutions in DMF
Left: T3573
Right: Before purification

- T3449 and T3573 provide clear DMF solutions suitable for perovskite precursors

Applications for Perovskite Solar Cells (PSC)

SnI_2 and $SnBr_2$ have been widely applied to lead-free and mixed metal perovskite solar cells

Examples of solvent-coordinated tin halide complexes as tin perovskite precursors

1) M. Ozaki, Y. Shimakawa, Y. Kanemitsu, A. Saeki, A. Wakamiya, *et al.*, *ACS Omega* **2017**, *2*, 7016.

Examples of lead-free perovskite solar cell research

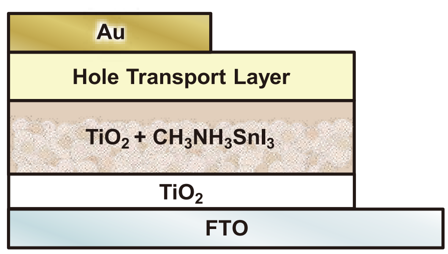
2) (PCE 11.5% $FA_{0.75}MA_{0.25}SnI_3$ in situ Sn(0) nanoparticle treatment) T. Nakamura, T. Sasamori, H. Ohkita, Y. Kanemitsu, A. Wakamiya, *et al.*, *Nat. Commun.* **2020**, *11*, 3008.

3) (PCE 9.0% $PEA_2FA_{24}Sn_{25}I_{76}$) S. Shao, J. Liu, G. Portale, H. Fang, G. R. Blake, G. H. ten Brink, L. J. A. Koster, M. A. Loi, *Adv. Energy Mater.* **2018**, *8*, 1702019.

Examples of mixed metal perovskite solar cell research

4) (PCE 14.8% $FA_{0.75}Cs_{0.25}Sn_{0.5}Pb_{0.5}I_3$ (single) 20.3%(tandem)) M. D. McGehee, H. J. Snaith, *et al.*, *Science* **2016**, *354*, 861

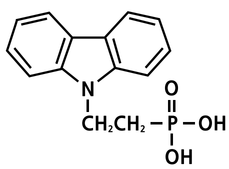
5) (PCE 21.4% $Cs_{0.1}FA_{0.6}MA_{0.3}Sn_{0.5}Pb_{0.5}I_3$ by maltol post-treatment) S. Hu, M. A. Truong, K. Otsuka, T. Handa, T. Yamada, R. Nishikubo, Y. Iwasaki, A. Saeki, R. Murdey, Y. Kanemitsu, A. Wakamiya, *Chem. Sci.* **2021**, *12*, 13513.



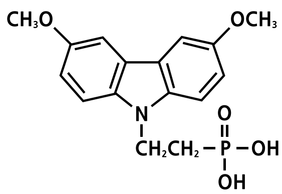
Typical device structure of lead-free perovskite solar cells

These products were commercialized by collaboration with Prof. Atsushi Wakamiya.

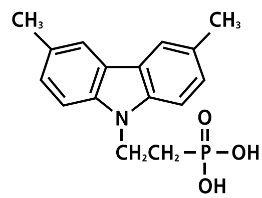
For Highly Efficient Solar Cells, Hole-Selective,
Self-Assembled-Monolayer (SAM) Forming Agent Series



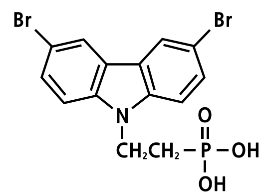
2PACz
500mg
C3663



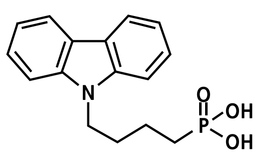
MeO-2PACz
500mg
D5798



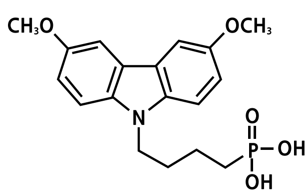
Me-2PACz
500mg
M3477



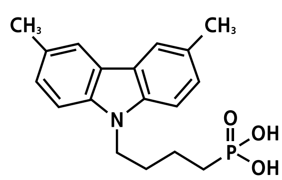
Br-2PACz
500mg
B6391



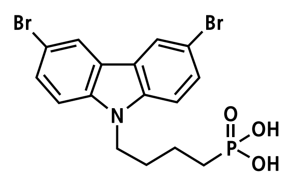
4PACz
500mg
P2995



MeO-4PACz
500mg
M3549



Me-4PACz
500mg
M3359



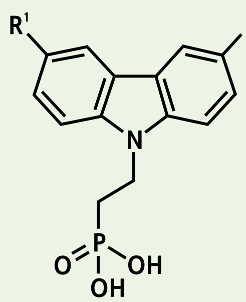
Br-4PACz
500mg
B6445

Advantages

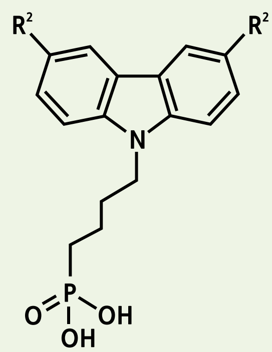
- Enable efficient, versatile and stable solar cell devices without additives, interlayers or dopants
- Self-assembly leads to conformal coverage of oxide surfaces (including textured)
- Simple, scalable and extremely cost-effective processing

For Highly Efficient Solar Cells, Hole-Selective,

Self-Assembled Monolayer (SAM) Forming Agents



2PACz series



4PACz series

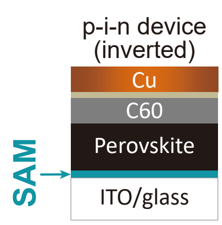
R[1]	Product Name	Size	Product No.
H	2PACz	500mg	**C3663**
MeO	MeO-2PACz	500mg	**D5798**
Me	Me-2PACz	500mg	**M3477**
Br	Br-2PACz	500mg	**B6391**

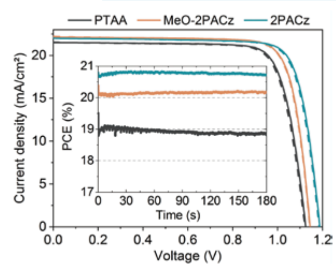
R[2]	Product Name	Size	Product No.
H	4PACz	500mg	**P2995**
MeO	MeO-4PACz	500mg	**M3549**
Me	Me-4PACz	500mg	**M3359**
Br	Br-4PACz	500mg	**B6445**

Advantages

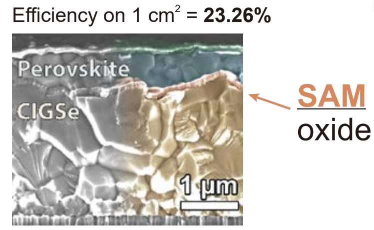
- **Enable efficient, versatile and stable solar cell devices without additives, interlayers or dopants**
- **Self-assembly leads to conformal coverage of oxide surfaces (including textured)**
- **Simple, scalable and extremely cost-effective processing**

Application





Efficiency on 1 cm² = **23.26%**



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/acsenergylett.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

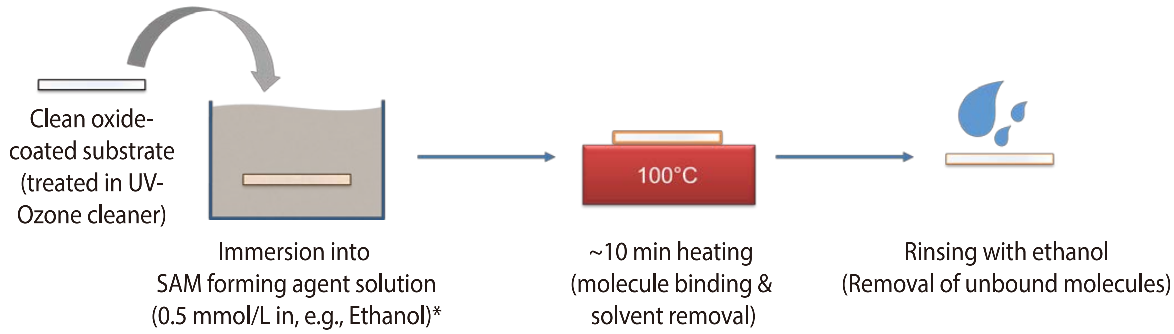
The 2PACz and 4PACz series are covered by a joint patent pending (PCT/EP2019/060586) of Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Germany and Kaunas University of Technology, Lithuania. TCI has been granted the right to manufacture and sell these materials.

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

Processing

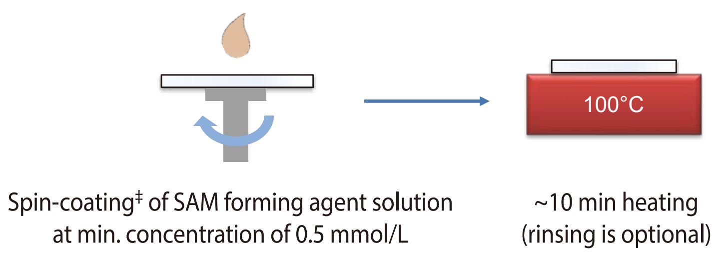
Method 1 : Dip coating

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 ≈ 0.3 mg/mL), MeO-2PACz powder was stored in air, while 2PACz and Me-4PACz were stored in a nitrogen gas-filled glovebox.**

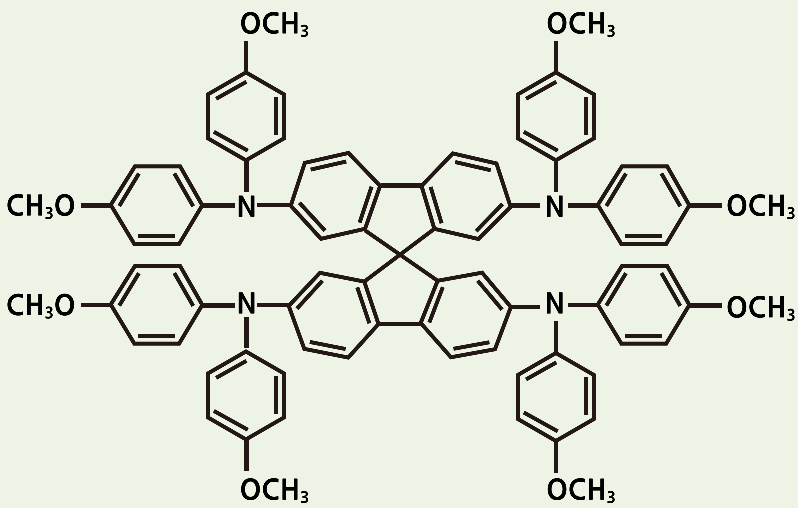
‡For more details, see supplementary information of the following reference.

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

Hole Transport Material Spiro-OMeTAD



Spiro-OMeTAD
1g / 5g
[T3672]

Advantages

- **Can be used as a hole transport material for perovskite solar cells, perovskite EL devices, dye-sensitized solar cells, and organic EL devices, etc.**
- **Suitable for solution process**
- **HOMO -5.0 eV**
  LUMO -1.5 eV
  (by photoemission spectroscopy)[1)]

References

1) Interface energetics in organo-metal halide perovskite-based photovoltaic cells
P. Schulz, E. Edri, S. Kirmayer, G. Hodes, D. Cahen, A. Kahn, *Energy Environ. Sci.* **2014,** *7,* 1377. https:/doi.org/10.1039/C4EE00168K

2) Mini-Review on Efficiency and Stability of Perovskite Solar Cells with Spiro-OMeTAD Hole Transport Layer : Recent Progress and Perspectives G. Tumen-Ulzii, T. Matsushima, C. Adachi, *Energy Fuels* **2021**, *35*, 18915. https://doi.org/10.1021/acs.energyfuels.1c02190

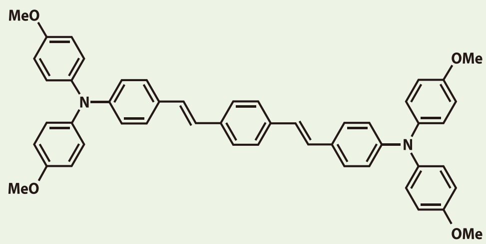
3) Lessons learned from spiro-OMeTAD and PTAA in perovskite solar cells
F. M. Rombach, S. A. Haque, T. J. Macdonald, *Energy Environ. Sci.* **2021,** *14,* 5161. https://doi.org/10.1039/D1EE02095A

Related Products

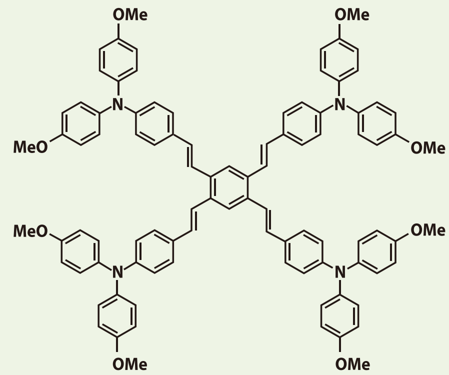
Lithium Bis(triuoromethanesulfonyl)imide (= LiTFSI)	25g / 250g	[B2542]
TOP-HTM-α1	1g / 5g / 25g	[B5672]
TOP-HTM-α2	1g / 5g / 25g	[T3722]

For further information please refer to our website at www.TCIchemicals.com. ▶▶▶ **TCI transport materials**

For Stable Perovskite Solar Cells, Hole Transport Materials : TOP-HTM



TCI Original & Practical Hole Transport Materials



TOP-HTM-α1
1g / 5g / 25g
[B5672]

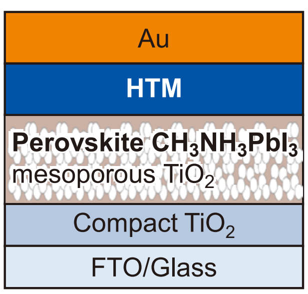
TOP-HTM-α2
1g / 5g / 25g
[T3722]

Advantages

- **Realize a high PCE both with or without additives**
- **Realize a highly stable perovskite solar cell with low cost**

Applications

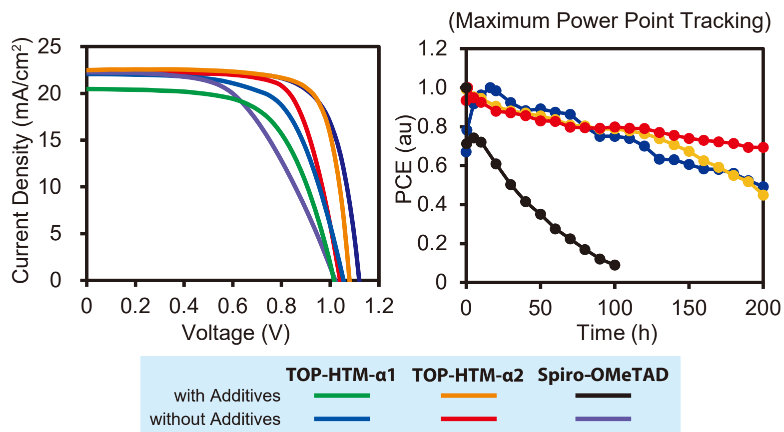
Device Structure



Device Performances

Device Performances

(Maximum Power Point Tracking)



Power Conversion Efficiency (PCE)

	TOP-HTM-α1	TOP-HTM-α2	Spiro-OMeTAD
with Additives	13.1%	18.6%	18.4%
without Additives	15.0%	16.6%	12.1%

***These data are from the following reference.**

H. Nishimura, I. Okada, T. Tanabe, T. Nakamura, R. Murdey, A. Wakamiya, *ACS Appl. Mater. Interfaces* **2020,** *12,* 32994.
http://doi.org/10.1021/acsami.0c06055

Device Fabrication Process

Preparation of HTM solution

1. With additives

HTMs are dissolved in chlorobenzene at concentration of 40 mg/mL with additives.

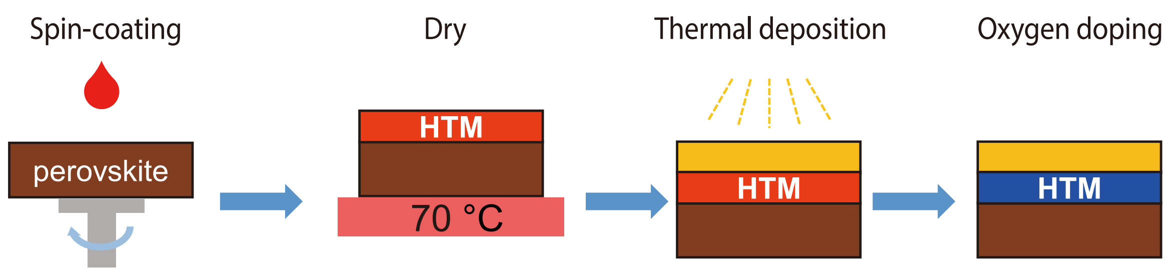
- **TOP-HTM-α1**
  The amount of LiTFSI and TBP are 4.8 mg and 15.2 μL for 1 mL of HTM solution.
  HTM solution is heated at 70 °C.

- **TOP-HTM-α2**
  The amount of LiTFSI and TBP are 6.0 mg and 19.0 μL for 1 mL of HTM solution.
  HTM solution is heated at 85 °C.

2. Without additives

HTMs are dissolved in 1,1,2,2-tetrachloroethane at concentration of 40 mg/mL.
HTM solution is heated at 70 °C.

Fabrication of devices



1) In a glove box filled with N2 gas, hole transport layers are deposited on the perovskite layer by spin-coating (slope 5 s, 4000 rpm 30 s, slope 5 s).
2) The resulting film is dried on a hot plate at 70 °C for 30 min.
3) A metal electrode (Au, etc.) is thermally deposited on the hole transport layer.
4) The solar cell devices are stored in air with ~20% relative humidity to promote oxygen doping.

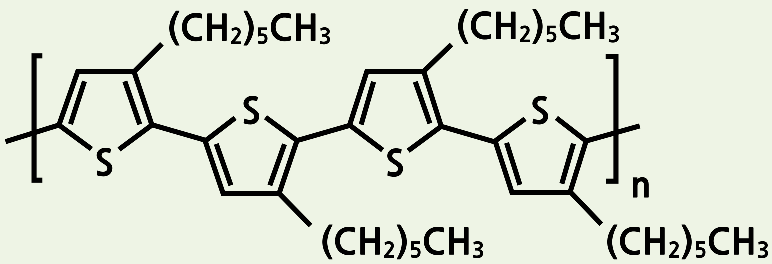
For more details, see the following reference.
H. Nishimura, I. Okada, T. Tanabe, T. Nakamura, R. Murdey, A. Wakamiya, *ACS Appl. Mater. Interfaces* **2020,** *12,* 32994.
http://doi.org/10.1021/acsami.0c06055

Related Products

Lithium Bis(trifluoromethanesulfonyl)imide (= LiTFSI)	25g / 250g	[B2542]
4-*tert*-Butylpyridine (= TBP)	5g / 25g	[B0388]

For further information please refer to our website at www.TCIchemicals.com. ▶▶▶ TCI perovskite

Organic Semiconducting Polymer
Highly Regioregular P3HT

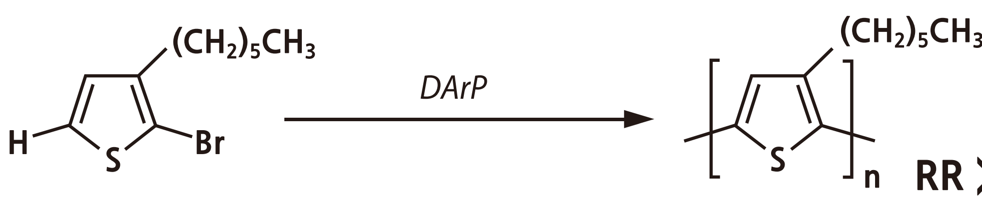


P3HT (regioregular) [for organic electronics]
100mg / 500mg
[P2513]

Advantages

- **High regioregularity (RR) >99.0%**
- **Number average molecular weight : M_n = 27,000 - 45,000**
- **Electronic material grade: High purity, low metal (Pd <100 ppm)**
- **Highly soluble, excellent to film**

Synthesis of P3HT by direct arylation polymerization (DArP) and physical properties[1,2)]



DArP = Direct Arylation Polymerization

[P2513]

RR > 99.0%

The data is extracted from Ref. 2)

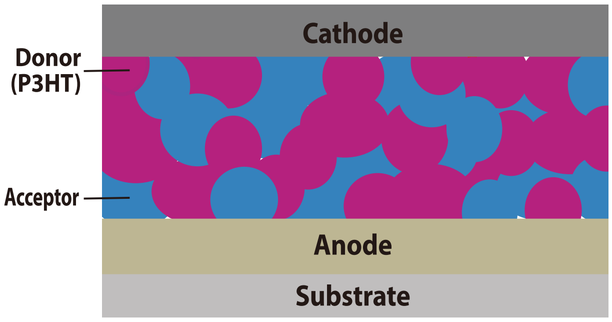
Method	M_n (PDI)	RR /%	T_m (°C)	μ_{max} (cm²/V·s)
DArP	33,000 (1.8)	99.5	237	0.19
Rieke	25,000 (1.3)	95.5	224	0.02
GRIM	88,000 (1.5)	98.0	234	0.11

References 1) Q. Wang, R. Takita, Y. Kikuzaki, F. Ozawa, *J. Am. Chem. Soc.* **2010,** *132,* 11420.
2) J.-R. Pouliot, M. Wakioka, F. Ozawa, Y. Li, M. Leclerc, *Macromol. Chem. Phys.* **2016,** *217,* 1493.

This product was commercialized under instruction by Prof. Fumiyuki Ozawa.

Applications

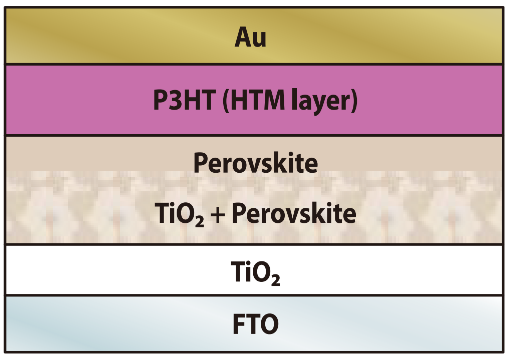
Organic Photovoltaics (OPV)[1)]



P3HT : Donor material

Usable for a solution processable OPV device
Fabricates a bulk heterojunction (BHJ) with a highly soluble donor and acceptor

Perovskite Solar Cell (PSC)[2)]



P3HT : Hole transport material (HTM)

Usable for a solution processable PSC device
Realizes high power conversion efficiency

Organic Transistor (OFET)[3)]

P3HT : p-Type semiconductor

Usable for a solution processable OFET device

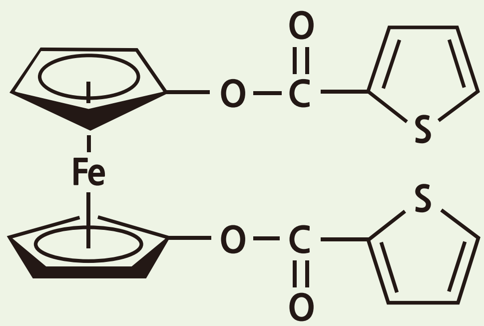
References

1) OPV :
a) E. L. Lim, C. C. Yap, M. A. M. Teridi, C. H. Teh, A. R. M. Yuso, M. H. H. Jumali, *Org. Electron.* **2016**, *36*, 12.
b)A. Marrocchi, D. Lanari, A. Facchetti, L. Vaccaro, *Energy Environ. Sci.* **2012**, *5*, 8457.

2) PSC : L. Calió, S. Kazim, M. Grätzel, S. Ahmad, *Angew. Chem. Int. Ed.* **2016**, *55*, 14522.

3) OFET : H. Sirringhaus, *Adv. Mater.* **2014,** *26,* 1319.

Interface Stabilizing Reagent for Inverted Perovskite Solar Cells

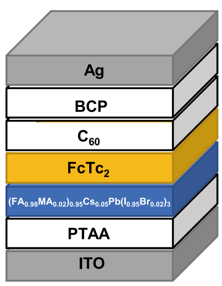


Bis(thiophene-2-ylcarbonyloxyl)ferrocene
(= $FcTc_2$)
500mg
[F1354]

Advantages

- **Improves the performance of inverted perovskite solar cells.**
- **Reduces device degradation under high temperature and humidity conditions.**

Application



$FcTc_2$ (1 mg/mL) coated on the perovskite layer* suppresses the ion migration on the surface of the perovskite layer. $FcTc_2$ improves the performance and prevent interface degradation.[1)]

$FcTc_2$	PCE (average)	PCE (max)
1 mg/mL	24.5%	25.0%
control	22.5%	23.0%

* Perovskite layer: $(FA_{0.98}MA_{0.02})_{0.95}Cs_{0.05}Pb(I_{0.95}Br_{0.02})_3$

Devices using FcTc2 maintain performance over long periods of time even at high temperatures and high humidity.[1)]

Conditions	Humidity/Temperature	Sealing	Time	PCE Retention Rate	
				$FcTc_2$	control
In Glovebox	25°C	No	1500h	98%	< 80%
Under Air	40~50% / 25°C	No	2000h	98%	< 75%
Under Air	85% / 85°C	Yes	1000h	95%	< 50%

References
1) Z. Li, Z. Zhu, *et al.*, *Science* **2022**, *376*, 416. https://doi.org/10.1126/science.abm8566
2) Inverted perovskite solar cell with 25% efficiency, *pv magazine* **2022**.
https://www.pv-magazine.com/2022/04/22/inverted-perovskite-solar-cell-with-25-efficiency

Related Products

Lead(II) Iodide (99.99%, trace metals basis) [for Perovskite precursor] 1g / 5g / 25g / 100g / 1kg **[L0279]**
Lead(II) Bromide (Low water content) [for Perovskite precursor] 1g / 5g / 25g **[L0346]**
Formamidine Hydroiodide (99.99%, trace metals basis) [for Perovskite precursor] 1g / 5g / 25g **[F1263]**

High Purity Perovskite Precursor

Related Products Table

Cation \ Anion	Iodide	Bromide	Chloride
Lead	L0279	L0288, L0346	L0291, L0292
Cesium	C2205	C2202	C2203
Tin	T3449	T3573	T3570
Bismuth	B5787	B6339	B3546
Rubidium	-	R0256	R0255
Formamidinium	F0974	F0973	F0103
Acetamidinium	A2902	A3292	A0008
Guanidinium	G0450	G0449	G0162
Ethylammonium	E1045	E0056	E0205
Propylammonium	P2212	P2502	P0522
Isopropylammonium	I0934	I1041	I0166
Butylammonium	B4433	B5186	B0710
Isobutylammonium	-	I1007	I0096
tert-Butylammonium	B4434	B5187	-
Dimethylammonium	D4555	D5092	-
Diethylammonium	D4643	D4667	D0468
Imidazolium	I0970	I1006	-
Phenylammonium	A2778	A2985	-
Benzylammonium	B4566	B5185	B0407
2-Phenylethylammonium	P2213	P2388	P0086
5-Aminovaleric Acid	A2984	A3094	A0436

Perovskite Solar Cell(PSC) Materials Products List

Interface Stabilizing Reagent for Inverted Perovskite Solar Cells

F1354	**Bis(thiophene-2-ylcarbonyloxyl)ferrocene (= $FcTc_2$)**	**>98.0%(T)(HPLC)**	**500mg**

Lead Halides

C3569	Cesium Lead Tribromide (Low water content)	>98.0%(T)	1g / 5g
C3570	Cesium Lead Triiodide (Low water content)	>98.0%(T)	1g / 5g
L0279	**Lead(II) Iodide (99.99%, trace metals basis) [for Perovskite precursor]**	**>98.0%(T)**	**1g / 5g / 25g / 100g / 1kg**
L0288	**Lead(II) Bromide [for Perovskite precursor]**	**>98.0%(T)**	**1g / 5g / 25g**
L0291	**Lead(II) Chloride (purified by sublimation) [for Perovskite precursor]**	**>99.5%(T)**	**1g / 5g**
L0292	**Lead(II) Chloride [for Perovskite precursor]**	**>99.0%(T)**	**1g / 5g / 25g**
L0346	**Lead(II) Bromide (Low water content) [for Perovskite precursor]**	**>98.0%(T)**	**1g / 5g / 25g**

Lead Compounds (Others)

L0315	**Lead(II) Acetate [for Perovskite precursor]**	**>98.0%(T)**	**1g / 5g / 25g**
L0330	Lead(II) Acetate Trihydrate	>99.0%(T)	25g / 100g

Tin Halides

T3449	**Tin(II) Iodide [for Perovskite precursor]**	**>97.0%(T)**	**1g / 5g**
T3570	Tin(II) Chloride [for Perovskite precursor]	>97.0%(T)	1g / 5g
T3573	**Tin(II) Bromide [for Perovskite precursor]**	**>97.0%(T)**	**1g / 5g**

Bismuth Halides

B5787	Bismuth(III) Iodide Anhydrous	>98.0%(T)	5g / 25g

Cesium Halides

C2202	Cesium Bromide	>99.0%(T)	25g / 100g
C2203	Cesium Chloride	>99.0%(T)	25g / 100g
C2205	Cesium Iodide	>99.0%(T)	25g

Rubidium Halides

R0255	Rubidium Chloride		5g / 25g
R0256	Rubidium Bromide		5g / 25g

Carrier Transport Materials Hole Transport Materials (HTM)

B3562	6,13-Bis(triisopropylsilylethynyl)pentacene	>98.0%(HPLC)	100mg
B4926	2,7-Bis[N-(1-naphthyl)anilino]-9,9-dimethylfluorene	>98.0%(HPLC)	200mg / 1g
B5672	**(E,E)-1,4-Bis[4-[bis(4-methoxyphenyl)amino]styryl]benzene**	**>98.0%(HPLC)(N)**	**1g / 5g / 25g**
B5942	6,13-Bis(triisopropylsilylethynyl)pentacene [for organic electronics]	>99.0%(HPLC)	100mg
B6391	**Br-2PACz**	**>99.0%(T)(HPLC)**	**500mg**
B6445	**Br-4PACz**	**>98.0%(T)(HPLC)**	**500mg**
C3645	Copper(II) Phthalocyanine (purified by sublimation) [for organic electronics]	>99.0%(T)	100mg / 500mg
C3663	**2PACz**	**>98.0%(T)(HPLC)**	**500mg**
D2448	N,N'-Diphenyl-N,N'-di(m-tolyl)benzidine	>98.0%(N)	1g / 5g
D3236	N,N'-Diphenyl-N,N'-di(m-tolyl)benzidine (purified by sublimation)	>99.0%(HPLC)(N)	1g / 5g
D3970	N,N'-Di-1-naphthyl-N,N'-diphenylbenzidine (purified by sublimation)	>99.0%(HPLC)(N)	1g / 5g
D5126	N,N'-Di-1-naphthyl-N,N'-diphenylbenzidine	>98.0%(HPLC)	1g / 5g

D5155	4,4'-(2,3-Dihydrothieno[3,4-b][1,4]dioxine-5,7-diyl)bis[N,N-bis(4-methoxyphenyl)aniline]	>98.0%(N)	200mg
D5798	**MeO-2PACz**	**>98.0%(T)**	**500mg**
M3359	**Me-4PACz**	**>99.0%(T)(HPLC)**	**500mg**
M3477	**Me-2PACz**	**>99.0%(T)(HPLC)**	**500mg**
M3549	**MeO-4PACz**	**>98.0%(T)(HPLC)**	**500mg**
P0767	Zinc Phthalocyanine	>95.0%(T)	1g / 5g / 25g
P1628	Pigment Blue 15 (purified by sublimation)	>98.0%(T)	1g
P2513	**Poly(3-hexylthiophene-2,5-diyl) (regioregular) [for organic electronics]**		**100mg / 500mg**
P2995	**4PACz**	**>98.0%(T)(HPLC)**	**500mg**
T0561	5,6,11,12-Tetraphenylnaphthacene	>98.0%(HPLC)	100mg / 1g
T1812	N,N,N',N'-Tetraphenylbenzidine	>98.0%(GC)	5g / 25g
T2233	5,6,11,12-Tetraphenylnaphthacene (purified by sublimation)	>99.0%(GC)	250mg / 1g
T3266	N,N,N',N'-Tetraphenylbenzidine (purified by sublimation)	>99.0%(GC)	1g / 5g
T3634	2,2',7,7'-Tetrakis(diphenylamino)-9,9'-spirobi[9H-fluorene]	>98.0%(HPLC)	1g
T3656	N,N,N',N'-Tetra([1,1'-biphenyl]-4-yl)[1,1':4',1''-terphenyl]-4,4''-diamine	>98.0%(HPLC)(N)	1g
T3672	**2,2',7,7'-Tetrakis-(N,N-di-4-methoxyphenylamino)-9,9'-spirobifluorene**	**>98.0%(HPLC)**	**1g / 5g**
T3722	**(E,E,E,E)-1,2,4,5-Tetrakis[4-[bis(4-methoxyphenyl)amino]styryl]benzene**	**>98.0%(HPLC)(N)**	**1g / 5g / 25g**
Z0037	Zinc Phthalocyanine (purified by sublimation)	>98.0%(T)	500mg

Carrier Transport Materials Electron Transport Materials (ETM)

B1641	Fullerene C60 (pure)	>99.5%(HPLC)	100mg / 500mg / 1g
B1694	Fullerene C70	>98.0%(HPLC)	100mg
B2694	Bathocuproine (purified by sublimation)	>99.0%(T)(HPLC)	1g / 5g
B2695	Bathophenanthroline (purified by sublimation)	>99.0%(T)(HPLC)	1g
B4576	Bis-PCBM (mixture of isomers)		50mg
D0711	Bathocuproine	>95.0%(T)(HPLC)	1g / 5g
D0905	Bathophenanthroline	>99.0%(T)	1g / 5g
D5581	2,9-Di(naphthalen-2-yl)-4,7-diphenyl-1,10-phenanthroline	>97.0%(T)(HPLC)	200mg / 1g
D5757	N,2-Diphenyl[60]fulleropyrrolidine (contains 5% Hexane at maximum)	>98.0%(HPLC)	100mg
F1232	Fullerene C60 (purified by sublimation) [for organic electronics]	>99.5%(HPLC)	100mg
F1233	Fullerene C70 (purified by sublimation) [for organic electronics]	>99.0%(HPLC)	100mg
M2088	[6,6]-Phenyl-C61-butyric Acid Methyl Ester	>99.5%(HPLC)	100mg
M2550	[6,6]-Phenyl-C71-butyric Acid Methyl Ester (mixture of isomers)	>98.0%(HPLC)	50mg
P2682	[6,6]-Phenyl-C61-butyric Acid Methyl Ester [for organic electronics]	>99.5%(HPLC)	100mg
P2683	[6,6]-Phenyl-C71-butyric Acid Methyl Ester (mixture of isomers) [for organic electronics]	>99.0%(HPLC)	100mg
P2744	N-Phenyl-2-hexyl[60]fulleropyrrolidine	>98.0%(HPLC)	100mg

Carrier Transport Layer Addives

A2278	2-Amylpyridine	>98.0%(GC)(T)	5g
B0388	**4-tert-Butylpyridine**	**>96.0%(GC)(T)**	**5g / 25g**
B2195	1-Butyl-3-methylimidazolium Tetrafluoroborate	>98.0%(HPLC)(N)	5g / 25g / 100g
B2477	1-Butyl-3-methylimidazolium Bis(trifluoromethanesulfonyl)imide	>98.0%(T)(HPLC)	5g / 25g
B2542	**Lithium Bis(trifluoromethanesulfonyl)imide**	**>98.0%(T)**	**25g / 250g**
C3263	Calcium(II) Bis(trifluoromethanesulfonyl)imide	>97.0%(T)	1g / 5g
D4470	2,3-Dihydro-1,3-dimethyl-2-phenylbenzimidazole	>98.0%(qNMR)	1g / 5g
D6182	4-(1,3-Dimethyl-2,3-dihydro-1H-benzimidazol-2-yl)-N,N-diphenylaniline	>95.0%(HPLC)(qNMR)	1g / 5g

Carrier Transport Layer Addives

E0496	1-Ethyl-3-methylimidazolium Tetrafluoroborate	>97.0%(N)	5g / 25g
E0599	1-Ethyl-3-methylimidazolium Bis(trifluoromethanesulfonyl)imide	>98.0%(T)(HPLC)	5g / 25g
L0146	Lithium Hexafluorophosphate	>97.0%(T)	25g / 100g
L0267	Lithium Bis(pentafluoroethanesulfonyl)imide	>98.0%(T)	1g / 5g
L0281	Lithium Bis(fluorosulfonyl)imide	>98.0%(T)	5g / 25g
L0295	Lithium (Fluorosulfonyl)(trifluoromethanesulfonyl)imide	>95.0%(T)	1g
L0307	Lithium Bis(nonafluorobutanesulfonyl)imide	>95.0%(T)	1g / 5g
S0989	Sodium Bis(trifluoromethanesulfonyl)imide	>98.0%(T)	1g / 5g
T1131	Tetrafluorotetracyanoquinodimethane (purified by sublimation)	>98.0%(N)	100mg / 1g
T2313	Tris(pentafluorophenyl)borane	>98.0%(NMR)	1g / 5g
Z0027	Zinc(II) Bis(trifluoromethanesulfonyl)imide	>98.0%(T)	1g / 5g

Organic Onium Salts Bromide Salts

A2985	Aniline Hydrobromide	>98.0%(HPLC)	1g / 5g
A3091	5-Azoniaspiro[4.4]nonane Bromide	>98.0%(T)	1g / 5g
A3094	5-Aminovaleric Acid Hydrobromide (Low water content)	>98.0%(T)	1g / 5g
A3292	Acetamidine Hydrobromide	>98.0%(T)	1g / 5g
B5185	Benzylamine Hydrobromide	>98.0%(T)(HPLC)	1g / 5g
B5186	Butylamine Hydrobromide	>98.0%(T)(N)	1g / 5g
B5187	tert-Butylamine Hydrobromide	>98.0%(T)(N)	1g / 5g
C3531	Cyclohexanemethylamine Hydrobromide	>98.0%(T)	1g / 5g
D4667	Diethylamine Hydrobromide	>98.0%(T)	1g / 5g
D5090	1,3-Diaminopropane Dihydrobromide	>98.0%(T)(N)	1g / 5g
D5092	Dimethylamine Hydrobromide	>98.0%(T)(N)	1g / 5g
D5250	1,4-Diazabicyclo[2.2.2]octane Dihydrobromide	>98.0%(T)(N)	1g / 5g
D5537	Dodecylamine Hydrobromide	>98.0%(T)(N)	1g / 5g
D5615	N,N-Dimethylethylenediamine Dihydrobromide	>98.0%(N)	1g / 5g
D5618	N,N-Dimethyl-1,3-propanediamine Dihydrobromide	>98.0%(T)	1g / 5g
D5685	1,4-Diaminobutane Dihydrobromide	>98.0%(T)	1g / 5g
D5768	Diisopropylamine Hydrobromide	>98.0%(N)	5g
D5853	Dipropylamine Hydrobromide	>98.0%(T)	5g
D5857	Dibutylamine Hydrobromide	>95.0%(T)	5g
E1221	Ethylenediamine Dihydrobromide	>97.0%(T)(N)	1g / 5g
F0973	Formamidine Hydrobromide (Low water content)	>98.0%(T)(N)	1g / 5g / 25g
F1227	4-Fluorobenzylamine Hydrobromide	>98.0%(HPLC)	1g / 5g
F1229	2-(4-Fluorophenyl)ethylamine Hydrobromide	>98.0%(HPLC)(N)	1g / 5g
F1244	Formamidine Hydrobromide (99.99%, trace metals basis) [for Perovskite precursor]	>99.0%(T)(N)	1g / 5g / 25g
F1272	4-Fluoroaniline Hydrobromide	>98.0%(T)(HPLC)	5g / 25g
G0449	Guanidine Hydrobromide	>98.0%(T)	1g / 5g
H1678	Hexylamine Hydrobromide	>98.0%(T)(N)	1g / 5g
I1006	Imidazole Hydrobromide (Low water content)	>98.0%(T)(HPLC)	1g / 5g
I1007	Isobutylamine Hydrobromide	>98.0%(T)(N)	1g / 5g
I1041	Isopropylamine Hydrobromide	>97.0%(T)(N)	1g / 5g
I1094	Isopentylamine Hydrobromide	>98.0%(T)	1g / 5g
M3239	2-(4-Methoxyphenyl)ethylamine Hydrobromide	>98.0%(HPLC)	1g / 5g
M3285	Morpholine Hydrobromide	>98.0%(T)	5g / 25g
M3287	2-Methoxyethylamine Hydrobromide	>98.0%(T)(N)	1g / 5g
N1156	Neopentylamine Hydrobromide	>98.0%(T)	1g / 5g
O0442	n-Octylamine Hydrobromide	>98.0%(T)	1g / 5g

P2388	2-Phenylethylamine Hydrobromide	>98.0%(T)(HPLC)	1g / 5g
P2484	Pyrrolidine Hydrobromide	>98.0%(T)	1g / 5g
P2490	Piperazine Dihydrobromide	>98.0%(T)(N)	1g / 5g
P2502	Propylamine Hydrobromide	>97.0%(T)(N)	1g / 5g
P2739	1-Pentanamine Hydrobromide	>98.0%(T)(N)	1g / 5g
T3783	2,4,4-Trimethylpentan-2-amine Hydrobromide	>97.0%(T)	1g / 5g
T3834	4-(Trifluoromethyl)aniline Hydrobromide	>98.0%(HPLC)	1g / 5g
T3837	4-(Trifluoromethyl)benzylamine Hydrobromide	>98.0%(HPLC)	1g / 5g

Organic Onium Salts Chloride Salts

A0008	Acetamidine Hydrochloride	>95.0%(T)	25g / 500g
A0436	5-Aminovaleric Acid Hydrochloride (Low water content)	>98.0%(T)	1g / 5g
A3092	5-Azoniaspiro[4.4]nonane Chloride	>98.0%(T)	1g / 5g
A3393	2-(1-Pyrrolidinyl)ethanamine Dihydrochloride	>98.0%(T)	5g
B0407	Benzylamine Hydrochloride	>98.0%(T)(HPLC)	25g / 100g / 500g
B0710	Butylamine Hydrochloride	>98.0%(T)	25g / 500g
D0468	Diethylamine Hydrochloride	>98.5%(T)	25g / 500g
D5251	1,4-Diazabicyclo[2.2.2]octane Dihydrochloride	>98.0%(T)(N)	1g / 5g
D5253	1,3-Diaminopropane Dihydrochloride (Low water content)	>98.0%(T)(N)	1g / 5g
D5617	N,N-Dimethyl-1,3-propanediamine Dihydrochloride	>98.0%(T)	1g / 5g
D5856	Dibutylamine Hydrochloride	>98.0%(T)	5g
D5860	N,N-Diethyl-1,2-ethanediamine Dihydrochloride	>98.0%(T)	5g
D5861	N,N-Diethyl-1,3-propanediamine Dihydrochloride	>98.0%(T)	5g
F0103	Formamidine Hydrochloride	>97.0%(T)	5g / 25g
F1250	2-Fluoroethylamine Hydrochloride	>97.0%(T)	1g / 5g
F1255	4-Fluorobenzylamine Hydrochloride	>98.0%(T)(HPLC)	1g / 5g
F1256	2-(4-Fluorophenyl)ethylamine Hydrochloride	>98.0%(T)(HPLC)	1g / 5g
F1271	4-Fluoroaniline Hydrochloride	>98.0%(T)(HPLC)	5g / 25g
G0162	Guanidine Hydrochloride	>98.0%(T)	25g / 500g
I0083	Isopentylamine Hydrochloride	>98.0%(T)	1g / 5g
I0096	Isobutylamine Hydrochloride	>99.0%(T)	25g / 500g
I0166	Isopropylamine Hydrochloride	>98.0%(T)(N)	25g / 100g / 500g
M3284	Morpholine Hydrochloride	>98.0%(T)	5g / 25g
O0484	n-Octylamine Hydrochloride	>98.0%(T)	1g / 5g
P0086	2-Phenylethylamine Hydrochloride	>98.0%(T)(HPLC)	25g / 100g / 500g
P0522	Propylamine Hydrochloride	>98.0%(T)(N)	25g
P2491	Piperazine Dihydrochloride	>98.0%(T)(N)	1g / 5g
P2736	1-Pentanamine Hydrochloride	>98.0%(N)	1g / 5g
T3784	2,4,4-Trimethylpentan-2-amine Hydrochloride	>98.0%(T)	1g / 5g
T3833	4-(Trifluoromethyl)aniline Hydrochloride	>98.0%(T)(HPLC)	1g / 5g
T3836	4-(Trifluoromethyl)benzylamine Hydrochloride	>98.0%(HPLC)(N)	1g / 5g

Organic Onium Salts Iodide Salts

A2778	Aniline Hydroiodide	>98.0%(HPLC)(N)	1g / 5g
A2902	Acetamidine Hydroiodide (Low water content)	>98.0%(T)	1g / 5g
A2984	5-Aminovaleric Acid Hydroiodide	>97.0%(T)(N)	1g / 5g
A3093	5-Azoniaspiro[4.4]nonane Iodide	>98.0%(T)	1g / 5g
A3112	β-Alanine Hydroiodide (Low water content)	>98.0%(T)(N)	1g / 5g
B4433	Butylamine Hydroiodide	>97.0%(T)(N)	1g / 5g

Organic Onium Salts Iodide Salts

B4434	tert-Butylamine Hydroiodide	>97.0%(T)(N)	1g / 5g
B4566	Benzylamine Hydroiodide (Low water content)	>98.0%(HPLC)(N)	1g / 5g
C3425	Cyclohexanemethylamine Hydroiodide	>98.0%(T)(N)	1g / 5g
C3532	Cyclohexylamine Hydroiodide	>95.0%(T)(N)	1g / 5g
D4555	Dimethylamine Hydroiodide	>98.0%(T)(N)	1g / 5g
D4643	Diethylamine Hydroiodide	>97.0%(T)(N)	1g / 5g
D5091	1,3-Diaminopropane Dihydroiodide	>98.0%(T)(N)	1g / 5g
D5252	1,4-Diazabicyclo[2.2.2]octane Dihydriodide	>98.0%(T)	1g / 5g
D5538	Dodecylamine Hydroiodide	>98.0%(T)(N)	1g / 5g
D5616	N,N-Dimethylethylenediamine Dihydroiodide	>98.0%(N)	1g / 5g
D5619	N,N-Dimethyl-1,3-propanediamine Dihydroiodide	>97.0%(T)	1g / 5g
D5686	1,4-Diaminobutane Dihydroiodide	>98.0%(T)	1g / 5g
D5769	Diisopropylamine Hydroiodide	>98.0%(N)	5g
D5858	Dibutylamine Hydroiodide	>98.0%(T)	5g
D6035	Hexane-1,6-diamine Dihydroiodide	>95.0%(T)	1g / 5g
E1222	Ethylenediamine Dihydroiodide	>98.0%(T)(N)	1g / 5g
F0974	**Formamidine Hydroiodide (Low water content)**	**>98.0%(T)(N)**	**1g / 5g / 25g / 100g**
F1203	2-(4-Fluorophenyl)ethylamine Hydroiodide	>98.0%(T)(HPLC)	1g / 5g
F1228	4-Fluorobenzylamine Hydroiodide	>98.0%(HPLC)	1g / 5g
F1263	**Formamidine Hydroiodide (99.99%, trace metals basis) [for Perovskite precursor]**	**>99.0%(T)**	**1g / 5g / 25g**
F1273	4-Fluoroaniline Hydroiodide	>98.0%(T)(HPLC)	1g / 5g
G0450	Guanidine Hydroiodide	>97.0%(T)	1g / 5g
H1679	Hexan-1-amine Hydroiodide	>98.0%(T)	5g
H1759	1-Hexyl-1,4-diazabicyclo[2.2.2]octan-1-ium Iodide	>98.0%(T)	5g
I0935	Isobutylamine Hydroiodide	>97.0%(T)(N)	1g / 5g
I0970	Imidazole Hydroiodide (Low water content)	>98.0%(T)	1g / 5g
I1095	Isopentylamine Hydroiodide	>98.0%(T)	1g / 5g
M3240	2-(4-Methoxyphenyl)ethylamine Hydroiodide	>98.0%(HPLC)	1g / 5g
M3286	Morpholine Hydroiodide	>98.0%(N)	5g / 25g
N1157	Neopentylamine Hydroiodide	>96.0%(T)	1g / 5g
O0485	n-Octylammonium Iodide	>98.0%(T)	1g / 5g
P2212	Propylamine Hydroiodide	>97.0%(T)(N)	1g / 5g
P2213	2-Phenylethylamine Hydroiodide	>98.0%(HPLC)(N)	1g / 5g
P2389	1,4-Phenylenediamine Dihydriodide	>98.0%(T)	1g
P2486	Pyrrolidine Hydroiodide	>98.0%(T)(N)	1g / 5g
P2492	Piperazine Dihydriodide	>98.0%(T)(N)	1g / 5g
P2672	Pyridine Hydroiodide	>98.0%(HPLC)	5g
P2740	1-Pentanamine Hydroiodide	>98.0%(T)(N)	1g / 5g
T3785	2,4,4-Trimethylpentan-2-amine Hydroiodide	>97.0%(T)	1g / 5g
T3838	4-(Trifluoromethyl)benzylamine Hydroiodide	>98.0%(HPLC)	1g / 5g

Pseudo Halide Salts Pseudo Halide Salts

F1153	Formamidine Thiocyanate	>98.0%(N)	1g / 5g
G0230	Guanidine Thiocyanate	>99.0%(T)	25g / 500g
T0914	Tetrabutylammonium Tetrafluoroborate	>98.0%(N)	25G / 100g / 500g
T2648	Tetrabutylammonium Tetrafluoroborate	>98.0%(N)	25G

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