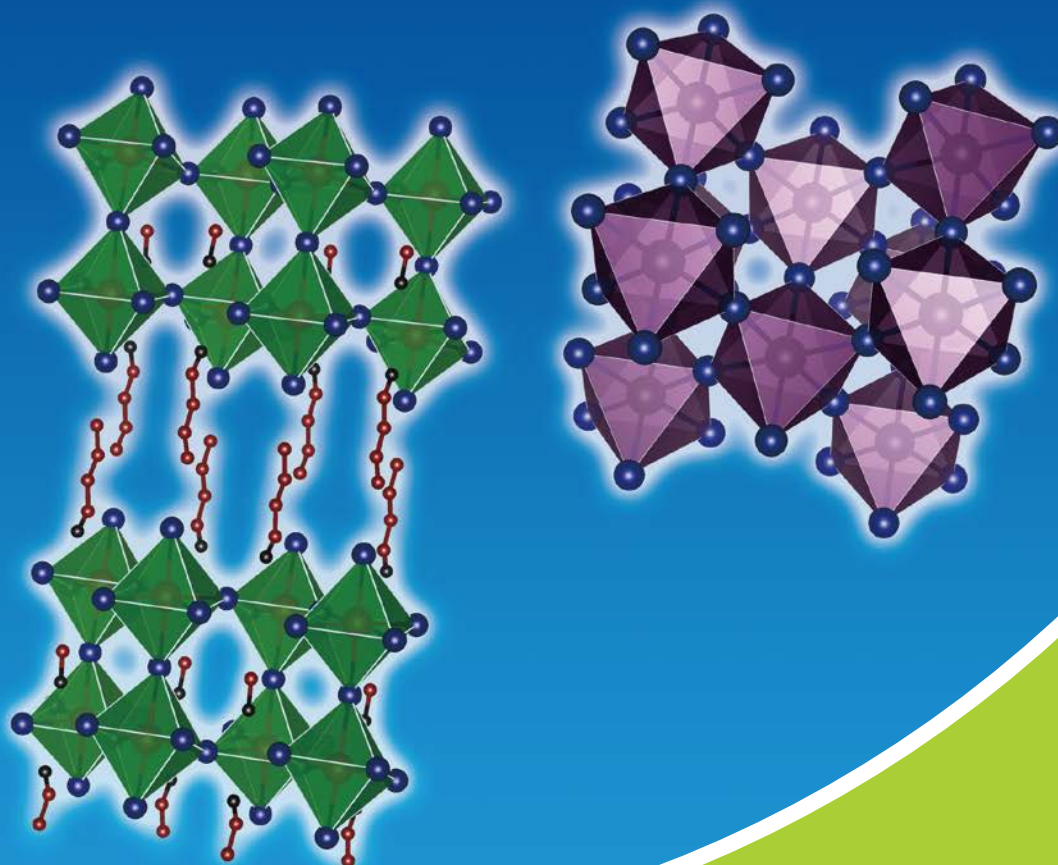


Organic-Inorganic Perovskite Precursors



Lead Halides

Other Lead Compounds

Cesium Halides

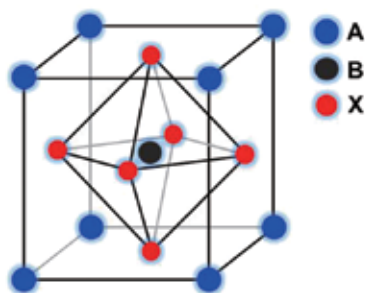
Bismuth Halides

Tin Halides

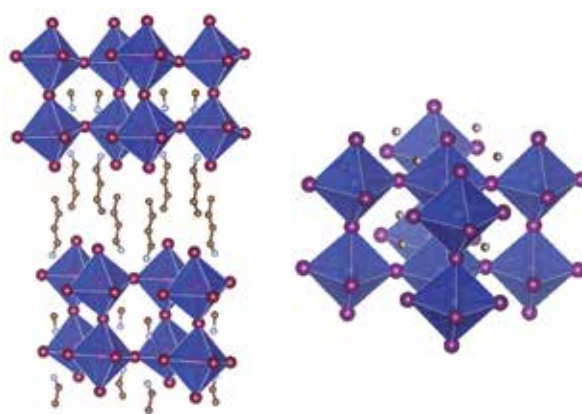
Organic Onium Salts

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.¹⁾ High temperature superconductive oxides with a unit of copper oxide are obtained from all perovskite compounds.²⁾ These perovskite compounds consist of metal ions and oxygen atoms, and are manufactured by a physical procedure (eg. sintering method).³⁾ 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.^{4,5)} This perovskite compound has the general formula $[(\text{RNH}_3)_m\text{MX}_n]$, 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,⁶⁾ and the lead one is better for optical properties.⁷⁾ A chemical modification of the halide controls band gap.⁸⁾ 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 $[(\text{MeNH}_3)\text{MX}_3]$ having a three-dimensional cubic perovskite structure.⁹⁾ A perovskite compound with $\text{R} = \text{C}_n\text{H}_{2n+1}$ ($n \geq 2$) provides a two-dimensional perovskite layer and the length of alkyl group can control the inter-layer distance.¹⁰⁾



An application of an organic-inorganic perovskite is a perovskite solar cell.¹¹⁻¹⁵⁾ This solar cell can usually be fabricated by the three-dimensional cubic perovskite $[(\text{MeNH}_3)\text{MX}_3]$. Doping effects of formamidinium¹⁶⁾ and cesium cations¹⁷⁾ to the A site were also investigated for the perovskite solar cell research. Wakamiya *et al.* recently developed a ready-to-use perovskite precursor, $\text{MeNH}_3\text{I}/\text{PbI}_2\text{-DMF}$ complex, enabling us to fabricate a well-uniformed crystalline film by a solution method.¹⁸⁾ 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.

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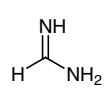
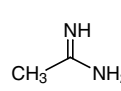
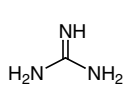
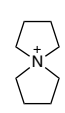
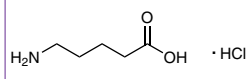
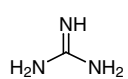
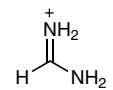
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Lead Halides		P24151g5g25gCH3NH3PbI3 / DMF PbI2/MAI(1:1) - DMF Complex (99.99%, trace metals basis)	L02791g5g25g100g1kgPbI2 Lead(II) Iodide (99.99%, trace metals basis) CAS RN: 10101-63-0	L02881g5g25gPbBr2 Lead(II) Bromide CAS RN: 10031-22-8
L02911g5gPbCl2 Lead(II) Chloride (purified by sublimation) CAS RN: 7758-95-4	L02921g5g25gPbCl2 Lead(II) Chloride CAS RN: 7758-95-4	C35691g5gCsPbBr3 Cesium Lead Tribromide (Low water content) CAS RN: 15243-48-8		
Other Lead Compounds		L03151g5g25g[CH3-C(=O)-O-]2Pb2+ Acetic Acid Lead(II) Salt CAS RN: 301-04-2	L033025g100g[CH3-C(=O)-O-]2Pb2+ · 3H2O Lead(II) Acetate Trihydrate CAS RN: 6080-56-4	
Cesium Halides		C220525gCsI Cesium Iodide CAS RN: 7789-17-5	C220225g100gCsBr Cesium Bromide CAS RN: 7787-69-1	C220325g100gCsCl Cesium Chloride CAS RN: 7647-17-8
Bismuth Halides		B57875g25gBiI3 Bismuth(III) Iodide Anhydrous CAS RN: 7787-64-6		
Tin Halides		T34491g5gSnI2 Tin(II) Iodide [for Perovskite precursor] CAS RN: 10294-70-9		

Organic Onium Salts		Iodide Salts		M2556 1g 5g 25g 100g $\text{CH}_3\text{NH}_2 \cdot \text{HI}$ Methylamine Hydroiodide CAS RN: 14965-49-2	E1045 1g 5g $\text{CH}_3\text{CH}_2\text{NH}_2 \cdot \text{HI}$ Ethylamine Hydroiodide CAS RN: 506-58-1
P2212 1g 5g $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2 \cdot \text{HI}$ Propylamine Hydroiodide CAS RN: 14488-45-0	I0934 1g 5g $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{NH}_2 \cdot \text{HI}$ Isopropylamine Hydroiodide CAS RN: 66735-20-4	B4433 1g 5g $\text{CH}_3(\text{CH}_2)_3\text{NH}_2 \cdot \text{HI}$ Butylamine Hydroiodide CAS RN: 36945-08-1	I0935 1g 5g $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{NH}_2 \cdot \text{HI}$ Isobutylamine Hydroiodide CAS RN: 205508-75-4	B4434 1g 5g $\text{CH}_3\text{C}(\text{CH}_3)_2\text{CH}_2\text{NH}_2 \cdot \text{HI}$ <i>tert</i> -Butylamine Hydroiodide CAS RN: 39557-45-4	
I1095 1g 5g $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 \cdot \text{HI}$ Isopentylamine Hydroiodide	T3785 1g 5g $\text{CH}_3\text{C}(\text{CH}_3)_2\text{CH}_2\text{C}(\text{CH}_3)_2\text{CH}_2\text{NH}_2 \cdot \text{HI}$ <i>tert</i> -Octylamine Hydroiodide	D5538 1g 5g $\text{CH}_3(\text{CH}_2)_{11}\text{NH}_2 \cdot \text{HI}$ Dodecylamine Hydroiodide CAS RN: 34099-97-3	C3532 1g 5g $\text{C}_6\text{H}_{11}\text{NH}_2 \cdot \text{HI}$ Cyclohexylamine Hydroiodide CAS RN: 45492-87-3	C3425 1g 5g $\text{C}_6\text{H}_{11}\text{CH}_2\text{NH}_2 \cdot \text{HI}$ Cyclohexanemethylamine Hydroiodide	
A2778 1g 5g $\text{C}_6\text{H}_5\text{NH}_2 \cdot \text{HI}$ Aniline Hydroiodide CAS RN: 45497-73-2	B4566 1g 5g $\text{C}_6\text{H}_5\text{CH}_2\text{NH}_2 \cdot \text{HI}$ Benzylamine Hydroiodide CAS RN: 45579-91-7	P2213 1g 5g $\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{NH}_2 \cdot \text{HI}$ 2-Phenylethylamine Hydroiodide CAS RN: 151059-43-7	F1203 1g 5g $\text{C}_6\text{H}_4(\text{F})(\text{CH}_2\text{CH}_2\text{NH}_2) \cdot \text{HI}$ 2-(4-Fluorophenyl)-ethylamine Hydroiodide CAS RN: 1413269-55-2	D4555 1g 5g $(\text{CH}_3)_2\text{NCH}_3 \cdot \text{HI}$ Dimethylamine Hydroiodide CAS RN: 51066-74-1	
D4643 1g 5g $(\text{CH}_3)_2\text{NCH}_2\text{CH}_3 \cdot \text{HI}$ Diethylamine Hydroiodide CAS RN: 19833-78-4	P2486 1g 5g $\text{C}_4\text{H}_8\text{NH} \cdot \text{HI}$ Pyrrolidine Hydriodide CAS RN: 45361-12-4	E1222 1g 5g $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2 \cdot 2\text{HI}$ Ethylenediamine Dihydroiodide CAS RN: 5700-49-2	D5091 1g 5g $\text{H}_2\text{NCH}_2\text{CH}_2\text{CH}_2\text{NH}_2 \cdot 2\text{HI}$ 1,3-Diaminopropane Dihydroiodide CAS RN: 120675-53-8	D5619 1g 5g $(\text{CH}_3)_2\text{NCH}_2\text{CH}_2\text{CH}_2\text{NH}_2 \cdot 2\text{HI}$ <i>N,N</i> -Dimethyl-1,3-propanediammonium Diiodide	
P2389 1g $\text{C}_6\text{H}_4(\text{NH}_2)_2 \cdot 2\text{HI}$ 1,4-Phenylenediamine Dihydroiodide CAS RN: 116469-02-4	P2492 1g 5g $\text{C}_4\text{H}_{10}\text{N}_2 \cdot 2\text{HI}$ Piperazine Dihydroiodide CAS RN: 58464-47-4	F0974 1g 5g 25g $\text{H}_2\text{NCH}=\text{NH} \cdot \text{HI}$ Formamidine Hydroiodide CAS RN: 879643-71-7	A2902 1g 5g $\text{CH}_3\text{C}(=\text{NH})\text{NH}_2 \cdot \text{HI}$ Acetamidine Hydroiodide CAS RN: 1452099-14-7	G0450 1g 5g $\text{H}_2\text{NC}(=\text{NH})\text{NH}_2 \cdot \text{HI}$ Guanidine Hydroiodide CAS RN: 19227-70-4	
I0970 1g 5g $\text{C}_3\text{H}_4\text{N}_2 \cdot \text{HI}$ Imidazole Hydroiodide CAS RN: 68007-08-9	A3093 1g 5g $\text{C}_{15}\text{H}_{24}\text{N}_2 \cdot \text{I}^-$ 5-Azoniaspiro[4.4]nonane Iodide CAS RN: 45650-35-9	A2984 1g 5g $\text{H}_2\text{NCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{COOH} \cdot \text{HI}$ 5-Aminovaleric Acid Hydroiodide CAS RN: 1705581-28-7	A3112 1g 5g $\text{H}_2\text{NCH}_2\text{CH}_2\text{COOH} \cdot \text{HI}$ <i>H</i> -β-Ala-OH·HI (Low water content) CAS RN: 2096495-59-7	A3113 1g 5g $\text{H}_2\text{NCH}_2\text{CH}_2\text{COOH} \cdot \text{HI}$ GABA·HI CAS RN: 2096495-60-0	
Bromide Salts		M2589 1g 5g 25g $\text{CH}_3\text{NH}_2 \cdot \text{HBr}$ Methylamine Hydrobromide CAS RN: 6876-37-5	E0056 25g 500g $\text{CH}_3\text{CH}_2\text{NH}_2 \cdot \text{HBr}$ Ethylamine Hydrobromide CAS RN: 593-55-5	P2502 1g 5g $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2 \cdot \text{HBr}$ Propylamine Hydrobromide CAS RN: 4905-83-3	I1041 1g 5g $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{NH}_2 \cdot \text{HBr}$ Isopropylamine Hydrobromide CAS RN: 29552-58-7

B5186 1g 5g Butylamine Hydrobromide CAS RN: 15567-09-6	I1007 1g 5g Isobutylamine Hydrobromide CAS RN: 74098-36-5	B5187 1g 5g tert-Butylamine Hydrobromide CAS RN: 60469-70-7	H1678 1g 5g Hexylamine Hydrobromide CAS RN: 7334-95-4	O0442 1g 5g n-Octylamine Hydrobromide CAS RN: 14846-47-0
T3783 1g 5g tert-Octylamine Hydrobromide CAS RN: 1093859-61-0	D5537 1g 5g Dodecylamine Hydrobromide CAS RN: 26204-55-7	A2985 1g 5g Aniline Hydrobromide CAS RN: 542-11-0	B5185 1g 5g Benzylamine Hydrobromide CAS RN: 37488-40-7	P2388 1g 5g 2-Phenylethylamine Hydrobromide CAS RN: 53916-94-2
F1229 1g 5g 2-(4-Fluorophenyl)ethylamine Hydrobromide CAS RN: 1807536-06-6	P2484 1g 5g Pyrrolidine Hydrobromide CAS RN: 55810-80-5	D5092 1g 5g Dimethylamine Hydrobromide CAS RN: 6912-12-5	D4667 1g 5g Diethylamine Hydrobromide CAS RN: 6274-12-0	E1221 1g 5g Ethylenediamine Dihydrobromide CAS RN: 624-59-9
D5090 1g 5g 1,3-Diaminopropane Dihydrobromide CAS RN: 18773-03-0	D5618 1g 5g N,N-Dimethyl-1,3-propanediamine Dihydrobromide	P2490 1g 5g Piperazine Dihydrobromide CAS RN: 59813-05-7	D5250 1g 5g 1,4-Diazabicyclo[2.2.2]octane Dihydrobromide CAS RN: 54581-69-0	F0973 1g 5g 25g Formamidine Hydrobromide CAS RN: 146958-06-7
G0449 1g 5g Guanidine Hydrobromide CAS RN: 19244-98-5	I1006 1g 5g Imidazole Hydrobromide (Low water content) CAS RN: 101023-55-6	A3091 1g 5g 25g 5-Azoniaspiro[4.4]nonane Bromide CAS RN: 16450-38-7	A3094 1g 5g 5-AVABr (Low water content)	Chloride Salts
M0138 25g 500g Methylamine Hydrochloride CAS RN: 593-51-1	E0205 25g 500g Ethylamine Hydrochloride CAS RN: 557-66-4	P0522 25g Propylamine Hydrochloride CAS RN: 556-53-6	I0166 25g 100g 500g Isopropylamine Hydrochloride CAS RN: 15572-56-2	B0710 25g 500g Butylamine Hydrochloride CAS RN: 3858-78-4
I0096 25g 500g Isobutylamine Hydrochloride CAS RN: 5041-09-8	I0083 1g 5g Isopentylamine Hydrochloride CAS RN: 541-23-1	O0484 1g 5g n-Octylamine Hydrochloride CAS RN: 142-95-0	T3784 1g 5g tert-Octylamine Hydrochloride CAS RN: 58618-91-0	B0407 25g 100g 500g Benzylamine Hydrochloride CAS RN: 3287-99-8
P0086 25g 100g 500g 2-Phenylethylamine Hydrochloride CAS RN: 156-28-5	P2485 1g 5g Pyrrolidine Hydrochloride CAS RN: 25150-61-2	D0468 25g 500g Diethylamine Hydrochloride CAS RN: 660-68-4	D5253 1g 5g 1,3-Diaminopropane Dihydrochloride (Low water content) CAS RN: 10517-44-9	P2491 1g 5g Piperazine Dihydrochloride CAS RN: 142-64-3

Organic-Inorganic Perovskite Precursors

D5251 1g 5g  $\cdot 2\text{HCl}$ 1,4-Diazabicyclo[2.2.2]-octane Dihydrochloride CAS RN: 49563-87-3	F0103 5g 25g  $\cdot \text{HCl}$ Formamidine Hydrochloride CAS RN: 6313-33-3	A0008 25g 500g  $\cdot \text{HCl}$ Acetamidine Hydrochloride CAS RN: 124-42-5	G0162 25g 500g  $\cdot \text{HCl}$ Guanidine Hydrochloride CAS RN: 50-01-1	A3092 1g 5g  Cl^- 5-Azoniaspiro[4.4]nonane Chloride CAS RN: 98997-63-8
A0436 1g 5g  $\cdot \text{HCl}$ 5-AVACI (Low water content) CAS RN: 627-95-2	Pseudo Halide Salts	M2991 1g 5g $\text{CH}_3\text{NH}_2 \cdot \text{HSCN}$ Methylamine Thiocyanate CAS RN: 61540-63-4	G0230 25g 500g  $\cdot \text{HSCN}$ Guanidine Thiocyanate CAS RN: 593-84-0	F1152 1g 5g  BF_4^- Formamidine Tetrafluoroborate
M2990 1g 5g $\text{CH}_3\text{NH}_3^+ \text{BF}_4^-$ Methylamine Tetrafluoroborate CAS RN: 42539-74-2	M3134 1g 5g $\text{CH}_3\text{NH}_2 \cdot \text{HOCN}$ Methylamine Cyanate CAS RN: 63405-91-4			

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