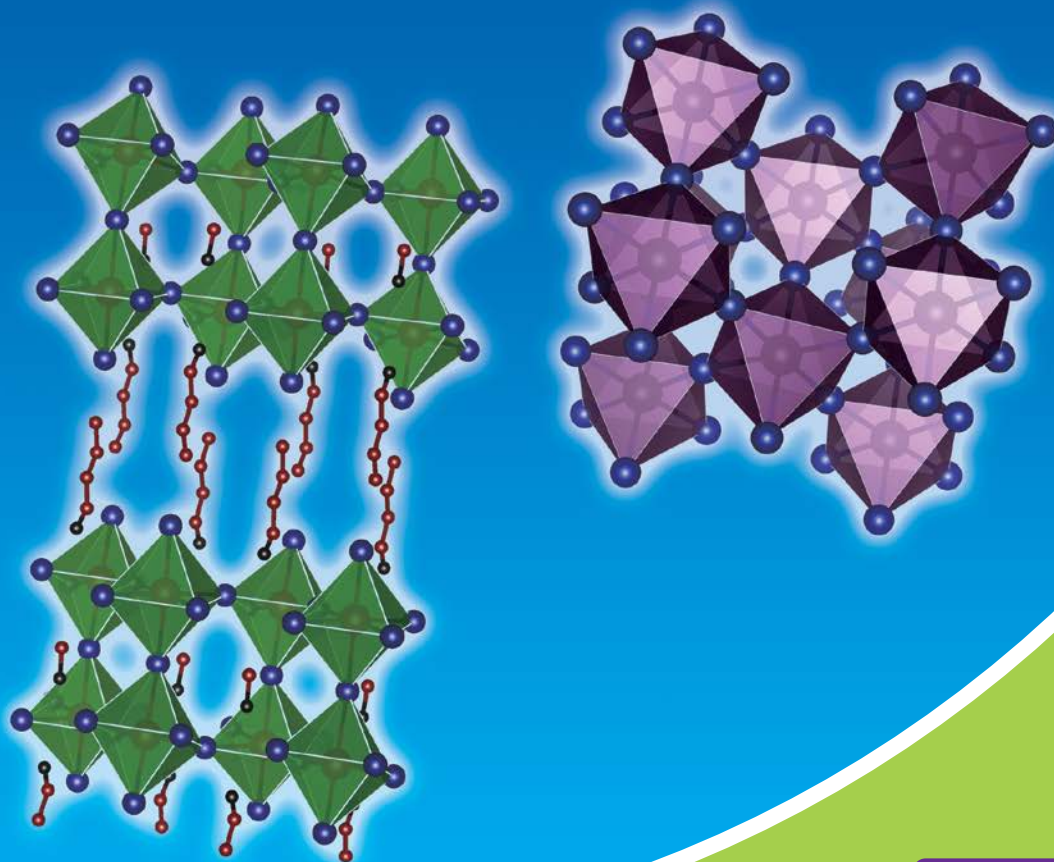


Organic-Inorganic Perovskite Precursors



Lead Halides

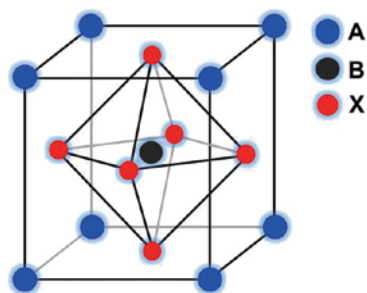
Organic Onium Salts

Cesium Halides

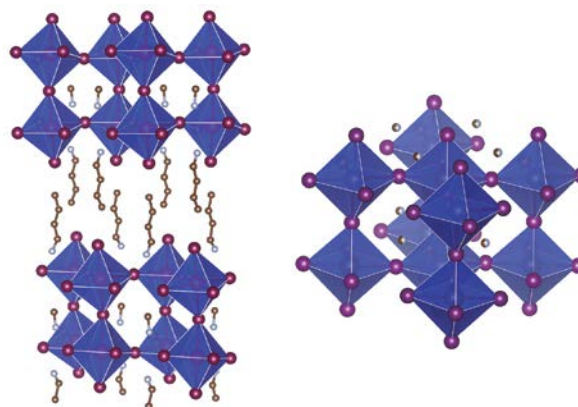


Organic-Inorganic Perovskite Precursors

"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 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⁾

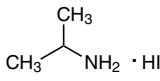
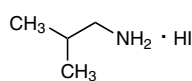
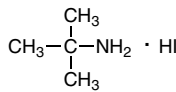

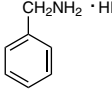
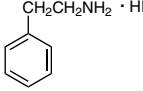
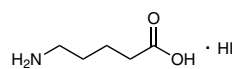
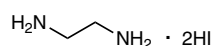
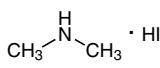
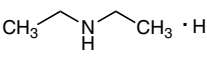
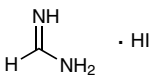
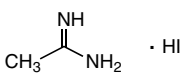


An application of an organic-inorganic perovskite is a perovskite solar cell.¹¹⁻¹⁵⁾ This solar cell can usually be fabricated by the three-dimensional cubic perovskite $[(\text{MeNH}_3)\text{MX}_3]$. Doping effects of formamidinium¹⁶⁾ and cesium cations¹⁷⁾ to the A site were also investigated for the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

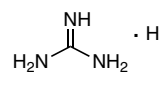
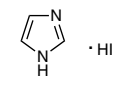
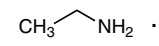
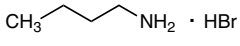
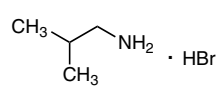
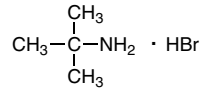
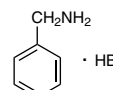
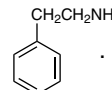
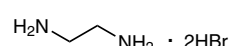
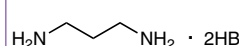
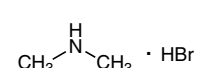
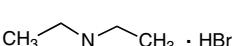
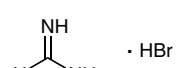
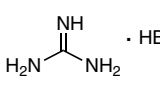
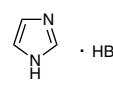
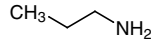
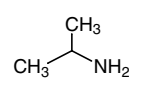
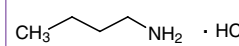
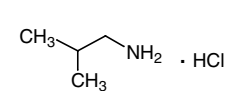
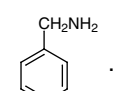
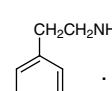
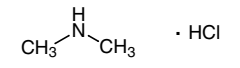
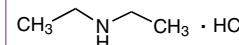
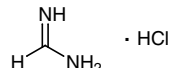
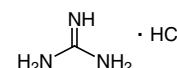
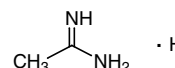
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Lead Halides		L0279 1g 5g 25g 100g	P2415 1g 5g 25g	L0288 1g 5g 25g
		PbI ₂ Lead(II) Iodide (99.99%, trace metals basis) [10101-63-0]	CH ₃ NH ₃ PbI ₃ / DMF PbI ₂ /MAI(1:1) - DMF Complex (99.99%, trace metals basis)	PbBr ₂ Lead(II) Bromide [10031-22-8]
L0292 1g 5g 25g	L0291 1g 5g			
PbCl ₂ Lead(II) Chloride [7758-95-4]	PbCl ₂ Lead(II) Chloride (purified by sublimation) [7758-95-4]			
Organic Onium Salts		Iodide Salts		
		M2556 1g 5g 25g	E1045 1g 5g	
		CH ₃ NH ₂ · HI Methylamine Hydroiodide [14965-49-2]	CH ₃ CH ₂ NH ₂ · HI Ethylamine Hydroiodide [506-58-1]	
P2212 1g 5g	I0934 1g 5g	B4433 1g 5g	I0935 1g 5g	B4434 1g 5g
CH ₃ CH ₂ CH ₂ NH ₂ · HI Propylamine Hydroiodide [14488-45-0]	 Isopropylamine Hydroiodide [66735-20-4]	CH ₃ (CH ₂) ₃ NH ₂ · HI Butylamine Hydroiodide [36945-08-1]	 Isobutylamine Hydroiodide [205508-75-4]	 tert-Butylamine Hydroiodide [39557-45-4]
A2778 1g 5g	B4566 1g 5g	P2213 1g 5g	A2984 1g 5g	E1222 1g 5g 25g
 Aniline Hydroiodide [45497-73-2]	 Benzylamine Hydroiodide [45579-91-7]	 2-Phenylethylamine Hydroiodide [151059-43-7]	 5-Aminovaleric Acid Hydroiodide [1705581-28-7]	 Ethylenediamine Dihydroiodide [5700-49-2]
D5091 1g 5g	D4555 1g 5g	D4643 1g 5g	F0974 1g 5g	A2902 1g 5g
H ₂ NCH ₂ CH ₂ CH ₂ NH ₂ · 2HI 1,3-Diaminopropane Dihydroiodide [120675-53-8]	 Dimethylamine Hydroiodide [51066-74-1]	 Diethylamine Hydroiodide [19833-78-4]	 Formamidine Hydroiodide [879643-71-7]	 Acetamidine Hydroiodide [1452099-14-7]

Organic-Inorganic Perovskite Precursors

G0450 1g 5g  Guanidine Hydroiodide [19227-70-4]	I0970 1g 5g  Imidazole Hydroiodide [68007-08-9]	Bromide Salts	M2589 1g 5g $\text{CH}_3\text{NH}_2 \cdot \text{HBr}$ Methylamine Hydrobromide [6876-37-5]	E0056 25g 500g  Ethylamine Hydrobromide [593-55-5]
B5186 1g 5g  Butylamine Hydrobromide [15567-09-6]	I1007 1g 5g  Isobutylamine Hydrobromide [74098-36-5]	B5187 1g 5g  tert-Butylamine Hydrobromide [60469-70-7]	B5185 1g 5g  Benzylamine Hydrobromide [37488-40-7]	P2388 1g 5g  2-Phenylethylamine Hydrobromide [53916-94-2]
E1221 1g 5g  Ethylenediamine Dihydrobromide [624-59-9]	D5090 1g 5g  1,3-Diaminopropane Dihydrobromide [18773-03-0]	D5092 1g 5g  Dimethylamine Hydrobromide [6912-12-5]	D4667 1g 5g  Diethylamine Hydrobromide [6274-12-0]	F0973 1g 5g  Formamidinium Hydrobromide [146958-06-7]
G0449 1g 5g  Guanidine Hydrobromide [19244-98-5]	I1006 1g 5g  Imidazole Hydrobromide [101023-55-6]	Chloride Salts	M0138 25g 500g $\text{CH}_3\text{NH}_2 \cdot \text{HCl}$ Methylamine Hydrochloride [593-51-1]	P0522 25g  Propylamine Hydrochloride [556-53-6]
I0166 25g 100g 500g  Isopropylamine Hydrochloride [15572-56-2]	B0710 25g 500g  Butylamine Hydrochloride [3858-78-4]	I0096 25g 500g  Isobutylamine Hydrochloride [5041-09-8]	B0407 25g 100g 500g  Benzylamine Hydrochloride [3287-99-8]	P0086 25g 100g 500g  2-Phenylethylamine Hydrochloride [156-28-5]
D0644 25g 500g  Dimethylamine Hydrochloride [506-59-2]	D0468 25g 500g  Diethylamine Hydrochloride [660-68-4]	F0103 5g 25g  Formamidinium Hydrochloride [6313-33-3]	G0162 25g 500g  Guanidine Hydrochloride [50-01-1]	A0008 25g 500g  Acetamidinium Hydrochloride [124-42-5]
Cesium Halides		C2205 25g CsI Cesium Iodide [7789-17-5]	C2202 25g CsBr Cesium Bromide [7787-69-1]	C2203 25g 100g CsCl Cesium Chloride [7647-17-8]

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