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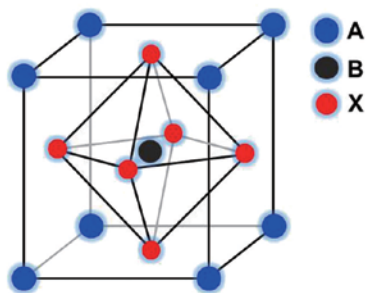
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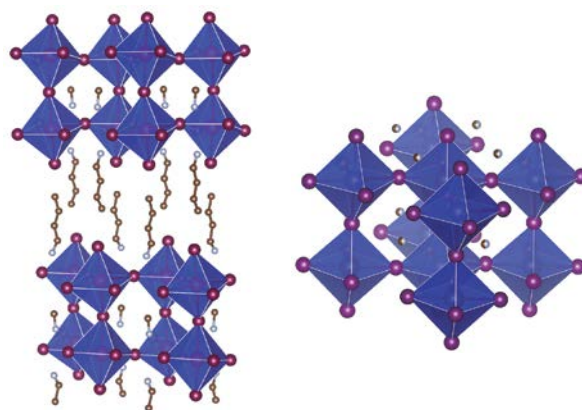
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Organic-Inorganic Perovskite Precursors

"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. 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.

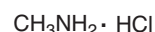
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Organic Onium Salts

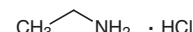
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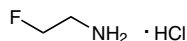
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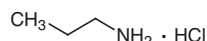
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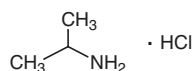
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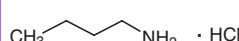
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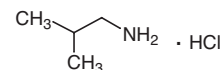
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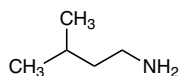
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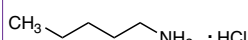
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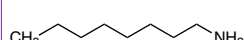
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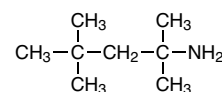
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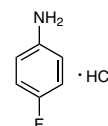
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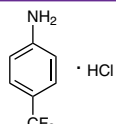
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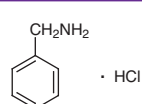
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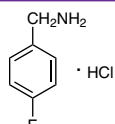
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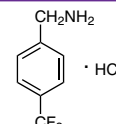
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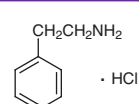
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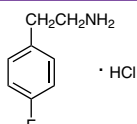
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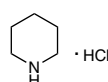
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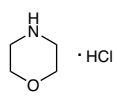
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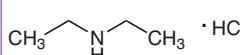
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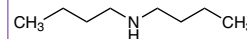
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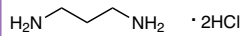
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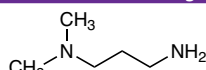
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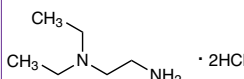
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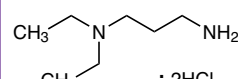
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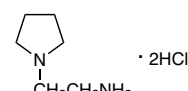
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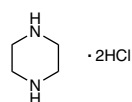
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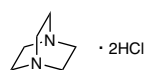
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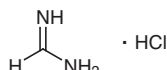
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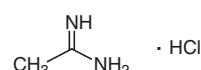
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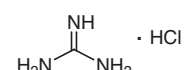
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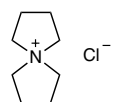
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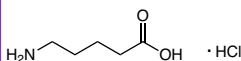
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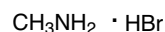
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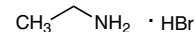
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P2388 1g 5g 2-Phenylethylamine Hydrobromide CAS RN: 53916-94-2	F1229 1g 5g 4-Fluorophenethylamine Hydrobromide CAS RN: 1807536-06-6	M3239 1g 5g 2-(4-Methoxyphenyl)ethylamine Hydrobromide CAS RN: 2705331-53-7	P2484 1g 5g Pyrrolidine Hydrobromide CAS RN: 55810-80-5	P2487 1g 5g Piperidine Hydrobromide CAS RN: 14066-85-4
M3285 5g 25g Morpholine Hydrobromide CAS RN: 6377-82-8	D5092 1g 5g Dimethylamine Hydrobromide CAS RN: 6912-12-5	D4667 1g 5g Diethylamine Hydrobromide CAS RN: 6274-12-0	D5853 5g Dipropylamine Hydrobromide CAS RN: 7334-96-5	D5768 5g Diisopropylamine Hydrobromide CAS RN: 30321-74-5
D5857 5g Dibutylamine Hydrobromide CAS RN: 10435-44-6	E1221 1g 5g Ethylenediamine Dihydrobromide CAS RN: 624-59-9	D5090 1g 5g 1,3-Diaminopropane Dihydrobromide CAS RN: 18773-03-0	D5685 1g 5g 1,4-Diaminobutane Dihydrobromide CAS RN: 18773-04-1	D5615 1g 5g N,N-Dimethylethylenediamine Dihydrobromide CAS RN: 1245570-04-0
D5618 1g 5g 3-(Dimethylamino)propylamine Dihydrobromide CAS RN: 2710685-13-3	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 Formamidinium Hydrobromide (Low water content) CAS RN: 146958-06-7	F1244 1g 5g 25g FABr (99.99%, trace metals basis) CAS RN: 146958-06-7

A3292 1g 5g Acetamidine Hydrobromide CAS RN: 1040352-82-6	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 5-Azoniaspiro[4.4]nonane Bromide CAS RN: 16450-38-7	A3094 1g 5g 5-Aminovaleric Acid Hydrobromide (Low water content) CAS RN: 2173111-73-2
Iodide Salts				
	M2556 1g 5g 25g 100g $\text{CH}_3\text{NH}_2 \cdot \text{HI}$ Methylamine Hydroiodide (Low water content) 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	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 Isobutylamine Hydroiodide CAS RN: 205508-75-4	B4434 1g 5g tert-Butylamine Hydroiodide CAS RN: 39557-45-4	P2740 1g 5g $\text{CH}_3(\text{CH}_2)_4\text{NH}_2 \cdot \text{HI}$ Pentylamine Hydroiodide CAS RN: 60762-85-8	I1095 1g 5g Isopentylamine Hydroiodide CAS RN: 2733412-76-3	N1157 1g 5g Neopentylamine Hydroiodide
H1679 5g $\text{CH}_3(\text{CH}_2)_5\text{NH}_2 \cdot \text{HI}$ 1-Hexanamine Hydroiodide CAS RN: 54285-91-5	O0485 1g 5g $\text{CH}_3(\text{CH}_2)_7\text{NH}_2 \cdot \text{HI}$ 1-Octanamine Hydroiodide CAS RN: 60734-63-6	T3785 1g 5g tert-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 Cyclohexylamine Hydroiodide CAS RN: 45492-87-3
C3425 1g 5g Cyclohexanemethylamine Hydroiodide CAS RN: 2153504-15-3	A2778 1g 5g Aniline Hydroiodide CAS RN: 45497-73-2	F1273 1g 5g 4-Fluoroaniline Hydroiodide CAS RN: 85734-19-6	B4566 1g 5g Benzylamine Hydroiodide (Low water content) CAS RN: 45579-91-7	F1228 1g 5g 4-Fluorobenzylamine Hydroiodide CAS RN: 2097121-30-5
T3838 1g 5g 4-(Trifluoromethyl)-benzylamine Hydroiodide	P2213 1g 5g 2-Phenylethylamine Hydroiodide CAS RN: 151059-43-7	F1203 1g 5g 2-(4-Fluorophenyl)-ethylamine Hydroiodide CAS RN: 1413269-55-2	M3240 1g 5g 2-(4-Methoxyphenyl)-ethylamine Hydroiodide	D4555 1g 5g Dimethylamine Hydroiodide CAS RN: 51066-74-1
D4643 1g 5g $\text{CH}_3\text{CH}_2\text{NHCH}_2\text{CH}_3 \cdot \text{HI}$ Diethylamine Hydroiodide CAS RN: 19833-78-4	D5769 5g Diisopropylamine Hydroiodide CAS RN: 132396-99-7	D5858 5g Dibutylamine Hydroiodide CAS RN: 79886-80-9	P2486 1g 5g Pyrrolidine Hydroiodide CAS RN: 45361-12-4	M3286 5g 25g Morpholine Hydroiodide CAS RN: 58464-45-2
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	D5686 1g 5g $\text{H}_2\text{NCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 \cdot 2\text{HI}$ 1,4-Diaminobutane Dihydroiodide CAS RN: 916849-52-0	D6035 1g 5g $\text{H}_2\text{NCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 \cdot 2\text{HI}$ 1,6-Hexanediamine Dihydroiodide CAS RN: 20208-23-5	D5616 1g 5g N,N-Dimethylethylenediamine Dihydroiodide CAS RN: 244234-52-4

D5619 1g 5g <i>N,N</i> -Dimethyl-1,3-propanediamine Dihydroiodide CAS RN: 2561497-43-4	D5861 5g 3-(Dimethylamino)-propylamine Dihydroiodide CAS RN: 99310-71-1	P2389 1g 1,4-Phenylenediamine Dihydroiodide CAS RN: 116469-02-4	P2492 1g 5g Piperazine Dihydroiodide CAS RN: 58464-47-4	D5252 1g 5g 1,4-Diazabicyclo[2.2.2]octane Dihydroiodide CAS RN: 33322-06-4
H1759 5g 1-Hexyl-1,4-diazabicyclo[2.2.2]octan-1-ium Iodide CAS RN: 1009321-13-4	F0974 1g 5g 25g 100g Formamidine Hydroiodide (Low water content) CAS RN: 879643-71-7	F1263 1g 5g 25g Formamidine Hydroiodide (99.99%, trace metals basis) CAS RN: 879643-71-7	A2902 1g 5g Acetamidine Hydroiodide (Low water content) CAS RN: 1452099-14-7	G0450 1g 5g Guanidine Hydroiodide CAS RN: 19227-70-4
I0970 1g 5g Imidazole Hydroiodide (Low water content) CAS RN: 68007-08-9	P2672 5g Pyridine Hydroiodide CAS RN: 18820-83-2	A3093 1g 5g 5-Azoniaspiro[4.4]nonane Iodide CAS RN: 45650-35-9	A2984 1g 5g 5-Aminovaleric Acid Hydroiodide (Low water content) CAS RN: 1705581-28-7	A3112 1g 5g β-Alanine Hydroiodide (Low water content) CAS RN: 2096495-59-7
Pseudo Halide Salts				
M2990 1g 5g Methylamine Tetrafluoroborate CAS RN: 42539-74-2	M2991 1g 5g Methylamine Thiocyanate CAS RN: 61540-63-4	F1153 1g 5g Formamidine Thiocyanate CAS RN: 1821033-48-0	G0230 25g 500g Guanidine Thiocyanate CAS RN: 593-84-0	F1152 1g 5g Formamidinium Tetrafluoroborate CAS RN: 2607106-18-1
M2990 1g 5g Methylamine Tetrafluoroborate CAS RN: 42539-74-2	M2989 1g 5g Methylammonium Hexafluorophosphate CAS RN: 28302-50-3	M3134 1g 5g Methylamine Cyanate CAS RN: 63405-91-4	T0914 25g 100g 500g Tetrabutylammonium Tetrafluoroborate CAS RN: 429-42-5	T2648 25g Tetrabutylammonium Tetrafluoroborate (Br < 0.02 %) CAS RN: 429-42-5
Lead Halides				
L0291 1g 5g Lead(II) Chloride (purified by sublimation) [for Perovskite precursor] CAS RN: 7758-95-4	L0292 1g 5g 25g Lead(II) Chloride [for Perovskite precursor] CAS RN: 7758-95-4	L0279 1g 5g 25g 100g 1kg Lead(II) Iodide (99.99%, trace metals basis) [for Perovskite precursor] CAS RN: 10101-63-0	L0288 1g 5g 25g Lead(II) Bromide [for Perovskite precursor] CAS RN: 10031-22-8	L0346 1g 5g 25g Lead(II) Bromide (Low water content) [for Perovskite precursor] CAS RN: 10031-22-8
L0291 1g 5g Lead(II) Chloride (purified by sublimation) [for Perovskite precursor] CAS RN: 7758-95-4	L0292 1g 5g 25g Lead(II) Chloride [for Perovskite precursor] CAS RN: 7758-95-4	C3569 1g 5g Cesium Lead Tribromide (Low water content) CAS RN: 15243-48-8	C3570 1g 5g Cesium Lead Triiodide (Low water content) CAS RN: 18041-25-3	
Other Lead Compounds				
L0315 1g 5g 25g Lead(II) Acetate [for Perovskite precursor] CAS RN: 301-04-2	L0330 25g 100g Lead(II) Acetate Trihydrate CAS RN: 6080-56-4			

Cesium Halides

C2202 25g 100g

Cesium Bromide
CAS RN: 7787-69-1

C2203 25g 100g

Cesium Chloride
CAS RN: 7647-17-8

C2205 25g

Cesium Iodide
CAS RN: 7789-17-5

Bismuth Halides

B5787 5g 25g

Bismuth(III) Iodide
Anhydrous
CAS RN: 7787-64-6

Tin Halides

T3449 1g 5g

Tin(II) Iodide
[for Perovskite precursor]
CAS RN: 10294-70-9

T3570 1g 5g

Tin(II) Chloride
[for Perovskite precursor]
CAS RN: 7772-99-8

T3573 1g 5g

Tin(II) Bromide
[for Perovskite precursor]
CAS RN: 10031-24-0

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