

Diversified use of various Salts in Organic Synthesis

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Abstract

Salt chemistry is of great importance because of its immense potential from the daily life use to the synthetic chemistry like as workup material, as reagents, as phase transfer catalyst, as acid, as base, as catalyst, as agents for asymmetric synthesis, for some specific reaction transformation, to increase yield, decrease reaction time, ecofriendly synthesis, handling easiness and many more. This review summarizes the basic background of salts, its application, synthesis of new salts, and list of individual category of major commercially available salts with some structure.

Keywords:

Organic synthesis, green chemistry, salts, catalyst, reagent, asymmetric synthesis, acid, base

Introduction

In chemistry, the salt is a solid chemical compound having related numbers of cations (positively charged ions) and anions (negative ions) assembled to form a mass, so the whole mass is electrically neutral (without a net charge). These ions particle can be either inorganic (chloride- Cl^- , fluoride- F^- etc.) or organic (acetate- CH_3CO_2^-) and can be as a monoatomic (fluoride- F^-) or polyatomic (sulfate- SO_4^{2-})[1].

For the organic synthesis, the considerations about various factors play a crucial role. With this respect, the organic and inorganic salts always remain core corner in reagents category. For the greener approach to the specific oriented synthesis, the salt plays main role. Various nontoxic approach are carried out with applying green chemistry principle[2]. The phase transfer catalyst as salt form always plays a great role to carry out the reaction in two immiscible solvents[3].

The acids and bases are regular used reagents in organic as well as inorganic synthesis, and many time behaves as a salt form[4]. The proper selection of solvents, considering its relative reactivity, dissolution capacity, orientation of reaction etc. always remains in front line of synthesis and a need of proper consideration about salt is necessary[5]. In the field of chemistry, various novel discovery leads to winning Nobel Prize. Our previous review discussed about it in detail, where most of the synthetic chemist employed the salts at beginning, at middle or at the end phase of reactions throughout their research works[6]. In our biological system also the salt plays a potent role for the action potential, transport of nutrients and many more[7]. The drugs are metabolized in the liver and converted to the water soluble salt form so easily excreted from body[8].

The consumption of cow urine is considered as beneficial and reported due to the presence of various salts excreted in cow urine as a solubilized ionic form which replace the normal deficiency in the human body[9]. Various drug molecules also formulated in salt form to potentiate its activity, increase bioavailability, decrease toxicity, increase dissolution capacity etc.[10-12]. The molten form of salts having great significance are reporting[13], the role of various salts in therapeutic[14] and the role of guanidinium salt in isolation of RNA[15] shows diverse potential of salts. Plato elaborate salts as dear to gods, Homer called salt as a divine substance, and Mark Kurlansky wrote a book 'salt: a world history' describing how a salt shaped human civilization, war, the political activities around it and many more[16].

Through this concise review, we tried to summarize the role of salts in organic synthesis with some recent examples, some of the commercially available salts in sigma Aldrich[17] and TCI chemical[18] are listed in **Table 1**[17, 18].

Classification of salts:

The salts can be further classified into various ways. The broader category is based on their characteristics after dissolution, like those salts capable of forming acidic solution or having replaceable hydrogen are acidic salts, those producing hydroxide ion on dissolving in water are alkali salts but those group of salts which neither form acidic nor basic are neutral salts. The zwitterions like metabolites, amino acids, peptides and proteins also contains both the cations and anions in a same molecule but not considered as salt[19].

1. Acidic Salts: NH_4Cl , NaHCO_3 , NaHSO_4 , NaH_2PO_4 , Na_2HPO_4
2. Basic Salts: Na_2CO_3 , CH_3COONa , KCN , Na_2S
3. Neutral Salts: NaCl , KCl , KBr

Properties of salts:

Color: The most common solid salt, sodium chloride is transparent (fig 1.b). The size of individual crystal may cause apparent transparency. The various colors of salts can be observed like the sodium chromate (fig 1.c) is yellow due to chromate ion, copper sulfate (fig 1.d) is blue due to copper (II) chromophore, the magnesium sulfate and sodium chloride are colorless or white due to the constituent anion and cation cannot absorb visible part of spectrum[19].

Taste: The variety of salts can exhibit all five basic tastes. Like sodium chloride (salty), potassium bitartrate (sour), monosodium glutamate (savory), lead diacetate (sweet), and magnesium sulfate (bitter)[19].

Odor: The strong salts from strong acids or bases are nonvolatile so often odorless, but the weak salts from weak acids or bases smell as their conjugate acids or bases like ammonium salts smell like ammonia and acetates smell like acetic acid[19].

Solubility: The compounds having ionic character are usually solubilized significantly in water as well as other polar solvents. To be solubilized, the salts should undergo dissociation into its anionic and cationic components. The

cohesive forces (lattice energy) between these ions determine the actual solubility. The solubility plays a crucial role in organic synthesis. How much salts can interact with the solvents determines its relative solubility. The salts of sodium and potassium are well solubilized in water with exception to potassium cobaltnitrile and ammonium hexachloroplatinate[19].

Conductivity: Molten or solution form of salts can conduct electricity like sodium chloride in water is a good electrolyte[19].

Melting Points: Mostly the solid salts have high melting points (NaCl melts at 801 °C). So the compounds having possibility of low boiling points are converted into its salt form to increase its melting points. The mixture of salts (molten salts) usually containing organic cations can behave as solvent[19].

Nomenclature:

The naming of salts usually starts with the name of cation followed by anion like sodium (cation) chloride (anion). The **Table 1** shows the various categories (ammonium, calcium, iron, potassium, magnesium, sodium, and copper etc.) of salts with common examples of them used in organic synthesis.

Formation of Salts:

The **Table 1** shows the various examples of salts. The individual category of salt can tell us by what kind of chemical reaction it is formed from. The each category having representative chemical structure of salts is shown in **Chart 1**. Some major reaction processes are listed below[19]:

Reaction between-

- base and acid, e.g., $\text{NH}_3 + \text{HCl} \rightarrow \text{NH}_4\text{Cl}$
- metal and acid, e.g., $\text{Mg} + \text{H}_2\text{SO}_4 \rightarrow \text{MgSO}_4 + \text{H}_2$
- metal and non-metal, e.g., $\text{Ca} + \text{Cl}_2 \rightarrow \text{CaCl}_2$
- base and acid anhydride, e.g., $2 \text{NaOH} + \text{Cl}_2\text{O} \rightarrow 2 \text{NaClO} + \text{H}_2\text{O}$
- acid and base anhydride, e.g., $2 \text{HNO}_3 + \text{Na}_2\text{O} \rightarrow 2 \text{NaNO}_3 + \text{H}_2\text{O}$
- By mixing the solutions of different salts, their ions can recombine, and the newly formed salt is insoluble and precipitates, eg., $\text{Pb}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow \text{PbSO}_4\downarrow + 2 \text{NaNO}_3$

Diversified use of salts in organic synthesis:

The use of salts in our body, other plants and creatures of this world is diversified. Here the centered focus will be the use of various salts in organic synthesis. Below is the major category of salt's application in organic synthesis:

- As a catalyst
- As a reagent
- In workup
- To quench the reaction
- To enhance solubility
- As a Phase Transfer Catalyst (PTC)
- As an acids
- As a bases
- As a neutral solution
- As an electrolytes
- As conversing agents to salt form
- As Lewis acid and
- As Lewis base etc.

These above category are compiled here with the research citation of some recent published work with regard to use of individual salt since 2015. Various papers are published with discussing the role of individual salts, their selective way of transformation, role in asymmetric synthesis and many more. Some of the recent influencing research on application of salts in organic synthesis are use of diaryliodonium salts for novel arylation[20], applications of ferrocenium salts[21], salt as linker source[22], pyridinium salts as radical reservoir[23], use of vinylidonium salts for alkenylation of nitriles[24], use of sulfonium salts for synthesis of spirocyclopropanyl para-dienones[25], use of phosphonium salts for selective functionalization of pyridines[26], tropylium salts as lewis acid to catalyze acetalization and transacetalization[27], use of Phenyltrimethylammonium salts in nickel-catalyzed methylation of C–H bonds[28], aryldiazonium salts for carbohydroxylation of styrenes[29], synthesis of bicyclic aziridines from pyridinium salts[30], nucleophilic arylation with tetraarylphosphonium salts[31], application of trimethylsilanolate alkali salts in organic synthesis[32], use of α , β -unsaturated acylammonium salts for asymmetric organocatalysis[33], review on cesium salts use in organic synthesis[34], iodonium salts as benzyne precursors[35], use of bunte salts as a sulfur source for synthesis of 3-thioindoles[36], and C–H functionalization of arenes by diaryliodonium salts[37] etc.

The use of salts are not limited to the old one, neither recently discovered one only but the new and new category, various structural diversity, different properties and

reactivity's having salts are discovering every years. Various synthetic pathways of old salts, synthesis of new salts, modification of existing salts are reporting. Some recent reported since 2015 are, synthesis of unsymmetrical aryl (2, 4, 6-trimethoxyphenyl) iodonium salts with its scope and stability[38], synthesis of aryl (2, 4, 6-trimethoxyphenyl) iodonium trifluoroacetate salts[39], hydrogen-bonding catalysis of sulfonium salts[40], difluoromethylthiolation of aryl and heteroaryl diazonium salts[41], synthesis of quaternary phosphonium salts from phosphine oxides[42], synthesis of liquid nickel salts[43], synthesis of diaryliodonium salts from arenes and aryl iodides with oxone–sulfuric acid[44], synthesis of N, N-diphenyl carbazolium salts[45], and synthesis of chiral bicyclic guanidinium salts using di (imidazole-1-yl) methanimine[46] etc. The **Table 1** shows the overall major category of salts like aluminum, ammonium, antimony, arsenic, barium, beryllium, bismuth, cadmium, calcium, cerium, cesium, chromium, cobalt, copper, dysprosium, erbium, europium, gadolinium, gallium, germanium, gold, hafnium, holmium, indium, iridium, iron, lanthanum, lead, lithium, lutetium, magnesium, manganese, mercury, molybdenum, neodymium, nickel, niobium, osmium, palladium, platinum, potassium, praseodymium, rhenium, rhodium, rubidium, ruthenium, samarium, scandium, selenium, silver, sodium, strontium, tantalum, terbium, thallium, thulium, tin, titanium, tungsten, vanadium, ytterbium, yttrium, zinc, and zirconium salts with the examples derived from these individual category.



Fig 1. Different salts and their color.

Table 1: List of different category of salts with common examples[17, 18]:

Category	Some Examples
Aluminum Salts	Aluminum chloride, Aluminum acetate, Aluminum bromide, Aluminum fluoride, Aluminum hydroxide, Aluminum iodide, Aluminum L-lactate, Aluminum nitrate, Aluminum perchlorate, Aluminum phosphate, Aluminum potassium sulfate, Aluminum silicate, Aluminum sulfate, Ammonium aluminum sulfate
Ammonium Salts	Ammonium acetate, Tetrabutylammonium bisulfate, Tetrabutylammonium bromide, Ammonium baborate tetrahydrate, Ammonium bicarbonate, Ammonium bromide, Ammonium carbamate, Ammonium carbonate, Ammonium cerium(IV) sulfate dihydrate, Ammonium chloride, Ammonium chromate, Ammonium citrate dibasic, Ammonium dichromate, Ammonium dihydrogenphosphate, Ammonium fluoride, Ammonium formate, Ammonium heptafluorotantalate(V), Ammonium hexachloroiridate(III) monohydrate, Ammonium hexachloroiridate(IV), Ammonium hexachloroosmate(IV), Ammonium hexachloropalladate(IV), Ammonium hexachloroplatinate(IV), Ammonium hexachlororhodate(III), Ammonium hexafluorogermanate(IV), Ammonium hexafluorophosphate, Ammonium hexafluorosilicate, Ammonium hexafluorostannate, Ammonium hexafluorotitanate, Ammonium hydrogen difluoride, Ammonium hydrogenoxalate hydrate
Antimony Salts	Antimony(III) acetate, Antimony(III) chloride, Antimony(III) fluoride, Antimony(III) iodide, Antimony(III) sulfate, Antimony(V) chloride, Antimony(V) chloride solution, Antimony(V) fluoride, Fluoroantimonic acid hexahydrate, Nitronium hexafluoroantimonate, Nitrosonium hexafluoroantimonate, Potassium antimony(III) tartrate hydrate
Arsenic Salts	Arsenic(III) chloride, Arsenic(III) iodide
Barium Salts	Barium acetate, Barium bromide, Barium carbonate, Barium chloride, Barium chromate, Barium fluoride, Barium hydroxide, Barium iodide, Barium manganate, Barium metaphosphate, Barium nitrate, Barium phosphate, Barium sulfate, Barium tetrafluorocobaltate, Barium tetrafluoronickelate
Beryllium Salts	Beryllium sulfate tetrahydrate
Bismuth Salts	Bismuth(III) bromide, Bismuth(III) carbonate basic, Bismuth(III) chloride, Bismuth(III) fluoride, Bismuth(III) iodide, Bismuth(III) nitrate pentahydrate, Bismuth(III) oxychloride, Bismuth(III) subnitrate
Cadmium Salts	Cadmium acetate dihydrate, Cadmium bromide tetrahydrate, Cadmium carbonate, Cadmium chloride, Cadmium chloride hemi(pentahydrate), Cadmium chloride hydrate, Cadmium iodide, Cadmium nitrate tetrahydrate, Cadmium perchlorate hydrate, Cadmium sulfate
Calcium Salts	β -tri-Calcium phosphate, Calcium acetate monohydrate, Calcium bromide, Calcium carbonate, Calcium chloride, Calcium citrate tribasic tetrahydrate, Calcium cyanamide, Calcium fluoride, Calcium hydride, Calcium hydrogenphosphate dihydrate, Calcium hydroxide, Calcium hypochlorite, Calcium iodate, Calcium iodide, Calcium nitrate, Calcium oxalate, Calcium perchlorate tetrahydrate, Calcium phosphate
Cerium Salts	Ammonium cerium(IV) nitrate, Ammonium cerium(IV) sulfate, Cerium(III) bromide, Cerium(III) carbonate, Cerium(III) chloride, Cerium(III) fluoride, Cerium(III) iodide, Cerium(III) nitrate, Cerium(III) oxalate, Cerium(III) sulfate, Cerium(IV) fluoride, Cerium(IV) hydroxide, Cerium(IV) sulfate
Cesium Salts	Cesium acetate, Cesium bromide, Cesium carbonate, Cesium chloride, Cesium fluoride, Cesium formate, Cesium hydroxide, Cesium iodide, Cesium metavanadate, Cesium nitrate, Cesium oxalate, Cesium perchlorate, Cesium sulfate
Chromium Salts	Chromium(II) chloride, Chromium(III) chloride, Chromium(III) fluoride, Chromium(III) nitrate, Chromium(III) potassium sulfate, Chromium(III) sulfate, Chromyl chloride, Potassium

	chromium(III) oxalate, Potassium dichromate
Cobalt Salts	Ammonium cobalt(II) sulfate, Cobalt(II) acetate, Cobalt(II) bromide, Cobalt(II) carbonate, Cobalt(II) chloride, Cobalt(II) cyanide, Cobalt(II) fluoride, Cobalt(II) hydroxide, Cobalt(II) nitrate, Cobalt(II) oxalate, Cobalt(II) perchlorate, Cobalt(II) phosphate, Cobalt(II) sulfate, Cobalt(II) tetrafluoroborate, Cobalt(II) thiocyanate, Cobalt(III) fluoride, Hexaamminecobalt(III) chloride, Pentaamminechlorocobalt(III) chloride
Copper Salts	Copper(I) bromide, Copper(I) chloride, Copper(I) cyanide, Copper(I) iodide, Copper(I) thiocyanate, Copper(II) acetate, Copper(II) bromide, Copper(II) carbonate, Copper(II) chloride, Copper(II) cyclohexanebutyrate, Copper(II) D-gluconate, Copper(II) fluoride, Copper(II) hydroxide, Copper(II) nitrate hemi(pentahydrate), Copper(II) perchlorate, Copper(II) pyrophosphate, Copper(II) selenite, Copper(II) sulfate, Copper(II) tartrate, Copper(II) tetrafluoroborate, Tetraamminecopper(II) sulfate
Dysprosium Salts	Dysprosium(II) iodide, Dysprosium(III) chloride, Dysprosium(III) fluoride, Dysprosium(III) nitrate
Erbium Salts	Erbium(III) bromide, Erbium(III) chloride, Erbium(III) nitrate, Erbium(III) perchlorate
Europium Salts	Europium(II) chloride, Europium(II) iodide, Europium(III) bromide, Europium(III) chloride, Europium(III) fluoride, Europium(III) nitrate
Gadolinium Salts	Gadolinium(III) chloride, Gadolinium(III) fluoride, Gadolinium(III) hydroxide, Gadolinium(III) nitrate, Gadolinium(III) sulfate, Gadolinium(III) sulfate
Gallium Salts	Gallium(II) chloride, Gallium(III) bromide, Gallium(III) chloride, Gallium(III) iodide, Gallium(III) nitrate, Gallium(III) perchlorate, Gallium(III) sulfate
Germanium Salts	Germanium(II) bromide, Germanium(II) chloride dioxane complex (1:1), Germanium(II) iodide, Germanium(IV) chloride, Germanium(IV) iodide
Gold Salts	Gold(I) chloride, Gold(I) iodide, Gold(III) bromide, Gold(III) chloride, Gold(III) hydroxide, Potassium gold(III) chloride
Hafnium Salts	Hafnium(IV) chloride, Hafnium(IV) chloride tetrahydrofuran complex (1:2), Hafnium(IV) fluoride, Hafnium(IV) iodide, Hafnium(IV) oxychloride hydrate, Hafnium(IV) sulfate
Holmium Salts	Holmium(III) bromide, Holmium(III) chloride, Holmium(III) fluoride, Holmium(III) nitrate pentahydrate, Holmium(III) perchlorate, Holmium(III) phosphate
Indium Salts	Indium(I) iodide, Indium(II) chloride, Indium(III) bromide, Indium(III) chloride, Indium(III) fluoride, Indium(III) hydroxide, Indium(III) iodide, Indium(III) nitrate, Indium(III) perchlorate, Indium(III) sulfate
Iridium Salts	Hydrogen hexachloroiridate(IV) hydrate, Iridium(III) bromide hydrate, Iridium(III) chloride, Iridium(IV) chloride hydrate, Pentaamminechloroiridium(III) chloride, Tetrairidium dodecacarbonyl
Iron Salts	Ammonium iron(II) sulfate hexahydrate, Ammonium iron(III) citrate, Ammonium iron(III) sulfate, Iron(II) bromide, Iron(II) chloride, Iron(II) fluoride, Iron(II) iodide, Iron(II) oxalate dihydrate, Iron(II) perchlorate, Iron(II) sulfate, Iron(II) sulfide, Iron(II) tetrafluoroborate, Iron(III) bromide, Iron(III) chloride, Iron(III) citrate, Iron(III) ferrocyanide, Iron(III) fluoride, Iron(III) nitrate, Iron(III) nitrate, Iron(III) phosphate, Iron(III) sulfate, Potassium ferricyanide(III), Potassium hexacyanoferrate(II) trihydrate
Lanthanum Salts	Lanthanum(III) bromide, Lanthanum(III) carbonate, Lanthanum(III) chloride, Lanthanum(III) fluoride, Lanthanum(III) hydroxide, Lanthanum(III) iodide, Lanthanum(III) nitrate, Lanthanum(III) oxalate, Lanthanum(III) phosphate, Lanthanum(III) sulfate
Lead Salts	Lead hydrogen phosphate, Lead(II) acetate trihydrate, Lead(II) bromide, Lead(II) carbonate, Lead(II) chloride, Lead(II) chromate, Lead(II) fluoride, Lead(II) iodide, Lead(II) nitrate, Lead(II) perchlorate, Lead(II) sulfate
Lithium Salts	Dilithium tetrabromonickelate(II) solution, Dilithium tetrachlorocuprate(II) solution, Lithium acetate dihydrate, Lithium azide solution, Lithium benzoate, Lithium bromide, Lithium carbonate, Lithium chloride, Lithium chloride/potassium chloride eutectic, Lithium fluoride, Lithium

	formate, Lithium hexafluoroarsenate(V), Lithium hexafluorophosphate, Lithium hydroxide, Lithium iodate, Lithium metaborate, Lithium nitrate, Lithium perchlorate, Lithium phosphate
Lutetium Salts	Lutetium(III) chloride, Lutetium(III) fluoride, Lutetium(III) nitrate, Lutetium(III) trifluoromethanesulfonate
Magnesium Salts	Magnesium carbonate hydroxide pentahydrate, Magnesium nitrate hexahydrate, Ammonium magnesium phosphate hydrate, Magnesium acetate tetrahydrate, Magnesium bromide, Magnesium bromide ethyl etherate, Magnesium chloride, Magnesium chromate hydrate, Magnesium di- <i>tert</i> -butoxide, Magnesium fluoride, Magnesium hydroxide, Magnesium iodate tetrahydrate, Magnesium iodide, Magnesium perchlorate, Magnesium permanganate hydrate, Magnesium phosphate hydrate, Magnesium sulfate
Manganese Salts	Manganese sulfate, Manganese(II) acetate, Manganese(II) bromide, Manganese(II) carbonate, Manganese(II) chloride, Manganese(II) cyclohexanebutyrate, Manganese(II) fluoride, Manganese(II) formate hydrate, Manganese(II) iodide, Manganese(II) nitrate, Manganese(II) perchlorate, Manganese(II) sulfate, Manganese(III) fluoride
Mercury Salts	Mercury(I) chloride, Mercury(I) nitrate, Mercury(I) sulfate, Mercury(II) acetate, Mercury(II) bromide, Mercury(II) chloride, Mercury(II) fluoride, Mercury(II) iodide, Mercury(II) perchlorate, Mercury(II) sulfate, Mercury(II) thiocyanate
Molybdenum Salts	Molybdenum(III) chloride, Molybdenum(V) chloride, Molybdenum(VI) dichloride dioxide, Sodium molybdate dihydrate
Neodymium Salts	Neodymium(III) chloride, Neodymium(III) fluoride, Neodymium(III) hydroxide, Neodymium(III) nitrate, Neodymium(III) sulfate
Nickel Salts	Ammonium nickel(II) sulfate, Nickel carbonate, Nickel(II) acetate, Nickel(II) bromide, Nickel(II) carbonate, Nickel(II) chloride, Nickel(II) fluoride, Nickel(II) hydroxide, Nickel(II) iodide, Nickel(II) nitrate, Nickel(II) perchlorate, Nickel(II) sulfamate, Nickel(II) sulfate, Potassium nickel(IV) paraperiodate, Potassium tetracyanonickelate(II) hydrate
Niobium Salts	Ammonium niobate(V) oxalate, Niobium(III) chloride 1,2-dimethoxyethane, Niobium(IV) chloride tetrahydrofuran complex, Niobium(V) chloride, Niobium(V) fluoride
Osmium Salts	Osmium(III) chloride, Pentaammine(trifluoromethanesulfonato)osmium(III) triflate
Palladium Salts	(Ethylenediamine)palladium(II) chloride, Palladium(II) bromide, Palladium(II) chloride, Palladium(II) cyanide, Palladium(II) iodide, Palladium(II) nitrate, Palladium(II) sulfate, Tetraamminepalladium(II)bromide, Tetraamminepalladium(II) chloride
Platinum Salts	<i>cis</i> -Diamminetetrachloroplatinum(IV), Hydrogen hexabromoplatinate(IV) hydrate, Hydrogen hexahydroxyplatinate(IV), Platinum(II) bromide, Platinum(II) chloride, Platinum(II) iodide, Platinum(IV) chloride, <i>trans</i> -Diamminetetrachloroplatinum(IV), <i>trans</i> -Platinum(II)diammine dichloride
Potassium Salts	Aluminum potassium sulfate dodecahydrate, Potassium (meta)periodate, Potassium acetate, Potassium aminetrichloroplatinate(II), Potassium antimonyl tartrate trihydrate, Potassium aquapentachlororuthenate(III), Potassium benzoate, Potassium bicarbonate, Potassium bisulfate, Potassium borohydride, Potassium bromate, Potassium bromide, Potassium carbonate, Potassium chlorate, Potassium chloride, Potassium chromate, Potassium cyanate, Potassium cyanide, Potassium dichromate, Potassium disulfate, Potassium disulfite, Potassium fluoride, Potassium fluorosulfate, Potassium formate, Potassium hexachloroosmate(IV), Potassium hexacyanoferrate(III), Potassium hexaiodoplatinate(IV), Potassium hydrogen diiodate, Potassium hydroxide, Potassium iodate, Potassium manganate, Potassium metavanadate, Potassium molybdate, Potassium nitrate, Potassium <i>p</i> -toluenethiosulfonate, Potassium phthalate, Potassium sorbate, Potassium tellurite, Potassium thiocyanate
Praseodymium Salts	Praseodymium(III) chloride, Praseodymium(III) nitrate hexahydrate
Rhenium Salts	Rhenium(III) chloride, Rhenium(III) iodide, Rhenium(V) chloride
Rhodium Salts	Rhodium(II) acetate dimer, Rhodium(II) heptafluorobutyrate dimer, Rhodium(III) chloride,

	Rhodium(III) nitrate, Rhodium(III) sulfate
Rubidium Salts	Rubidium bromide, Rubidium carbonate, Rubidium chloride, Rubidium chromate, Rubidium fluoride, Rubidium hydroxide, Rubidium iodide, Rubidium sulfate
Ruthenium Salts	Hexaammineruthenium(II) chloride, Pentaamminechlororuthenium(III) chloride, Ruthenium iodide, Ruthenium(III) chloride, Ruthenium(III) nitrosyl nitrate
Samarium Salts	Samarium(II) iodide, Samarium(III) chloride, Samarium(III) iodide, Samarium(III) nitrate, Samarium(III) phosphate, Samarium(III) sulfate octahydrate
Scandium Salts	Scandium(III) chloride, Scandium(III) fluoride, Scandium(III) nitrate, Scandium(III) perchlorate
Selenium Salts	Diphenylphosphine selenide, Selenium oxychloride, Selenium tetrachloride
Silver Salts	Silver acetate, Silver bromide, Silver carbonate, Silver chlorate, Silver chloride, Silver chromate, Silver citrate, Silver cyanate, Silver cyanide, Silver cyclohexanebutyrate, Silver diethyldithiocarbamate, Silver heptafluorobutyrate, Silver iodide, Silver lactate, Silver nitrate, Silver nitrite, Silver <i>p</i> -toluenesulfonate, Silver perchlorate, Silver phosphate, Silver sulfate, Silver thiocyanate, Silver(I) fluoride, Silver(II) fluoride, Silver(I) sulfadiazine, Silver(I) perrhenate
Sodium Salts	Sodium pyruvate, Sodium citrate tribasic dihydrate, Sea salts, Soda ash, Sodium acetate, Sodium arsenate, Sodium arsenyl tartrate, Sodium benzoate, Sodium bicarbonate, Sodium bismuthate, Sodium bisulfite, Sodium bisulfite, Sodium borohydride, Sodium bromate, Sodium bromide, Sodium carbonate, Sodium chlorate, Sodium chloride, Sodium chlorite, Sodium chromate, Sodium cyanide, Sodium ethoxide, Sodium fluoride, Sodium formate, Sodium hexachlororhodate(III), Sodium hexafluoroaluminate, Sodium hexafluoroferrate(III), Sodium hexafluorosilicate, Sodium hexahydroxyplatinate(IV), Sodium hexanitrocobaltate(III), Sodium hydrogen difluoride, Sodium hydrogen selenite, Sodium hydrosulfite, Sodium hypophosphite, Sodium iodide, Sodium iodate, Sodium methoxide, Sodium nitrate, Sodium oxalate, Sodium percarbonate, Sodium peroxide, Sodium salicylate, Sodium selenate, Sodium selenite, Sodium sulfate
Strontium Salts	Strontium bromide, Strontium carbonate, Strontium chloride, Strontium fluoride, Strontium hydroxide, Strontium iodide, Strontium nitrate
Tantalum Salts	Tantalum(V) chloride, Tantalum(V) fluoride
Terbium Salts	Terbium(III) chloride, Terbium(III) fluoride, Terbium(III) nitrate, Terbium(III) sulfate
Thallium Salts	Thallium(I) bromide, Thallium(I) carbonate, Thallium(I) chloride, Thallium(I) iodide, Thallium(I) nitrate, Thallium(I) sulfate
Thulium Salts	Thulium(III) chloride, Thulium(III) fluoride
Tin Salts	Tin(II) acetylacetonate, Tin(II) bromide, Tin(II) chloride, Tin(II) fluoride, Tin(II) iodide, Tin(II) pyrophosphate, Tin(IV) bromide, Tin(IV) chloride, Tin(IV) fluoride, Tin(IV) iodide
Titanium Salts	Titanium carbonitride, Titanium(III) fluoride, Titanium(IV) bromide, Titanium(IV) chloride, Titanium(IV) fluoride, Titanium(IV) iodide, Titanium(IV) oxysulfate
Tungsten Salts	Sodium tungstate dihydrate, Tungsten(IV) chloride, Tungsten(VI) chloride, Tungsten(VI) oxychloride, Tungstic acid, Tungstosilicic acid hydrate
Vanadium Salts	Vanadium(II) chloride, Vanadium(III) chloride, Vanadium(V) oxychloride
Ytterbium Salts	Ytterbium(II) iodide, Ytterbium(III) chloride, Ytterbium(III) fluoride, Ytterbium(III) nitrate
Yttrium Salts	Yttrium trifluoroacetate, Yttrium(III) carbonate hydrate, Yttrium(III) chloride, Yttrium(III) iodide, Yttrium(III) nitrate

Zinc Salts	Zinc sulfate, Zinc acetate, Zinc bromide, Zinc carbonate, Zinc chloride, Zinc citrate, Zinc cyanide, Zinc fluoride, Zinc iodide, Zinc methacrylate, Zinc molybdate, Zinc nitrate, Zinc oxalate, Zinc <i>p</i> -toluenesulfonate, Zinc perchlorate, Zinc phosphate, Zinc sulfate, Zinc tetrafluoroborate
Zirconium Salts	Ammonium zirconium(IV) carbonate, Zirconium(IV) carbonate hydroxide oxide, Zirconium(IV) chloride, Zirconium(IV) fluoride, Zirconium(IV) hydroxide, Zirconium(IV) iodide, Zirconium(IV) oxynitrate, Zirconium(IV) sulfate, Zirconyl chloride

The salts can be formulated in various physical forms like powder, solid, crystalline, beads, liquids, solution, polymer linked and pellets. Usually the salts have high boiling and melting points, pH value diverse from acidic, neutral to basic.

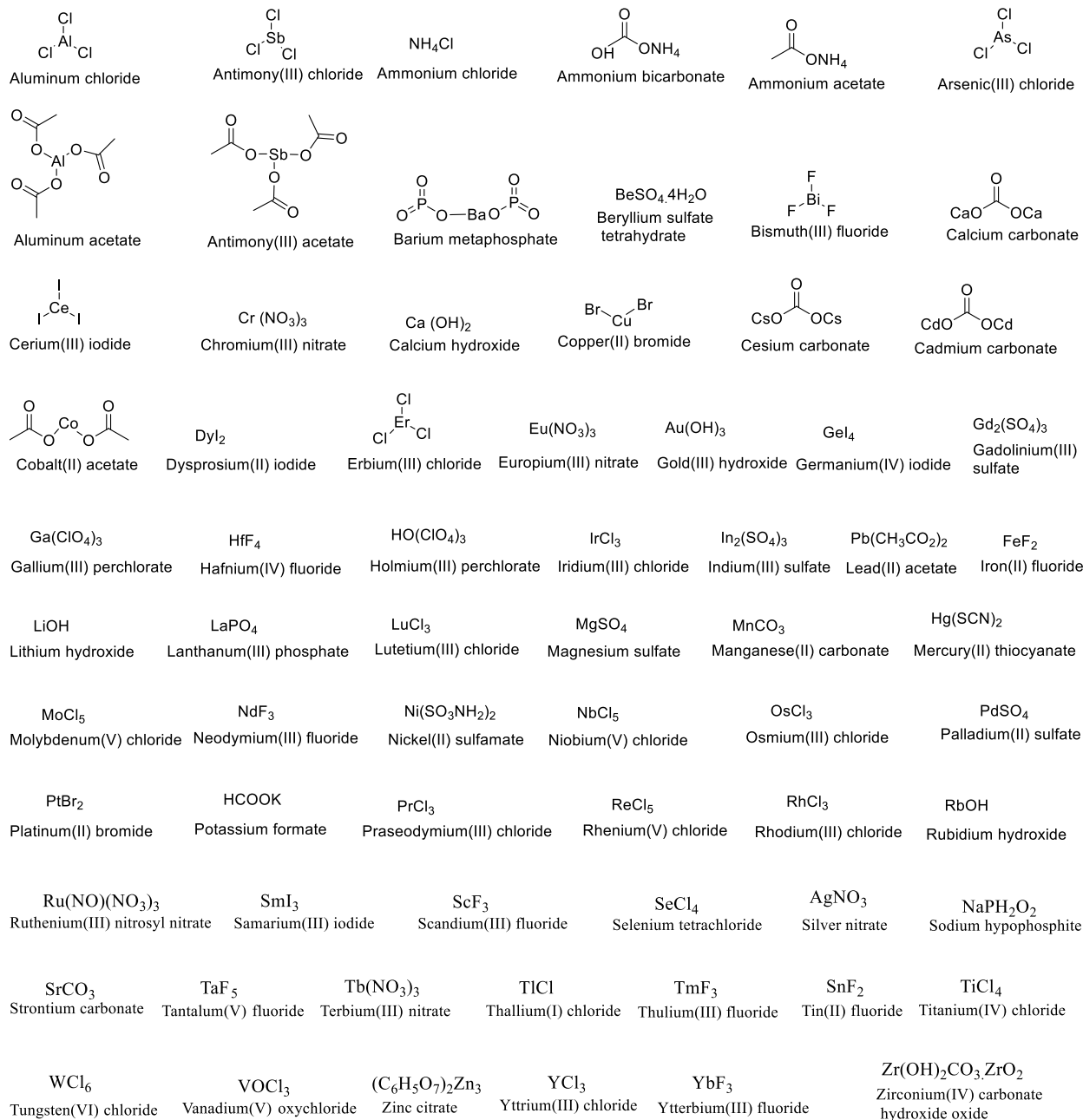


Chart 1. Structure of various Salts

Conclusion

From the above discussion, it shows the diversified use of salt from the daily life to the synthetic application. The transitional metals and other elements like nitrogen,

phosphorus, lithium, sodium, potassium etc. specifically coordinate with the halogen atom and other to form salt and many more other forms. These diverse salts affect the reactivity, selectivity, easiness and many more. A further deep review is needed to discuss about the individual salts structures and their roles in specific reactions, their toxicity and many more about the salts chemistry.

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