IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 21, Issue 4, Ser. III (Jul - Aug 2019), PP 12-15
www.iosrjournals.org

Research about Properties of Chromium Compounds and Usage of It in Industry

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***Abstract**: Chromium element is located in VIB group. Metallic Chromium is bright and resistant against corrosion ,it named because of its colorfull compositions. The main reason of writing this topic is to introduce the Chromium properties ,its compounds and its usage in different fields(industry,business and daily life) as its every compounds have wondrous and special properties , colours and usages and has elegant role in different fields so I interested to research about this topic. This topic is written in library routine and use from reliable sources and websites so it is very help full scientific subject matter for chemistry students and those who are interested in this field.*

Date of Submission: 26-07-2019 Date of Acceptance: 12-08-2019

I. Introduction

The electronical structure of last level of Chrome is $\mathbf{3d^5\ 4s^1}$ and adopt different oxidation numbersin different compounds. Always there is an oxidic securiticalthin cortex on this element, accordingly it become resistant against corrosion and its chemical activity is low in normal tempretures. Chrome solves in HCl and H_2SO_4 and like other elements of d it form cationic complexes with low oxidation numbers and anionic complexes with high oxidation numbers.Cr (III) can form cationic and anionic complexes whereas Cr(VI) usually form anionic complexes.

The data of this writing introduce the properties of Chrome and its compounds moreover it express the importance and usages of Cr in different fields like industry , business and daily life.

Research about properties of Chromium compounds and usages of it in industry

Chrome like Venadium has different compounds with several oxidation numbers, the most famous compounds are (CrO_4^{-2}) , {Cr(VI)} and ($Cr_2O_7^{-2}$). These compounds are strong oxidizers,compounds in this oxidation state rarely found because of instability of Cr(V) and Cr(IV) ions ,for example: CrF_5 and CrF_4 quickly hydrolized by water, also CrF_5 is used less as an oxidizer. The oxidic property of Crf_4 is less than CrF_5 therefore it will not react with NH_3,SO_2 and BrF_3 in room tempreture .The most stable and famous oxidation state of Chrome specially in aqueous circumentances is Cr(III) . (225:2).

The exchange energy of (Cr) $4s^1 3d^5$ and (Mn)$4s^2\ 3d^5$ is so high and it shows when the metallic lattice structure have more electrons ,the structures(first the orbitals which have less energy will fill from electrons: according to the afba theory (10:45).

Ferro Chromate , $Fe(CrO_2)_2$ (extra oxid of Chrome and Ferrium) is one of the important minerals of Chrome that can accrue Chrome from reduction of Ferro Chromate by the help of Carbon in furnace with electrical arc.The mixture of Ferro Chrome is used in preparation of stainless steel and produce the pure Chrome from reduction of Cr_2O_3 by Almunium or Silicone , as first the ore will dry in baseenvironment and it will react in the presence of air as following equation:

$4FeO.Cr_2O_3+8K_2CO_3+7O_2$……..$8K_2CrO_4 + 2Fe_2O_3 + 8CO_2$

The resultant Chromate is solvent in water , whereas Fe_2O_3 is insolvent so in order to this, Ferrium separate from Chrome by following equation:

$2K_2CrO_4 + 2C$ ……..$K_2CO_3 + K_2O + CO + Cr_2O_3$

Or

$2K_2CrO_4 + H_2SO_4$ ……..$K_2Cr_2O_7 + K_2SO_4 + H_2O$

Then dry the solution and diminish of it in presence of carbon , got the Cr_2O_3 oxide.

$K_2Cr_2O_7 + 2C$ …..$Cr_2O_3 + K_2CO_3 + CO$

Finally (Cr_2O_3) react with Almmonium and got the Chrome by following equation:

$Cr_2O_3 + 2Al$ ……$Al_2O_3 + 2Cr$

$2Cr_2O_3 + 3Si + 3CaO$ ……..$3CaSiO_3 + 4Cr$

The Chromium metal thermodynamically ,in powdered state is very good reduction factor,rapidly and completely react with Oxygen , however in metallic state the surface of metal is hidden by oxide that block the oxidation of metal. In this state it is very resistant against accident so Chromium is used as a decorator wrapper and guard for other metals . when it together with other metal as an alloy raise the resistance of metal. Chromium is a hard and glossy metal and melt in 1890 ^{o} c, its density is equal to 7.19 g/cm^{3} . Chromium is resistant against water and weather in room tempreture . H_2SO_4 and HCl are thin acids ,simultaneous solve the Chromium by ejection of H_2 . Chromium dissolve in cold thick HNO_3 acid and by reaction of Chromium with this acid a very thin oxidic layer hide the metal surface and make it inactive . Chromium form three kind oxides , Cr O(II) oxide which has basic property,Cr2O3(III) oxide which has amphoteric property and CrO3 (VI) oxide (Chromium anhydride) that has acidic property. Chromium compounds (II) dissolve the Chromium inHydro chloric acid and got the Chromium chloride (II). whether a base add on this solvent Chromium hydroxide (II) Cr $(OH)_2$ sediment in yellow color .this compound is movable and quickly oxidized by oxygen to Chromium (III) compounds. Chromium compound Cr_2O_3 (III) has green color and molten very late and called green color Chromium mineral, which used in oily and glue colors . From molting of Cr2O3 with silicates , silicates adopt green color therefore used Cr2O3 for coloring of glasses and porcelains. Also Chromium oxide (III) is used in polishers . Cr $(OH)_3$ Chromium Hydroxide (III) settle from reaction of base and Chromium salt (III) as a blue color.

Cr $(OH)_3$ like $Al(OH)_2$ and Zn ($OH)_2$ has amphoteric property and it make Chromium III salt in acids , in bases it make Chromates green color solvent:

Cr $(OH)_3$ + 3 Na (OH)…….Na_3 [Cr $(OH)_6$]

Cr (OH) + 3 OH……. [Cr $(OH)_6$]

Chromates that are came from molting of Chromium oxide Cr2O3 with metal oxides two valences, have general formula M $(Cr O_2)_2$which is Meta Chrome acid (III) H Cr O_2 and Chrome natural iron stone Fe$(Cr O_2)_2$ which belongs to this salt. Form From Chromium (III) saltzamch Chromo Potassium K Cr $(SO_4)_2$.12H_2O which is Chromium and Potassium double salt and found everywhere , and form as blue purple crystals which used in hid crafts (berets) and also in tannage and in loom to color the fabrics.

Chromium (III) salts are very same to Almonium salts and hydrolyzed in aqueous solutions and change to bases salts . Generally Chromium(III) salt solutions have blue purple color , by heating it change to green color but when it become cold adopt its first color and the reason of this color changes is formation of isomerized aqueous salt (Hydride) . isomerized aqueous salt is a abstruse compound in which one part or complete molecules of H_2O in complexe state have coordination bond . in some cases , isomerized aqueous salts are found as solid, for example : Chromium Chloride aqueous salt Cr $CrCl_3$.6H_2O (III) are exist in three isomerized form indigo purple, dark green and light green and their shapes are the same (9:140-141).

The structure of these isomers can specified by reaction of newly prepared solution of $AgNO_3$. If add AgNO3 on Chromium Chloride $CrCl_3$ .6H_2O which has blue purple color all Chloride ions sediment from solution ,by reaction of AgNO3 with hydrate solution which has dark green color, sediment 2/3 portion of chloride and that salt which has light green only 1/3 portion of chloride . By usage of this results the coordination number of Chromium which is six ,we can write the structure of isomerized aqueous salt as following:

[Cr (H_2O) 6]Cl_3 [Cr $(H_2O)_4$ Cl_2]Cl .2H_2O [Cr $(H_2O)_5$ Cl]Cl

Dark green blue purple light green

In this way formation of aqueous Chromium (III) salt isomers belongs to the different replacement of H_2O molecules of Chloride ions , different replacement of H_2O molecules and Cl^- ions in inside and outside coordination state is one of the examples for formation of hydrated isomers (9:70) .

All different isomers of $CrCl_3$ .H_2O have a octahedron complex (CrIII) ,but they are different coordinated ligands ,for example: there is a solid compound in the first isomers of three Cl- ions in crystal lattice which is directly belongs to metal(5:226).

By x rays techniques it has shown that Ni(CO)4 , Fe (CO)5 and Cr(CO)6 in order have tetragonal , pyramidal triangular and octagon structures . The changes which happen in formation of metal-ligand bond ,this study is important according to the hybridization of metal atom because this method shows the connection of it with atomic number or with magnetic carbonyls (8:315).

Chromium (VI) compounds which called Chromium anhydride also, is CrO_3 . according to Chromium oxide CrO_3 (VI) , its salt is H_2CrO_4 and $H_2Cr_2O_7$ acids which analysis to H_2O and CrO_3. It is citable that salt of these acids are very constant . salt of H_2CrO_4 acid is called chromates and salt of H_2CrO_7 bi chromates or di chromates . Majority of chromates have yellow color and some used in painting colors . in group (6) Cr(VI) as $Cr_2O_7^{-2}$ in acidic environment is a very strong oxidizer (it is unstable) whereas Wo_3 . MoO_3 has not this property (181:3).

Chromates which solve difficultly are the following : Hg_2 Cr O_4 red , Pb Cr O_4 yellow , Ag_2 Cr O4 red, Ba Cr O_4 yellow , lead Chromate pb Cr O4 which has yellow color used in painting as chromium .

All di Chromates are soluble in water , in aqueous solution there is balance between Cr O_4- and $Cr_2O_7^{-2}$thus that Chromates which notified above sediment from di chromates neutral solvents,if the H^+ ion will got away from reaction as equation sedimentation will be so good.

$2Ba^{+2} + Cr_2 O_7^{-2} + H_2O$……..2Ba Cr $O_4 + 2H^+$

To reach to this aim we used from Acetic Acid that buffer with Sodium acetate .

Chromium (IV) oxide Cr O3 that form the base of Chromates analysis very easy in 250^{o}c and form Cr_2O_3 and oxygen .

$$2Cr O_3 \ldots\ldots Cr_2 O_3 + 11/2\ O_2$$

Above reaction which give oxygen so easy, work as a strong oxidant . if from Cr O3 crystals we pass dry ammonia , ammonia under flame oxidized to nitrogen :

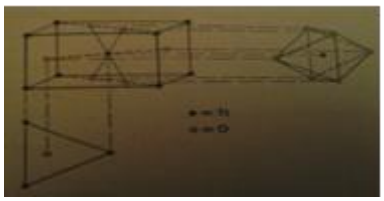
$2NH_3 + 2Cr O_3$…..$N_2 + Cr_2O_3 + 3H_2O$ + 170.8Kcal

If heating the big crystal of di Chromate, the reaction will improve ,all crystals will change to powdered green color mass of $Cr_2 O_3$ under heat and fume (diffusion of nitrogen) .

$$(NH_4)_2\ Cr_2\ O_7 \ldots\ldots\ldots 2NH_3 + 2Cr\ O_3 + H_2O$$

Chlorid*e Chromic acid which called Chromyle chloride Cr O_2 Cl_2 , come from influence of Hydro Chloric acid on Chromic acid , thus this reaction is revolving Chromyle Chloride analysis by water and produce Chromic Acid and Hydro chloric Acid again , so while outcome , the formed water will go away from reaction by Sulfuric acid . Used this reaction in analytical chemistry, distinguish Chlorides beside Bromides and Iodides as add di Chromet and Sulfuric acid on it which distinguish the Clorides in it ,heating it and pass the produced vapors from Sodium Hydro oxide . the existence of Chloride express the formation of yellow Chromate . Bromides and Iodides in above reaction unlike chlorides change to elemental state . anyway produce the same compounds of Chromyle Chloride with Fluorides which called Chromyl Fluoride (7:212-213).

Cr O2 is the formula of Chromium oxide (IV) or Chromite without water , produce from reduction of CrO3 by hydrogen and heat .CrO2 has rutile structure (rutile structure is a structure that positive ions lattice (Ti^{+4}) occupy the octagon holes which formed from the accumulation of oxide ions and its coordination number is six. thus number of oxide ions are double then (Ti^{+4}) ions ,so the coordination number of oxide ions will be three, it means that every anion with a triangle plane structure surrounded by three cations . unit cell for titanium ions in this lattice as figure (1) approximately is like center filled cubic like figure (1) , and is Ferro magnetite (407:4).



(Cr O2) is conductive of electricity , that this conductivity belongs to the replacement of electrons in layers of energy and become from interference of d orbitals of metal and pπ orbitals of oxygen .in addition we can get this oxide by following reaction (11: 5).

$$[Cr(OH)_4]^- \ldots\ldots CrO_2 + 2H_2O$$

The magnetic property of solid crystals like :CrO2 is rather then paramagnetic property in room temperature. The difference between these substances which are famous to ferro magnetic and general paramagnetic substances is that, when a general paramagnetic substance will take place in magnetic field they got magnetic property, as its direction is parallel to the outside field ,but when it out from field it lose the magnetic proprety. Whereas a ferro magnetic substance in presence of outside field quickly become lodestone and in absence of it also preserve somewhat of this property (125:1).

$Cr(OH)_3$ change to Chromium oxide(III) very easy by heating or dehydration .Cr_2O_3 is insoluble in acids and bases , according to its amphoteric property and its reaction with Sulfuric acid and its vaporization to Chromium III $Cr_2(SO_4)_3$ and by melting with base (hydro oxides) in absence of air produce Chromite ,as it give glassy green color and molten which used in coloring of glasses and porcelain .Also its usage in painting as green color is general .the mixed crystals come from Cr_2O_3 with Al_2O_3 which has less Cr_2O_3 and has pink color and called nature ruby also can produce artificial .chromium III Chloride (CrCl3) in pure state is insoluble in water , in presence of extraordinary less Chromium (II) salt ,by losing of more heat it easily dissolve , produce $CrCl_3.6H_2O$ hydrate which has dark green color. After passing of time this solution change to light green same to blue and finally adopt purple color . the reason of this change is isomer hydrate ,as by insolubility ,first clorin which has abstruse bond gradually substitute with water , change to clorin which has ionic bond.

$[CrCl_3(3H_2O)_3]$. $3H_2O$ …..$[CrCl_2(H_2O)_4]Cl.2H_2O$…..$[CrCl(H_2O)_5]\ Cl_2.H_2O$…$[Cr(H_2O)_6]Cl_3$

The Chlorine which has ionic bond with Chromium atom , is written outside of corner arc produce Argentinean chloride with Argentinian nitrate solution . water molecules (written outside corner arc), the crystals then water separate very easy by dryness in desiccator which has abstruse connection .

II. Conclusion

Chromium metal in powdered state is a good reduction factor , quickly react with oxygen ,but in metallic state metal surface hidden by oxidelayer ,which is very resistant against accident . Chromium used in decorative wrappers and as a metal guard and when together with other metal as alloy raise the resistance of metal . Chromium formed three kind oxide . Cr (VI) compounds are very strong oxidizer .Chromium compounds Cr_2O_3 (III) is a green color substance and melted very late and used in oily colors . Silicates adopt green color by melting of Cr_2O_3 with silicones so Cr_2O_3 used in coloring of glasses and porcelains. Chromium (III)oxide also add in polishers like oily colors and from lead Chromate Pb Cr O4 which has yellow color used in painting colors, also artificial crystals are made from mixing of Cr_2O_3 with Al_2O_3 .so we can say that Chromium named by this name because of its colorful formation .the usage of Chromium compounds in different purposes of daily life shows the importance and value of Chromium .

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Laila mia qadiri. " Research about Properties of Chromium Compounds and Usage of It in Industry" IOSR Journal of Computer Engineering (IOSR-JCE) 21.4 (2019): 12-15.