Coordination Chemistry
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Lecture - 12
Isomerism – II

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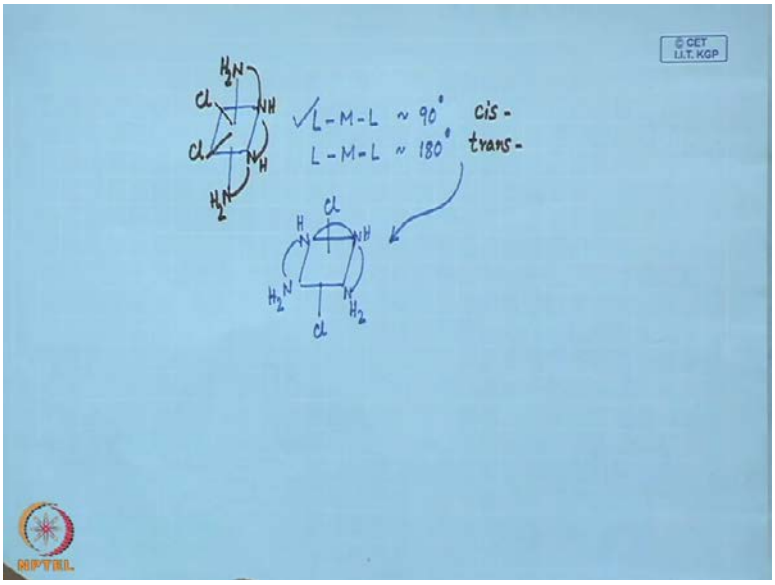

Good evening everybody. So, we will just continue the isomerism part, where we will see that the, in case of the corresponding octahedral compound that we can have two different types of middle ligand arrangements; where the L M L angles of two different types - one is close to 90 degree and another is close to 180 degree. And if we just consider these two types of angles as the cis angles, and the other as the trans angle; and that would be very easy to identify, that means when we have two adjacent ligands of these say these two are say, chloride for any octahedral compound. If we just simply look at these two positions only, we are not looking at anything else, which will also be true when we have these all other positions are occupied by some other ligand say, some ligand which is also chelating NH 2, NH, NH and NH 2; if it is chelating then all the four positions of this particular case are blocked, and we will have only the cis isomer.

And if we just lucky enough to get the corresponding arrangement of these two chloride as Cl and Cl, and this chelating ligand as NH, NH and NH 2, we get this as the corresponding trans arrangement. So, we will focussing on attention on Cl metal Cl bond angle, and we get 2 different type of arrangement; in case of octahedral compound also, like that of the cis platen, we will consider this also as the corresponding cis variety as well as the trans variety.

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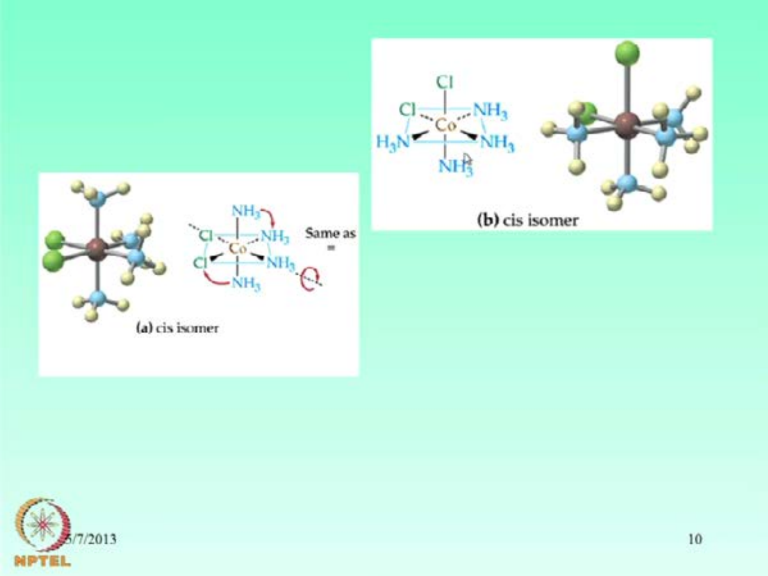

(b) cis isomer

(a) cis isomer

So, what we are just see that, in case of cis isomer we have this arrangement; and if we try to rotate it, because along this axis, this is the rotational axis, and if we rotate this molecule along this axis, around this particular arrows, so this is the rotational axis, so NH 3 will come over here; this NH 3 will go over here; and this chloride will go over this particular position. So, this chloride will remain here; this chloride will occupy this position. So, this is the position. So, this is another particular type of arrangement, which is different from this arrangement, but again, in this particular arrangement also we have the Cl Co Cl angle of 90 degree.

So, by different orientation only, we have rotated the molecule from one particular state to the other; by rotation only, we have generated another form, but the isomeric form of this particular compound is also same, which is still the corresponding cis isomer.

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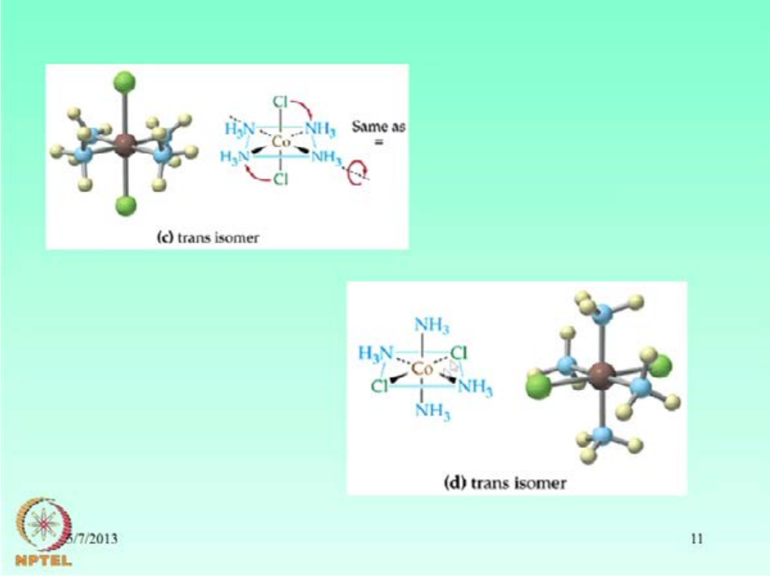

(c) trans isomer

(d) trans isomer

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But, in case of the trans isomer, where the Cl Co Cl angle is 180 degree, again we try to rotate it through this axis, this N Co N axis we will get the corresponding compound as the other compound; that means, when we rotate this Cl will come over here, and this Cl will come over there. So, we have the Cl Co Cl as the trans isomer. So, this is one trans orientation; and through rotation we get another trans orientation; and both of them can be designated as the corresponding trans isomer.

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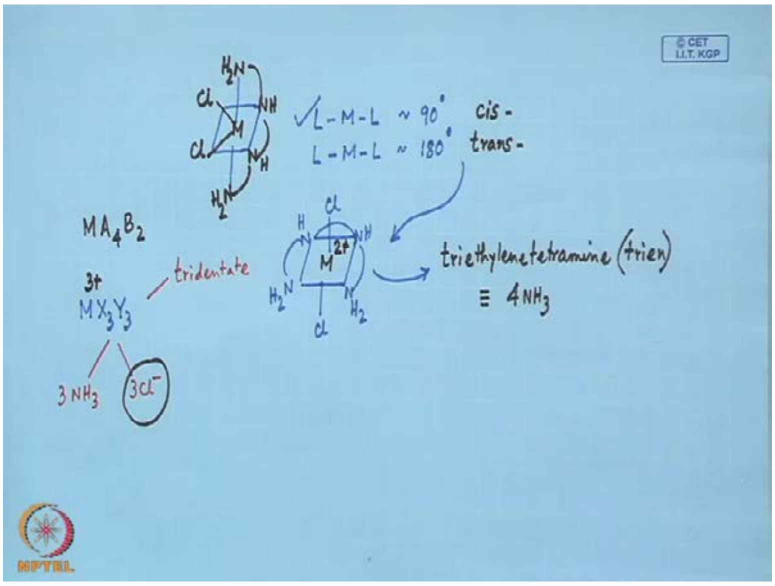

✓ L – M – L ~ 90° cis -

L – M – L ~ 180° trans -

MA_4B_2

$MX_3Y_3^{3+}$ — tridentate

3 NH_3 $3Cl^-$

triethylenetetramine (trien)

$\equiv 4NH_3$

So, in case of several such octahedral complexes, we can consider that other form that, whatever we are talking here was in case of octahedral complexes is M A 4 B 2 type; that means, 2 of them are of different type. Now, we just simply move on to the other system, where we can have 2 different ligands again, like A and B or X and Y, it is all same. But their numbers are now 3 each; that means 3 of X and 3 of Y. And what type of possibilities we can have, if we can have a type of arrangement like this. And when we considered this type of thing related to the chelating ligand also; that means, this ligand, this NH 2, NH, NH 2 ligand, which is the corresponding ligand, which is known as tri ethylene tetramine, which will be very much equivalent to the donor properties of 4 ammonia groups. So, in this particular case, what we see that, you can have the 4 ammonia molecule and 2 chlorine, or you can have 2 chlorine atom and the chelating tri ethylene tetramine ligand which is also known as the trien.

Now, we see that, in this particular case, that means, when we have X and Y, both of them are 3, that means, either we can talk about 3 NH 3 function and 3 chloride function or the chloride group, or we can have a situation where one is the corresponding tridentate ligand. And also this particular observation is very much useful for us that, since we are talking about the chloride binding, in this particular case if the metal centre is there, and 2 chloride groups are present over there, and metal is balancing the corresponding positive charge by 2 chloride groups, then this compound is present in the bivalent state; that means, is the bivalent compound of the corresponding metal ion.

But, in this particular case, when 3 of one type and 3 of other, we are balancing the corresponding charge by 3 chloride groups. So, the compound in this particular case is in the 3 plus oxidation; that means the trivalent oxidation state. Therefore, the size of this cat ion is bigger, compared to the size of this cat ion. So, whatever geometrical isomerism we will be talking about, is due to this arrangement around a small cat ionic species, which is trivalent.

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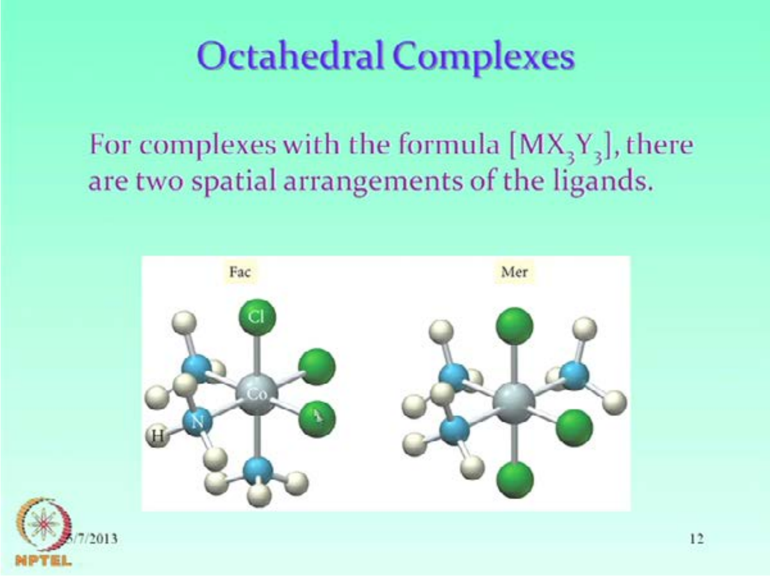

Octahedral Complexes

For complexes with the formula $[MX_3Y_3]$, there are two spatial arrangements of the ligands.

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So, when the formula is M X 3 Y 3 type, there are again 2 spatial arrangements of the ligands. So, we can have 2 possibilities. So, critically, if we see the 2 different geometric arrangements, we will see that, in one particular arrangement the green spheres are the chloride groups; and these are the ammonia groups. So, it is a basically a corresponding species, which we were talking about the hexa amine cobalt 3 chloride. So, here, instead of that in that particular molecule 3 chloride groups where outside the chordsons sphere. Now, all 3 chloride groups have come and entered into the chord sons sphere and bound to the cobalt centre by giving 3 cobalt chloride bonds. So, these 3 cobalt chloride bonds basically gives rise to a particular type of arrangement, where the 3 groups, the 3 chloride groups occupying one face of the octahedron. So, the octahedron, we all know that there are 8 triangular faces, and if one of the face is occupied by 3 chloride groups, we will get a corresponding arrangement which is known as the facial arrangement, and the isomer is known fake isomer.

And, in another case these 3 chloride groups basically what we are doing we are interchanging this chloride, with this NH 3 groups. So, if this 2 are interchanged, these 2 cis positions: one is occupied by the Cl and the another is occupied by the NH 3; if these 2 are interchanged, we get the orientation of these 3 chloride groups in such a one that it is spanning the corresponding meridian of the sphere.

The meridian of the sphere is occupying by 3 chloride groups as well as 3 NH 3 groups; and in the case of facial isomer, we have all cases, the Cl Co Cl bond angles are 90 degree; in other case, the corresponding Cl Co Cl angle 2 of them are 90 degree, but at least of one them is 180 degree; that means, they are trans to each other. So, in case of meridianal isomer 2 groups which is also true for the binding of the ammonia; this 2 ammonia groups are diagonally opposite; that means, the nitrogen, cobalt nitrogen bond angle is 180 degree. So, we get the corresponding meridianal isomer. So, these 2 isomeric forms are very important, which we are talking about the corresponding face binding.

And if 3 of these chloride groups, or 3 of these ammonia groups are occupying 2 diagonally opposite faces of the molecule; we will consider this particular face is capped by the chloride ligand, and this particular face is capped by the ammonia molecules. But in this particular case, no such face is capped by either the chloride ligands or the ammonia ligands; it is the meridian of one particular hemisphere is occupied by same type of ligand system. So, from there we just find what we see for the corresponding chirality of the molecules.

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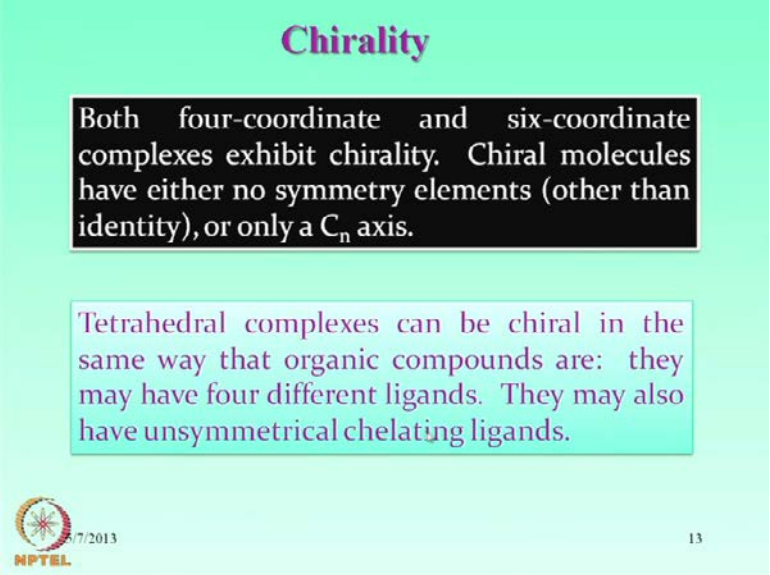

Chirality

Both four-coordinate and six-coordinate complexes exhibit chirality. Chiral molecules have either no symmetry elements (other than identity), or only a C_n axis.

Tetrahedral complexes can be chiral in the same way that organic compounds are: they may have four different ligands. They may also have unsymmetrical chelating ligands.

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So, the chirality of the molecules will be coming for the cis coordinate geometry also, but for the four coordinate as well, as well as the six coordinate complexes, they exhibit chirality. And these molecules have either no symmetry elements other than the identity element that mean the e operation, or only a C n axis. If they have only the C n axis, other than this C n axis they do not have any other symmetry element, then we consider this molecules as they are corresponding chiral analog.

So, tetrahedral complexes can be chiral in the same way that organic compound are; that means, if we have a carbon centre; and carbon, we all know, that is bound to 4 other groups in tetrahedral orientation. In a same fashion, if we can have a centre for the metal ion, and they have 4 different ligands attached to them; then they can be unsymmetricaly chelating ligands also; then that particular arrangement can give rise to some chiral centre to the metal ion.

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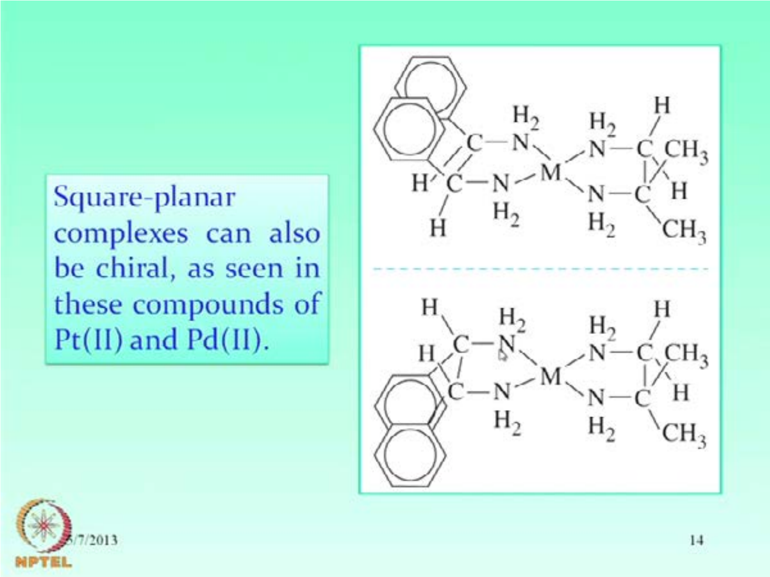

Square-planar complexes can also be chiral, as seen in these compounds of Pt(II) and Pd(II).

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Then, the square planar complexes can also be chiral, such as the platinum and the palladium compounds of these 2 types, where this is the corresponding unsymmetrical diamine type of ligand, when this carbon is substituted by 2 methyl groups; and on the other side, we have the phenyl rings, 2 phenyl rings above the square plane and the mirror image of that; the mirror plane of this particular mirror image is also the other one; and they are not super imposable to each other; they can also be chiral; provided that, we can have a different orientations of this group attached to this particular carbon centre related to that of our ethylene diamine molecule.

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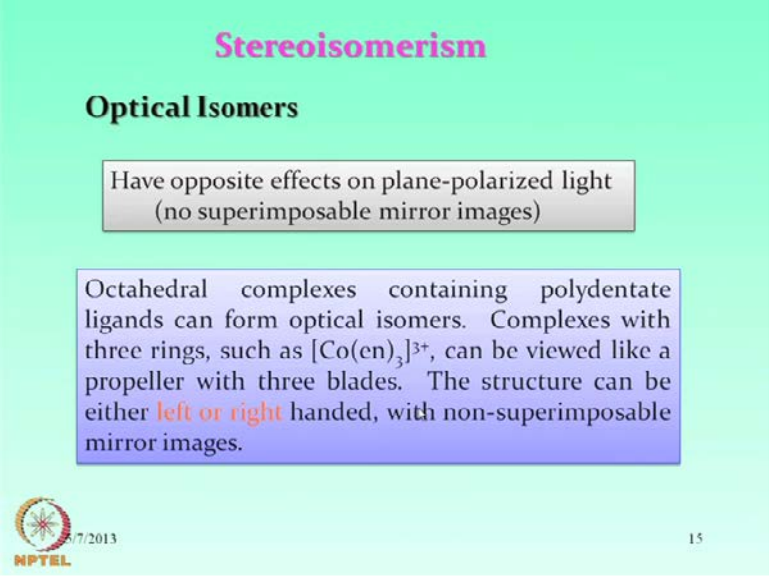

Stereoisomerism

Optical Isomers

Have opposite effects on plane-polarized light (no superimposable mirror images)

Octahedral complexes containing polydentate ligands can form optical isomers. Complexes with three rings, such as $[Co(en)_3]^{3+}$, can be viewed like a propeller with three blades. The structure can be either left or right handed, with non-superimposable mirror images.

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Similarly, we just find, when we have the corresponding stereo chemistry related to the isomers in space, we can find that optical isomerism can be operating over there, we have some effect on plane polarised light. And when this plane polarised light can be moved from one plane to the other, we can have some one particular type of arrangement. So, optical isomers can have opposite effect on plane polarised light; that mean one particular isomer can rotate the plane of polarisation in one direction, and the other isomer can rotate the plane of polarisation in opposite direction, and these two isomers are not super imposable to each other, and they do not have the corresponding mirror image, which can be super imposed to the other molecule. So, octahedral complexes contain polydentate ligands, particularly the bidented ligands.

If we have a bidented ligand like ethylene diamine, it can be seen that the 3 ethylene diamine ligands are bound to the cobalt centre in such a fashion that, similar to this type of arrangement; that means, that NH, NH 2 type of binding, what we are seeing for the part, what is there for the triethylene molecule, triethylene tetramine molecule.

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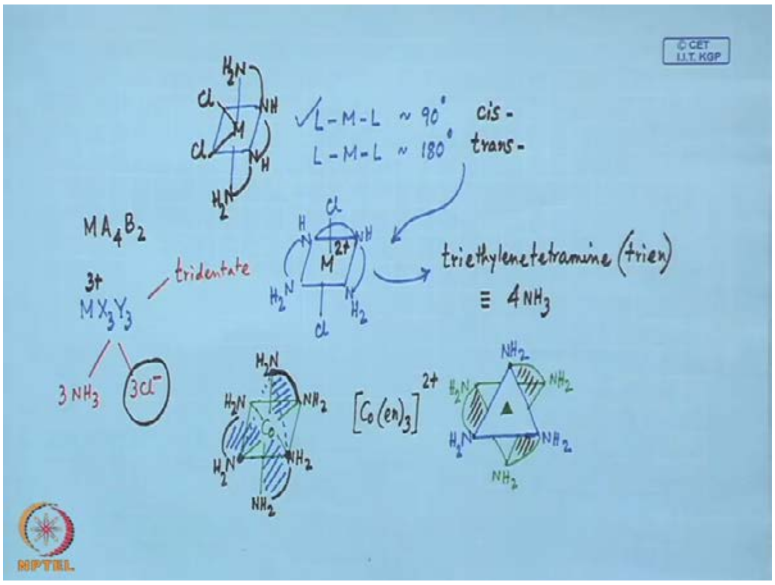

Similarly, if we have the cobalt centre which is going to form 6 bonds, and we have the ethylene diamine. So, this basically coming from, this is above the square plane, and this is backside of the, that particular plane; that means, the plane of the paper. So, we have this arrangement; that means, one binding of this NH 2 group; similarly, if we have the second one, this is the other one, and the third one. So, 3 ligands can bound to these 3 positions fulfilling the corresponding compound as Co e n 2 plus. So, when they are forming this coordination to the metal centre, so we get one particular plane; this is another chilate plane; and this is the third chilate plane. So, we can have the 3 chilate planes from there.

And if we just focus our attention on these 3 positions, basically we see that particular, one particular triangular face; that means, we can visualise the molecule like this. So, this is the face; this is the top face. So, that top face is there. So, we have NH 2; we have this NH 2; and we have the other NH 2 from there. Now, we have the other face; that means, this NH 2, this NH 2, and this NH 2, from the other side. So, we can draw the other 3 faces like this. So, we have, so this is the visualisation of the octahedral geometry, once we view through that c 3 plane.

So, we have 8 such c 3 plane; and this is viewing the c 3 plane through one such planes which are diagonally opposites; that means, these two planes, basically they are not eclipse, they are staggered. When they basically move to each other, we get the corresponding trigonal prismatic geometry; that we have discussed when we are discussing about the coordination number of other geometry. So, these two will be connected by this. So, this second one is like this, and the third one is like this. So, we have these basic structure for these 3 planes. So, we have one plane like this, and the second plane like this, and the third plane like this. So, once we move from here to here, here to here, here to here, we basically get a clockwise movement. So, these propeller blades, this we can consider as some propeller blade type of arrangement.

So, when the 3 bidented chilate rings are bound to the metal centre, we get 3 propeller blades; and the orientation of these propeller blades can either be through the, a direction through, a direction which is clockwise, or it can be anti clockwise. So, that gives rise to 2 different types of arrangements. So, when tris ethylene diamine cobalt 3 can be viewed through these 3 blades, the structure can either be left or right handed, with their non super imposable mirror image. So, when it is left handed, we name them as one particular isomer; when it is right handed, we name them as other isomer. So, if we just consider these arrangements which is left handed and right handed, it can also be considered it as the corresponding helicity.

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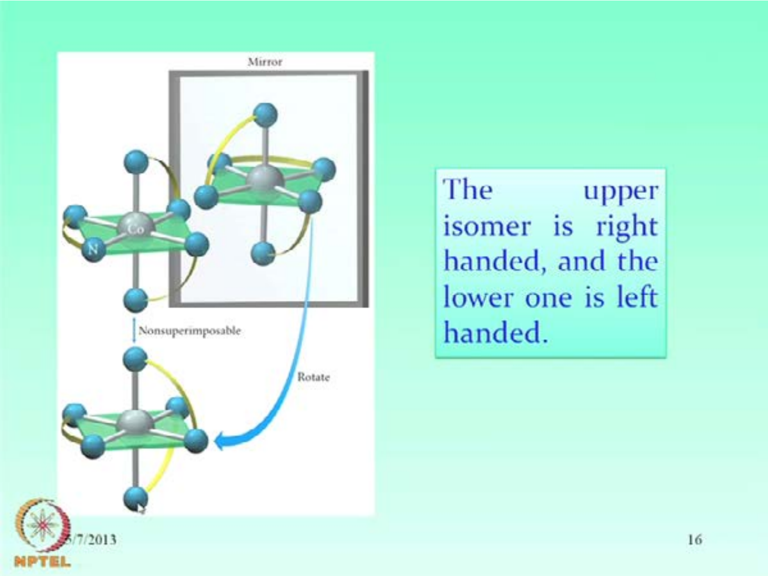

The upper isomer is right handed, and the lower one is left handed.

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So, helicities are all different. So, when we have this arrangement, so this is one particular type of arrangement. And if we have the corresponding mirror image, the mirror image is this one; this one is the mirror image. And if this mirror image we rotate through some angle of 90 degree say, anticlockwise we just get this particular arrangement. But these 2 are non super imposable to each other, because this arrangement we cannot put on this, which will be similar or same. So, they are providing us some non superimposable mirror images. So, that is why, they should be optically active.

So, the upper isomer is right handed and the lower one is left handed. So, this one, this chelate ring is going from here to this; that means, the right hand; here to here is right hand, and here to here is also right hand. But this particular one when we move from there; that means, this is in the different direction; that means, the face, this is the trigonal face which is facing the viewer. So, this trigonal face is facing the viewer. So, when we move from there; that means, we just move from here to this particular face, it is in anticlockwise direction; similarly, from here to here is anticlockwise direction; and here to here, these are on the other direction.

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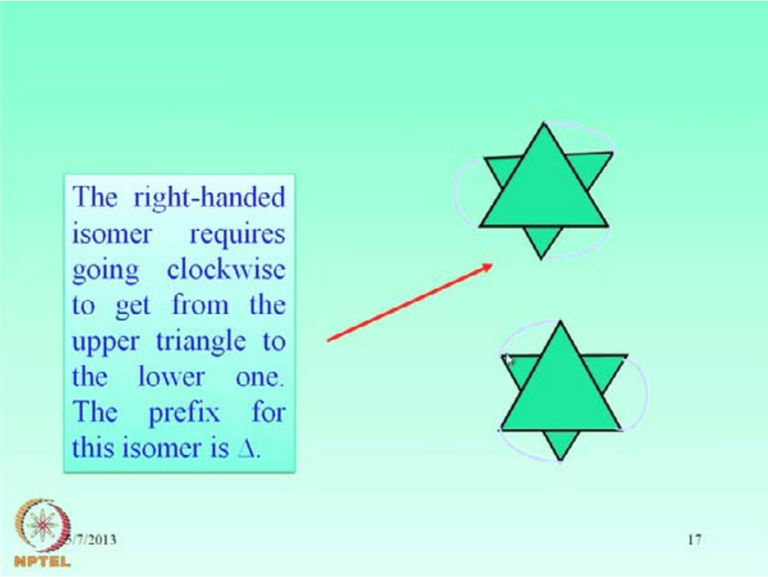

The right-handed isomer requires going clockwise to get from the upper triangle to the lower one. The prefix for this isomer is Δ.

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So, the right handed isomer also requires going clockwise to get from the upper triangle to the lower one. So, if the isomer is of right hand type, that means, this one, even you view through 2 triangular faces; and one such triangular face is such that we can have viewing this particular one which is facing us, the way we have drawn it, just now, and we see that this is one particular type of NH 2, NH 2 ethylene diamine ligand; then we have the second one like this; and then we have the third one.

So, just we go for a corresponding motion from here; that means, the top triangular face; this is the top triangular face, and from top of the triangular face we just move to the next bide; that means, this is the bidented chelate bit; so obviously, this 2 positions are fixed for binding to this particular ethylene diamine molecule. And for doing so we have to move for a clockwise movement; and here to here, we can go only through a clockwise direction. Similarly, for the second upper face of the triangle; that means, the second point, we move again from here to here in a clockwise direction. And the third one in the same way, it is also in a clockwise direction.

So, when the movement is taking place in a clockwise direction to get from the upper triangle to the lower one, if we have the upper triangle and the next one is the lower one, the prefix for this isomer should be delta. So, the clockwise movement is designated as only the delta isomer. So, this particular case also, we can have the different one; that means, the binding is not through this. So, this is in the opposite direction. So, upper to lower in anticlockwise direction, upper to lower again from anticlockwise direction, and then upper to lower in another anticlockwise direction. So, this particular movement is going from one form to the other.

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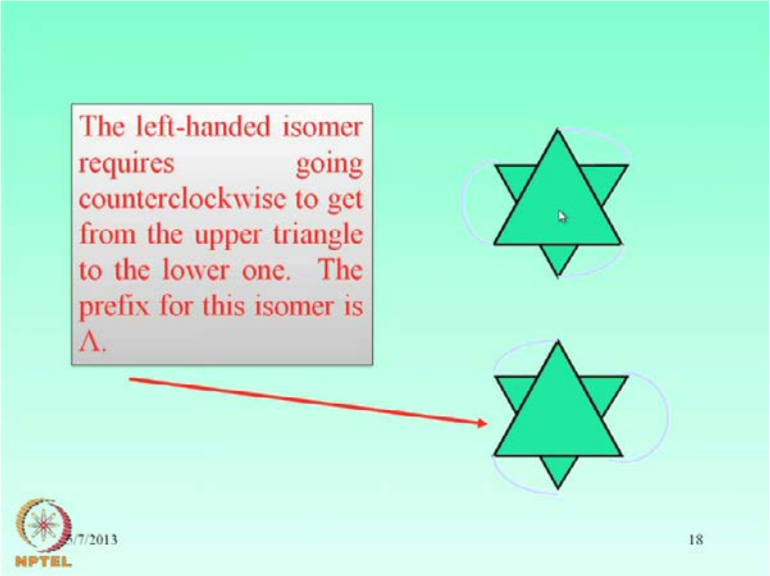

The left-handed isomer requires going counterclockwise to get from the upper triangle to the lower one. The prefix for this isomer is Λ.

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So, in a same fashion, the left handed isomer requires going counter clockwise to get from the upper triangle to the lower one. The prefix for that isomer would be capital delta. So, the counter clockwise movement will be designated as the corresponding lambda isomer, compared to the delta isomer what is in the clockwise direction. So, this is from top to bottom in counter clockwise direction, then top to bottom in the counter clockwise direction, and then top to bottom face in again in counter clockwise direction. So, this is one arrangement, and the other arrangement is also a different type; and these two things can tell us that how these 2 arrangements can take place side by side. So, this is for the lambda arrangement, and this is for the delta arrangement. So, these 2 forms basically give rise to the 2 isomers.

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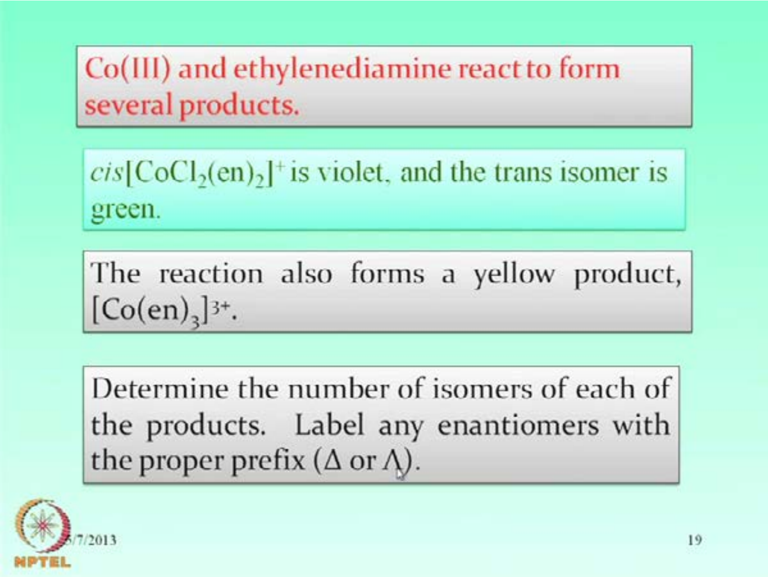

Co(III) and ethylenediamine react to form several products.

cis$[CoCl_2(en)_2]^+$ is violet, and the trans isomer is green.

The reaction also forms a yellow product, $[Co(en)_3]^{3+}$.

Determine the number of isomers of each of the products. Label any enantiomers with the proper prefix (Δ or Λ).

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Now, we will see how this cobalt III can react with ethylenediamine to give us the different products.

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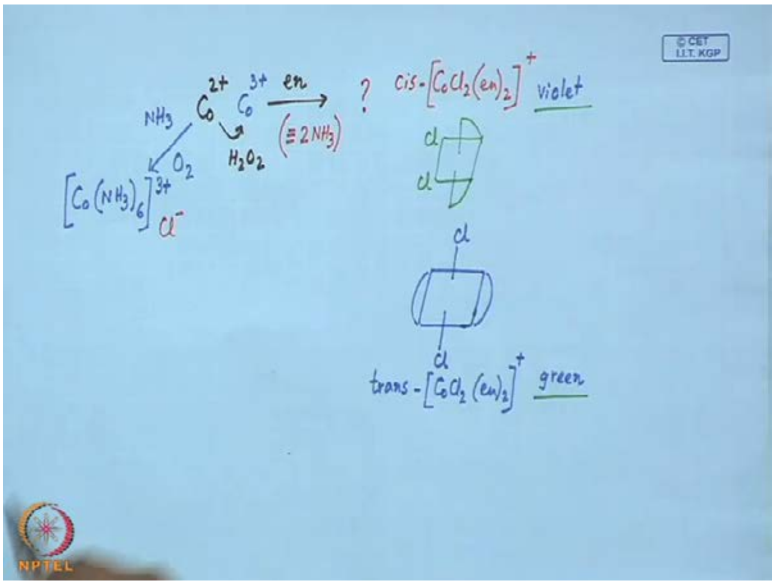

So, as we have seen, in other cases also, that when we have the cobalt 2 and we react with ammonia and oxygen of the air we get cobalt hexamine compound, which has 3 positive charge to counter balance with the available chloride. Similarly, this when react with ethylenediamine; that means, ethylenediamine we are allowing to react with cobalt 2 which is oxidised initially with say, O 2 or hydrogen peroxide; that means, in solution we get cobalt 3 plus. So, we will consider, the way we are considering that the reaction of cobalt 3 with ammonia giving rise to hexamine cobalt 3 compound; here also, how this cobalt 3 plus can be reacting with ethylenediamine, we can have several products out of this reactions, and where ethylenediamine can be considered as binding of 2 ammonia molecules.

So, 2 of these positions can be occupied, what we cannot control in presence of Cl minus; that means, the binding of the cobalt chlorine bond. But in this particular case, if we are lucky enough, we can get some compound, where cobalt chlorine bounds are still present, which can give rise to one particular isomeric form. So, we get the corresponding cis variety, where 2 ethylenediamine molecules are bound to the cobalt centre and 2 chlorides are still there, which is violet in colour, and the trans isomer is green in colour. So, we have cis Co Cl 2 e n 2, which has one single positive charge. 2 of these chlorides are in cis position; and this is that ethylenediamine, which is violet in colour; and also the trans isomer, trans means we have 2 Cl over there; and these are the

2 ethylenediamine molecule, which is therefore, trans Co Cl 2 n 2 plus, which is green in colour.

So, as we have seen in case of linkage isomers that, the different types of isomers, these are the corresponding stereo isomers also; that the cis variety and the trans variety have different colours, one is green and another is violet. So, how we can identify all these different products, even if we are reacting cobalt 3 with ethylene diamine? So, not only these, that means, the cis variety and the trans variety, but when we exhaustibly replace all the Cl groups, we get the tris ethylene diamine cobalt 3 compound also, which is yellow in colour.

So, if we ask now the question that, if this 2 are reacting each other competitively the chloride function as the ethylene diamine function, how we can determine the number of isomers of each of the product; that means, we have the violet product, we have the green product, and also we have the yellow product; and how we can identify them, and level any enantiomers with the proper prefix; that means, the delta or the lambda prefix, for the particular orientation related to their corresponding 3 fold axis.

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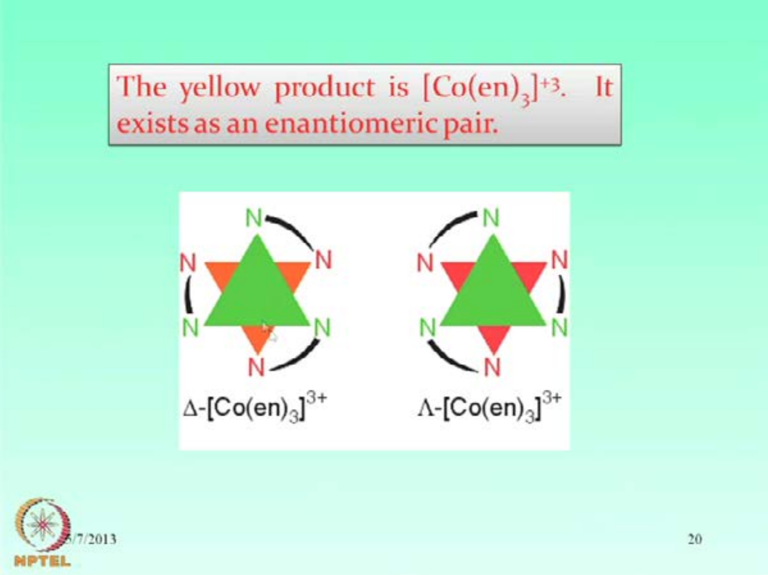

The yellow product is $[Co(en)_3]^{+3}$. It exists as an enantiomeric pair.

Δ-$[Co(en)_3]^{3+}$ Λ-$[Co(en)_3]^{3+}$

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So, the yellow product is definitely the corresponding Co e n whole 3 3 plus, it exist as an enantiomeric pair; that means, one form is optically active, the other form is also optically active that, the clockwise arrangement and the counter clockwise arrangement. So, one is therefore, the arrangement which leads to the delta Co e n whole 3 3 plus, where we have the clockwise arrangement from the top to bottom; top to bottom and top to bottom in clockwise arrangement; and other one from top to bottom; that means, the green triangle to red triangle from top to bottom in counter clockwise direction. And this counter clockwise direction will give rise to corresponding level as lambda. So, this delta and lambda isomers are there for us, in this particular case.

But, since, all these arrangements, like all these nitrogen's are of same type; that means, we do not have any other choice for the facial and meridianal isomer, they are all of Co n 6 type, this is also Co n 6 type, but still within the Co n 6 environment, we can have 2 different isomers.

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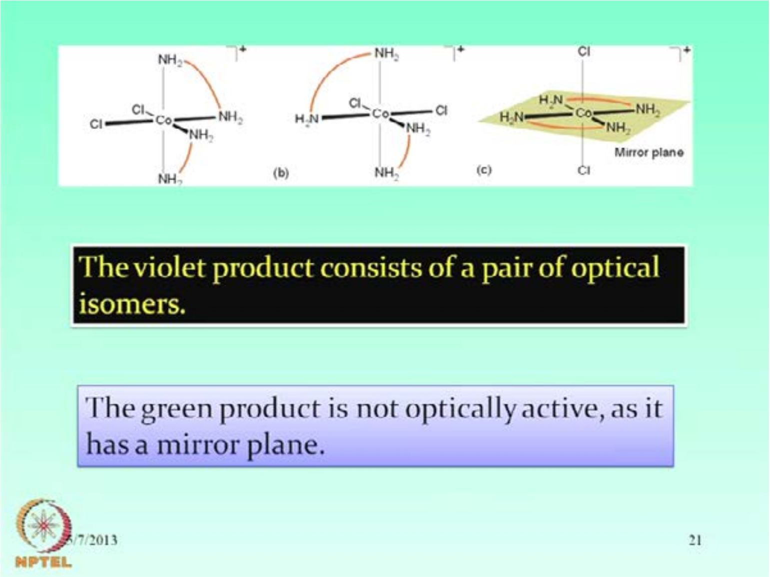

The violet product consists of a pair of optical isomers.

The green product is not optically active, as it has a mirror plane.

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But, in the case of the corresponding chloro derivatives, that means, the cis compounds; these are the 2 cis compounds, and this is the trans; and this 2 cis compounds, we can have the corresponding form that mean this is one isomeric form, which is in the form, which is in the delta; that means, delta which is going from the top to bottom in one direction; and this is also from top to bottom in other direction, and that gives rise to a different type of arrangement for that. So, we get for the cis arrangement, these 2 isomers. And these 2 isomers are optically active also, but the trans isomer, the trans plane itself is the mirror plane. So, we get, we have only one particular isomer, which is a optically inactive, and which has a mirror plane, which is the corresponding plane or containing the 2 chilate rings.

The violet product, therefore, that means, the cis product; the violet product is the cis product; and this violet product therefore, consist of a pair of optical isomers; and these are the 2 pairs. So, whatever we find and we identify these compounds, we can level this violet at the corresponding cis dichloro compound; and these 2 cis dichloro compounds are optically active; one is levelled as delta, and the other can be levelled as lambda.

And, the green product is not optically active, because it has a mirror plane. So, the green product, the trans product is optically inactive product, which we get as one isomeric form. So, thus we get the 3 different types of products, and we can level all of them according to their corresponding isomeric form.

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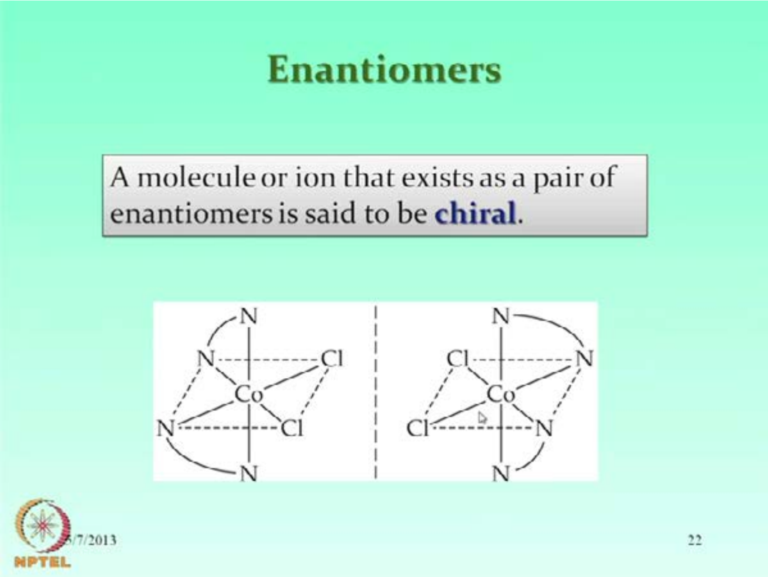

Enantiomers

A molecule or ion that exists as a pair of enantiomers is said to be **chiral**.

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So, once we determine this particular thing, that means, we have the corresponding different forms, we get them as their enantiomers. So, a molecule or ion that exists as a pair of enantiomers is said to be chiral. So, we have a pair of isomers, like that of our tris chelate or the dichlorocis compound; then we thus call them as the chiral molecule.

So, these are the 2 compounds that is the corresponding cis dichloro ethylene diamine cobalt 3; and this is one form, and this is its mirror image which are not super imposable to each other.

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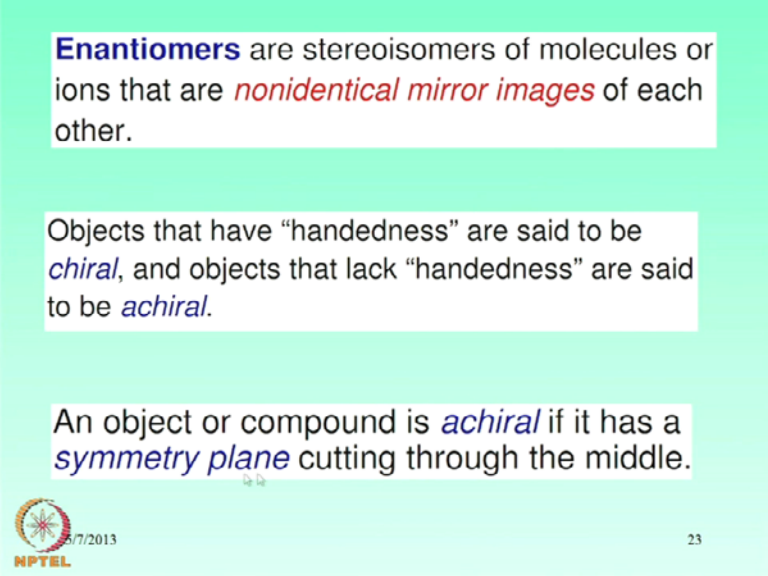

Enantiomers are stereoisomers of molecules or ions that are *nonidentical mirror images* of each other.

Objects that have “handedness” are said to be *chiral*, and objects that lack “handedness” are said to be *achiral*.

An object or compound is *achiral* if it has a *symmetry plane* cutting through the middle.

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So, they are optically active. So, these enantiomer what we get, are stereo isomers of molecules or ions. So, enantiomers are therefore, we get, they are not diastereo isomers, they are enantiomers; and they are also known as stereo isomers; and their molecule or ion itself can be a neutral molecule, or can be the cationic or the anionic species, that are nonidentical mirror images of each other. So, you can have the mirror images which cannot be super imposable to the other. So, therefore, you consider them as non identical mirror images. So, mirror images are not identical.

Next, we see that the objects that have handedness are said to be chiral, and objects that lack handedness are said to be achiral. So, it is related to the corresponding handedness behaviour; that means, how the right handed behaviour or the left handed behaviour can consider the molecule as a chiral molecule; and if that is not there like that of a trans isomer, we consider them as achiral.

So, achiral molecules are also known to us. So, when these achiral molecules are there, an object or compound would be achiral if it has a symmetric plane cutting through the middle.

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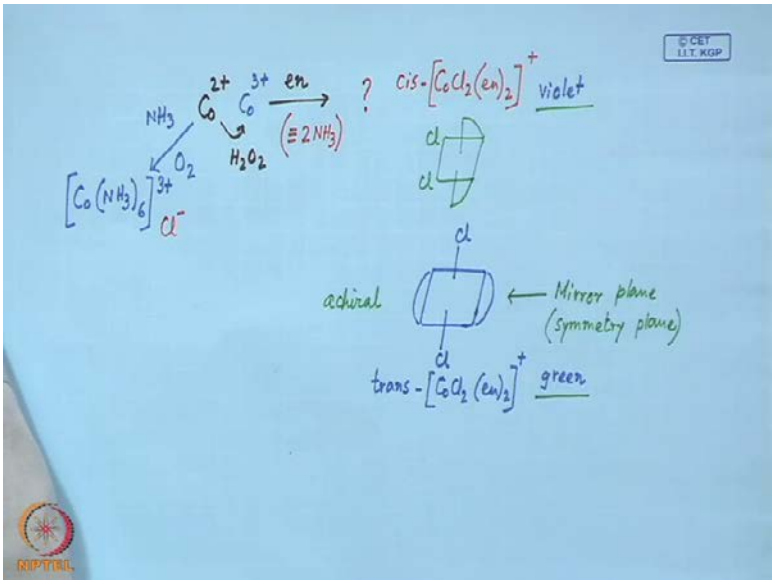

Co^{2+} Co^{3+} $\xrightarrow{en}$? cis-$[CoCl_2(en)_2]^+$ violet

$(\equiv 2NH_3)$

NH_3, O_2, H_2O_2

$[Co(NH_3)_6]^{3+}$ Cl^-

achiral

← Mirror plane (symmetry plane)

trans-$[CoCl_2(en)_2]^+$ green

So, this trans molecule, where we can consider this plane as its mirror plane. So, we have a symmetric plane. This we consider as a symmetric plane. And this symmetric plane basically gives rise to a molecule where one half of the molecule is the mirror image of the other half, and which is basically dividing the molecule into 2, and that is why the molecule is achiral. So, if such mirror plane or such symmetric plane is present within the molecule itself, it would be optically inactive.

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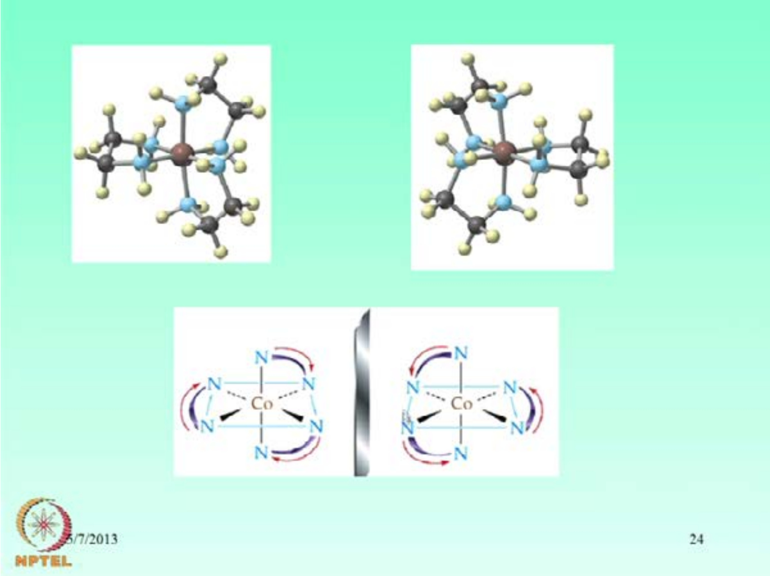

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So, next, what we see that, the molecule like this, what we have seen that the tris chelate, that 3 ethylene diamine groups are attaching to the central metal ion. And this is the other form; that means, the corresponding mirror image of this, and this one basically giving rise to another form. So, we have this one, the first one on the left; the cobalt centre, this is the nitrogen, and this is the nitrogen of the ethylene diamine backbone. So, this is the corresponding chilate bide. So, this is the corresponding balanced diagram what we get by determining the excess structures for the molecules and the spotted plot for that basically gives rise to similar type of arrangement which is the corresponding 3 dimensional arrangement.

And, this 3 dimensional arrangement once is in your hand, and we write in this particular form; that means, we write the cobalt and we write the particular square plane, and then the atom which is above the square plane, and then the atom which is below the square plane, and then we complete the corresponding connectivity through the ethylene backbone. So, we get this particular molecule on the left, and its mirror image on the right. So, we basically get the other as this corresponding mirror image. So, it is moving from, this particular one from top to bottom of the triangular face; it is in the clockwise direction, and it is in the anticlockwise direction.

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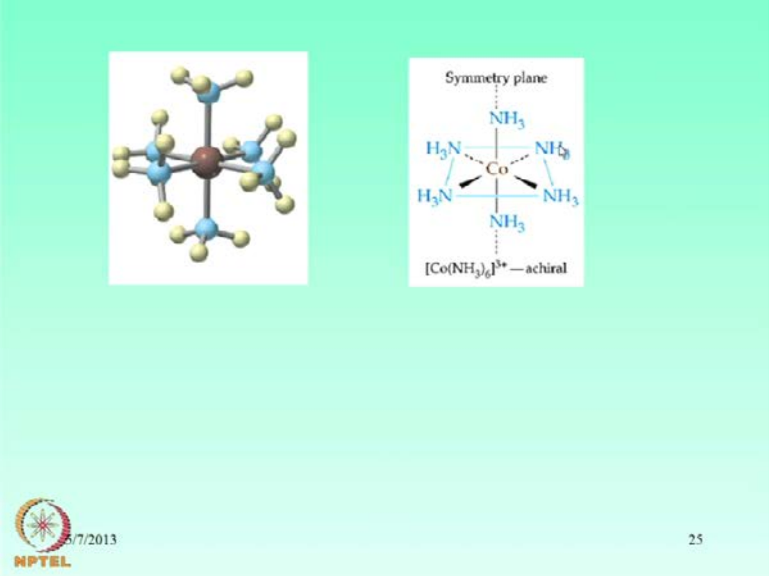

$[Co(NH_3)_6]^{3+}$ — achiral

Then, we have the corresponding one, what we have seen just that for, the other compound which has the symmetry plane; if it is a dichloro compound which is also achiral; and if it is a hexamine compound which is also achiral, because we have the symmetric plane inside the molecule, which is dividing the molecule itself into 2, and one half is the mirror image of the other.

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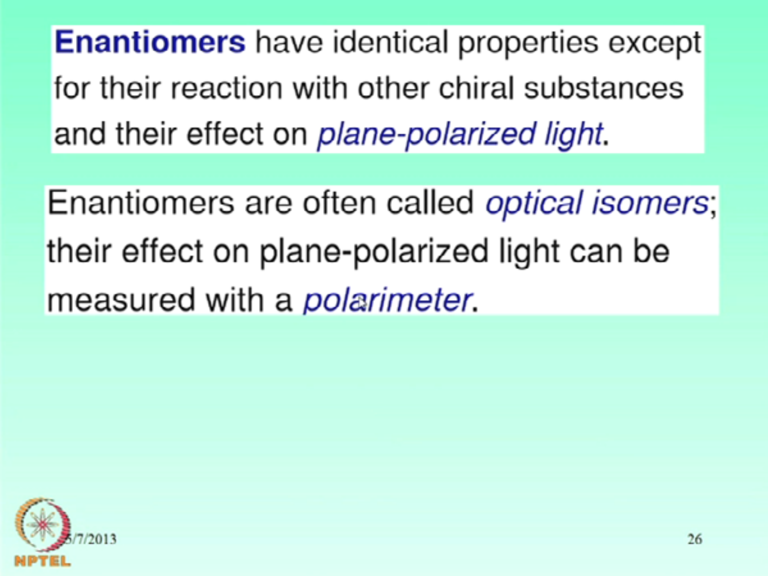

Enantiomers have identical properties except for their reaction with other chiral substances and their effect on *plane-polarized light*.

Enantiomers are often called *optical isomers*; their effect on plane-polarized light can be measured with a *polarimeter*.

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So, what we see that, experimentally how this enantiomers can be identified? The enantiomers have identical properties. So, all other properties are same, only difference is that it can react differently with some chiral substances. If it is reacting for the ligand substitution or any other type, where it is reacting with the chiral molecule, then only it can have a different property with respect to the chiral compound, which is coming and reacting with the molecule. And their next, other property is that, they behave differently with plane polarised light, so plane polarised light will behave differently with that of the 2 different enantiomers.

So, enantiomers are therefore, we call as optical isomers. If we have 2 enantiomers, we will call them as optical isomers; and their effect on the plane polarised light can be measured by using a polarimeter. So, the plane polarised light if it pass through the solution of these optical isomers, we will see that the plane of polarisation will be rotated.

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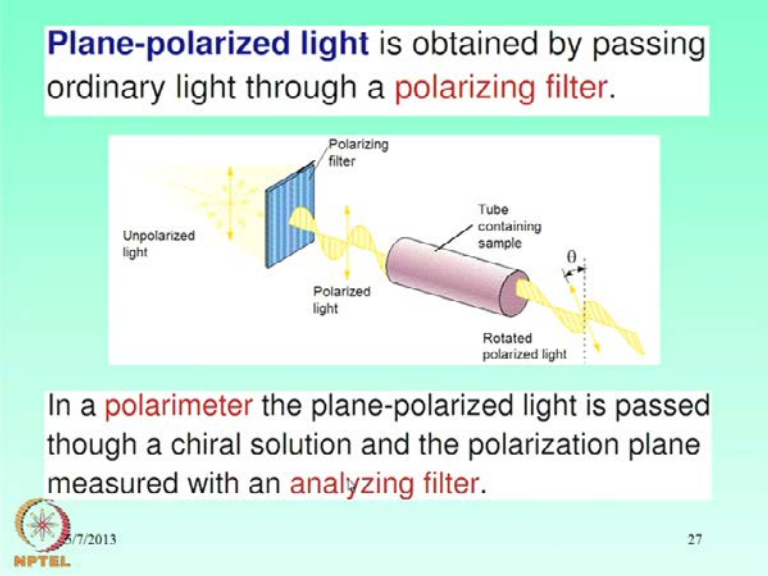
Plane-polarized light is obtained by passing ordinary light through a polarizing filter.

In a polarimeter the plane-polarized light is passed though a chiral solution and the polarization plane measured with an analyzing filter.

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So, how we get the plane polarised light? We obtain it by passing ordinary light through a polarising filter. So, polarising filter is responsible for polarising the plane light; that means, the unpolarised light. So, if we have unpolarised light which has the corresponding vibrations in all directions, the polarisations in all directions, so they are not, their corresponding electromagnetic components are not defined with respect to one particular plane. And if we just pass through the polarising filter which will allow only, because it has the corresponding grid like arrangement; it will only pass the plane polarised light only; that means, one direction, it will have only this particular light. So, we get the corresponding polarised light.

And, when this polarised light is passed through the sample; that means, the sample which is optically active is kept inside this particular tube, and the tube containing this sample is allowed to pass through this polarised light. And when the light is coming out, there will be some analyser; and that, analyser will monitor with respect to the light which is entering the solution that how much movement has taken place.

So, the movement of this particular amount, that means, the theta amount, the movement of that much will be known as the corresponding optical rotation of the molecule; and where we see that the corresponding plane of polarisation is rotated by the solution which is present as the optically active compound in the medium. So, that measurement basically gives us the experimental proof or the experimental monitoring for the optical activity. So, the through the chiral solution, the molecule which is chiral, and we made the solution, and the plane polarised light is passed through it, and we just monitor here through the analysing filter. And analysing filter will measure the amount of rotation with respect to the plane of polarisation which is originally present over there.

So, if the plane rotates in the right hand direction, we call the molecule as the dextro rotatory compound. So, now related to the corresponding direction of the rotation, we will call as the dextro rotatory compound.

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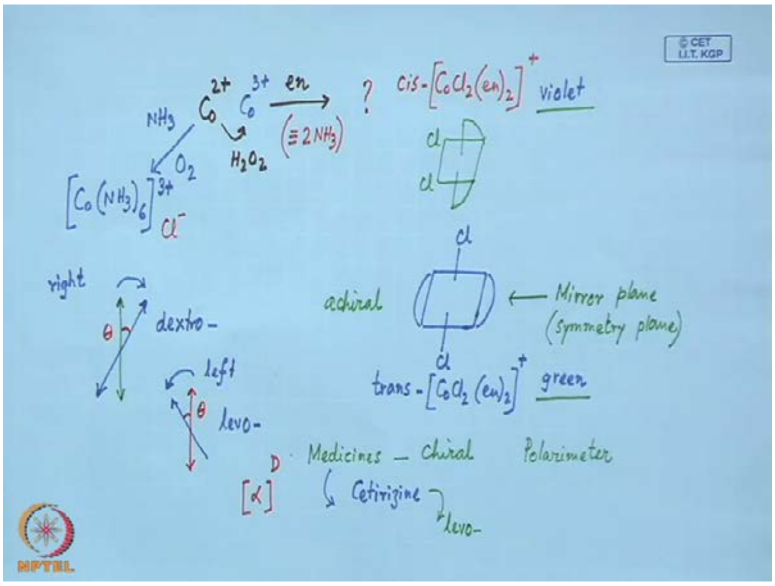

So, we have the plane polarised light, if it is rotated in one particular direction, that means, towards the right, we call it as dextro rotator, dextro rotator. And, if the movement of the plane polarised light that the particle direction, always we are considering the plane polarised light which is entering the solution, then if its moves towards the left; this is the movement towards right, and this is the movement towards the left. So, the other form will be known as levorotatory, if the plane rotates towards the left. So, we have the levorotatory. So, for optically active different molecules, the different chiral compounds what we can have, they can also be used for good drug molecule or good medicines. So, different types of medicines also, though we do not have any metal ion present over there, but if the molecule is a purely organic compound, and which is chiral in nature.

And, we can measure the corresponding optical activity by measuring the corresponding rotation of the plane polarised light by polarimeter. The instrument which is used for measurement of those things are polarimeter, and that polarimeter is basically finding that how much movement is taking place, that means, the corresponding theta angle for this. And this theta angle for this, which can also be represented as a corresponding optical rotation with respect to some sodium d line as alpha d values, so these alpha d values, through that measurement will consider that whether our compound what we are considering as a good drug molecule or the medicine, whether the molecule is dextro rotatory or levo rotator.

And, we have seen that some of these compounds when we have the 50 percent mixture of dextro and 50 percent mixture of the levo, we see that most of the compounds; where we see that some of this compounds, the levo rotation is necessary. And levo rotatory molecules are the active component for these drug molecules. So, we know that anti allergic drugs, some citrizine is well known to us; and this citrizine molecule. Previously we do not know what particular form, whether the dextro form or the levo form is useful. Now is well known that the levo form is active form, that is why in the market also the levo citrizine is also available; and this levo citrizine is levelled and which has the corresponding measurement for this optical activity, and we prescribe this as the corresponding molecule, as the levo citrizine.

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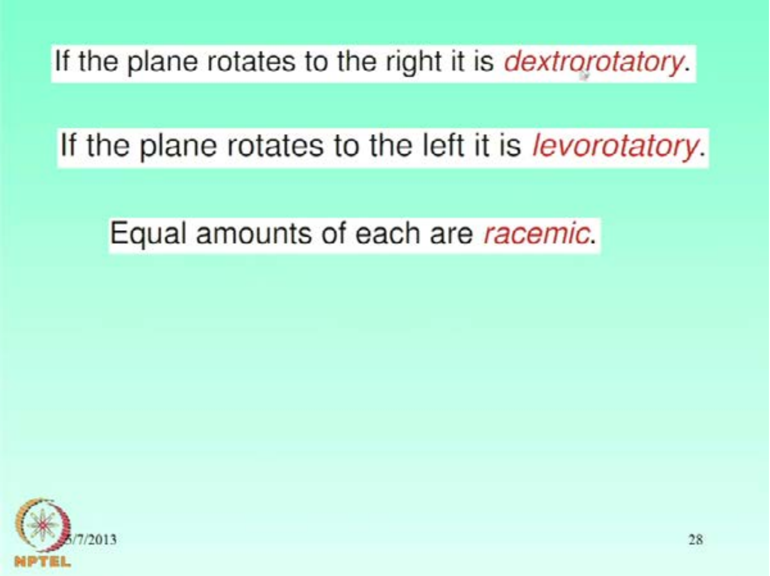

If the plane rotates to the right it is *dextrorotatory*.

If the plane rotates to the left it is *levorotatory*.

Equal amounts of each are *racemic*.

So, when we have both of them together, we consider it as the racemic mixture. And that racemic mixture is not very much active for all this cases, because only 50 percent of the molecule is only working, the other 50 percent is not active and which is not useful to our system, for our treatment.

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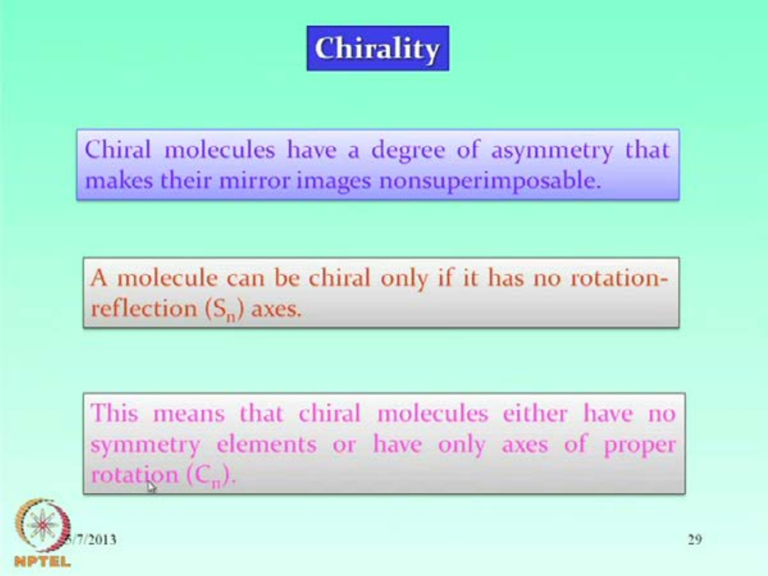

Chirality

Chiral molecules have a degree of asymmetry that makes their mirror images nonsuperimposable.

A molecule can be chiral only if it has no rotation-reflection (S_n) axes.

This means that chiral molecules either have no symmetry elements or have only axes of proper rotation (C_n).

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So, chirality is therefore, is defined as the chiral molecules which have a degree of asymmetry that makes their mirror images non super imposable. And molecule can be chiral only if it has no rotation reflection axis; that means, it do not have the S n axis; rotation followed by reflection, if this axis, if it has no rotation reflection axis then the, only the molecule is optically active and chiral. So, chiral molecules either have no symmetry elements or have only axes of proper rotation, and that we have also discussed earlier.

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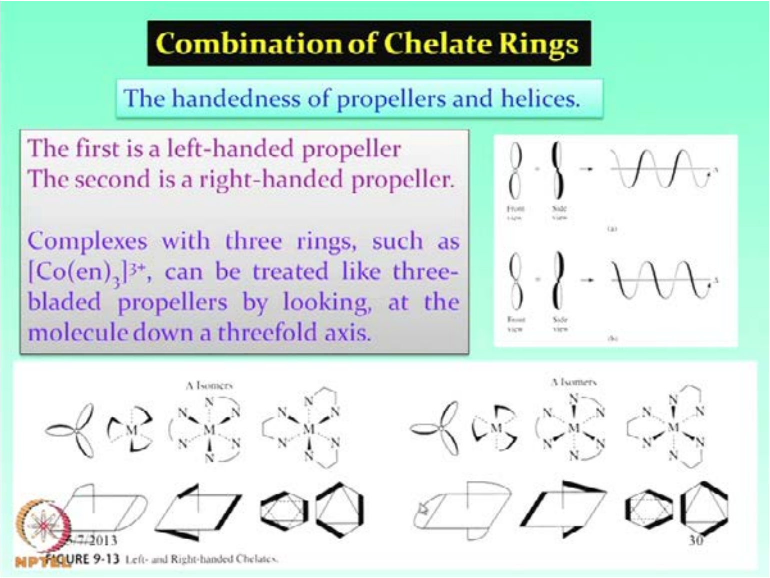

Combination of Chelate Rings

The handedness of propellers and helices.

The first is a left-handed propeller
The second is a right-handed propeller.

Complexes with three rings, such as $[Co(en)_3]^{3+}$, can be treated like three-bladed propellers by looking, at the molecule down a threefold axis.

FIGURE 9-13 Left- and Right-handed Chelates.

So, if we have the combination of these chelate rings what we see that, handedness of and propellers and helices. So, if we have the front view is like this, the propeller view and the side view of this is that, if as the bold view at the side one, then in this particular (( )) is one form, is a moving from one direction to the other; that means, it is in the lambda form, which is in the left hand direction. So, it is in the left hand. And when is in the other form, that means, when is in the right hand direction, we get at, is as the corresponding delta Watson.

So, we already discussed all these things; that means, the cobalt tris ethylene diamine. It has 3 bladed propellers and looking as a molecule down to, in the 3 fold axis. So, what we have seen that, either we can consider it as this blades, or this one, or this one, or this one. So, when we have this; that means, when we consider this as from the connectivity from this side to this side, or the connectivity from this to this and this to, so it is in the counter clockwise direction. So, we have the lambda isomer; and when this connectivity is going for in other way; that means, we have the isomer in this form; that means, this is the top triangular face, and this top triangular face is going from this clockwise direction, from this nitrogen to this nitrogen, from this to this; so this is another diagram for getting this particular arrangement.

So, any of this arrangement is fine, either this arrangement or this arrangement; or, in some hexagonal geometry also can tell us whether we have this particular drawing, or this particular drawing, for lambda isomer and for delta isomer. So, in all this cases, it is important that viewing through this triangular faces, how this can accommodate the lower face, and how they are connected, if they are connected in the clockwise direction, or if they are connected by counter clockwise directions.

So, one such good example made by Jorgensen which is a famous person who did all these molecules for so many years, and described the molecule as hexol. And this salt can be prepared by simple heating the corresponding diacho compound of the tetramine cobalt 3 with dilute base such as ammonia.

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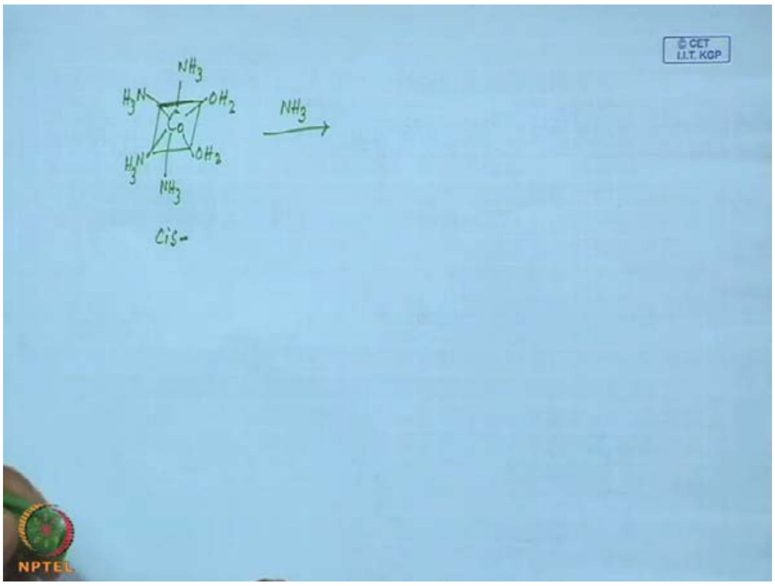

And when we get this; that means, when we have the cobalt, important thing is that, we have NH 3. So, if we take the cis compound, and if we heat it with ammonia, then what happens?

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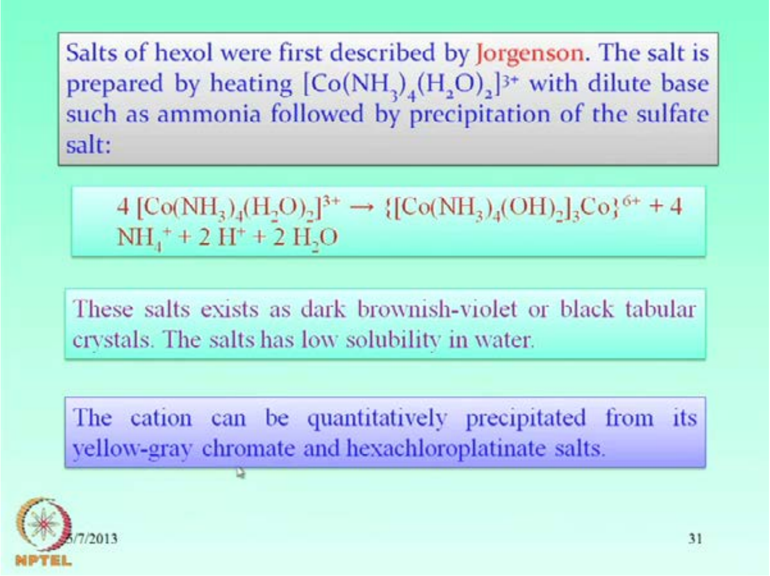

Salts of hexol were first described by Jorgenson. The salt is prepared by heating $[Co(NH_3)_4(H_2O)_2]^{3+}$ with dilute base such as ammonia followed by precipitation of the sulfate salt:

$$4\,[Co(NH_3)_4(H_2O)_2]^{3+} \rightarrow \{[Co(NH_3)_4(OH)_2]_3Co\}^{6+} + 4\,NH_4^+ + 2\,H^+ + 2\,H_2O$$

These salts exists as dark brownish-violet or black tabular crystals. The salts has low solubility in water.

The cation can be quantitatively precipitated from its yellow-gray chromate and hexachloroplatinate salts.

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So, the compound, which next get can be precipitated as its sulphate salt, because if it is cationic we need to have some anions to get it precipitated. So, the reaction is very simple; the 4 molecules of this is reacting, giving a tetra nuclear compound which is a big molecule basically, and which has 6 positive charge with the liberation of 4 molecules of this amine ligands as ammonium ion, and 2 of them as proton and 2 water molecules.

And, these salts exist as dark brownish violet or black tabular crystals; and the salt has low solubility in water. So, how these are forming? So, the tetra nucleation what is forming over there, is due to the corresponding condensation reaction, what is there; that means, it is can be isolated as yellow gray chromate or hexachloroplatinate salts.

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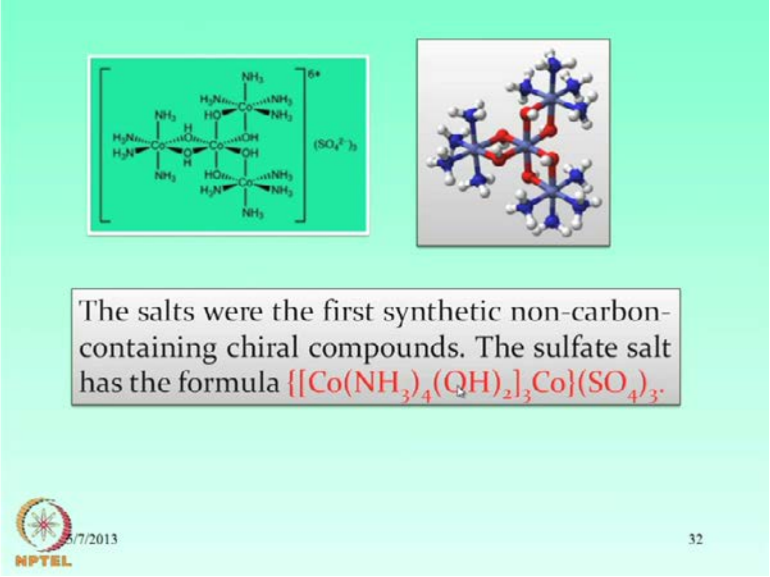

The salts were the first synthetic non-carbon-containing chiral compounds. The sulfate salt has the formula $\{[Co(NH_3)_4(OH)_2]_3Co\}(SO_4)_3$.

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So, this is the compound, what is forming over there, like the tris chelate now, is a purely typical inorganic compound, no organic ligand is present; and this mono nucleus species; that means, the tetra amine cobalt part is behaving as a bidented ligand from this side, from this side, and from that side. So, it is a very unique tetra nuclear compound, where this particular part that, this is the complex itself; the 3 surrounding complexes are behaving as 3 bidented ligands. So, that is why, that gives rise to the corresponding optical activity for the molecules.

And, the salts were first synthesised, synthetic non carbon containing chiral compounds. And the sulphate salt has this particular formula, because it has 6 positive charge. So, 3 units have sulphates groups should be present over there, which can crystallise it as a unique tetra nuclear compound, which is optically active, and which is purely inorganic in nature, because it has no organic ligand present in it.

Thank you very much.