Symmetry, Stereochemistry and Applications
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Module No # 04
Lecture No # 17
Drawing One Projection from Another

Welcome back to the course entitled symmetry, stereochemistry and applications. In the previous lectures, we have discussed about various isomerismS and we have learned little bit about different types of projection formula. So in today's lecture I would like to concentrate on how you can inter convert one type of projection formula to another type of projection formula. So let us start the discussion by drawing different types of projection that are possible for a tetrahedral carbon center and let us start the discussion with methane.

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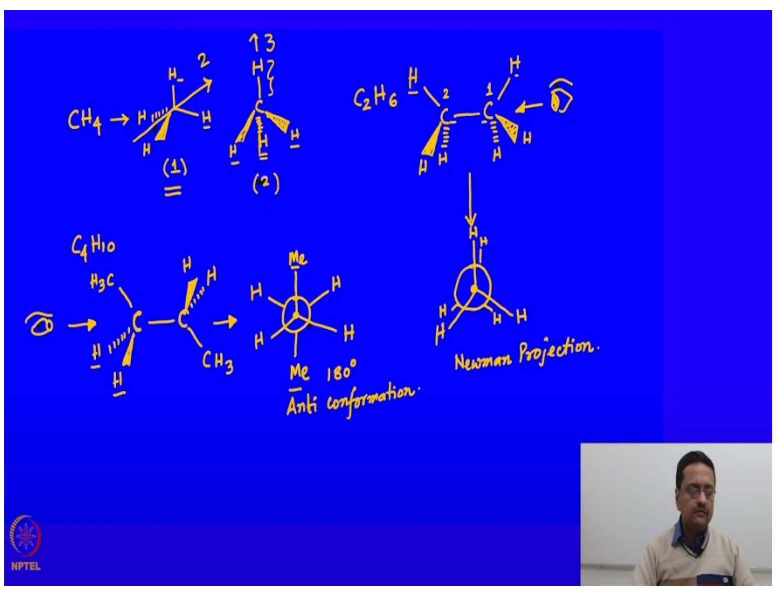

As you know methane is a tetrahedral molecule with 4 bonds placed at 109.28 degree. So this methane can be projected in 2 dimensional piece of paper or on this board, in this way. So this projection indicates that the 2 hydrogens which are shown here are on the plane of this projection and the other 2 hydrogens are above and below the plane of projection. This bold Wedge represents the hydrogen, which is above the plane of projection, and the dash line indicates the hydrogen is below the plane of projection.

One can also represent methane in this way as well, which means that the carbon hydrogen bond shown here is in the plane of projection. These 2 hydrogens are above the plane of projection and this third hydrogen here is below the plane of projection. So at some point you may see that when the molecule is drawn in the first type of projection, It is drawn to show that the molecule contains a 2 fold axis.

The second type of projection is drawn to show that the molecule has a 3 fold axis. So depending on what we are trying to represent the molecule can be drawn in different ways. So now if there are more than one carbon atoms, suppose we are talking about C2H6 what we know that the 2 carbon atom are bonded. And if we assume those carbon atoms form a plane then we can draw 2 hydrogens also on the same plane on either carbon atoms.

And then just like the type 1 we can draw 2 hydrogen atoms like this and here 2 hydrogen atoms like that which indicates that 2 hydrogens are above the plane of the other 4 atom. That is the 4 atoms that we have drawn at the beginning and then 2, hydrogens are below the plane of projection. So this type of projection is called the sawhorse projection that you have already learnt. I have discussed about Sawhorse projection while talking about molecular conformations in the previous week.

So now this sawhorse conformation can be converted to something called a Newman projection and in that we look at the molecule through one of the bonds. So when we look through the C-C bond the front carbon is numbered as 1 and the back carbon is numbered as 2. So we write the front carbon as the dot and the back carbon as a larger circle. So when we are trying to see this molecule from the right hand side the front carbon has 1 hydrogen upwards, 1 hydrogen to the right and the other hydrogen to the left.

Similarly the back carbon has 1 hydrogen up, 1 hydrogen down here and 1 hydrogen down on the left hand side. So this is called the Newman projection. Now suppose, I have a molecule which is butane, C4H10 which we can write as the C-C bond that is the middle carbon atoms. Then I can have a methyl group here, the other methyl group is here and then the hydrogens on the carbon 2 and 3 are marked like that. Whereas the hydrogens on this should be identified like that.

So if we look at this molecule suppose from the left hand side, this carbon is my front carbon and the second carbon is the back carbon. So if we look at the molecule from one side, in this case the left hand side on the front carbon at top you have a methyl group. On you right and left you have hydrogens, on the back carbon downwards you have a methyl group and you have 2 hydrogens on the right and left.

So what we have done is we have converted the Sawhorse projections to Newman projections. Here what we can see that this methyl group are in opposition. So the dihedral angle between the 2 methyl groups is 180 degree. Therefore this conformation is called the anti-conformation, right.

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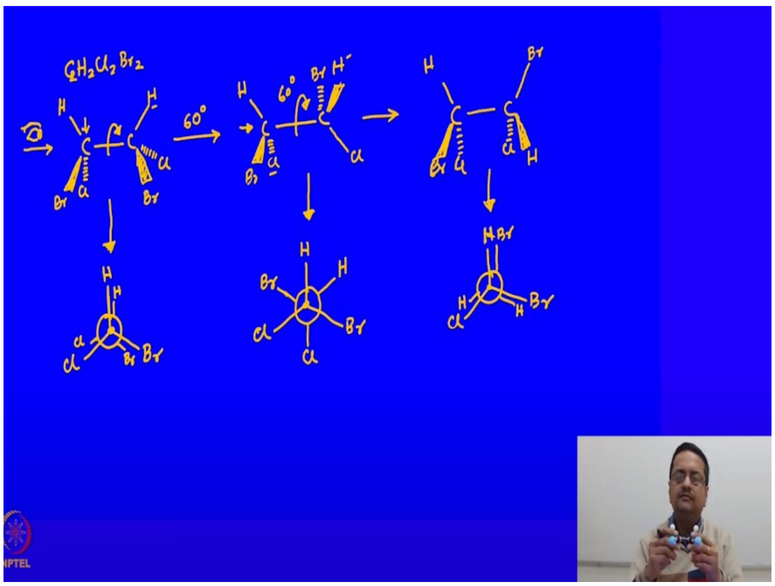

So let us now try to concentrate on some molecules which have different groups connected to the 2 corresponding carbon atoms which we are talking about. Suppose we have a molecule like this here. So each carbon contains 3 different groups and if you look at the molecule like this, it is in a perfectly eclipse condition. And if I rotate it about a C-C bond and make it like this then this conformation is anti.

Because what you can see is this blue and blue is in 180 degree torsional angle and this red and red are 180 degree dihedral angle and this white and white are again 180 degree dihedral angle. So this particular molecule if I first draw the fully eclipsed conformation in Sawhorse notation.

Suppose these red ones are bromines and those blue ones are chlorines so the molecule is C2H2Cl2Br2.

So the molecule in the eclipse conformation in the Sawhorse projection should be drawn like this. The 2 hydrogens are in the plane with other with carbon atoms in the plane of projection this bromines are also eclipsed. So both the bromines are above the plane of projection and the chlorine which is there, both the chlorines are below the plane of projections. So when you try to draw, the Newman projection of this particular geometry or this particular conformation by looking at the molecule from this side.

What we see is the front carbon and the back carbon, the front carbon has the hydrogen up, the bromine is on the right hand side, chlorine is on the left hand side. Similarly for the back carbon hydrogen is above, bromine is on the right hand side and chlorine is on the left hand side. Suppose if I rotate about this bond by 60 degree keeping the front carbon fixed so what should happen?

The front carbon should remain as it is. This hydrogen which is here should come somewhere here by making it exactly opposite to that chlorine. This chlorine should come down making it opposite to the hydrogen and this in 60 degree I think the direction of rotation is right. So the bromine would be going down or I think bromine would come here. So the corresponding Newman projection should look like the following.

Again we are looking at it from the left hand side, the front carbon does not change, the back carbon the hydrogen is rotated by 60 degree so it comes here opposite to chlorine you see this hydrogen and chlorine, hydrogen is above the plane of projection and chlorine is below the plane of projection. So they are in anti-conformation. Here again the hydrogen and chlorine are also anti and of course bromine and bromine are in anti -conformation. If you rotate it by another 60 degree what we get is this one.

So when we draw the Newman projection for this what we see on the front carbon the situation has not change but the back carbon bromine is behind hydrogen and then for the front carbon the back side is hydrogen here and the chlorine and chlorine are in eclipse conformation. So this is how we convert the Sawhorse projection to Newman projection. But what we see in this particular molecule is that both carbon atoms are chiral because you have 4 different groups attached to both the carbon atoms. So for this chiral compound we should be able to draw a Fischer projection.

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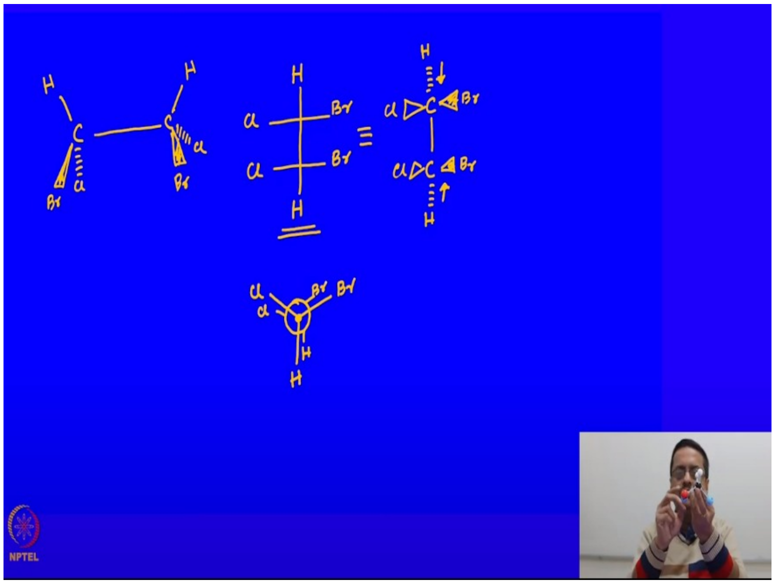

So suppose if we draw the molecule in a Sawhorse conformation with the hydrogens in the eclipsed conformation, bromine and bromine in eclipse conformation, chlorine-chlorine in eclipsed condition that is the fully eclipsed conformation. So what we have drawn is like that. So simply if we try to now convert this into Fischer projection we have to make it look like this and those 2 hydrogens should come backwards or you can keep the 2 bromine backwards.

So depending on how you see the molecule you should try to draw the Fischer projection of this molecule. Suppose we want to keep the 2 hydrogen backwards like this so the corresponding Fischer we will have 2 carbon centers. The top carbon center has 1 hydrogen which is pointed backwards so that hydrogen should come at the top and on your right is bromine and on your left is chlorine. Similarly on the lower carbon, hydrogen is at the carbon, and bromine is on your right and chlorine is on your left.

So this is the correct Fischer projection of this molecule. This essentially means that you have two carbon atoms in the plane of projection, 2 hydrogen atoms which are going below the plane of projection. The bromine atoms on the right, both are above the plane of projection. And the chlorine atoms on left are also above the plane of projection as shown here. So this identifies the Fischer projection of this molecule.

So what we have learnt by now, how to convert a Sawhorse projection to Newman projection and Sawhorse projection to a Fischer projection. So now if you try to convert this Fischer projection to a Newman projection we keep it in mind that then we are looking at the molecule from the bottom side. That means from the side of this carbon or from the top from that carbon. So if we try to convert this into Newman projection we need to keep the front carbon as a dot, the back carbon as a circle.

Now on the front carbon we have the hydrogen downwards, the bromine on the right hand side, chlorine on the left hand side. Similarly on the back carbon we have hydrogen downwards, chlorine on the left hand side and bromine on the right hand side. Suppose if we have a different isomer of this molecule where this overlap of chlorine-chlorine and bromine-bromine is not present. Rather they are in opposition. So then the molecule should look like this.

So hydrogen-hydrogen is in eclipse condition but bromine and chlorine are in eclipse in this particular molecule. So let us try to draw that molecule in the Sawhorse projection first.

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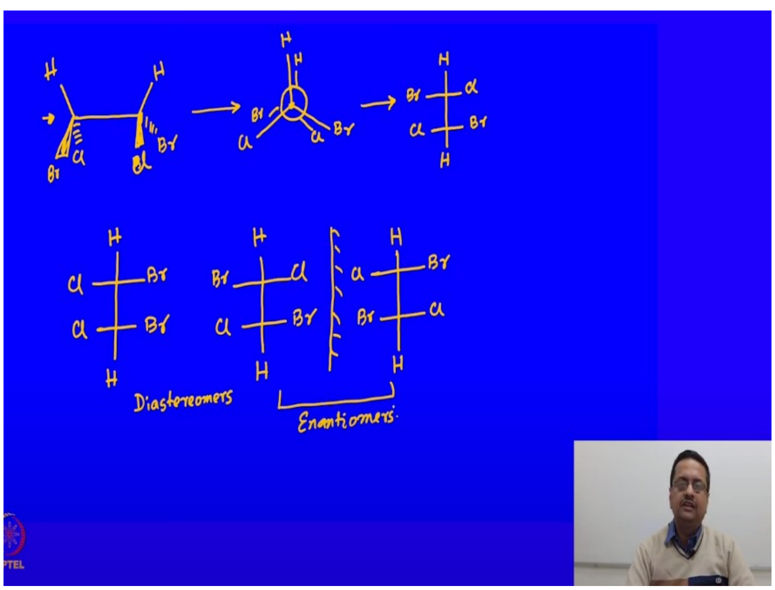

So this is the Sawhorse projection of this particular molecule. So now if I try to draw the Newman projection by looking at the molecule from this side. What should happen? On the front carbon we have hydrogen at the top, bromine on the right, chlorine on the left. And on the back carbon we have hydrogen at the top, chlorine on the right and the bromine on the left.

So this now if we try to convert it into a Fischer projection, like this. So when we convert it into Fischer projection we draw the straight vertical line and 2 horizontal lines. The vertical line as usual identifies the 2 carbon atoms and the top position is hydrogen because which is pointing towards me both the hydrogen top and bottom. Now on the top carbon you have bromine on the left and chlorine on the right.

On the bottom carbon, you have chlorine on the right and bromine on the left. So these become the Fischer projection of the other isomer of that particular compound. What we had is this one and what we now have is a different molecule as you can see because these 2 molecules are different. If I ask you what is the relationship between these 2 molecules. Let us see that by using Fischer projection.

The first molecule that I had drawn was this one and the second molecule that I have drawn has a Fischer projection formula this one, they are not mirror images. So they are stereo isomers. These types of isomers are called diastereomers. The stereo isomers which do not have any mirror image relationship are called the diastereomers. This second molecule if I draw the mirror image of that what we would get is this one.

These 2 mirror images are non-super imposable mirror images. So, these two are the enantiomers. Therefore you can see that the importance of having a Fischer projection. If you draw a molecule in a Fischer projection you can easily identify what relationship is there between the molecules which are isomers, which are some kind of stereoisomers. Whether it is a diastereomer or enantiomer it is very easy to identify if you draw the molecule in the corresponding Fischer projection.

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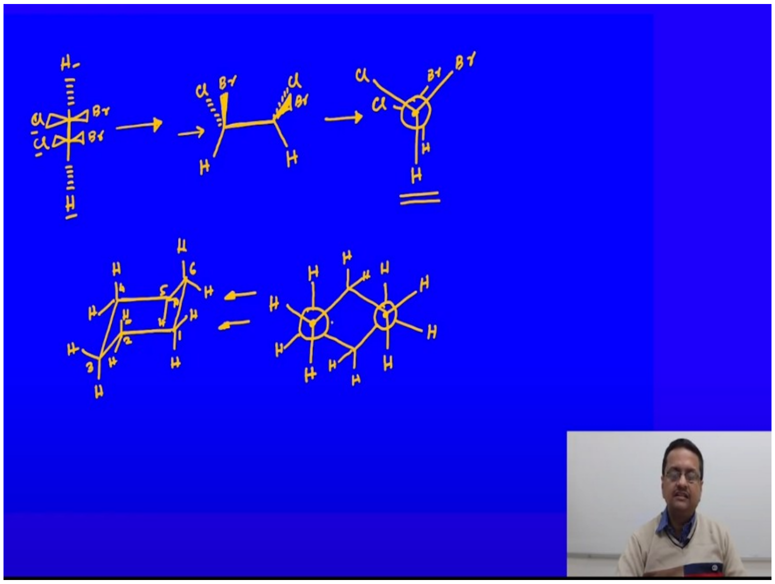

So what we know that in case of Fischer projection the bonds which are at the top are below the plane of projection and the bond which are in the horizontal direction are above the plane of projection. So one can easily convert this into a Sawhorse notation assuming that this bond in the middle is represented here, what we see is that the hydrogen-hydrogen are in eclipse conformation and both are pointed downwards.

Then the chlorines are on the left hand side above the plane of projection and bromines are on the right hand side but above the plane of projection. So we draw that chlorines like that and the bromines are drawn like this. So if you look at the molecule from this side, you can identify this representation is correct. And then if we convert it into again back to a Newman projection what you gain is this one. The down is hydrogen, right is bromine, left is chlorine and the same is there for the back carbon as well.

So in today's class we have learned how to convert from 1 particular projection to another using simple drawing tools. So this drawing will be very much useful for you to understand the stereochemistry of different organic reaction. As you have seen in one of the classes where we were discussing about the conformation of cyclohexane. There we have also shown how the cyclohexane can be drawn using Newman projection. I just like to remind you about that in today's lecture.

So this is the chair conformation of cyclohexane. So what we have is the hydrogens are drawn here. So what we try to do is to draw the molecule by looking at the molecules through these bonds. So when you are drawing the molecule looking through those 2 bonds essentially we have a double system of this type of projection. So if I identify those as 1, 2, 3, 4, 5 and 6 then when I am drawing it from here as 1, this is my 2. Here the back carbon is 4, the front carbon is 5.

So, on the front carbon number 1, I have 1 hydrogen downwards, 1 hydrogen to the left and this methyl group on my right at the top which is connected to the number 5. And on this carbon here also you have a hydrogen at downwards and the other hydrogen on the right hand side. When you look at the back carbon from this side this hydrogen is above. This particular hydrogen is here and the third bond is connected through carbon number 3 to the back carbon 4.

And this back carbon 4 has 1 hydrogen upwards, and a second hydrogen in the downwards direction making an angle 60 degree. See this conformation will be important when we try to understand some chemistry related to substitution reaction or some chemistry related to elimination reaction. So that is where we will need this conformation to be understood properly. So I would like you to draw these conformations yourself and practice how to draw from the cyclohexane chair form, this line dash conformation to the corresponding Newman projection. So we will start discussed about SN1, SN2, E1, E2 etc., certain reaction in the following classes.