Welcome dear students. I'm doctor Durga Kamat from

DCT'S Dhempe College of Arts and Science. Today's lecture is for first year BSc students Semester one in the subject of chemistry.
Course code is CHC 101. Course
Title: Inorganic and organic chemistry, section B.
Title of the unit is, Unit 2 stereo chemistry module number 27.
Configuration: Geometrical and optical isomerism. We will discuss about classification of configurational isomers, geometrical isomerism, optical activity and optical isomerism in this module.
At the end of this module you will be able to differentiate between the two types of configurational isomers. Explain the concept of geometrical and optical isomerism and discuss the properties of configurational isomers.
Stereoisomers are the compounds which have same molecular formula. But differ in the three dimensional relative arrangement of atoms in space, stereo isomers are of two types. Configurational isomers and conformational isomers. Configurational isomers can be further divided into 2 classes. Geometrical isomers and optical isomers.
Conformational isomers differ only by rotation around carbon carbon single bond.
Unlike the conformational isomers, configurational isomers do not readily interconvert under normal conditions, and thus can be separated and isolated. Their configuration is fixed. And Interconversion in these stereoisomers usually involves a bond breaking process.
Now what is configuration? Configuration Is the particular arrangement of atoms in space which characterizes a particular isomer.
Configurational isomerism can exist as a result of geometrical or optical isomerism.

Geometrical isomerism describes the orientation of functional groups within a molecule that occur as a result of restricted rotation.Geometrical isomers can be classified as compounds having double bonds or cyclic compounds.

Stereoisomerism about double bonds originates because of the restricted rotation. Keeping The substituents fixed relative to each other. For the geometric isomers resulting from the carbon carbon double bond, an important condition besides restricted rotation is that each of the doubly linked carbon atoms should be attached to two different univalent atoms or groups.

If we replace any one hydrogen attached to carbon 1 by the other hydrogen in this molecule we will get an identical molecule and we cannot call these two compounds as geometrical isomers.

Where as cis butene and trans butene can be called as geometrical isomers as they differ in the relative position of the substituents across carbon carbon double bond and each carbon that is SP2 carbon is attached to two different substituents or groups.

In case of cis but-2-ene the identical groups are on the same side of the carbon carbon double bond and in case of trans but-2-ene, the identical groups are on the opposite side.

The E, Z isomers of 1-bromo-1- chloro propene are also geometrical isomers.

Geometrical isomerism is also observed in the compounds containing carbon nitrogen double bond. For example, aldoximes or ketoximes.The aldoxime obtained from an aldehyde can be either syn or anti.

There is a lone pair present in one of the SP2 orbitals of nitrogen, so the position of hydroxyl group is fixed. In case of Syn isomer, the hydroxyl group is on the same side as that of the hydrogen attached to the carbon of the carbon nitrogen double bond. And in case of anti isomer, it is on the opposite side.

In case of substituted azo compounds, each nitrogen Atom has a lone pair and a group.
If the two groups are on the same side of the nitrogen nitrogen double bond, then we get a syn isomer.

And if they are on the opposite side then we get anti isomer. Geometrical isomerism is also observed in monocyclic and fused ring systems due to restricted rotation. In general, if any two sp3 carbons in a ring have two different substituents or groups geometrical isomerism is possible. For example, in case of cyclopropane 1,2 - dicarboxylic acid, the cis isomer has the two carboxylic acid groups lying on the same side that is either above or below the plane of the three membered ring. And in case of trans isomer, these carboxylic acid groups are on the opposite side of the plane of the ring.

Here are the examples of four membered, 5 membered and six membered cyclic systems which exhibit geometrical isomerism. Generally, geometrical isomers have different physical properties. For example, the Cis isomer of 1, 2- Dichloroethene has different boiling point whereas trans isomer has different and generally the Cis isomer of 1, 2- Dichloroethene has higher boiling point compared to that of the trans isomer. Let's take example of cis isomer of 1,2-dichloroethene which is a polar molecule and the trans isomer which is non-polar. The molecules of Cis isomer have a overall molecular dipole and because extra energy is required to break these dipole dipole interactions. The Cis isomer boils at a higher temperature. In case of the trans isomer the melting point is higher compared to that of the cis isomer.

As for intermolecular forces of attraction to work well, the molecules need to be packed efficiently together in a crystal or in the solid state. So this packing is more efficient in case of trans isomer than the cis isomer.
The geometrical isomers have same functional groups. But they are not identical compounds. They tend to react with the same chemical reagents but at different rates. Maleic acid when heated at around 150 degree Celsius loses water readily to form maleic anhydride. Whereas it's geometrical isomer, Fumaric acid requires higher temperature to form this maleic anhydride. Geometrical Isomers can be separated on basis of the difference in their properties and also their configuration can be determined.
Now let's see what are optical isomers. For this we need to first understand what is optical activity. Optical activity is a property of a molecule to rotate the plane of plane polarized light.

Light has oscillating electric and magnetic field. The electric field of light oscillates in all planes. When a beam of ordinary light is allowed to pass through a polarizer in a polarimeter, only the light waves which oscillate in single plane are allowed to pass through.The light emerging from the polarizer is said to be plane polarized and here we can see that the plane polarized light is allowed to pass through the sample tube containing solution of the compound which may rotate the plane of plane polarized light and the magnitude of this rotation alpha is directly proportional to the concentration of the sample and the length of the sample tube.

Alpha in square bracket is a constant basically called as specific rotation. And each optically active compound has a characteristic specific rotation. Specific rotation is the rotation caused by a solution of 1 gram of compound in one milliliter of solution present in a sample tube of 1 decimeter length at a specified temperature and wavelength. Specific rotation can be calculated from the observed
rotation using this formula. The compounds which rotate plane of plane polarized light in the clockwise direction or to the right are called dextrorotatory. Compounds indicated by plus sign or small d and the compounds which rotate plane of plane polarized light in the anticlockwise direction or to the left are known as laevorotatory compounds represented by minus sign or small l. So basically the compounds which rotate the plane of plane polarized light are said to be optically active. So what type of compounds show this optical Activity? For a compound to be optically active, it has to be chiral.

You have seen in the previous modules that a chiral compound has a non superimposable mirror image like our hands. And the very basic cause of chirality in a sample or in a compound is the presence of asymmetric center. Here in this case we can see that there is one asymmetric carbon Atom and using the general formula, two raised to n, we can draw two possible stereoisomers for this structure. If we imagine a mirror plane between these two compounds, then we can see that they are mirror images of each other. Moreover they are nonsuperimposable mirror images.
Thus they are different compounds and they are called as optical isomers or enantiomers.

Enantiomers share many of the same physical and chemical properties. In fact, all the physical properties of enantiomers are same except their optical activity. The specific rotation of the R isomer of 2-methyl-1-butanol is equal to plus 5.75 and it's S isomer shows specific rotation equal to minus 5.75, so the magnitude of rotation is same but in opposite direction.
A mixture of two enantiomers in the same ratio is called Racemic mixture. In a racemic mixture each enantiomer rotates the plane of polarized light in equal and opposite directions. So the net result is zero optical activity. For a mixture of enantiomers to be optically active one enantiomer has to be in excess over the other. So we have seen what are configurational isomers, the type of configurational isomers and their examples.

You will learn more about configurational isomers rules for assigning their configuration and nomenclature in further modules.

These are the references.

Thank you.