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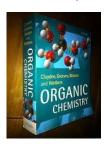
Organic Chemistry

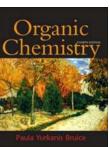
Topics

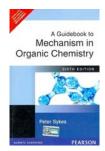
- ***** Stereochemistry
- **❖**Conformational Analysis
- **❖** Nucleophilic Substitution at a Saturated Carbon
- **Pericyclic Reactions**

Recommended Books

- 1. Organic Chemistry by Clayden, Greeves, Warren and Wothers
- 2. Organic Chemistry by P. Y. Bruice
- 3. A Guide Book to mechanism in Organic Chemistry by P. Sykes







Stereochemistry

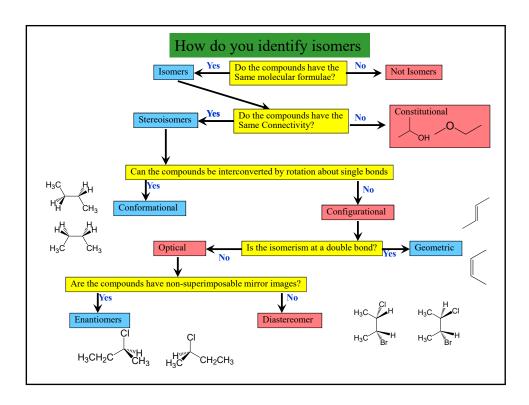
Stereochemistry refers to the 3-dimensional properties and reactions of molecules. It has its own language and terms that need to be learned in order to fully communicate and understand the concepts.

Static Stereochemistry Stereochemistry of Molecules

Number of isomers, structure, energy, physical and chemical properties

Dynamic Stereochemistry Stereochemistry of Reactions

Stereochemical requirements and outcome of chemical reactions



Chiral An object that has a non-superimposable mirror image is said to be "**chiral**" (Greek = cheir (*handedness*)) and one that has a superimposable mirror image is "**achiral**".









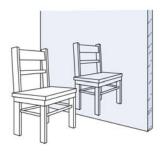
Left hand

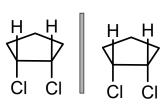
Right hand

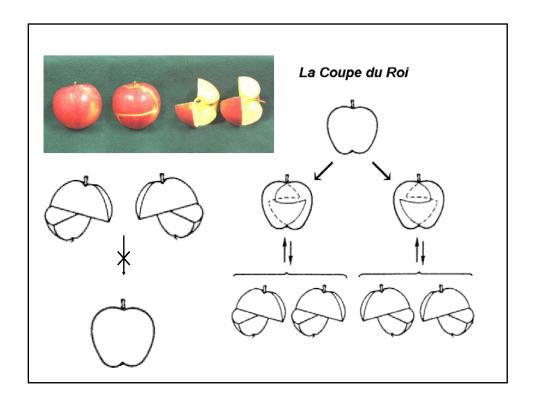
CHIRALITY is a property of an object which is **non-superimposable** with its mirror image. Most objects in the environment are chiral. In chemistry this term applies to molecules, specific conformations of molecules, as well as to macroscopic objects such as crystals.

<u>Chirality is removed if an object /molecule acquires a plane of symmetry, or a center of symmetry.</u>

- Many molecules and objects are achiral:
 - identical to its mirror image
 - not chiral





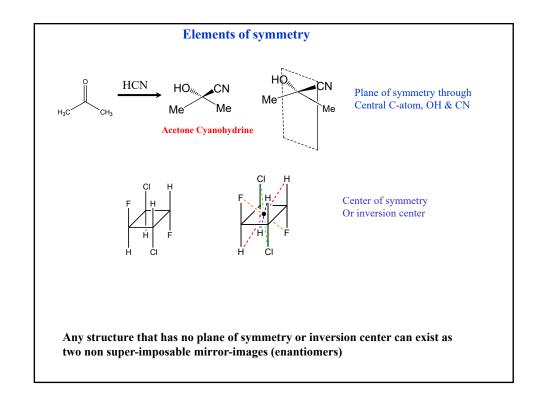




Enantiomers A pair of molecules that are non-superimposable mirror images of each other.

The most common type of "chirality" is observed when a carbon atom has *four* different groups attached to it (so it *must* be sp³ hybridized). This carbon atom is then described as a **chirality center**.

Other terms are chiral, asymmetric or stereogenic center (stereocenter).



Stereogenic centres

If a molecule contains one carbon atom carrying four different groups, generally do not possess a plane of symmetry or inversion center and must therefore be chiral.

A carbon atom carrying four different groups is a stereogenic or chiral centre

Constitutional and Stereo Isomers

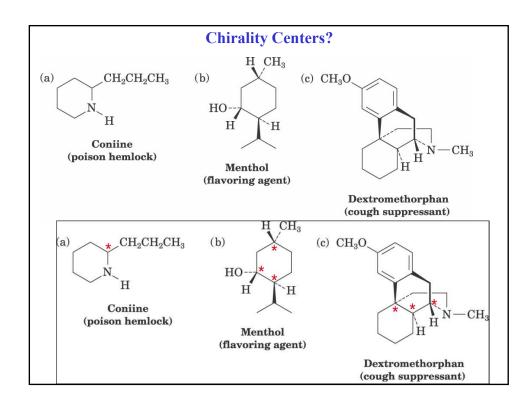
Constitutional Isomers

Going from one enontiomer to the other requires bond breaking

Trans-cis isomers

 π -bond should be broken Stereo isomers

Three conformations of same enontiomer: Going from one to the other requires rotation about C-C bond



Racemic mixture

A racemic mixture is a mixture of two enantiomers in equal proportion

Cahn-Ingold-Prelog rules:



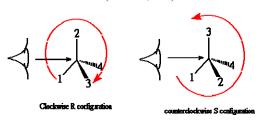
Absolute configuration: The R & S notation

Both are "2-butanol"

- 1. Assign priority sequence to the four groups attached to a stereogenic carbon following *sequence rule*
- 2. Observe the stereogenic centre from a direction opposite to the group of lowest priority
- 3. Trace the path from 1 to 2 to 3.

If clockwise R (rectus, right)

If anti clockwise S (sinister, left)



Sequence rules:

1. Priority is first assigned on the basis of the atomic number of the atom that is directly attached to the stereo centre.

(1)
$$HO = \begin{array}{c} CH_3 & ? \\ \hline \\ CH_2 & ? \\ CH_3 \end{array}$$

2. When a priority cannot be assigned on the basis of AN, then the next set of atoms/groups are examined.

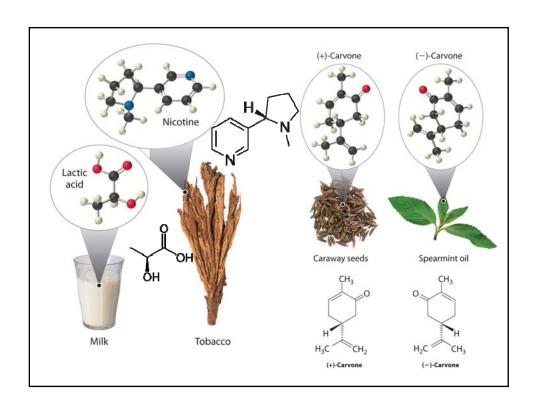
3. Rotate the structure so that (4) is directed away from us.

HO
$$\begin{array}{c}
CH_3 \\
CH_2 \\
CH_2
\end{array}$$
 $\begin{array}{c}
CH_3^3 \\
CH_2CH_3
\end{array}$
 $\begin{array}{c}
CH_2CH_3
\end{array}$
 $\begin{array}{c}
R
\end{array}$

4. Groups containing double or triple bonds are assigned as if both atoms were duplicated and triplicated.

Vinyl or ethyl which one gets higher priority?

Vinyl>Ethyl

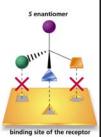


Chiroptical properties

Enantiomers: similar chemical and physical properties (melting points, boiling points, heat of combustion *etc.*),

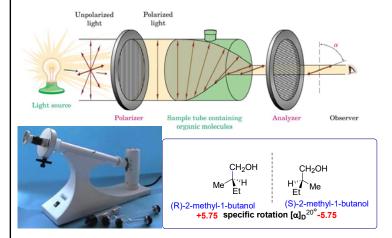
Differences in direction of rotation of plane polarised light and interactions with chiral molecules (reagents, solvents, catalysts etc).





Diastereomers have different physical and chemical properties

- •Any material which rotates the plane of the polarized light can be termed as "optically active"
- •Compounds featuring chiral centers are optically active if they do not contain plane of symmetry or an inversion symmetry.
- •Rotation of plane of polarized light
 - •towards left (levorotatory), it will be designated as 1, or -
 - •towards right (dextrorotatory), will be designated as d, or +
- •Enantiomers rotate plane of polarised light in opposite directions, but to the same extent (clockwise = +ve, counterclockwise = -ve).
- •An achiral molecule is optically inactive and cant show any rotation



The specific rotation is the number of degrees of rotation caused by a solution of 1.0 g of the compound per mL of solution in a sample tube 1.0 dm long at a specified temperature and wavelength.

[α 1 α 2

$$[\alpha]^{\mathsf{T}}_{\lambda} = \frac{\alpha}{|\mathsf{xc}|}$$

 $[\alpha]$ = specific rotation;

T = temperature in °C;

 λ = wavelength of the incident light

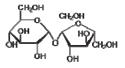
(when the sodium D-line is used, λ is indicated as D)

 α = observed rotation;

l = length of the sample tube in decimeters;

c = is the concentration of the sample in grams per milliliter of solution

Temperature	Rotation of a sucrose solution	
°C	α	
	[º angle deg]	
20	40.000	
21	39.981	
25	39.906	



Description of the	Wavelength	Specific rotation
light source		$[\alpha]_{D}^{20^{0}}$
	[nm]	
	[j	[0 cm ³ /g dm]
Mercury, green	546.23	+ 78.4178
Sodium, yellow	589.44	+ 66.5885
HeNe Laser	632.99	+ 57.2144
Near Infrared (NIR)	882.60	+ 28.5462

A 50:50 mixture of a pair of enantiomers is called a racemic mixture. This is optically inactive since the rotations produced by each of the enantiomers must cancel each other out.

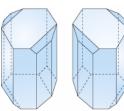
If there is more of one enantiomer than the other, then the optical purity of a sample can be determined by measuring the rotation and comparing it to that of a pure enantiomer. This can be used to establish the enantiomeric excess (ee) of the mixture.

$$\frac{\text{optical purity}}{\text{(enantiomeric excess; ee)}} = \frac{\text{observed specific rotation } (\alpha_{\text{obs}})X \text{ 100}}{\text{specific rotation of the pure enantiomer } (\alpha_{\text{max}})}$$

= % of R - % of S

65 of % of R and 35 % of S ee of the compound is 30%

COO⁻ Na⁺ H-C-OH HO-C-H



Louis Pasteur

D and L-systems (relative configuration)

The D/L systems relies on the chemical correlation of the configuration of the chiral center to D-glyceraldehyde.

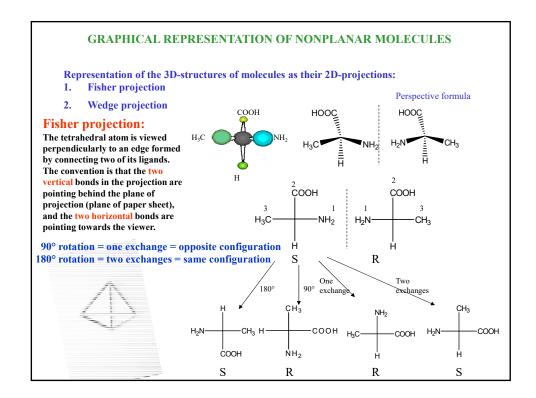
The accepted convention for drawing D(+)-glyceraldehyde places the hydrogen atom at the left and the hydroxyl at the right, with the aldehyde at the top.

IMPORTANT NOTE:

Although D-glyceraldehyde is dextrorotatory (rotates the plane of polarized light to the right), the compounds correlated to D-glyceraldehyde do not have to be dextrorotatory, i.e. could rotate light to the left.

Therefore, D-prefix is not correlated with the (+) or (-) specific rotation, and the D-compound can be l, (or -), and vice versa L-compound can be d (or +).

D/L-system is almost abandoned in favor of the Cahn-Ingold-Prelog (CIP) nomenclature, exception with **carbohydrates and aminoacids**, where the DL-nomenclature has been traditionally used.



Wedge projection:

It is obtained by viewing the tetrahedral center perpendicularly to the plane formed by three atoms. The remaining atoms are oriented behind the plane of projection (dashed bond) and towards the viewer (boldface bond).

This projection is therefore by far less ambiguous than Fisher projection.

In the case of large linear molecule the molecule backbone has to be laid on the plane of the paper such that the substituents pointed towards and/or away from the viewer

Sawhorse projection The C-C bond is viewed at an angle. This projection is difficult to use with acyclic molecules but is most popular for representation of cyclic molecules e.g. saturated six-membered rings.

Newman projection:

The molecule with two tetrahedral centers is viewed along the C-C axis.

The atom in front is represented as a three-way branch, the atom in the back as a circle with three outgoing bonds.

$$DH_2C-CH_2D \longrightarrow H \longrightarrow D$$
Newman projection

This projection is most useful to understand steric relations between ligands linked to adjacent tetrahedral centers and is most popular

Interconversions of representations

Fisher projection

Sawhorse projection

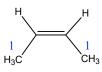
Z/E Geometry of Double Bonds

CIP rules used to geometrical isomers of olefinic compounds Precedence of ligands at both X & Y of the double bonds is determined pairwise. If both higher precedence ligands are on the same side of the double bond the configuration is Z, if on the opposite sides the configuration is E.

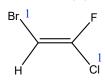
Z (zusammen, together)



E (entgegen, opposite)



(Z)-2-butene Or cis-2-butene



(E)-2-bromo-1-chloro-1-fluoroethene