Isomerism in Organic Chemistry

Isomerism is a phenomenon where two or more compounds have the same molecular formula but different structures or spatial arrangements. These compounds are called isomers. Isomerism can be broadly classified into two main categories: structural isomerism and stereoisomerism.

1. Structural Isomerism (Constitutional Isomerism)

Structural isomers differ in the connectivity of atoms within the molecules. Types of structural isomerism include:

- **Chain Isomerism**: Isomers differ in the carbon chain structure.
  - Example: Butane (C_4H_{10}) and isobutane (C_4H_{10}).
- **Position Isomerism**: Isomers differ in the position of a functional group or substituent.
  - Example: 1-Butanol ($CH_3CH_2CH_2CH_2OH$) and 2-Butanol ($CH_3CH_2CH(OH)CH_3$).
- **Functional Group Isomerism**: Isomers differ in the functional groups present.
  - Example: Ethanol (CH_3CH_2OH) and dimethyl ether (CH_3OCH_3).
- **Tautomeric Isomerism (Tautomerism)**: Isomers exist in dynamic equilibrium, typically involving the shift of a hydrogen atom and a double bond.
  - Example: Keto-enol tautomerism, where acetone (CH_3COCH_3) and its enol form ($CH_2=C(OH)CH_3$) are tautomers.
- **Metamerism**: Isomers differ due to different alkyl groups attached to a polyvalent atom or functional group.
  - Example: Diethyl ether ($CH_3CH_2OCH_2CH_3$) and methyl propyl ether ($CH_3OCH_2CH_2CH_3$).

2. Stereoisomerism

Stereoisomers have the same connectivity but differ in the spatial arrangement of atoms. Types of stereoisomerism include:

- **Geometric Isomerism (Cis-Trans Isomerism)**: Isomers differ in the arrangement of groups around a double bond or ring system.
  - Example: Cis-2-butene ($CH_3CH=CHCH_3$) and trans-2-butene ($CH_3CH=CHCH_3$).
- **Optical Isomerism**: Isomers differ in the way they rotate plane-polarized light due to the presence of chiral centers (atoms, usually carbon, with four different groups attached).
  - Example: Lactic acid ($CH_3CH(OH)COOH$) has two enantiomers, D-lactic acid and L-lactic acid.
  - **Enantiomers**: Non-superimposable mirror images of each other.
    - Example: (R)-2-butanol and (S)-2-butanol.
  - **Diastereomers**: Isomers that are not mirror images and not superimposable.
    - Example: 2,3-dichlorobutane has two pairs of enantiomers (2R,3R and 2S,3S) and (2R,3S and 2S,3R), where each pair are diastereomers of the other.