Stereoisomers and stereoisomerism

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Intended learning outcome

- Define stereoisomers
- Explain types of stereoisomers
- Describe the physical properties
- Discuss the importance and uses of stereoisomers.

Introduction

An isomer is a molecule with the same molecular formula as another molecule, but with a different chemical structure. Isomers contain the same number of atoms of each element but have different arrangements of their atoms. Isomers do not necessarily share similar properties unless they also have the same functional groups. There are two main forms of isomers: constitutional (structural) and stereoisomer. Stereoisomers have identical molecular formulas and arrangements of atoms. They differ from each other only in the spatial orientation of groups in the molecule.

Enantiomers

Enantiomers are chiral molecules that are mirror images of one another. Furthermore, the molecules are non-superimposable on one another. This means that the molecules cannot be placed on top of one another and give the same molecule. Chiral molecules with one or more stereocenters can be enantiomers. It is sometimes difficult to determine whether or not two molecules are enantiomers.

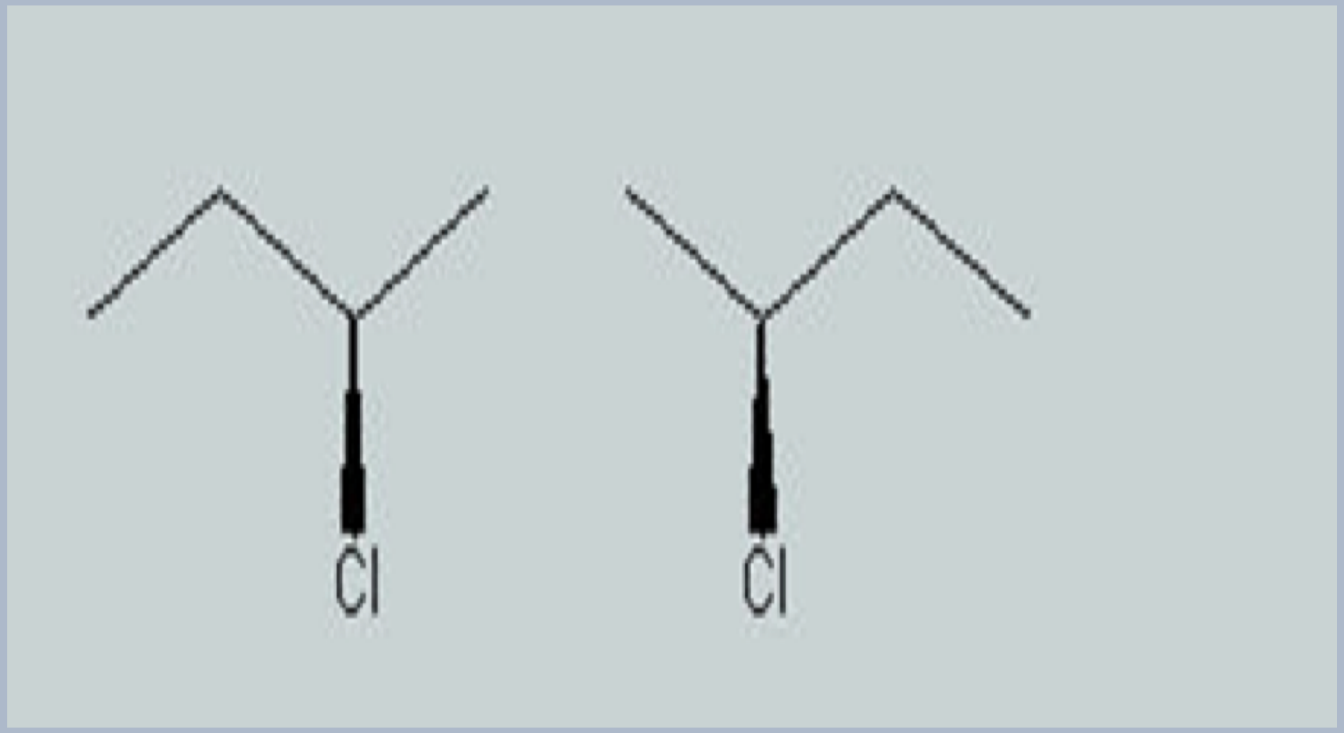
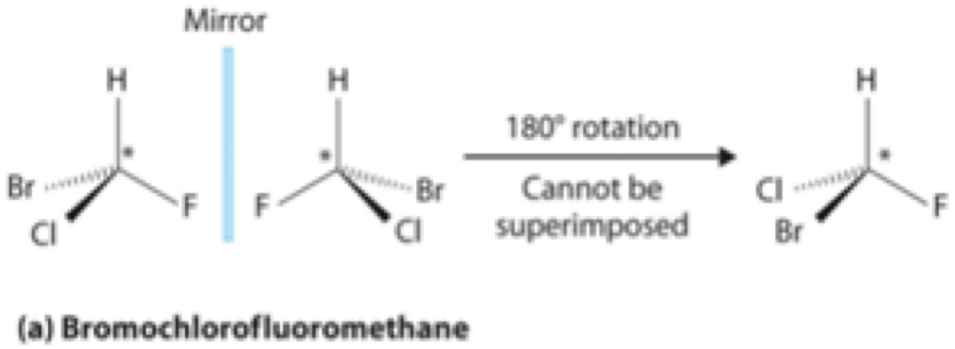
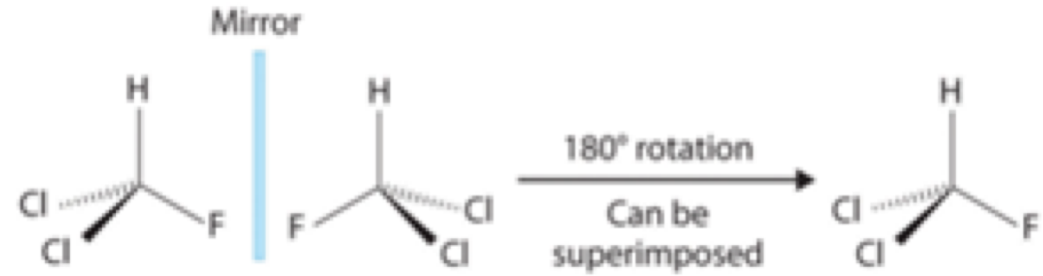


Figure 1: enantiomers



(a) Bromochlorofluoromethane



(b) Dichlorofluoromethane

Figure 2: Comparison of Chiral and Achiral Molecules. (a) is a chiral molecule whose stereocenter is designated with an asterisk. Rotation of its mirror image does Bromochlorofluoromethane not generate the original structure. To superimpose the mirror images, bonds must be broken and reformed. (b) In contrast, dichlorofluoromethane and its mirror image can be rotated so they are superimposable.

Diastereomers

- Diastereomers are stereoisomers with two or more organic compounds that have at least two stereocenters. These configurations are not mirror images of one another.
- A stereocenter is an atom (usually carbon) within a molecule that contains four different atoms or groups of atoms bonded to it.
- Diastereomers can have different physical properties and reactivity. They have different melting points and boiling points and different densities.

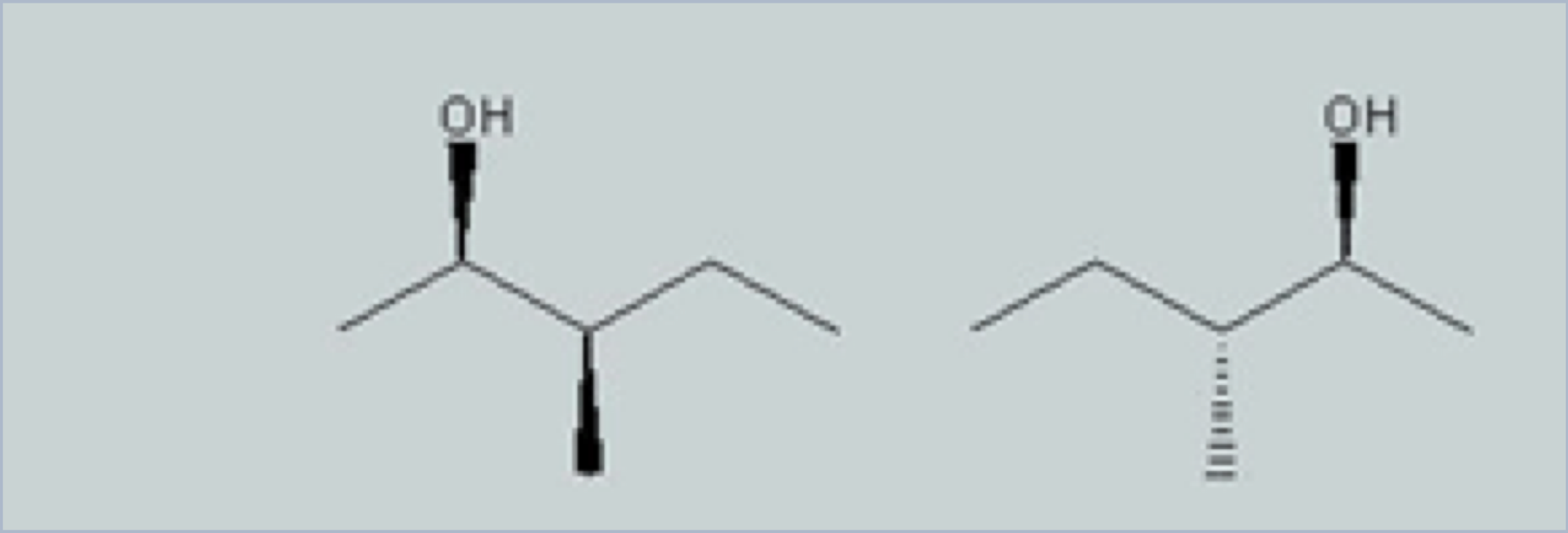


Figure 3: These molecules are not mirror images of one another. Additionally, these molecules are non-superimposable because if one of these molecules is flipped 180 degrees (so that the alcohols and methyls are aligned, as shown below), the stereochemistry is different at one carbon (the alcohols) and the same at another carbon (the methyls). Therefore, these molecules are diastereomers.

Geometric isomers

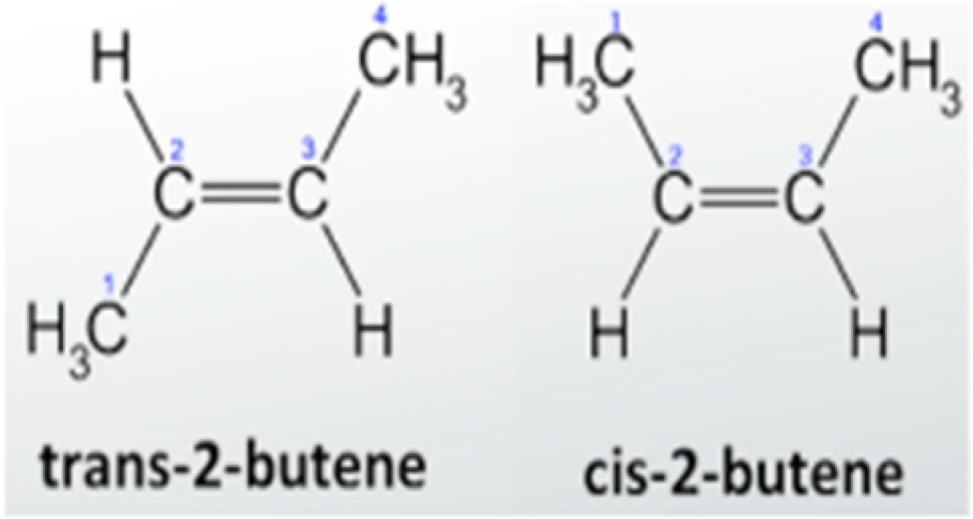


Figure 4: shows cis and trans structure.

Geometric isomers (also called cis/trans isomers) are a type of stereoisomer resulting from a double bond or a ring structure. The double bond or ring in the structure means that not all bonds are free to rotate, giving rise to geometric isomers whose shapes cannot interconvert.

Physical properties

Enantiomers are equal in all their physical properties except for their optical rotation, as they rotate the plane of polarized light by equal amounts in opposite directions. In contrast, diastereomers are characteristically different in their physical properties, such as melting and boiling points, densities, solubilities, heats of formation, and Gibbs free energies. If a molecule contains more than one chirality center and therefore consists of several pairs of enantiomers and diastereomers, the physical properties of each diastereomer must be noted.

Importance of stereoisomers

Stereochemistry may seem like a trivial subject because differences between stereoisomers are usually subtle. In nature, however, and most importantly, in biological systems such as the human body, these subtle differences have sweeping implications. Most drugs for example, are often composed of a single stereoisomer of a compound, and while one stereoisomer may have positive effects on the body, another stereoisomer may be toxic. Because of this, a great deal of work done by synthetic organic chemists today is in devising methods to synthesize compounds that are purely one stereoisomer.

Summary

Three types of stereoisomers:

- Enantiomers (mirror images of each other).
- Diastereomers (not mirror images of each other).
- Geometric (cis/trans)

The physical properties in enantiomers are the same however the differ in the rest.
Stereoisomers are very important in because you may mix up compounds where one could have negative effects on the body.

Reference

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QUESTIONS?