Chemistry 343  Summer 2002
Lecture 11 - Stereochemistry

Topics
Overview of types of isomers
Chiral/achiral definitions
Biological Implications of chirality
Using the R-S naming system
Compounds with more than one stereogenic center - diastereomers and meso forms,
Optical Activity

Demos/Props/Visuals
Large models of 2-chlorobutane

Announcements
This week's quiz will cover up through today's lecture topics.

Isomers

Constitutional Isomers  Stereoisomers

Enantiomers  Diastereomers
Stereoisomers that are non-superimposable mirror images.
Stereoisomers that are not mirror images.
Chem 343 Lecture

Stereochemistry

Introduction

A. Definitions

1) Stereochemistry - the branch of chemistry concerned with the 3-dimensional structure of molecules.

2) Symmetry - similarity of form or arrangement of parts about a center.

3) Chirality = "handedness"

   Molecule lacking internal plane of symmetry is termed chiral.

   Molecule possessing internal plane of symmetry is termed achiral.

4) Simplest case and most important source of chirality is the carbon with four different substituents - asymmetric center or stereogenic center.
B. Implications

1) Why spend much time studying stereochemistry and specifically chirocity?

Ans.

Ans. Small differences in stereochemistry can have profound implications with respect to the reaction chemistry of organic molecules, particularly in biological systems.

2) Examples.

a. Chemistry of smell

(+) - carvone = smell of caraway

(-) - carvone = smell of spearmint

b. Chemistry of taste

(duo! glucose?) need example (duo! tyrosine) d = sweet 1 = bitter.

c. Chemistry of drug activity.

(S) - Ibuprofen vs (R) - ibuprofen

active analgesicinactive
Biological Implications of Chirality

Sense of Smell

(5)-carvone (caraway)

(R)-carvone (spearmint)

Sense of Taste — Aspartame = Nutrasweet

\[
\begin{align*}
&\text{(S)} \quad \text{H} & \quad \text{O} \\
&\text{H}_2\text{N} - \text{C} - \text{C} - \text{N} - \text{C} - \text{C} - \text{O} - \text{CH}_3 \\
&\text{CH}_2 & \quad \text{H} & \quad \text{CH}_2 \\
&\text{CO}_2\text{H} & \quad \text{PH}
\end{align*}
\]

S,S isomer is 160 times sweeter than sugar, other isomers non-sweet or bitter.

Sense of Pain — Ibuprophen

S-isomer — analgesic (anti-inflammatory agent)
R-isomer — inactive.
II. Recognizing stereogenic centers and chiral molecules. - Assigning specification of configuration and nomenclature.

A. Cahn - Ingold - Prelog Sequence Rules

1. Assign priorities to atoms bonded directly to stereogenic center according to decreasing atomic number.

2. If more than one atom of the same atomic number is bonded to the stereogenic carbon, assign priority based on atomic numbers of atoms bonded to those attached to the stereogenic center until a difference in priority can be assigned.

3. Multiple-bonded atoms are considered the same as an equal number of singly-bonded atoms.

B. Assigning R (rectus) or S (sinister) configuration based on right hand/ left hand rule.
Example: specify the absolute configuration of (R)-2-chlorobutane. Using

\[
\begin{align*}
\text{H} & \quad \text{CH}_3 \\
\text{H}_3C & \quad \text{H}_2\text{C} \quad \text{CH}_3 \\
\text{C} & \quad \text{Cl}
\end{align*}
\]

Compounds with more than one stereogenic center.

III. Diastereomers - stereoisomers which are nonsuperimposable non-mirror image isomers.

Example: 2,3-dihydroxybutanoic acid

\[
\begin{align*}
\text{CO}_2\text{H} & \quad \text{HO}_2\text{C} \\
\text{H} & \quad \text{C} \quad \text{OH} \quad \text{HO}_2\text{C} \quad \text{CH}_3 \\
\text{H} & \quad \text{C} \quad \text{OH} \quad \text{HO}_2\text{C} \quad \text{CH}_3 \\
\text{H} & \quad \text{C} \quad \text{OH} \quad \text{HO}_2\text{C} \quad \text{CH}_3 \\
\text{CH}_3 & \quad \text{CH}_3 \\
2R, 3S & \quad 2S, 3S \\
2R, 3S & \quad 2S, 3S
\end{align*}
\]

Diastereomers - stereoisomers that are not mirror images of each other.
Example: tartaric acid

\[
\begin{align*}
\text{CO}_2\text{H} & \quad \text{HO}_2\text{C} \\
\text{H} & \quad \text{C} \quad \text{O} \quad \text{H} \quad \text{H} & \quad \text{C} \quad \text{O} \quad \text{H} \quad \text{H} & \quad \text{C} \quad \text{O} \quad \text{H} \quad \text{H} & \quad \text{C} \quad \text{O} \quad \text{H} \\
\text{H} & \quad \text{O} \quad \text{C} \quad \text{H} & \quad \text{H} & \quad \text{C} \quad \text{O} \quad \text{H} & \quad \text{H} & \quad \text{O} \quad \text{C} \quad \text{H} & \quad \text{H} & \quad \text{O} \quad \text{C} \quad \text{H} \\
\text{CO}_2\text{H} & \quad \text{HO}_2\text{C} \\
\end{align*}
\]

\[2R,3R \quad 2S,3S \quad 2S,3R \quad 2R,3S \]

Meso compound - compound which has stereogenic centers, but is achiral (i.e. contains internal plane of symmetry).

B. Compounds with more than two stereogenic centers.

Maximum \( \# \) of stereoisomers = \( 2^n \)

where \( n = \# \) of stereogenic centers.

\[\text{Review of Isomerism}\]

\[\text{Use diagram on pp. 18-20}\]