Stereochemistry

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Concepts of Molecular Structure

Definition of Constitutional Isomer

Constitutional isomers are compounds that have the same molecular formula but different structural formulae.

Definition of Stereoisomerism

Stereoisomerism deals with molecules that have the same order of attachment of the atoms, but different arrangements of the atoms in space.

Definition of Conformer

Any simple molecule which can have an infinite number of shapes as a consequence of rotating one carbon atom (and its attached hydrogens) with respect to the other carbon atom is called a conformer.

Distinctions between constitutional isomers, stereoisomers, and conformers

For the molecule C_2H_2O, there are two very different chemical substnaces known. One of these substances is a colourless liquid that boils at 78.5^oC, whereas the other is a colourless gas at ordinary temperatures ($bp - 23.6^oC$). The only possible explanation is that the atoms must be arranged differently in the molecules of each substance and that these arrangements are somehow responsible for the fact that one substances is a liquid and the other, a gas.

For the molecular formula C_2H_2O, there are two and only structural formulas posssible that satisfy the valence requirement of 4 for carbon, 2 for oxygen and 1 for hydrogen. They are *ethanol* and *methoxymethane*. In one formula, the two carbons are connected to one another by a single covalent bond; in the other formula, each carbon is connected to the oxygen. When we complete the valences by adding hydrogens, each arrangment requires six hydrogens. **Cis-trans isomerism** (sometimes called **geometric isomerism**) is one kind of stereoisomerism, and it is most easily understood with a specific case. Consider the possible structure of 1,2-dimethylcyclopentane. For simplicity, neglect the slight puckering of the ring and draw it as if it were planar. The two methyl groups may be on the same side of the ring plane or they may be on opposite sides. The methyl groups are said to be **cis**, on the same side as each other or, **trans**, across from each other. **Cis-trans differ from one another only in the way the atoms or groups are positioned in space**. Yet the difference is sufficient to give them different physical and chemical properties. **Cis-trans isomers are separate and unique compounds. Unlike conformers, they cannot be interconverted by rotation around carbon-carbon bonds.** Examples of structural isomers are ethanol and methoxymethane. Examples of stereoisomers are the staggered and eclipsed forms of ethane or the *cis* and *trans* isomers of 1,2-dimethylcyclopentane.

If compounds are stereoisomers, a further distinction can be made as to isomer type. If *bond rotation* easily interconverts the two stereoisomers (as with staggered and eclipsed ethane), we call them **conformers**. If the stereoisomers can be interconverted only be breaking and remaking bonds we call them **configurational isomers**.

Structural featues leading to stereoisomerim

Steroisomers *have the same atom connectivities, or order of attachment of the atoms, but different arrangements of the atoms in space.* Stereoisomers may be characterised according to the ease with which they can interconverted. That is, they may be **conformers**, which can be interconverted by rotation about a single, or they may be **configurational isomers**, which can be interconverted only by breaking and remaking covalent bonds.

Here, some consideration will be given to other useful ways of categorising stereoisomers.

Chirality and Enantiomers

Consider a pair of gloves and a pair of socks. A sock can be worn on either foot. A glove can only be worn on one hand. Like a pair of gloves, certain molecules possess this property of "handedness", which affects their chemical behaviour.

A molecule is either **chiral** or **achiral**.

A chiral molecule is one that exhibits the

property of handedness. An achiral molecule does not have this property.

A pair of molecules that are related as nonsuperimposable mirror images are called enamtiomers.

What is it about their structures that leads to chirality in 2-chlorobutane but not in 2-chloropropane? Notice that, in 2-chlorobutane, one carbon atom has four different groups attached to it (Cl, HCH_3 and CH_3CH_2. A carbon atom with four different groups attached to it is called a **stereogenic carbon atom**.

Let us examine the more general case of a carbon atom with any four different groups attached; let us call the groups A, B, C, D and E. The handedness of these molecules is apparent and they under clockwise or counterclockwise arrangement of the groups.

What happens when all four of the groups attached to the central carbon atom are *not* different from one another? Suppose two of the groups are identical-say, A, A, B and D.

endo

Conformational analysis

Acyclic systems. Cyclic systems; Baeyer vs Pitzer strain in 4, 5 and 6-membered rings, chair and boat conformations, axial and equatorial substituents in 6-membered rings. Anomeric effect in carbohydrates. Condensed 6-membered rings.

Stereochemistry and reactivity

Stereoselective and stereospecific reactions. Diastereoselectivty: Control of stereochemistry in additions to carbonyl groups. Reactivity differences between diastereomers. Enantioselectivty: Use of chiral reagents, catalysts (including enzymes) and "chiral auxiliaries" to transform achiral molecules into chiral enantiomerically pure products.

If you detect any errors in these notes pls cont act me at pwalsht@maths.tcd.ie and I will try to amend them.

Notes after this point currently being drafted.