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# THE USE OF MOLECULAR MODELS IN ORGANIC CHEMISTRY

## PRELAB EXERCISE

Review the common functional groups in your class text.

You have seen a number of structures in two-dimensional representations on a chalkboard. In most instances, this description is sufficient. However, it is the three dimensionality of molecules that relates to their reactivity and physical properties. In this lab you will make some simple organic molecules with a molecular model set.

## STRUCTURAL ISOMERISM

Structural Isomerism results when two or more molecules have the same molecular formula but different atomic arrangements. There are not structural isomers of methane, ethane, or propane, because there is only one possible arrangement of the carbon and hydrogen atoms in each of these molecules. However, all alkanes with four or more carbon atoms have structural isomers. Consider the different atomic arrangements of the two molecules shown with the formula  $C_4H_{10}$ , shown in Figure I. In Figure I (a), the four carbon atoms are joined in an unbranched chain; in Figure I(b), the four carbon atoms are joined in a branched chain.

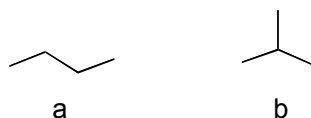


Figure 1

These two compounds are structural isomers. The isomer containing the unbranched carbon chain is called n-butane (normal butane), because the four carbon atoms are connected in a continuous, nonbranched carbon chain. The other isomer has only three carbon atoms in the longest continuous carbon chain. Its name is therefore based on propane, the 3-carbon alkane. The "2-methyl" prefix indicates the presence of a methyl group,  $CH_3$ , attached to the second carbon atom in the chain. This compound is also called isobutane, in order to distinguish it from n-butane. -

You should understand that n-butane and 2-methylpropane (isobutane) are distinctly different compounds. Although they have the same molecular formula and, therefore the same molar mass, their different structures give them different properties. For example, n-butane boils at  $0.5^\circ C$ ; 2-methylpropane boils at  $-11.7^\circ C$

## PROCEDURE

Obtain a molecular model kit, containing a group of differently colored balls along with pegs and springs or flexible connectors, representing covalent bonds that are used to connect the balls. The pegs represent single bonds; springs, double bonds. The balls are color coded as follows:

Color	Atom
Yellow	Hydrogen
Black	Carbon
Red	Oxygen
Green	Chlorine

### PART I. HYDROCARBONS

1. Assemble a model of methane,  $\text{CH}_4$ . Draw the shape of methane and describe it. Are all the hydrogen atoms in equivalent positions?
2. The compound n-pentane is one of three structural isomers with the molecular formula  $\text{C}_5\text{H}_{12}$ . Assemble models of the other two isomers. Write their structural formulas and sketch each one.

### PART II. OTHER STRUCTURAL ISOMERS

The molecular formula  $\text{C}_4\text{H}_{10}\text{O}$  represents more than two chemical compounds, and, in fact, represents more than one functional group (ethers and alcohols). These isomers have the same numbers and kinds of atoms, but quite different properties due to the dissimilar atomic arrangements.

Assemble models of a few of these structural isomers. Then draw (using the bondline drawing method) their structural formulas. Make sure you get all seven.

### PART III. FUNCTIONAL GROUPS

Assemble models for the following molecular formulas and sketch their structure(s).

- a.  $\text{C}_2\text{H}_2$
- b.  $\text{CH}_3\text{NO}$  (nitrosomethane - connect the atoms as shown, and also formamide)
- c.  $\text{CH}_3\text{CO}_2\text{H}$  (a carboxylic acid)
- d.  $\text{CH}_3\text{OH}$
- e.  $\text{C}_2\text{H}_2\text{Cl}_2$  (this molecule has a carbon carbon double bond and 3 ways of distributing the chlorines)