Experiment 2 – Properties of Organic Compounds

Organic compounds are compounds based on carbon. They contain carbon and hydrogen, and can also contain other nonmetal elements such as oxygen, nitrogen, or halogen atoms. The properties of organic compounds are very different from the properties of inorganic compounds that you have been using up to this point. In this lab, you will explore some of the differences in the properties of organic vs. ionic substances.

Most organic compounds are nonpolar and thus do not mix with polar molecules like water. Therefore organic substances, in general, are insoluble in water. However, they are soluble in nonpolar solvents. Most ionic substances, on the other hand, are soluble in water and insoluble in nonpolar solvents.

Organic compounds can be gases, liquids, or solids at room temperature. Ionic compounds are all solids at room temperature with very high melting points. Organic compounds have relatively low melting points and boiling points. The reason for these differences lies in the type of attractive forces holding the particles next to each other in each case. Ionic compounds consist of a vast array of alternating positive and negatively charged ions. Ionic substances are held together by very strong electrostatic forces and there are no individual molecules present. In order to melt an ionic compound, the ions must be able to move around each other, so a huge amount of energy is needed to break these strong electrostatic forces and thus ionic compounds have very high melting points. Organic compounds, on the other hand, consist of individual molecules held together by covalent bonds. The attractive forces between molecules consist of relatively weak London dispersion forces. Since the attractive forces between molecules are weak, it doesn't take much energy to disrupt them and thus organic molecules have low melting and boiling points.

Organic compounds burn in the presence of oxygen to form carbon dioxide and water. This process is called **combustion** and it is the process that happens when gasoline is burned in a car's engine or when natural gas (which is mostly methane) burns in a stove or a heater. Combustion reactions, in general, give off a lot of heat – they are exothermic. Shown below are the equations for combustion of methane and octane:

$$CH_{4\,(g)} + 2\,O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2\,H_2O_{\,(g)} + \text{heat}$$

$$2\,C_8H_{18\,(l)} + 25\,O_{2\,(g)} \rightarrow 16\,CO_{2\,(g)} + 18\,H_2O_{\,(g)} + \text{heat}$$

Ionic compounds, in general, do not burn in oxygen.

Safety Precautions:

- Organic compounds are extremely flammable. Do not use Bunsen burners in the organic chemistry laboratory.
- Keep the organic solvents (hexane and toluene) under the fume hood.
- Wear your safety goggles.

Waste Disposal:

- Any waste that contains hexane or toluene (or any other organic solvents) must be placed in the **organic** waste containers (which have a **pink** label) in one of the fume hoods.

Procedure

Part 1: Physical Properties

1. If a display of the compounds to be used is available, observe the samples in a test tube rack in the fume hood. If a display is not available, get out your test tube rack and 6 test tubes. Place a small amount of each of the following substances in its own test tube: NaCl, KI, benzoic acid ($C_7H_6O_2$), hexane (C_6H_{14}), toluene (C_7H_8), and water.
2. Record the formula, the physical state (gas, liquid, or solid), and odor of each sample on the report sheet. To test for odor, take a breath and hold it while you fan the air above the open test tube toward you. Get a chemistry handbook or chemical catalog, look up the melting point of each substance, and record it on the laboratory report. On the report form, state the type of bonds in each substance (ionic or covalent) and classify each substance as organic or inorganic.

Part 2: Solubility

3. Make sure to work in the hood. You will need five clean, dry test tubes and a test tube rack. In the first test tube, place 10 drops of hexane and 10 drops of deionized water. Shake the test tube to mix the two substances. Determine which liquid is in the upper layer and which is in the lower layer by adding a little more water to see which layer increases in volume. Record your observations. Dispose of the mixture in the organic waste container (with a pink label).
4. Place a small amount (a few crystals) of NaCl in a clean, dry test tube. Place about 10 drops of toluene in a different clean, dry test tube. Add about 15 drops of hexane to each tube, and shake each of the tubes to mix the contents. Record whether each substance is soluble or insoluble in hexane. Discard in the organic waste container.
5. Place a small amount (a few crystals) of NaCl in a clean, dry test tube. Place about 10 drops of toluene in a different clean, dry test tube. Add about 15 drops of water to each tube, and shake each of the tubes to mix the contents. Record whether each substance is soluble or insoluble in water. Discard the toluene mixture in the organic waste container, and the NaCl/water mixture in the inorganic waste container.
6. Based on the solubility of NaCl and toluene in each of the solvents, identify them as either organic or inorganic.

Part 3: Combustion

7. Set up a ring stand with an iron ring in one of the fume hoods. Place a porcelain evaporating dish from your locker on the iron ring, and put a pea-sized amount of NaCl in the evaporating dish. Light a wooden splint with a match, and hold the flame of the burning splint to the crystals. Record whether the NaCl melts, changes color, or burns.
8. Repeat the above procedure using 5 drops of hexane instead of NaCl. If the substance burns, record the color of the flame.
9. From the combustion data, identify each compound as either organic or inorganic.

Questions

1. Describe three experimental tests that you could use to distinguish between organic and inorganic compounds. Describe the expected results of each test for an organic compound and for an inorganic compound.
2. A white solid is flammable and dissolves in hexane. Would you expect this compound to be organic or inorganic? Explain.
3. A clear liquid, when mixed with water, forms a layer on top of the water. Is this liquid organic or inorganic? Explain.