Laboratory 2: Chemical Reactions

Topics Covered

- Periodic Table
- Atomic weights of elements
- Calculating molecular weights using the atomic weights of the elements
- Chemical reactions

Equipment Needed (per pair or group)

- A Periodic Table
- Two 500 mL Erlenmeyer flasks with stoppers
- One 1000 mL Erlenmeyer flask with stopper
- Two beakers
- Glass stirring rods
- Weighing scale (readable to 0.01 g)

Reagents Needed (per pair or group)

- Calcium chloride
- Sodium carbonate

Background Information -- Molecular Weight

The weight of a molecule is the sum of the weights of the atoms in the molecule. If we know the formula of the molecule, we can calculate the molecular weight.

For example, one of the products used in the manufacturing of biodiesel is ethanol. The formula for ethanol is C_2H_6O. We can calculate its molecular weight by looking up the individual atom weights. The atomic weight for C (carbon) is 12.011, H (hydrogen) is 1.008, and O (oxygen) is 15.999. From the formula we see that ethanol has 2 carbons, 6 hydrogens, and a single oxygen atom. Adding these up, we get 46.069 for the molecular weight of ethanol as shown in the following table.

ATOM	NUMBER	ATOMIC WEIGHT Of the ATOM	TOTAL WEIGHT
Carbon	2	12.011	24.022
Hydrogen	6	1.008	6.048
Oxygen	1	15.999	15.999
			46.069

Background Information -- Chemical Reactions

A chemical reaction is when different chemicals come in contact with each other and a change takes place involving the disappearance of a substance and the appearance of a new substance. Accompanying this is a change in the chemical energy of the substances. This change can be either an increase, where heat is absorbed (an endothermic reaction), or a decrease, when heat is released, or transferred to the surroundings (an exothermic reaction).

Another component of chemical reactions is how long it takes: the reaction time. Combustion, for example, is a fast reaction, whereas the reaction between alcohol and vegetable oil in making biodiesel is slower. The following four factors control reaction speed:

1. The nature of the reacting substance. Reactions between ions generally occur almost instantaneously, for example in a solution, as fast as they can collide with each other.
2. The concentration of the reacting material. Increasing the concentration increases the speed of the reaction. If the reacting material is a gas, increasing the pressure will speed-up the reaction. If dealing with solids, increasing the degree of subdivision, exposing more surface, also increases the reaction speed.
3. The temperature. The higher the temperature, the faster the reaction.
4. The presence of a catalyst.

These four factors are major considerations in making biodiesel, and the industry has developed techniques to speed up the reaction.

Knowing the molecular weight of substances will allow us to combine just the right amount to produce the desired reaction, with nothing left over.

In this laboratory exercise we are going to dissolve calculated quantities of two substances separately into water, forming ions. When we mix these two solutions, the ions will react very rapidly making a product not soluble in water, and thus dropping out of the action zone. By the use of their molecular weights, we can determine the amount of the two substances we need, with nothing left over to form the non-soluble product.

To show the results clearly and aid in the mixing, we have selected two compounds that will dissolve in water, and when mixed will form a third compound that is not soluble in water and will precipitate out. The compounds are calcium chloride ($CaCl_2$) and sodium carbonate (Na_2CO_3). When mixed together, they will form calcium carbonate ($CaCO_3$), which is not soluble and will precipitate out.

$$CaCl_2 + Na_2CO_3 \longrightarrow CaCO_3\downarrow + 2\,NaCl$$

We see that one calcium chloride molecule combines with one sodium carbonate molecule to form one calcium carbonate molecule. The table salt (NaCl) formed will stay in solution and is of no concern to us in this lab.

Therefore we will weigh out one gram-molecular weight of each for mixing. If we have mixed the correct amount needed, there will be no calcium chloride or sodium carbonate left in the solution. We can show this by pouring off 2 samples of the solution and adding more calcium chloride to one and more sodium carbonate to the other. If no precipitate appears in either sample, there was no excess. The actual number of atoms and molecules matched the calculated amounts needed to form the calcium carbonate.

Pre-Lab Exercises

- Calculate the molecular weight of methanol (CH_3OH), a common alcohol used in biodiesel production.
- Calculate the molecular weight of potassium hydroxide (KOH), a common catalyst used in biodiesel production.

Laboratory Procedure

1. Take the 2 smaller, 250 mL flasks and fill each with about 200 ml of distilled water.
2. Label one $CaCl_2$ and the other Na_2CO_3 and put them aside.
3. Using the periodic table, calculate the molecular weights of the two compounds.
4. Weigh out an amount in grams numerically equal to one-tenth the molecular weight of each compound (to the nearest 0.01 g). (For example, if the molecular weight of a particular compound is 50.00, you would weigh out 5.00 grams).
5. Pour the calcium chloride into the flask with the $CaCl_2$ label. Insert a rubber stopper and shake until the $CaCl_2$ has dissolved.
6. Pour the Na_2CO_3 into the flask with the Na_2CO_3 label. Insert the stopper and shake until the Na_2CO_3 has dissolved.
7. Now pour these two mixtures into the larger flask, insert the stopper, and shake until thoroughly mixed. Observe the precipitate formed, and watch it fall to the bottom.
8. When the upper liquid is clear and free of any precipitate, pour about 50 ml each into two clean beakers. Add a few grams of calcium chloride to one beaker and a few grams of sodium carbonate to the other. Stir until they have dissolved.
9. Was any precipitate formed in the beakers? Why or why not?
10. Was there any cloudiness in one of the beakers? Explain.