***Experiment 5***

***Physical and Chemical Properties of Alkanes and Alkenes***

***OBJECTIVES***

The objectives of this experiment are: (a) to test the solubility of alkanes and alkenes in water and in benzene, (b) to test the reactivity of alkanes and alkenes with bromine, and (c) to use UV-light to speed up the slow reactions.

***INTRODUCTION***

Open chain alk**a**nes are saturated hydrocarbons having a general formula of (CnH2n+2). Examples of alk**a**nes are: meth**a**ne (CH4), eth**a**ne (C2H6), prop**a**ne (C3H8), hex**a**ne (C6H14), and oct**a**ne (C8H18). Open chain alk**e**nes are unsaturated hydrocarbons having a general formula of (CnH2n), such as *1-*hex**e**ne.

 

*Hex****a****ne 1-*Hex**e**ne

Alkanes and alkenes are also existing in cyclic structures such as cyclohex**a**ne and cyclohex**e**ne (see question 4 on page 5).

Alkanes and Alkenes are both non-polar substances, therefore they are not expected to dissolve or mix with water. Thus if hexane is added to water, it forms a separate layer on the surface of water, since its density is less than that of water. On the other hand, organic liquids are soluble in each other, as you will experience in the solubility test below.

Alk**a**nes react with molecular halogens (F2, Cl2, Br2, and I2) to form alkyl halides. This reaction is known in organic chemistry as **halogenation**. The reaction requires heat or ultraviolet light to take place. The mechanism of the reaction is known as a **substitution mechanism**, where a halogen atom replaces one of the hydrogen atoms in the hydrocarbon. An example of this reaction is halogenation of methane:

CH4 + Cl2  CH3Cl + HCl

A number of halogen-containing products are important materials in daily life. For example, dichlodifluoromethane, commercially known as Freon or CFCs, is used in refrigeration and air-conditioning equipment. Tetrachloromethane, known as carbon tetrachloride, is used as a solvent in dry cleaning.

Alk**e**nes also react with halogens and form halogenated hydrocarbons. The mechanism in this case is known as an **addition mechanism**. Addition mechanisms do not require light or heat; therefore, they are faster than substitution mechanisms. An addition mechanism involves breaking the double bond between the carbon atoms in the alkene, followed by the addition of a halogen atom to each carbon as illustrated by the equation below.



EXPERIMENTAL PROCEDURE

***1. Solubility of Organic Compounds in Water and in Benzene:***

Obtain **eight** large test tubes and divide them into two sets (four test tubes in each, mark the test tubes 1-4 in both groups). Add about 2.0 mL of distilled water to each test tube of the first set and about 2.0 mL benzene to each test tube of the second set. *(Note: you might be able to use a plastic dropper to measure roughly 2.0 mL solvent as 20 drops is equivalent to 1.0 mL).* Add 20 drops of only one of the hydrocarbons listed in Table 1 below to each test tube of the first set. Tap on the test tube to mix the liquids, and determine if the hydrocarbon is soluble in water or not. *(Note: formation of two distinct layers in the test tube indicates that the two liquids are insoluble or immiscible).* Repeat the procedure using the second set of test tubes to test for solubility in benzene. Record the results in the table below.

**Table 1. Solubility in Water and in Benzene\* *(0.25pnt each)***

|  |  |  |  |
| --- | --- | --- | --- |
| Hydrocarbon | Alkane or Alkene | Solubility in water | Solubility in Benzene |
| *n-*hex**a**ne | ***Alkane*** | ***No*** | ***Yes*** |
| cyclohex**a**ne | ***Alkane*** | ***No*** | ***Yes*** |
| *1-*hex**e**ne | ***Alkene*** | ***No*** | ***Yes*** |
| *n-*oct**a**ne | ***Alkane*** | ***No*** | ***Yes*** |

*\* Note: Do not discard in the sink. Ask your instructor for organic disposal bottle*

***2. Reactions with Bromine:***

Obtain four large test tubes; mark them 1-4. Place about 2.0 mL of each hydrocarbon listed in Table 2 in one of the test tubes. Add few (1-2) drops of 2% bromine solution, dissolved in dichloromethane, to each of the test tubes. Record your observation. *(Hint: bromine solution is brown in color, but when it reacts, its color disappears)*. If any of the samples do not react (the brown color of bromine persists in the test tube), place the test tube containing that mixture under sunlight or next to a sunny window, or under a UV lamp, for few minutes and observe the result. For the samples that react, estimate the time it takes for the brown color to disappear after the addition of the bromine solution to the test tube.

**Table 2. Reaction with Bromine *(0.25pnt each)***

|  |  |  |  |
| --- | --- | --- | --- |
| Hydrocarbon | Immediate Result (reaction or no reaction) | In Sunlight (positive/negative) | Time |
| *n-*hex**a**ne | ***No reaction*** | ***Positive*** | ***Sec*** |
| cyclohex**a**ne | ***No reaction*** | ***Positive*** | ***Sec*** |
| *1-*hex**e**ne | ***Reaction*** | ***-*** | ***-*** |
| *n-*oct**a**ne | ***No reaction*** | ***Positive*** | ***Sec*** |

*Question1: Write chemical equations for the reactions that occurred in experiment 2.*

*(Hint: refer to the equations on page 2).*  ***(2.5pnt)***

*Question 2: Draw structural formulas for:* ***(1pnt each)***

1. *Methane B. Propane*
2. *Butane D. Pentane*

*E. C7H16 F. Cyclohex****a****ne*

1. *Cyclohexene H. n-Octane*

*I. Benzene*

*Question 3: (a) Which of the compounds in Question 2 is the gas used in a chemistry laboratory. (b) Which compound is the cooking gas?*

***Methane and Propane (1pnt)***

*Question 4: Complete the following equations:*  ***(1pnt each)***



Cyclohex**a**ne



Cyclohex**e**ne