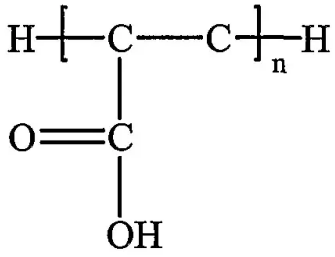
Name: _____ **Date:** _____

AP CHEMISTRY LAB: VISCOSITY OF POLYACRYLIC ACID AS A FUNCTION OF pH

Introduction

Acrylic acid is a weak, monoprotic acid that acts as the monomer unit for a common polymer, polyacrylic acid (HPA). Polyacrylic acid is used in products such as diaper gel because it is hydrophilic. The structure of PAA is given below, where "n" is the number of repeating units of acrylic acid.



In HPA, intermolecular forces between carboxyl units interact to form a coiled, compact structure.

In water, each carboxyl group in the polymer ionizes to produce polyacrylate anions (PA^{1-}). As the number of polyacrylate anions increases, repulsive forces between the anions increase leading to a less compact structure and a "straightening" of the polymer chain. The equilibrium of the reaction can be modified by altering the pH of the solution with strong acid (hydrochloric acid) or strong base (sodium hydroxide). The equilibrium of the reaction can be monitored by measuring the viscosity of the polymer solution at different pH values.

Objectives

1. Determine the types and relative strengths of intermolecular forces associated with functional groups within a polymer.
2. Perform an experiment to determine the viscosity of a weak acid polymer at different pH values and graph the data
3. Relate changes in pH to changes in the equilibrium of a reaction in terms of LeChatelier's principle.
4. Explain changes in polymer structure in terms of changes in types and strengths of IMFs.

Pre-Lab Questions

1. Write the equation for the ionization of polyacrylic acid (use the formula HPA) and the expression for K_a. (pKa of HPA is 4.2).

2. Determine the K_a for HPA

3. Describe the relative concentrations of polyacrylic acid [HPA] and its conjugate base [PA^{1-}]:
    a. At a pH below the pK_a

    b. At a pH = pK_a

    c. When the pH is greater than pK_a but less than the pH at the equivalence point

4. What effect will adding acid have on the equilibrium of the reaction?

5. What effect will adding base have on the equilibrium of the reaction if the equivalence point has not been reached?

6. If KOH is being used to titrate a sample of polyacrylic acid, what ions will be present in excess after the equivalence point is reached?

Materials

- pH meter (Ex: Vernier Accuquest probe system)
- Wash bottle filled with distilled water
- 0.01M polyacrylic acid solution
- 0.10 M sodium hydroxide solution
- 0.10 M hydrochloric acid solution
- Magnetic stirrer and stirrer bar
- U-tube viscometer
- 100 mL beaker-2
- Suction bulb
- Pipets
- Stopwatch

Procedure

1. Set up the viscometer as demonstrated by the instructor. The instructor will demonstrate how to use the viscometer to determine the efflux time of a solution.
2. Use the viscometer to measure the efflux time of distilled water. Record your data in the data table. Repeat for a second trial.
3. Connect the pH electrode to the Accuquest system and power on the system

4. Obtain approximately 50 mL of 0.01 M polyacrylic acid (PAA) solution in a 100 mL beaker containing a magnetic stirrer bar. Place the beaker on a magnetic stirrer
5. Remove the electrode from its container and place it in the PAA solution.
6. Add 0.10 M HCl solution, dropwise using a pipet to the PAA solution, with stirring until the pH measures 2.0 +/- 0.1.
7. Pour the PAA solution from step 4 into the viscometer and measure its efflux time to the nearest 0.1 second. Record the time in the data table. Repeat for a second trial.
8. Discard the PAA solution into the waste container supplied by the instructor.
9. Repeat steps 4-8 adjusting the pH of the PAA solution with 0.1 M HCl or 0.10 M NaOH to the pH's given in the data table.

Data Table

SOLUTION	EFFLUX TIME TRIAL 1	EFFLUX TIME TRIAL 2	EFFLUX TIME AVERAGE	RELATIVE VISCOSITY
DISTILLED WATER				
PAA pH 2				
PAA pH 4				
PAA pH 6				
PAA pH 8				
PAA pH 10				
PAA pH 12				

Analysis

1. Average the two trials for the efflux times and record these in the data table in the column "EFFLUX TIME AVERAGE"
2. Calculate the relative viscosities by dividing the average efflux times by the efflux time for distilled water. Record these in the data table.
3. Graph viscosity vs pH on the grid below:

Conclusions

1. Look up the electronegativity values of hydrogen, carbon and oxygen. In a carboxyl group is there more likely to be a polar bond between the carbon and the double bonded oxygen or between the oxygen and the hydrogen.

2. Polyacrylic acid usually has a compact, coiled structure due to interactions between adjacent carboxyl groups. Explain this based on your answer to the previous question.

3. As polyacrylic acid ionizes, what happens to the interactions between the adjacent carboxyl groups? What happens to the shape of a polaycrylic acid polymer chain as a result?

4. The graph should show three distinct parts. Explain what is happening in each part of the graph in terms of the relationship between the equilibrium of the ionization of HPA, the attractions between adjacent carboxyl groups in a polaycrylic acid chain and any ions that are in the resulting solution.