Kinetics of the Hydrolysis of Ethyl Acetate
by Sodium Hydroxide by a Conductivity Method

Objective

To determine the second order rate constant for the hydrolysis of ethyl acetate by sodium hydroxide using conductivity method.

Apparatus

10-mL graduated pipette
20-mL pipette
50-mL volumetric flask
100-mL conical flask
100-mL beaker (2)
200-mL beaker
conductometer
water bath (25 ^{o}C)
buret
stopwatch
thermometer

Chemicals

0.05 *M* NaOH (80 mL)
0.2 *M* ethyl acetate (15 mL)
0.1 M acetic acid (15 mL)

Introduction

The hydrolysis of an ester by an alkali is an example of a second order reaction in which the rate is directly proportional to the concentration of both reactants. If the initial concentration, a_O, of both the reactants are equal, and x being the number of moles of reactant per liter that have reacted at time t, then the rate law can be written as

$$\frac{dx}{dt} = k(a_o - x)^2 \tag{1}$$

where k is the rate constant of the reaction. Integrating equation (1) leads to

$$\frac{x}{a_o(a_o - x)} = kt \tag{2}$$

Consider the hydrolysis of ethyl acetate by dilute sodium hydroxide solution

$$CH_3COOC_2H_5 \ + \ OH^- \leftrightarrows \ CH_3COO^- \ + \ C_2H_5OH$$

The reaction can be studied by mixing equimolar quantities of sodium hydroxide and ethyl acetate that are at the same temperature. The reaction mixture is kept in a thermostat and a conductivity cell is dipped in it. During the hydrolysis, the conductivity of the reaction mixture will decrease with time due to the replacement of highly conducting hydroxyl ions by slow moving acetate ions. If κ_0 is the initial conductivity of the solution (sodium hydroxide), κ_t is the conductivity at time t, and κ_∞ is the conductivity after the reaction is complete, then x will be proportional to ($\kappa_0 - \kappa_t$) , and ($a_0 - x$) to ($\kappa_t - \kappa_\infty$). The second order reaction (2) can then be written as

$$\frac{\kappa_o - \kappa_t}{a_o(\kappa_t - \kappa_\infty)} = kt \qquad (3)$$

A plot of ($\kappa_0 - \kappa_t$)/($\kappa_t - \kappa_\infty$) versus t is a straight line with slope = ka_0 .

Procedure

1. Using a pipette, dilute the 0.05 *M* NaOH with deionized water to get 0.01 *M* in a 50-mL volumetric flask. Leave the flask in a thermostat bath (25 ^{o}C) until equilibrium temperature is reached. Measure the conductivity of this solution. This will be the initial conductivity κ_o .

2. Pipette 20.0 mL of 0.05 *M* NaOH and 50.0 mL of deionized water into a clean, dry 100 mL beaker. In another 100 mL beaker, pipette 5.0 mL of 0.2 *M* ethyl acetate and 25.0 mL deionized water. Place the beakers in a thermostat bath (25 ^{o}C) to equilibrate.

3. Mix the solutions in the beakers in a 200-ml beaker, start the stopwatch immediately. Place the conductivity cell in the mixture and use it to mix the solution well.

4. Take the conductivity readings at one-minute intervals for the first 15 minutes, and then every 2-5 minutes until a constant value of conductivity is obtained (about an hour). These readings will be the conductivities at given times κ_t of the reaction mixtures.

5. Stopper the beaker, label it and leave it aside overnight to measure κ_∞ (the final conductivity of the reaction mixture)

6. Plot a graph of ($\kappa_o - \kappa_t$)/($\kappa_t - \kappa_\infty$) versus time in minutes, and obtain rate constant k from the slope.

DATA SHEET

Temperature at which the experiment was conducted = ^{o}C

κ_o =

κ_∞ =

t (min)	κ_t ( )	$\dfrac{\kappa_o - \kappa_t}{\kappa_t - \kappa_\infty}$	t (min)	κ_t ( )	$\dfrac{\kappa_o - \kappa_t}{\kappa_t - \kappa_\infty}$
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Initial concentration, a_O, of the reactants =

Slope of plot of $(\kappa_o - \kappa_t)/(\kappa_t - \kappa_\infty)$ versus t =

Rate constant k =