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Kinetic Study of the Hydrolysis of Ethyl Acetate in Different Solvent Media

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A B S T R A C T

Hydrolysis of ethyl acetate is one of the most investigated reactions in physical chemistry, since it is seen as an ideal system for studying of reaction kinetics and generation of solvent effects and catalytic mechanisms. This paper studies kinetics of acid catalyzed hydrolysis of ethyacetate in various solvents including distilled water, water-methanol, water-ethanol and water-acetone mixtures. The main goal of the research is to assess the role of solvent polarity in the reaction rate, as well as obtain pseudo-first-order rate constants and activation energy by means of Arrhenius equation. The experiments in the laboratory have been conducted in controlled conditions, where excess water was used for conducting reaction in the way of pseudo-first order kinetics. Hydrochloric acid is selected as the catalyst. Observations of the conducted experiments were made throughout the process of interval sampling and titration with standard sodium hydroxide solutions. The data obtained was analyzed with the assistance of kinetic methods, Arrhenius plots, regression and statistical analysis. The experiments showed high dependency of rate of reaction in the environment of the solvent being used. The highest constant was found for distilled water due to its high value of dielectric constant and hydrogen bond formation ability. Adding organic solvents to the system resulted in slowing down the reaction rate significantly. The order of catalysts in terms of reaction speed is like this: Water > Water-Methanol > Water-Ethanol > Water-Acetone. Thus, the influence of solvent polarity on the transition state as well as kinetics of reaction can be confirmed by the results obtained.

Introduction

Chemical kinetics is a field of physical chemistry that examines chemical reaction rates and the elements that influence these rates. Chemical kinetics, in contrast to thermodynamics, explains not only if a particular reaction is possible but also how fast the reaction takes place and how reactants become products. Knowledge of reaction kinetics is necessary for the improvement of processes in the industry, design of chemical reactors, improvement of the formulation of medicines, and control of biochemical reactions. Reaction rates also allow predicting the stability of chemical substances during their storage and processing. Among many types of organic reactions, ester hydrolysis is one of the most well studied because it gives useful information about reaction mechanisms, transition-state formation, influences of solvents and catalytic processes. Ester hydrolysis is used as a model reaction in laboratory classes of both undergraduate and postgraduate students to study first-order kinetics and pseudo-first-order kinetics. Hydrolysis of esters is also important for industrial production, food technology, environmental chemistry, polymer degradation, and pharmaceutical synthesis.

Ethyl acetate is a simple aliphatic ester that is used as a solvent for paints, varnishes, inks, perfumes, adhesives, pharmaceutical agents, cosmetics, and food products. Ethyl acetate is widely used in kinetic studies, since it is easy to deal due to its simple chemical structure and predictable mechanism of the reaction. Ethyl acetate takes part in the hydrolysis reaction with water in the presence of s acid catalyst to form acetic acid and ethanol:

$$CH_3COOC_2H_5 + H_2O \rightleftharpoons CH_3COOH + C_2H_5OH$$

In acidic circumstances, the action of hydrochloric acid is that it protonates the carbonyl oxygen of ethyl acetate and as a result of that, the electrophilic characteristics of the carbonyl carbon are enhanced, allowing water molecules to successfully react and thus produce acetic acid and ethanol. Since acid catalysts are regenerated afterward, they are used over and over in hydrolysis procedures.

A considerable factor involved in the hydrolysis of esters is the solvent nature characteristics. The influence of solvents on reaction processes is due to the alterations in polarity, dielectric constant, viscosity, power of hydrogen bond formation, and solvation of substances. Water is characterized by high polarizability thanks to its high dielectric constant that allows stabilization of ionic intermediates and facilitates proton transfer reactions. The introduction of organic solvents such as methanol, ethanol, or acetone into the water system leads to decrease in polarity. This reduction in polarity results in higher activation energy for the reaction and, consequently, lower hydrolysis rate.

The study of the influence of solvent composition on reaction kinetics has garnered huge interest because the majority of industrial processes take place in mixed solvent systems.

Solvent engineering has become a useful tool for managing the speed of the reaction, selectivity, energy efficiency, and output of by-products. Thus, studying the hydrolysis of ethyl acetate in different solvents will lead to better understanding of the interactions between solvent and each reactant and establishment of the link between solvent properties and reaction mechanisms.

In the current research study, four solvent systems have been chosen for analysis:

•Distilled Water
•Water–Methanol Mixture
•Water–Ethanol Mixture
•Water–Acetone Mixture

Different dielectric constants and hydrogen-bonding capabilities together enable the systematic and comparative understanding of the effects of solvents. By providing high excess of water to ethyl acetate and running the hydrolysis reaction in pseudo-first-order reaction

conditions, water concentration can be treated as constant, drastically simplifying the analytical process of determining reaction kinetics, which is carried out by taking samples and completing their titration with sodium hydroxide.

The expectation is that the results will reveal that as the amount of organic solvent increases, hydrolysis reaction slows down; and water, because of its high polarity and excellent hydrogen-bonding capacity will be the fastest solvent in hydrolysis reactions, while mixtures of acetone will have the lowest reaction rates due to their low dielectric constant. The above conclusions are in line with the transition state theory and facilitate the understanding of the solvent effects. The significance of the research lies on its industrial application in chemistry, as well as in pharmaceutical production and reactions engineering. Understanding the reaction kinetics in solvents allows for optimizing industrial hydrolysis processes, improving reactor designs, and creating new synthesis methods.

Aim of the Study- The main objective of the research is to analyze the kinetics of acid-catalyzed hydrolysis of ethyl acetate in various solvent media and how solvent polarity affects the reaction rate. The study will determine the effect of variation in solvent composition on the rate constant, activation energy, and mechanism of the reaction. The study compares hydrolysis in pure water and mixed aqueous-organic solvents in order to have a better understanding of the role of solvent in the hydrolysis of esters in general and contribute to the field of chemical kinetics.

Scope of the Study-The purpose of the current paper is to provide kinetic studies of acid-catalyzed hydrolysis of ethyl acetate in different types of solvent systems in a laboratory setting. The experiments are limited to solvent systems comprised of water and aqueous-organic mixtures. The influence of solvent on the kinetics of the process and on the rate of reaction is taken into account.

In the research, rate constants will be calculated; behavior of different solvent mediums will be analyzed; kinetic and activation energy of the process will be computed; and effect of solvents will be studied using the transition state theory. The results of the experiments can have applications in pharmaceutical chemistry, chemical reaction engineering, and chemical industries.

Literature Review

A literature review is an indispensable part of every scientific investigation. The literature review gives the past status of research on the subject, shows the gap in knowledge, and indicates the importance of the present study. A lot of research has been done in the area of chemical kinetics focused on hydrolysis of esters in order to understand the mechanisms, effects of the catalyst, influence of solvents, and the thermodynamic properties of the process. Among all esters, ethyl acetate attracted the attention of researchers the most because of its easy structure, predictable course of reaction, and importance in the industry. The reactions of ethyl acetate hydrolysis have been taken as the model reaction for investigating pseudo-first-order kinetics, Arrhenius law, solvent influence, and transition state theory. The studies proved that reaction rates are influenced by solvent polarity, dielectric constant, catalyst concentration, and temperature. There are many studies on hydrolysis of esters in aqueous medium; however, the number of the works where hydrolysis in different mixed solvents was compared is much smaller. In the present research, the gap mentioned will be filled with the study hydrolysis of ethyl acetate in water, water-methanol, water-ethanol, and water-acetone solutions.

Historical Development of Chemical Kinetics- Chemical kinetics was first developed in the 1800s by various researchers. Chemists were mainly interested in the correlation between reactant concentrations and time changes as well as the role played by the conditions under which reactions took place. One of the most important steps which led to chemical kinetics becoming one of the modern disciplines was the formulation of the Arrhenius equation. It facilitated the transition to a quantitative study of kinetics in order to investigate how temperature influenced the speed of reaction.

Arrhenius (1889)-Svante Arrhenius proposed the famous Arrhenius equation, which relates the reaction rate constant to temperature through activation energy.

$$k = Ae^{-E_a/RT}$$

The author discovered that as temperature rises the reaction rate rises exponentially because of the increase of the number of molecules which get the right amount of energy to surpass activation energy. The Arrhenius equation is one of the key equations of chemical kinetics and is often applied in determining esters' hydrolysis. In this paper we are also applying the Arrhenius equation to find activation energy for hydrolysis.

Brønsted and Bjerrum-Ionic reactions that occur in various types of solvents have been tackled by Brønsted and Bjerrum in their work. They argued that this phenomenon lies in the influence of dielectric constant on the rates of the reactions taking place. They have shown that various polar solvents have different stabilization effect on the charged intermediates depending on their dielectric constant. Polar solvents take on the proton transfer process more efficiently than the non-polar ones. The studies conducted by Brønsted and Bjerrum have served as a theoretical basis for the understanding of the process of hydrolysis occurring more effectively in aqueous systems compared to mixtures of organic solvents with water.

Laidler (1987)-The research by Keith J. Laidler has significantly contributed towards the modern field of chemical kinetics. In his research, Laidler focused on the study of reaction mechanism and solvent effect, through which he came to certain conclusions. As per Laidler, solvent can affect reaction kinetics in multiple ways, such as follows:

•By altering dielectric character of the substance.
•By changing molecular diffusion.
•By stabilizing transition states.
•By changing hydrogen bonding.
•By changing activation energy.

From his study, he determined that in reactions involving polar transition states, there is a higher chance of reaction happening at faster rates in presence of highly polar solvents.

The findings made in the studies can be utilized to achieve the goals of this paper.

Atkins and de Paula-Peter Atkins and Julio de Paula explained ester hydrolysis as a well-known instance of nucleophilic acyl substitution. Their account of acid-catalyzed hydrolysis consists of the following steps:

- Protonation of the oxygen of the carbonyl compound
- Nucleophilic attack of water
- Creation of the tetrahedral intermediate
- Removal of ethanol from the reaction
- Recycling of the acid catalyst

The importance of the work done by Atkins and De Paula is that it helps understand why, if water is in a significant excess, the reaction is said to follow pseudo-first order kinetics.

Recent Investigations on Solvent Effects-A number of modern-day research studies have been conducted on how ester hydrolysis reactions are affected by the characteristics of the solvent. The outcomes of these studies show that with the rise in the concentration of organic solvent in mixtures, the speed of reaction decreases.

Some observations were made by researchers:

•The speed of hydrolysis reaction in water is maximum.
•The speed of hydrolysis reaction is lower in methanol when, compared to water.
•The speed of hydrolysis reaction is lower in ethanol than in methanol.
•Acetone produces the slowest reaction due to its low dielectric constant and lack of hydrogen bonding.

The above-mentioned points have been explained by the reduced stabilization of the transition state and increase in the activation energy in less polar solvent range.

Solvent Effects Reported in Previous Studies- Many researchers have indicated that the properties of the solvent play very important role in the process of ester hydrolysis. The most important solvent properties that influence the kinetics of the reaction are:

•Dielectric constant
•Solvent polarity
•Ability for hydrogen bonding
•The viscosity of the solvent
•Solvation energy
•Diffusion coefficient.

Water has the highest dielectric constant among the solvents used in this research. This is why the ionic transition states are the most stabilized by water.

On the contrary organic solvents reduce dielectric constant and as a result the rate of the reaction is lower.

Table 2.1 summarizes important studies relevant to the present

investigation.

Author	Year	Major Contribution	Relevance to Present Study
Arrhenius	1889	Temperature dependence of reaction rate	Activation energy determination
Brønsted & Bjerrum	1924	Solvent effects on ionic reactions	Solvent polarity explanation
Laidler	1987	Chemical kinetics and reaction mechanisms	Rate constant interpretation
Atkins & de Paula	Various editions	Acid-catalyzed ester hydrolysis	Reaction mechanism
Recent researchers	2015–2024	Mixed solvent effects	Comparison with present investigation

Research Gap- Although extensive research has been conducted on ester hydrolysis, a number of limitations exist. The majority of studies carried out:

•Are limited to evaluating only pure aqueous systems.
•Focus on only one solvent.
•Employ varying experimental conditions making comparisons difficult.
•Need to provide thorough statistical analysis.
•Do not systematically carry out a comparison of the water-ethanol, water-methanol, and water-acetone systems under identical experimental conditions.

Thus, there is a need for a comparative study where the different solvent systems are evaluated.

The current investigation is aimed at bridging this gap by using standardized procedures in conducting the experiments and carrying out the analysis of results.

Relevance of the Present Study

The current research builds upon past studies:

•Assesses four kinds of solvent media in same conditions.
•Computes pseudo-first-order reaction rate constants.
•Calculates activation energy through Arrhenius equation.
•Investigates systematically solvent polarity.
•Employs statistical methods for comparing different solvent systems.
•Connects experimental data and transition-state theory.

The findings may lead to more profound understanding of solvent-induced reaction kinetics with multiple applications in industrial and pharmaceutical settings.

Methodology

The present research methodology has been envisaged to elucidate the kinetics of acid-catalyzed hydrolysis of ethyl acetate in different solvent media in the laboratory environment. The laboratory experiment was planned in accordance to the predetermined levels of accuracy, reproducibility, and reliability, in particular, the chemical reagents were of analytical grade and the laboratory procedures were standardized. The process of reaction was carried out in distilled water, water–methanol, water–ethanol, and water–acetone systems at constant temperature. The changes of hydrolysis process were monitored by sampling the mixture and performing acid-base titration to analyze these samples. The experimental data obtained during the experiment were utilized in order to determine reaction rate constant, activation energy and the influence of the solvent polarity on the reaction kinetics.

The effectiveness of any kinetic experiment is greatly influenced by the quality and cleanliness of the chemicals used. Hence, all of the reagents used in this research had a quality of Analytical Reagent (AR) level, i.e. they were of very high grade. Fresh solutions were made before each experiment to minimize errors in the experiment and prevent contamination. The distilled water was taken for the study in order to avoid the possibilities of the dissolved impurities causing any trouble.

Chemicals Used

Chemical	Molecular Formula	Purity	Purpose
Ethyl Acetate	$C_4H_8O_2$	99.5%	Ester under investigation
Hydrochloric Acid	HCl	0.5 N	Acid catalyst
Sodium Hydroxide	NaOH	0.1 N	Standard titrant
Distilled Water	H_2O	Laboratory grade	Solvent
Methanol	CH_3OH	AR Grade	Mixed solvent
Ethanol	C_2H_5OH	AR Grade	Mixed solvent
Acetone	CH_3COCH_3	AR Grade	Mixed solvent
Phenolphthalein	$C_{20}H_{14}O_4$	Indicator	End-point detection

The reactant utilized for the study of hydrolysis kinetics was ethyl acetate. The catalytic agent, hydrochloric acid, was chosen as it facilitates hydrolysis without undergoing change itself. The sodium hydroxide solution was standardized and used in the titration of reaction samples to measure the acetic acid concentration produced in the course of hydrolysis. Methanol, ethanol, and acetone were selected as solvents due to their varied dielectric constants and hydrogen-bonding properties which enabled studies of their influence on reaction kinetics.

Instruments-Accurate measurements are essential in kinetic studies. The following instruments and laboratory apparatus were used during the investigation.

Table 2 Instruments Used

Instrument	Specification	Purpose
Thermostatic Water Bath	±0.1°C	Constant temperature
Burette	50 mL	Titration
Pipette	10 mL & 20 mL	Sampling
Conical Flask	250 mL	Reaction vessel
Volumetric Flask	100 & 250 mL	Solution preparation
Stopwatch	Digital	Time measurement
Thermometer	0–100°C	Temperature monitoring
pH Meter (Optional)	Digital	pH measurement
Analytical Balance	±0.001 g	Weighing chemicals

The benchtop water bath maintained an accurate temperature of 25 ± 0.1ºC, ensuring that temperature variations remained out of the way of the reaction. The volumetric glassware had been calibrated properly and the laboratory equipment was cleaned properly prior to the use to avoid contamination.

Experimental Procedure-The hydrolysis of ethyl acetate was conducted under pseudo-first-order reaction conditions in various solvent systems. The overall process has been standardized in terms of the fact that all the solvent systems were subjected to identical conditions of performing an experiment.

Preparation of Solvent Mixtures, Four solvent media were prepared:

•Distilled Water
•Water–Methanol (50:50 v/v)
•Water–Ethanol (50:50 v/v)
•Water–Acetone (50:50 v/v)

Measured volumes of each solvent were mixed using volumetric flasks to obtain homogeneous solutions.

Preparation of Reaction Mixture- The previously measured volume of hydrochloric acid was combined with chosen solvent. The combination of chemicals was allowed to stand for some time in the water thermostat at 25 °C. Ethyl acetate was then added very quickly, and the timing process was started immediately after the introduction of the solvent.

Sampling-Aliquots of the reaction mixture were withdrawn at regular intervals of 10 minutes using a clean pipette. Typical sampling times were:

•0 min
•10 min
•20 min
•30 min
•40 min
•50 min
•60 min

Quenching the Reaction-All samples taken from the tube were immediately immersed in ice-cold distilled water to stop all reactions. This enabled them to stop changing before testing.

Titration-Quenched samples were titrated with standardized NaOH

(0.1 N) in the presence of the phenolphthalein indicator. The endpoint of the titration was indicated by the appearance of a light pink pigment that stayed for about half a minute. The amount of sodium hydroxide used was carefully recorded for each sample.

Calculation of Concentration- Titration data were converted to obtain concentration figures of acetic acid that formed because of hydrolysis, and these concentrations have been utilized for finding the rate constant of the reaction:

$$CH_3COOC_2H_5 + H_2O \rightarrow CH_3COOH + C_2H_5OH$$

In the presence of hydrochloric acid:

$$CH_3COOC_2H_5 + H_2O + H^+ \rightarrow CH_3COOH + C_2H_5OH + H^+$$

The acid catalyst is regenerated at the end of the reaction and therefore does not undergo permanent chemical change.

Data Analysis-The results obtained from the titration experiment have been analyzed using standard rate equations. Since a large quantity of water was used during the experiment, we can judge that the process obeys pseudo-first-order kinetics due to the fact that the reaction can be treated as pseudo-first-order:

$$\ln\left(\frac{a}{a-x}\right) = kt$$

where:

•a = Initial concentration of ethyl acetate

•x = Amount hydrolyzed at time t

•t = Time (minutes)

•k = Pseudo-first-order rate constant

A graph of ln(a/(a − x)) versus time was plotted for each solvent system. The slope of the straight line gave the value of the rate constant (k).

The Arrhenius equation was used to determine the activation energy:

$$k = Ae^{-E_a/RT}$$

A plot of ln(k) versus 1/T was prepared, and the activation energy was calculated from the slope of the linear graph.

For statistical evaluation, the following analyses were performed:

•Mean and Standard Deviation (SD)

•Linear Regression Analysis (R^2)

•One-way Analysis of Variance (ANOVA)

These analyses were used to compare the hydrolysis rates in different solvent media and assess the significance of solvent polarity on reaction kinetics.

Results and Discussion

The hydrolysis reaction of ethyl acetate has been done in four solvent systems to know the effect of the polarity of the solvent in the kinetics of the reaction. The reaction is found to occur under pseudo-first-order conditions due to the presence of water in large excess. The results were obtained by titrating the aliquots taken from the reaction at the periodic interval of time. Kinetic parameters namely pseudo-first-order rate constant (k) and activation energy (Ea) are evaluated from the data obtained during the experiments. Results for different solvent systems showed that the composition of the solvent has an effect on the hydrolysis reaction:

•Distilled Water

•Water–Methanol (50:50)

•Water–Ethanol (50:50)

•Water–Acetone (50:50)

The experimental observations are presented in tabular form, followed by graphical representation and detailed discussion.

Experimental Observations

Table 2 Rate Constants of Ethyl Acetate Hydrolysis in Different Solvent Media

Solvent Medium	Rate Constant, k (min^{-1})	Relative Rate
Distilled Water	**0.018**	Highest
Water–Methanol	**0.015**	High
Water–Ethanol	**0.013**	Moderate
Water–Acetone	**0.010**	Lowest

The hydrolysis process is fastest in distilled water, as shown by the findings. An increase in the proportion of organic solvents reduces the reaction rate. Water–methanol system is faster than the water–ethanol system, while the lowest rate is recorded in the water–acetone solvent pair. The tendency points towards the decisive impact of the solvent's polarity on the hydrolysis of esters.

Effect of Solvent Media on Hydrolysis Rate-The medium enzyme reaction takes place in is highly significant in deciding rate of hydrolysis. Water has high dielectric constant of about 78.5 at 25°C and so ionic intermediates are stabilized, which creates a conducive condition for transfer of the proton. That's why hydrolysis occurs quicker in said medium as compared to other solvents. On the contrary, though adding methanol, ethanol or acetone decreases the total polarity of the solvent system thus making it less effective in the stabilization of the transition state and inhibits the reaction rate:

Water > Water–Methanol > Water–Ethanol > Water–Acetone

This trend agrees with the expected influence of solvent polarity on acid-catalyzed ester hydrolysis.

First-Order Kinetic Analysis- The hydrolysis of ethyl acetate follows pseudo-first-order kinetics because water is present in large excess. The rate constant was calculated using the integrated first-order equation:

$$\ln\left(\frac{a}{a-x}\right) = kt$$

A graph of ln(a/(a−x)) versus time produced a straight line for each solvent system, confirming first-order behavior.

Table 4.2 Correlation Coefficient (R^2) for First-Order Plots

Solvent	R^2 Value
Water	0.998
Water–Methanol	0.996
Water–Ethanol	0.995
Water–Acetone	0.994

The high values of R^2 indicate excellent agreement with pseudo-first-order kinetics.

Arrhenius Analysis-The Arrhenius equation was used to determine the activation energy:

$$k = Ae^{-E_a/RT}$$

The plot of ln(k) against 1/T yielded a straight line. The activation energies calculated for different solvent systems are presented below.

Table 4 Activation Energy in Different Solvent Media

Solvent	Activation Energy (kJ mol^{-1})
Water	47.6
Water–Methanol	50.2
Water–Ethanol	53.8
Water–Acetone	58.1

The activation energy increases as solvent polarity decreases. This indicates that additional energy is required to reach the transition state in less polar solvent systems.

Statistical Analysis-The kinetic data were analyzed statistically to evaluate the reliability of the results.

Table 5 Statistical Summary

Parameter	Value
Mean Rate Constant	0.014 min^{-1}
Standard Deviation	0.0034
Coefficient of Variation	24.3%
ANOVA (p-value)	<0.05

The ANOVA results indicate that the differences in rate constants among the solvent systems are statistically significant.

The analysis of the results reveals that solvent composition significantly affects the kinetics of ethyl acetate hydrolysis. It is interesting to note that the highest rate constant was established in distilled water, while the lowest value was found in the water-acetone mixture. In essence, this situation can be explained by developing theories that focus on the dielectric constant of the solvent and stabilization of the transition state. Water has a high dielectric constant and creates a network of hydrogen bonds that keep the protonated state stable during acid-catalyzed hydrolysis due to the effect of hydrogen bonds. Such stability helps to reduce activation energy and improve the reaction rate. Methanol and ethanol are less polar than water. Although both alcohols can be involved in hydrogen bonding, their dielectric constant is lower than that of the solvent. Thus, charged intermediates are less stable, which results in a reaction rate reduction. As for acetone, its dielectric constant is low, and it does not have a similar capacity for hydrogen bonding as water, which results in a less stabilised transition state and the most sluggish reaction. The increase in the activation energy of the run of mixed solvents also goes along with the confirmation of the theory that claims that the activation energy should be higher, which means that the energy barrier is higher. Thanks to the excellent linear correlation of the first-order plots, it can be stated that the hydrolysis process follows pseudo-first-order kinetics. The findings are consistent with

the theories of Arrhenius, Brønsted, Bjerrum, Laidler, and Atkins concerning solvent effects on the kinetics. To sum up, the results gathered in the course of the experiment confirm that solvent polarity is one of the most important factors affecting ethyl acetate hydrolysis and such mixed solvents can be applied in industrial and laboratory processes.

Conclusion

The present research examined the kinetics of ethyl acetate hydrolysis by acid in different media in order to find how different media affected the rate of chemical reaction and kinetic parameters. The hydrolysis reaction was performed at controlled lab conditions with distilled water, water–methanol, water–ethanol, and water–acetone solvent systems. The progress of the reaction was measured by titrimetric analysis, and the kinetic data were analyzed by using pseudo-first order rate equations in combination with the Arrhenius equation. The results obtained from the study confirmed that the hydrolysis of ethyl acetate is carried out in accordance with pseudo-first order kinetics in the presence of excess water. The straight line obtained as a result of plotting first-order kinetics conforms the use of the first-order rate equation for all types of solvent systems under consideration. High value of R^2 of the rate equation shows that experimental results are valid. The author of the article identified that the type of solvent has a strong effect on the hydrolysis rate. According to the findings of the study, distilled water has the largest rate constant among the solvent systems. Organic solvents such as methanol, ethanol and acetone led to lowering of the reaction rate as their presence decreased the polarity of the system and increased the necessary for the reaction activation energy. The following order of hydrolysis rate has been determined in the course of investigation:

Water > Water–Methanol > Water–Ethanol > Water–Acetone

The observed trend correlates with the theoretical principles of solvent effects, transition state theory as well as the literature available to date. The values of activation energy obtained through calculations increased continuously along with a decrease of the solvent polarity, which means that the less polar solvents are used, the more energy is needed to form an activated complex. Additionally, the statistical analysis provided evidence that the differences observed with solvent systems are statistically significant. The small error of determination and correspondence of the theoretical and experimental values received suggest that the methods applied in the study are effective for researching ester hydrolysis kinetics. As a result, the study has shown that the solvent composition is among the most important factors affecting the process of ethyl acetate hydrolysis. The obtained information adds to the existing knowledge of the solvent-solute interactions, reaction mechanisms, and kinetics of various reactions occurring in mixed solvent systems. The information received during this research can be used for the improvement of the processes of hydrolysis on the scale of industry and pharmaceutical production as well as for theoretical research on observed reactions with esters occurring in different solvents and/or catalysts. Ethyl acetate hydrolysis is commonly considered as one of the examples of an acid catalyzed ester hydrolysis reaction and it is widely used in the study of chemical kinetics. In this experiment, the kinetics of hydrolysis was studied in four different solvents, i.e. distilled water, water–methanol, water–ethanol, and water–acetone. The main aim of the study was to observe the effect of polarity of solvents on the reaction rate, calculate different kinetic parameters and evaluate the reactions taking place in different solvent systems. The hydrolysis is carried out under constant temperature conditions and pseudo-first order conditions. Hydrochloric acid was used as the catalyst for the reaction and the extent of hydrolysis at different times of reaction was measured using sodium hydroxide titration. The constant rates were calculated using integrated first-order rate equation and activation energy was calculated using Arrhenius equation. The results indicated that maximum reaction rate was achieved in distilled water due to its high polarity and conductivity. The rate of hydrolysis reaction was getting lower at adding methanol, ethanol, and acetone. And among the other solvent systems, water–acetone system showed the lowest rate constant. In the Kinetic plots, the reaction followed pseudo-first-order behavior in all systems of solvents. The finding of the Arrhenius analysis showed that as polarity of the solvent decreased, the activation energy increased. This confirmed that solvent polarity does play an important role in determining the kinetics of ethyl acetate hydrolysis and the findings fit well with chemical kinetics theories.

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