CHAPTER V

COMPARATIVE STUDY OF THE CATIONIC SURFACTANTS AND THEIR INFLUENCE ON THE ALKALINE HYDROLYSIS OF ACETYLSALICYLIC ACID

SUMMARY

Kinetic study of the reaction of acetylsalicylic acid (aspirin) with sodium hydroxide has been studied in the presence of some conventional and novel cationic surfactants. The pseudo-first-order rate constant increases with surfactant concentration initially and then decreases. In comparison to conventional cationic surfactants i.e. cetyltrimethylammonium bromide and cetylpyridinium bromide, novel cetyldiethylethanolammonium bromide (R = C₁₆) surfactant accelerated the alkaline hydrolysis significantly. The pseudo-phase ion exchange model has been applied to fit the experimental results. Activation parameters have also been evaluated.

🌟 Part of this work has been published in Int. J. Chem. Kinet., 2011, 43, 1-8.
CHAPTER V: COMPARATIVE STUDY OF THE CATIONIC SURFACHTANTS AND THEIR INFLUENCE ON THE ALKALINE HYDROLYSIS OF ACETYLSALICYLIC ACID

5.0 INTRODUCTION

Acetylsalicylic acid is now a proved effective drug used for minor pains, muscle ache, fever, and arthritis, blood-thinning long-term low doses to prevent heart attacks [1-7]. A lot of effort has been put into research on the effect of self-organizing assemblies and its pharmaceutical formulation, solubilization and stability etc. The hydrolysis of aspirin has been studied extensively to understand its stability in biological systems for pharmaceutical formulation [8-14]. The unique role of surfactants in solubilizing the drugs depends on numerous factors such as chemical structure of the surfactant, chemical structure of the drug, temperature, pH and ionic strength [15]. Furthermore, surfactants have capacity to modify rates and equilibria of chemical reaction, which have an important role in the formulation of pharmaceutical forms by reducing toxicity and increasing their stability. Self organizing assemblies like micelle and micro emulsions are highly efficient drug delivery vehicles for hydrophobic and partially hydrophilic drugs [16, 17]. Determining a stable environment for drugs are of crucial importance for the design and process of adequately implanting pharmaceutical formulae in biological systems. Therefore, it becomes necessary to collect kinetic data on the influence of cationic surfactants on the alkaline hydrolysis of aspirin. In comparison to reactions in aqueous solutions, reaction kinetics in micellar solutions may undergo alterations, which may be favorable or unfavorable nature, depending on micelle charge [18-20], micelle counter ion [21], head group size [22, 23] and the chain length of the hydrophobic tail of the surfactant [24]. Kinetically, micelles make a highly appealing reaction medium. Because of their structure, they can inhibit chemical reactions by encapsulating a reactant within equally, they can catalyze reactions by having the reactants concentrated at the interface thus acting as micro reactors.
5.1 REVIEW OF THE EARLIER WORK

The alkaline hydrolysis of aspirin has been widely studied in micellar media, whose effects depend on substrate and surfactant structure. Broxton, Rodenas and Vera [25-32] et al. have made a significant contribution in this context. Alvarez et al. [33] have studied the alkaline hydrolysis of acetylsalicylic acid with potassium hydroxide in cationic micelles of N-cetyl-N-ethyl-N-N-dimethyl ammonium bromide (CDMEABr) by fluorescence measurements at 25 °C. They observed that cationic micelle accelerate the rate of reactions at below concentration of surfactants and inhibit at higher concentration of surfactants for the hydrolysis of acetylsalicylic acid. The hydrophobic and electrostatic forces are important between charged substrates and ionic micelles. These forces change the surface polarity of micelle and thus affect the ion equilibria and binding equilibria of substrates, which strongly affect the rate of reactions. The forces affect bimolecular reaction not only by incorporating both reactants into the small volume of the Stern layer of the micelle, but also modifying the free energy of the transition state.

Similarly Ferrit [34-37] and research group have investigated the alkaline hydrolysis of acetylsalicylic acid and triflusal using potassium hydroxide (KOH) and sodium hydroxide (NaOH) in presence of cationic, anionic, zwitterionic, and nonionic surfactants by spectrophotometrically at 37 °C. In cationic micelles, there is a catalytic effect at low concentrations. In anionic micelle, a catalytic effect occurs, while in zwitterionic and non-ionic micelles there is an inhibitory effect. Such reactions are attributable to changes in reactants on the micellar surface, or to the fact that both reactants are found in different microenvironments. The pseudophase (PS) and pseudophase ion-exchange (PIE) models were found to be consistent with the experimental result. Furthermore, the association constants for both drugs could be determined together with micellar rate constants in heterogeneous media. The presence of both drugs in the different micelles is apparent from the binding constant (Ks) values obtained, which in order of magnitude were as follows: cationic> zwitterionic>nonionic >anionic micelles. They studied that the rate data was higher for triflusal than it was for acetylsalicylic acid, due to the greater electrophilic and lipophilic nature of the trifluoromethyl group. Guo et al [38] have investigated the solubility of ibuprofen with a water-soluble polymer, poly (ethylene glycol) (PEG) in presence of nonionic surfactants. The morphology and aggregation behavior of micelles
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and micelles/PEG complexes in aqueous solution are investigated by 1H NMR technology, dynamic light scattering (DLS), isothermal titration calorimetry (ITC), and fluorescence resonance energy transfer (FRET). Dar et al. [39] have studied the solubilization of naproxen by micellar solutions using single and mixed surfactant systems. Solubilization capacity determined with spectrophotometry and tensiometry has been quantified in terms of molar solubilization ratio, micelle-water partition coefficient, and locus of solubilization under reaction conditions. Oussama et al. [40] have investigated the hydrolysis of lysine acetylsalicylic compound (LAS) using hydronium ion and hydroxide catalyzed in aqueous media. Nome et al. [41] have studied the reaction of hydroxylamine with aspirin in aqueous solution at 25 °C. They observed that the reaction is faster than the intramolecular general base catalyzed hydrolysis for the carboxylate anion, as it is also for the COOH form of aspirin.

5.2 PRESENT INVESTIGATION

In this work, we have investigated micellar effects on the alkaline hydrolysis of aspirin [Scheme 5.1] using alkyldiethylethanolammonium bromide (R = C_{12}H_{25}, C_{14}H_{29}, C_{16}H_{33}), cetyltrimethylammonium bromide (CTAB) and cetylpyridinium bromide (CPB) [Scheme 5.2] surfactants. Alkanol amine surfactants combine the characteristics of the amine and hydroxyl groups in terms of reactivity patterns. The presence of both amine and hydroxyl groups in alkanolamines makes them very versatile for the present investigation.

\[
\text{Acetyl Salicylic Acid} + \text{H}_2\text{O} \xrightarrow{\text{NaOH}} \text{Salicylic Acid} + \text{Acetic acid}
\]

Scheme 5.1
5.3 EXPERIMENTAL

5.3.1 MATERIALS

Aspirin USV limited product (Bangalore, India) was used as supplied. Cetyl-diethylethanolammonium bromide (CDEABr), tetradecyldiethylethanolammonium bromide (TDEABr) and dodecyldiethylethanolammonium bromide (DDEABr) were obtained from Professor R. M. Palepu, (Retired) St. Francis Xavier University, antigonish, Canada. Cetyltrimethylammonium bromide (CTAB) and cetylpyridinium bromide were procured from Sigma/Aldrich. Sodium hydroxide (NaOH) was obtained from Merck (Mumbai, India) and acetonitrile from s.d. fine chemicals. All chemicals were used without further purification and all the solutions were prepared in triple distilled water.

5.3.2 METHOD

The kinetic studies were performed using a Varian Carry 50 UV-visible spectrophotometer equipped with Peltier temperature control unit. The reaction was followed by measuring the appearance of the salicylate ion at the wavelength 296.5 nm at \(27\pm1^\circ\text{C}\). All reactions were carried out under pseudo-first-order conditions in which sodium hydroxide concentration (0.005 M) was always in larger excess over the substrate. The stock solution of aspirin (0.006 M) was prepared in acetonitrile. The final
concentration were [substrate] = 3×10^{-4} \text{ M}, 5\% (v/v) acetonitrile, [NaOH] = 0.005 \text{ M} in reaction mixture. The pseudo-first-order rate constants ($k_{\text{obs}}$) were determined from the plots of log ($A_0 - A_t / A_\infty - A_t$) versus time with $A_0$, $A_t$ and $A_\infty$ being the absorbance readings at zero, time and infinite time respectively. Fig. 5.1 (a) shows the UV absorption spectra in the absence of micelle and Fig. 5.1 (b) show in the presence of micelle [CDEABr]. The absorption band centered at $\lambda = 296.5$ nm increases with time.

![Absorption spectra](image)

(a) Absence of micelle  
(b) Presence of micelle

**Fig. 5.1** (a) Repeat scans every 0.2 min showing the increasing absorbance at 296.5 nm due to the hydrolysis of aspirin in the absence of micelle. Temp. = 27±1°C, [Substrate] = 3×10^{-4} \text{ M}, Medium 5\% (v/v) acetonitrile.

(b) Repeat scans every 0.1 min showing the increasing absorbance at 296.5 nm due to the hydrolysis of aspirin in the presence micelle. Temp. = 27±1°C, [Substrate] = 3×10^{-4} \text{ M}, Medium 5\% (v/v) acetonitrile.

### 5.4 RESULTS AND DISCUSSION

#### 5.4.1 Effects of Sodium Hydroxide (NaOH)

The reaction was first order with respect to NaOH. Hence, in water the rate equation for the process is $k_{\text{obs}} = k_w [\text{OH}^-]$, where $k_w$ is the second-order rate constant. The alkaline hydrolysis of aspirin was studied at 0.001, 0.005 and 0.01 M NaOH concentration in absence and presence of CDEABr at 27±1°C. The observed rate constant values are given in Table 5.1. Fig. 5.2 displays the corresponding experimental data.
Table 5.1 Observed first-order rate constants for hydrolysis of acetylsalicylic acid (aspirin) in the absence and presence of cationic micelles with [NaOH].

<table>
<thead>
<tr>
<th>Substrate</th>
<th>[NaOH] (M)</th>
<th>Aqueous</th>
<th>CDEABr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$k_w$ $10^3$ $k_{obs}$ ($S^{-1}$)</td>
<td>$k_w$ ($M^{-1}$ $s^{-1}$)</td>
</tr>
<tr>
<td>ASA</td>
<td>0.001</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>ASA</td>
<td>0.005</td>
<td>0.73</td>
<td>0.14</td>
</tr>
<tr>
<td>ASA</td>
<td>0.01</td>
<td>1.3</td>
<td>0.13</td>
</tr>
</tbody>
</table>

**Reaction conditions:** Temp. = 27±1°C, [substrate] = 3×10^{-4} M, Medium 5% (v/v) acetonitrile

![Variation of pseudo-first order rate constants (kobs) with NaOH](image)

**Fig. 5.2** Variation of the pseudo-first order rate constants ($k_{obs}$) with NaOH in the absence and presence of CDEABr at 27±1°C. [substrate] = 3×10^{-4} M, Medium 5% (v/v) acetonitrile.
The pseudo-first-order rate constant increases linearly with an increase in [NaOH]. The intercept at the origin of the straight line indicates that spontaneous water catalyzed reaction is insignificant in comparison with the OH⁻ ion and surfactant.

5.4.2 Alkaline Hydrolysis in the Presence of Surfactant

The effect of cationic micelles on the alkaline hydrolysis of aspirin was studied at fixed [NaOH] and [surfactants] varied between 0.25 and 21 mM at 27°C. The values of pseudo-first-order rate constant ($k_{obs}$) in alkanol amine surfactants and conventional surfactants are given in Table 5.2. The reaction rates initially increase as the surfactant concentration is increased. The effect is very significant in CDEABr surfactant. The presence of catalyst is easily explained as an electrostatic effect, the cationic nature of the surfactant favors the presence of OH⁻ in the micellar medium, accelerating the hydrolysis of the substrate associates to micelles. The $k_{obs}$ values in the presence of cationic micelles gradually accelerated at low surfactant concentration and at high surfactant concentration show the inhibition effects for hydrolysis of aspirin. The variation of $k_{obs}$ values of the reactions depends on the micellar structure i.e., hydrophobic tail length and counter ion etc.

The rate constants in a variety of association colloids are slightly higher than in water and increase modestly with increasing micellar media involves variation in the surfactant tail groups and changes in the interfacial region. Analysis of kinetic data indicates that the cetyldiethylethanolammonium bromide shows higher reactivity. The increase of $k_{obs}$ values with increasing alkyl chain lengths (R = 16) of the surfactants, i.e., with increasing aggregation number of micelle is mainly due to the increase in the electrical surface potential of the micelle and partially due to an increase of hydrophobicity of the palisade layer of the micelle. In all cases, the [CDEABr] rate profile maximum as compared to [TDEABr] and [DDEABr] surfactant because [CDEABr] corresponding to complete solubilization of the substrate in the micellar pseudophase and alkanol group can exert a protective effect on the positive charge, thus lowering the attractive electrostatic interactions between the quaternary ammonium center of the micelle and corresponding negative charge of the dissociated acid group. The effect of CTAB is not very significant. The reactivity order follows the trend CDEABr > TDEABr > DDEABr > CPB > CTAB.
Table 5.2 Observed first-order-rate constants for hydrolysis of acetylsalicylic acid in the presence of cationic surfactants.

<table>
<thead>
<tr>
<th>Conc. of Surfactants (mM)</th>
<th>$10^4 k_{obs}$ (s$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CDEABr</td>
</tr>
<tr>
<td>0.00</td>
<td>0.73</td>
</tr>
<tr>
<td>0.25</td>
<td>1.40</td>
</tr>
<tr>
<td>0.50</td>
<td>2.05</td>
</tr>
<tr>
<td>1.00</td>
<td>4.16</td>
</tr>
<tr>
<td>1.50</td>
<td>5.50</td>
</tr>
<tr>
<td>2.00</td>
<td>6.12</td>
</tr>
<tr>
<td>2.60</td>
<td>8.72</td>
</tr>
<tr>
<td>4.00</td>
<td>11.6</td>
</tr>
<tr>
<td>5.00</td>
<td>12.5</td>
</tr>
<tr>
<td>8.00</td>
<td>15.9</td>
</tr>
<tr>
<td>10.5</td>
<td>15.8</td>
</tr>
<tr>
<td>12.5</td>
<td>14.7</td>
</tr>
<tr>
<td>15.0</td>
<td>14.0</td>
</tr>
<tr>
<td>21.0</td>
<td>11.8</td>
</tr>
</tbody>
</table>
5.4.3 Application of Pseudophase Model

The experimental results can be explained by means of the pseudophase model developed by Bunton et al. [43] which considers the total volume of micelles as a separate phase uniformly distributed in the aqueous phase and that the reaction occurred independently in both phases, with an equilibrium distribution of substrate between both phases according to Scheme 5.3.

\[
\begin{align*}
\text{nD} & \quad \text{K}_s \\
S_w + D_n & \quad k'_W \\
\text{Products} & \quad k'_M \\
\end{align*}
\]

where S is the substrate, D is the monomeric surfactant, Dₙ is micellized surfactant, whose concentration is given by \([D_n] = [D] - \text{cmc}\) (cmc being the critical micelle concentration), n is the number of monomers within a micelle, the subscripts M and W denote the micellar and aqueous phase, respectively and \(K_s\) is the binding constant of the substrate to the micelle expressed in terms of micellized surfactant, defined where \(k'_W\) and \(k'_M\) are the pseudofirst-order rate constants for the reactions in aqueous and micellar pseudophases, given by

\[
K_s = \frac{[S_M]}{[S_w][D_n]} \quad (5.1)
\]

\[
k'_W = [\text{OH}^-_w] \quad (5.2)
\]

\[
k'_M = k_M[\text{OH}^-_M] \quad (5.3)
\]

For reactions where two ions compete for the charged micelle surface assuming that ions bind to micelles according to the exchange model developed for ion-exchange resins. The Romsted, pseudophase-ion-exchange model [44] considered that the neutralized fraction of micellar head groups, \(\beta\), can be taken as constant when one of the ions in solution binds
very strongly to a micelle. For the reactive ions (OH⁻) and the bromide ion as a micelle counterion, the ion-exchange equilibrium can be expressed by

\[ \text{OH}^-_M + \text{Br}^-_w \rightleftharpoons \text{OH}^-_w + \text{Br}^-_M \]  

(5.4)

with an equilibrium constant

\[ K_{\text{Br}}^{\text{OH}} = \frac{[\text{OH}^-_w][\text{Br}^-_M]}{[\text{OH}^-_M][\text{Br}^-_w]} \]

Setting

\[ m_{\text{OH}} = \frac{[\text{OH}^-_M]}{[D_n]} \quad \text{and} \quad m_{\text{Br}} = \frac{[\text{Br}^-_M]}{[D_n]} \]

and \( \beta = m_{\text{OH}} + m_{\text{Br}} \) according to Scheme 5.3 and Eqs. 5.1 to 5.4, the pseudo-first-order rate constant can easily derived as

\[ k_{\text{obs}} = \frac{k_w[\text{OH}^-]_T + (k_M K_s - k_w) m_{\text{OH}}[D_n]}{1 + K_s[D_n]} \]  

(5.5)

where

\[ [\text{OH}^-]_T = [\text{OH}^-_w] + [\text{OH}^-_M], \quad [\text{Br}^-]_T = [\text{Br}^-_w] + [\text{Br}^-_M] \]

All the concentrations used to refer to the total volume of the solutions. Calculation of \( m_{\text{OH}} \) proceeds from the equation.

\[ m_{\text{OH}}^2 + m_{\text{OH}} \left[ \frac{[\text{OH}^-]_T K_{\text{Br}}^{\text{OH}} [\text{Br}^-]_T}{(K_{\text{Br}}^{\text{OH}} - 1)[D_n]} - \beta \right] \left( \frac{\beta[\text{OH}^-]_T}{(K_{\text{Br}}^{\text{OH}} - 1)[D_n]} \right) = 0 \]  

(5.6)

According to experimental results, it is possible to explain the variation to the experimental pseudo-first-order rate constant with the CDEABr, TDEABr, DDEABr, CPB and CTAB in Fig. 5.3.
Fig. 5.3 Observed first-order-rate constants for hydrolysis of acetylsalicylic acid (aspirin) in the presence of cationic micelles.

The data are shown in Table 5.2. In the case of CDEABr the observed rate maximum is the result of two competing effects in pseudo-phase ion exchange model; increasing surfactant concentration increases the concentration of substrate associates to the micelle but also increases the concentration of Br⁻ ions. In pseudophase ion-exchange model, the nucleophile (OH⁻) and inert counterion (Br⁻) of cationic micelle compete at the micellar surface level reaching an ion-exchange equilibrium Eq. 5.4 provides a representation to this process. The pseudophase ion-exchange model explains the variation of the pseudofirst-order rate constant with different cationic micelles.

When the surfactant is present in small amounts, the relative concentrations of substrate and ionic reactant in the micellar Stern layer increase rapidly with surfactant concentration accelerating the reactions; this effect can account for the ascending branch of the curve. The substrate is in micellar pseudophase, an increase in the surfactant concentration carries out an increase in the unreactive counter ions (Br⁻), which provokes a displacement of the micellar, bound OH⁻ ions in the proximity of the bound substrate. This could account for the descending branch of the experimental curve at high surfactant concentrations.
Table 5.3 Values of parameters calculated for PPIE model for the alkaline hydrolysis of aspirin.

<table>
<thead>
<tr>
<th>Surfactant</th>
<th>$k_w$</th>
<th>$K_{Br}^{OH}$</th>
<th>$k_M$</th>
<th>$K_S$ (M$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDEABr</td>
<td>0.146</td>
<td>10</td>
<td>0.43±0.06</td>
<td>68±14</td>
</tr>
<tr>
<td>CPB</td>
<td>0.146</td>
<td>4</td>
<td>(1.1±0.1)x10$^{-2}$</td>
<td>1100±300</td>
</tr>
</tbody>
</table>

Reaction conditions: Temp. = 27°C, [substrate] = $3\times10^{-4}$ M, Medium 5% v/v acetonitrile, [NaOH] = 0.005 M, cmc = $0.96\times10^{-3}$ M (CDEABr) and $0.95\times10^{-3}$ M (CPB), $\beta = 0.80$

Fig. 5.4 Influence of surfactant concentration upon pseudo-first-order rate constant for alkaline hydrolysis of aspirin in cationic micelles (CDEABr). The solid line is calculated by the PPIE model. Temp. = 27 °C, [substrate] = $3\times10^{-4}$ M, Medium 5% (v/v) acetonitrile.
Fig. 5.5 Influence of surfactant concentration upon pseudo-first-order rate constant for alkaline hydrolysis of aspirin in cationic micelles (CPB). The solid line is calculated by the PPIE model. Temp. = 27°C, [substrate] = 3×10⁻⁴ M, Medium 5 % (v/v) acetonitrile.

The experimental rate constants can be adapted to equations (5.5) and (5.6) by using a computer program. The variation of kinetic rate data, \( k_{\text{obs}} \), with surfactant and reactive ion concentrations have been investigated at different values of the parameters \( k_w, \text{cmc}, \beta, K_s, k_M \) and \( K_{\text{OH}^+} \). The experimental results have been calculated \( \beta \) values are taken as a constant (0.8) for all cationic surfactants. The kinetic rate constant \( k_w \) is the value obtained for the aqueous alkaline hydrolysis. The other parameters \( k_M, K_s \) and \( K_{\text{OH}^+} \) can be used as adjustable parameters. The cmc values 0.96×10⁻³ M, 3.05×10⁻³ M, 12.5×10⁻³ M, 0.95×10⁻³ M, 0.96×10⁻³ M for CDEABr, TDEABr, DDEABr, CPB and CTAB were taken from literatures [45-47]. Computer simulation of the variation of the observed rate constant \( (k_{\text{obs}}) \) with surfactant at fixed [NaOH], however has shown that for the best fit the pseudo-first-order rate constant in the micellar rate constant and calculated second-order rate constant in the micellar rate constant \( (k_M) \) is approximately 100 times smaller than that for reaction in water. The binding constant \( (K_s) \) are observed for CDEABr is 68±14 M⁻¹ and CPB, 1100±300 M⁻¹, which are depend on the micellar head group size. It has been observed that the \( K_s \) values are independent of the OH⁻ concentration; these results are different from those obtained in the presence of cationic micelles. The second order rate constant \( (k_M) \) were calculated from computer simulation. The value of second order rate
constant \((k_M)\) 0.011-0.43 M\(^{-1}\)s\(^{-1}\) depend upon the surfactant head group size [35]. In the case of aspirin, \(K_s\) values are higher for CPB than CDEABr. The pseudophase ion-exchange model has been applied to the experimental results and the best fitting results are in Table 5.3 and graphical representation shown in Figs. 5.4 and 5.5. The concentration of substrate in micelle would constant and surfactant chain length was varied and the effect of this on the alkaline hydrolysis of acetylsalicylic acid studied some support for the best fit ion-exchange model with CDEABr and CPB but other surfactants TDEABr, DDEABr, CTAB are not fitted in pseudophase ion-exchange model. Thus comparison of micellar binding constant of drug in the CPB and CDEABr micelles provide the conclusive information on the reactivity patterns.

In order to determine various activation parameters \((E_a, \Delta H^\# , \Delta S^\# , \Delta G^\#)\) the pseudo-first order rate constants for the alkaline hydrolysis of aspirin in the absence and presence of CDEABr have been studied at two temperatures (27±1 and 37±1°C). The activation parameters are given in Table 5.4. This table shows that the observed activation energy and enthalpy decrease in the micellar phase as compared to the aqueous medium. The high negative value of \(\Delta S^\#\) in micelle indicates that the reagent should be ordered to form the transition state. The binding constant \((K_s)\) values of acetylsalicylic acid have been compared in cationic micelles of the same chain length but different head group size, with the result that the difference between them is higher in cationic micelle CPB>CDEABr respectively. According to these established relationships, it can be deduced that the hydrophobic nature of the substrate has a greater influence in cationic micelle.

**Table 5.4** Values of activation parameters.

<table>
<thead>
<tr>
<th>System</th>
<th>(E_a) kJ mol(^{-1})</th>
<th>(\Delta S^#) J K(^{-1})mol(^{-1})</th>
<th>(\Delta H^#) kJ mol(^{-1})</th>
<th>(\Delta G^#) kJ mol(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aqueous</td>
<td>63.5</td>
<td>-95.7</td>
<td>61.0</td>
<td>90.2</td>
</tr>
<tr>
<td>CDEABr</td>
<td>41.3</td>
<td>-152</td>
<td>38.7</td>
<td>85.2</td>
</tr>
</tbody>
</table>

**Reaction Condition:** \([\text{CDEABr}] = 1\times10^{-3} \text{ M, } [\text{NaOH}] = 0.005 \text{ M and Temp. } = 27\pm1^\circ\text{C} and 37\pm1^\circ\text{C}\)
5.5 CONCLUSIONS

The kinetics of the alkaline hydrolysis of acetylsalicylic acid in the presence of different surfactants has been studied. The reaction was studied in the presence of alkanol amine surfactants with different carbon chain lengths. The cationic surfactants catalyze the hydrolysis. The result fits, the pseudophase-ion exchange model.
5.6 REFERENCES

21. C Bonan, R Germani, P P Ponti, G Savelli, G Cerichelli, R Bacaloglu, C A


