EFFECT OF DIFFERENT ADDITIVES ON CLOUD POINT OF NON IONIC SURFACTANT

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By

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NATIONAL INSTITUTE OF TECHNOLOGY,
ROURKELA

CERTIFICATE

This is to certify that the thesis entitled "**Effect of Different Additives on Cloud Point of Non Ionic Surfactant**", submitted by **Dhananjay Singh** for the requirements of bachelor's degree in Chemical Engineering Department of National Institute of Technology, Rourkela is an original work to the best of my knowledge, done under my supervision and guidance.

Date-12/06/11

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In the pursuit of this academic endeavour, I feel I have been singularly fortunate. I should fail in my duty if I do not record my profound sense of indebtedness and heartfelt gratitude to my supervisor Dr. Santanu Paria who inspired and guided me in the pursuance of this work.

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Date-12/06/11 **Dhananjay Singh**

CONTENTS

ABSTRACT

Determination of cloud point of non-ionic surfactants have wide applications as it is the temperature where the mixture starts to phase separate and the two phases appear, thus becoming cloudy. Non-ionic surfactants find suitable applications for recovery of membrane components under mild non-denaturing condition. Knowing the cloud point helps us to determine the storage stability since storing formulations at temperatures significantly higher than the cloud point may result in phase separation and instability. Generally, non-ionic surfactants show optimal effectiveness when used near or below their cloud point.

In this present work, effects of different additives on cloud point of non-ionic surfactants have been studied. Triton X-100 (TX-100) has been used as the non-ionic surfactant and observations have been done subsequently for different concentration of TX-100 by taking various additives like NaCl, Na_2SO_4, $CaCl_2$ and corresponding temperature were noted down. Other than non-ionic surfactants, experiments were conducted for both cationic as well as anionic surfactants. Based upon the result, graphs were plotted which comply well with the theoretical study.

Keywords: cloud point, non-ionic surfactants.

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CHAPTER 1

INTRODUCTION

Introduction

1.1 Surfactants

Surfactants are compounds that lower the surface tension of a liquid, the interfacial tension between two liquids, or that between a liquid and a solid. There is a broad range of different surfactant types, each having unique properties and characteristics. Depending on the type of the charge of the head, a surfactant belongs to the anionic , cationic, non-ionic or amphoteric/zwitterionic family.

1.1.1Anionic Surfactants

In solution, the head is negatively charged. The anionic surfactants have the advantage of being high and stable foaming agents; however, they do have the disadvantage of being sensitive to minerals and the presence of minerals in water (water hardness) or pH changes. They include alkylbenzenesulfonates (detergents), (fatty acid) soaps, lauryl sulfate (foaming agent), di-alkyl sulfosuccinate (wetting agent), lignosulfonates (dispersants).

1.1.2 Cationic Surfactants

In solution, The head is a positive charge on the head. A very large proportion of this class consists of nitrogen compounds such as fatty amine salts and quaternary ammoniums, with one or several long chain compounds, which are derived from natural fatty acids. Common examples of cationic surfactants are Benzalkonium chloride, Benzethonium chloride, Bronidox, Cetrimonium bromide, Cetrimonium chloride, Lauryl methyl gluceth-10 hydroxypropyl dimonium chloride, Tetramethylammonium hydroxide and Dimethyldioctadecylammonium chloride.

1.1.3 Non-Ionic Surfactants

Nonionic surfactant is a different class of surfactant that about 45% of the total surfactant production worldwide. This type of surfactants does not have any net positive or negative charges on their head groups. They do not ionize in aqueous solution, because their hydrophilic group is of a non-dissociable type, such as alcohol, phenol, ether, ester, or amide. A large proportion of these non-ionic surfactants are made hydrophilic by the presence of a polyethylene glycol chain, obtained by the polycondensation of ethylene oxide. They are called polyethoxylated non-ionic. Depending on the head group this surfactant can be classified in different groups. The percentage of different group non-ionic surfactant those are more important for the industrial applications are given in the table 1.1.

1.1.3.1 Types of Non-ionic Surfactants

Table 1.1. The list of different non-ionic surfactant groups depending on the head groups. (Salager, 2002)

Surfactant Type	**% Total**
Ethoxylated Linear Alcohols	40
Ethoxylated Alkyl Phenols	15
Fatty Acid Esters	20
Amine and Amide Derivatives	10
Alkylpolyglucosides	---
Ethleneoxide/Propyleneoxide Copolymers	---
Polyalcolols and ethoxylated polyalcohols	---
Thiols (mercaptans) and derivates	---

Some common non-ionic surfactants are Triton X-100, TX-165, cetomacrogol 1000, poloxamer, cetyl alcohol, stearyl alcohol, lauryl glucoside, octylglucoside, cocamide DEA, nonoxynols and sorbitantristearate.

1.2.3 Zwitterionic Surfactants

When a single surfactant molecule exhibit both anionic and cationic dissociations it is called amphoteric or zwitterionic. This is the case of synthetic products like betaines or sulfobetaines and natural substances such as aminoacids and phospholipids.

1.3 Cloud Point

The cloud point of a fluid is the temperature at which dissolved solids are no longer completely soluble, precipitating as a second phase giving the fluid a cloudy appearance.

The cloud point is an important criterion for determining the storage stability of surfactants. Cloud points are characteristic properties of nonionic surfactants. Anionic surfactants are more water-soluble than nonionic surfactants due to the presence of negatively charged head, and typically exhibits higher cloud points. The presence of other components in the formulation of surfactant can affect the cloud point of the mixture.

1.4 Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by individual particles or suspended solids in a solution or mixture. The turbidity measurement acts as a key characteristic for water quality.

1.5 Objective

To determine the effects of additives on the cloud point of non-ionic surfactants.

Following are some of the applications of cloud point determination

- The cloud point of petroleum products and biodiesel fuels is an index of the lowest temperature of their utility for certain applications. Wax crystals of sufficient quantity can plug filters used in some fuel systems.
- Petroleum blending operations require a precise measurement of the cloud point.
- For low-foam applications, the cloud point of the product should be just below the use temperature.
- Cloud point extraction is used for determination of pyrene in natural water.
- For determining of the Nickel and zinc through the cloud point pre-concentration.
- For finding out the lead from the water samples by using cloud point extraction flow injection-atomic absorption.
- For pre-concentration of fulve and bumic acids by using cloud point extraction technique.

CHAPTER 2

LITERATURE REVIEW

Literature Review

2.1 Single Surfactant

This study report and investigations on the effect of organic additives on the cloud point of Triton X-100 . The cloud point of Non ionic surfactants is useful as compare to other because it application emulsifier .as a detergent and in pharmaceutical formulation. The cloud point depends upon on the TX-100 solutions range 1-10% have been measured. The estimates cloud point of TX-100 Solutions over this concentration range is shown on the graph (Alauddin et al.2009).

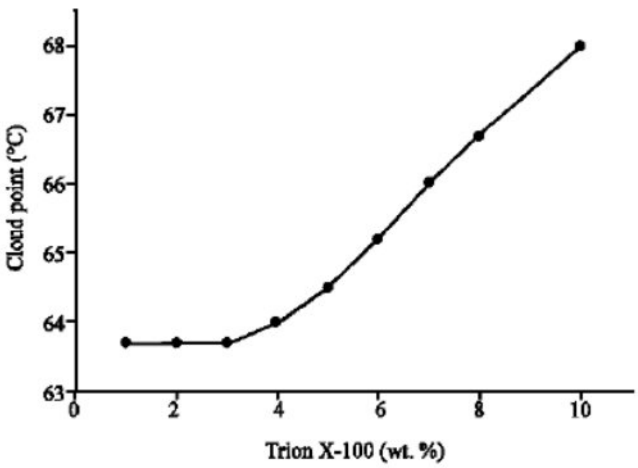

Fig. 2.1: Cloud point of aqueous solutions of Triton X-100 as a function of its concentration(Alauddin, et al.2009).

2.2 Mixed Surfactants

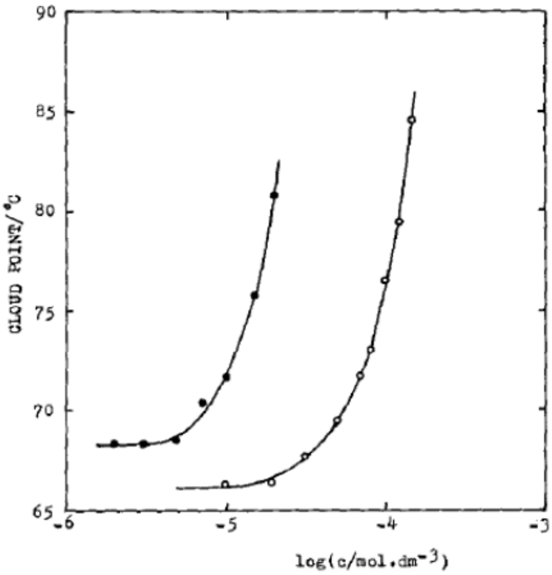

Fig.2.2 The effect of the addition of CTAB on the cloud point of 0.1% (●) and 1% (○)solutions of TX-100 (Gu, et al.1989).

Fig 2.2: Shows the results of addition of small amounts of CTAB into two different concentration (.1 and 1%) of solution of TX-100 .Fig.:2.3 shows the effect of hydrocarbon chain length of sodium alkyl sulfates on the cloud point of anionic-nonionic mixed solution as well as that of alkyltrimethyl ammonium bromides on the cloud point of cationic-nonionic mixed solutions in the presence of small amount of ionic surfactant. The concentrations of the ionic surfactants of 10^{-5} and 10^{-4} mole dm^{-3} will correspond to a maximum of about one ionic surfactant molecule per micelle of TX-100 in 0.1 and 1% solutions, respectively. CMC and the aggregation number of TX-100 used in the calculation were 3.2 x 10^{-4} mole dm^{-3} and 150 respectively (Gu, et al.1989).

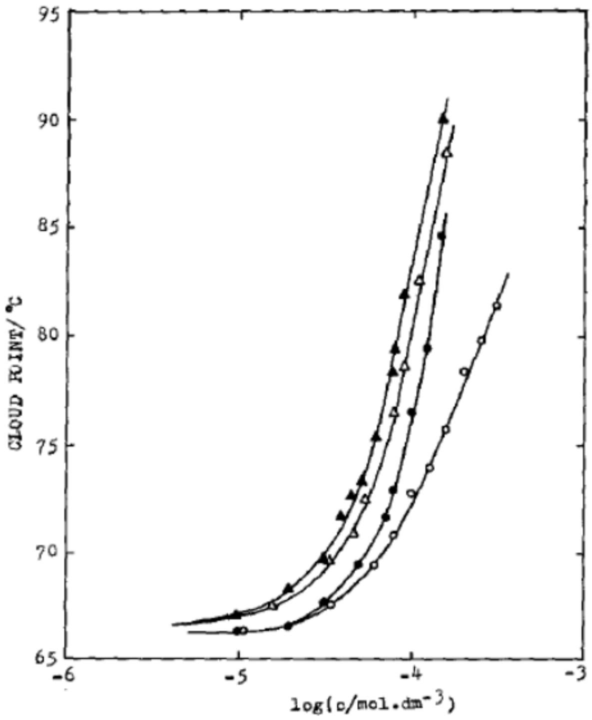

Fig. 2.3. The effect of hydrocarbon chain length of ionic surfactant homologs on the cloud point of 1%. Solution of TX-100 .▲,SCS;△,SDS;●,CTAB;○,DTAB (Gu, et al.1989).

It can be see that concentration of the ionic surfactants was far below the concentration of TX-100 and far below the CMC of the ionic surfactant used .Thus it was safe to assume that the surface active cations as well as surface active anions were present either as monomers or as mixed micelles with TX-100 and that there were no pure ionic surfactant micelles. The rise in the cloud point was due to the formation of mixed micelles which changed the nature of the micelle surface by a small amount of ionic surfactant (Gu, et al.1989).

2.3 Effect of Electrolyte

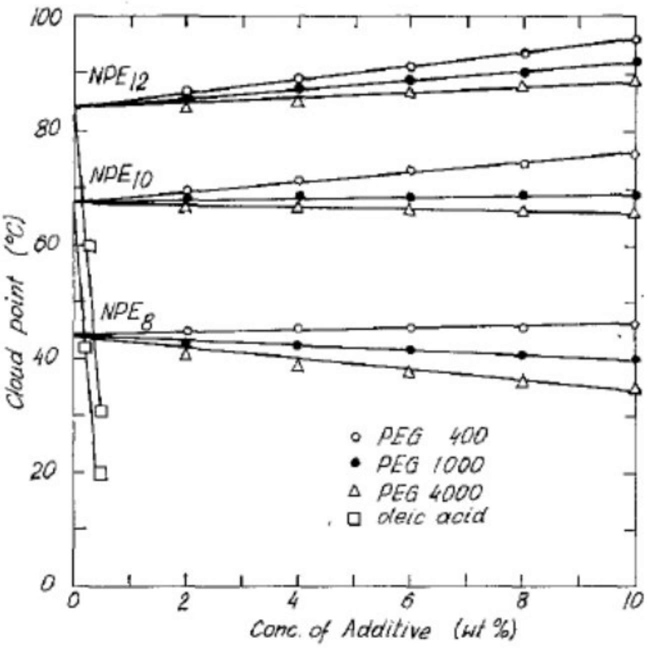

Fig. 2.4: Relation between cloud point of 1 wt% aqueous solutions of NPE_8, NPE_{10}, NPE_{12}, and concentration of additives: oleic acid, PEG 400, PEG 1000, and PEG4000(Marszall, 1997).

Fig. 2.4 depicts the effects of oleic acid and various other additives on the cloud points of NPE_x, (x = 8, 10, and 12) aqueous solutions. Oleic acid depresses the cloud points significantly. This result is satisfactory, according to comparisons with other research studies. Therefore, Oleic acid can be considered to decrease the effective HLB value of the surfactants since there was decrease in the cloud point recorded (Marszall, 1997).

Fig. 2.5 indicates the effect of various electrolytes on the cloud point of the non-ionic surfactant poloxamine 908. The research study was carried out with electrolytes methanol, ethanol, n-propanol, i-propanol and glycerol, and propylene glycol. It was concluded that the monoalcohols, ethanol, methanol and iso propanol had effective effects on boosting the cloud point. However, it was also evident that n-propanol and glycerol were only slightly effective. The results obtained clearly stated that the cloud point of surfactants can be modified using various electrolytes (George, et al.1999).

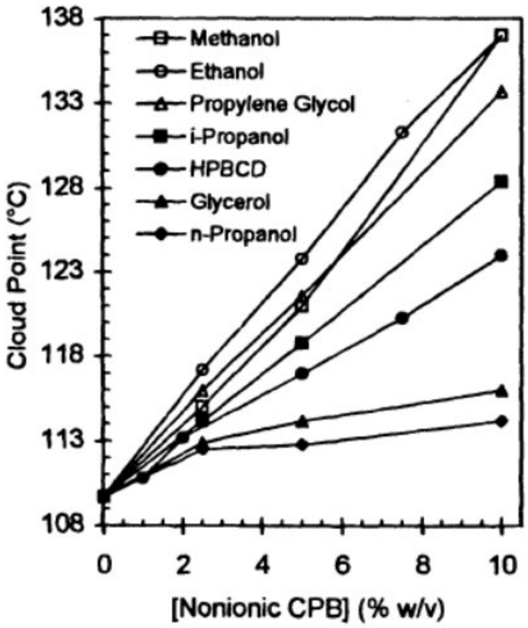

Fig. 2.5: Effects of nonionic additives on the cloud point of poloxamine 908 at 1 % (w/v) (George, et al.1999).

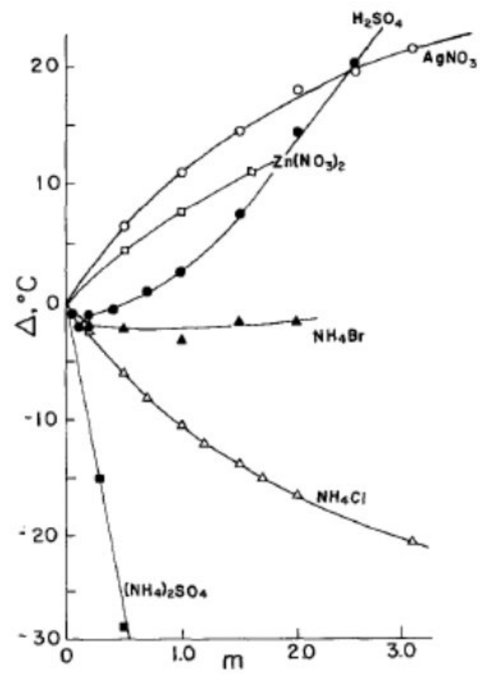

Fig. 2.6: Cloud point shift values Δ of 2.0% Triton X-100 solutions as a function of the molality of added electrolytes (Scott, et al.1986).

Various studies on the shift in cloud point was done on Triton X-100 using sulfuric acid, silver nitrate, ammonium bromide, ammonium chloride, $Zn(NO_3)_2$ and $(NH_4)_2SO_4$. The cloud point shift was plotted as a function of molality of the electrolytes in Fig. 2.6. The studies led to the conclusion that the sulfuric acid and silver nitrate had great cloud point boosting abilities on triton X-100 (Scott, et al.1986).

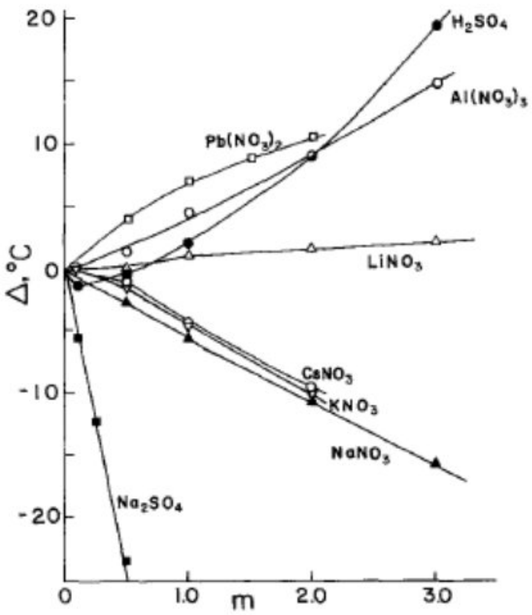

Fig. 2.7: Cloud point shift values Δ of 1.0% Brij 76 solutions as a function of the molality of added electrolytes(Scott, et al.1986).

Similar studies were carried out with Brij 76 and it was concluded that sulfuric acid provided to be the best cloud point booster. However, even small concentrations of Na_2SO_4 decreased the cloud point by large values. Fig. 2.7, depicts the same results as a function of molality of the electrolytes (Scott, et al.1986).

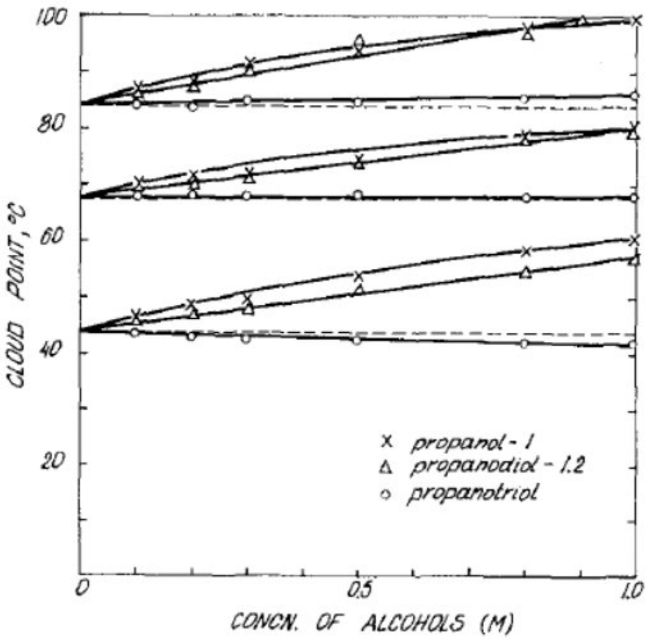

Fig. 2.8: The effect of the alcohols on the cloud point of 2 wt % NPE_x solutions (Marszall,1977).

The effects of various alcohols on the cloud point of NPEx solutions were studied. The results obtained from the research have been plotted in Fig. 2.8. The values indicate that alcohols act as agents to increase the cloud point of the NPEx solutions (Marszall, 1977).

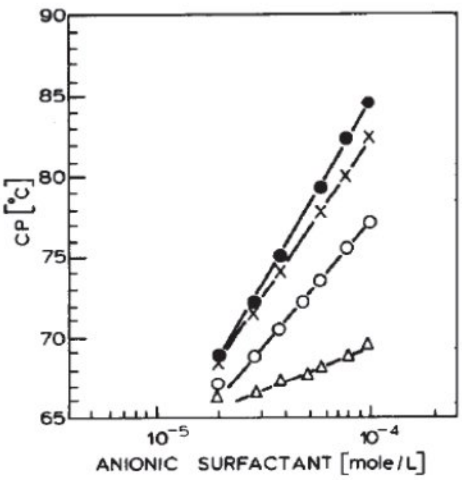

Fig. 2.9: Cloud point (CP) of a 1 % solution of Triton X-100 as a function of the molar concentration of added sodium alkyl sulfates: $C_8H_{17}OSO_3Na$ (O), $C_{12}H_{25}OSO_3Na$ (X), and $C_{14}H_{29}OSO_3Na$ (●)(Marszall, 1989).

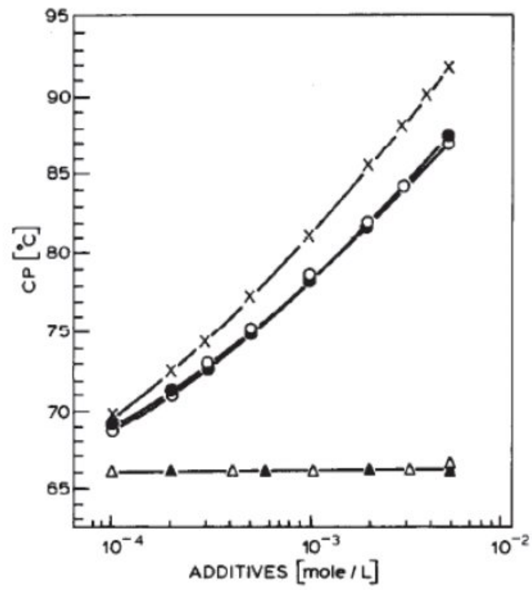

Fig. 2.10: The effect pf cryptand 222 (Δ) and NaCl (▲) on the cloud point (CP) of a 1% solution of Triton X-100 and the cloud point data for Triton X-100- sodium octyl sulfate (SOS) mixtures without (X) and with cryptand 222 (O) and NaCl (●). The molar ratios of cryptand 222/SOS and NaCl/SOS were 1:1(Marszall, 1989).

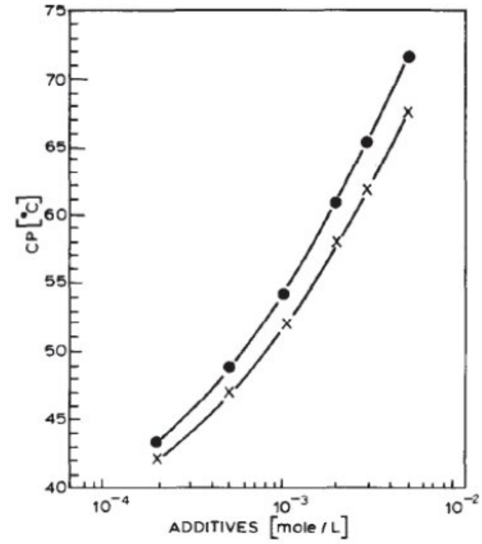

Fig . 2.11: The effect of cryptand 222 (X) on the cloud point (CP) of C8E4-sodium octyl sulfate (SOS) mixtures (●). The molar ratio of cryptand 222/SOS was 1:1(Marszall, 1989).

Fig. 2.9, 2.10 and 2.11 denotes the various studies carried out on the cloud point variation using electrolyte systems on single and mixed surfactant systems (Marszall, 1989).

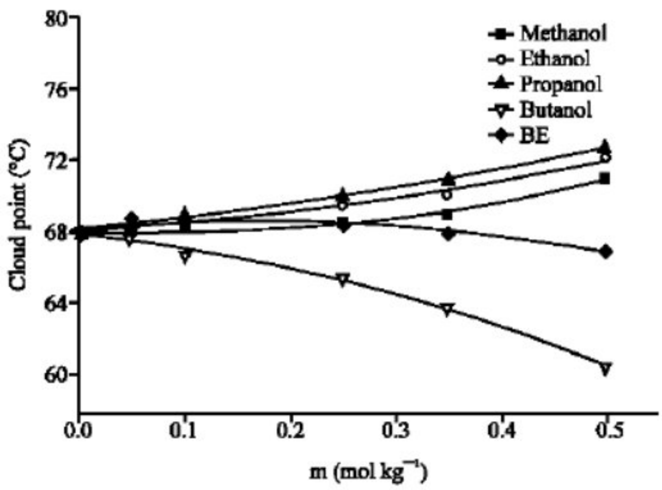

Fig. 2.12: Cloud point of 10 % Triton X-100 solution in the presence of methanol, ethanol, propanol, butanol, and butoxyethanol (BE) of different concentrations (Alauddin, et al.2009).

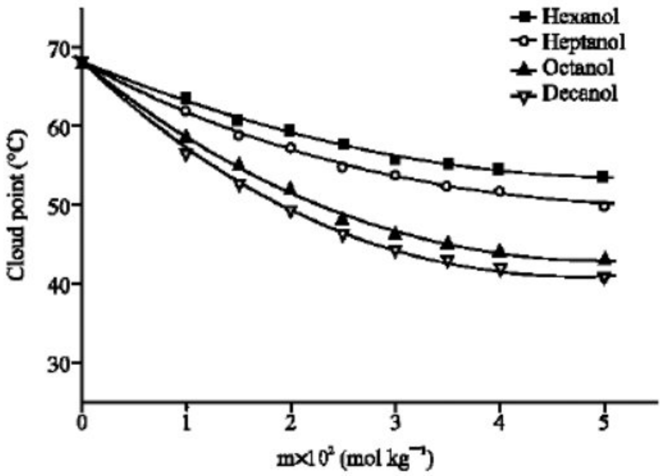

Fig. 2.13: Cloud point of 10 % Triton X-100 solution in the presence of hexanol, heptanol, octanol and decanol of different concentrations (Alauddin, et al.2009).

Fig. 2.12 and 2.13 depict the various results obtained on studies done on the cloud point of Triton X-100. In these studies, The cloud point was then varied using different concentration of organic alcohols. The various results obtained from these experiments have been plotted in Fig. 2.12 and Fig. 2.13(Alauddin, et al.2009).

Table 2.1 denotes the various surfactants and additives that have been used for studies by various researchers.

Table 2.1: Previous Studies using various additives and surfactants.

Sl. No.	Surfactants Used	Additive Used
1	TX-100	Toxic Eosin Dye[3]
2	Poloxamine 908	Polyglycols[4]
3	Poloxamine 908	Alcohols and Polyalcohols[4]
4	Poloxamine 908	Saccharides[4]
5	Poloxamine 908	Phospholipids[4]
6	Octoxynol 9	Primidone[5]
7	Octoxynol 9	Prednisone[5]
8	Triton X-100	NaBr[6]
9	Triton X-100	Na_2SO_4[6]
10	Triton X-100	Urea[7]
11	Triton X-100	Methylurea[7]
12	Triton X-100	Acetamide[7]

CHAPTER 3

EXPERIMENTAL WORK

Experimental Work

3.1 Materials

The surfactants used were Triton X-100 (molecular weight 617gm/mole from Loba Chemie, India). CTAB (Cetyl trimethyl ammonium bromide) (molecular weight 364.46gm/mole from Loba Chemie, India). SDS (Sodium dodecyl sulphate) (molecular weight 288.38gm/mole from Loba Chemie, India).

Electrolyte used were NaCl (molecular weight58.44 from Rankem, India). Na_2SO_4 (molecular weight124.02gm/mole from Rankem, India). $CaCl_2$ (molecular weight147.02gm/mole from Rankem , India) . No further surfactants or electrolytes was adopted for cloud point.

3.2. Methods

For determining cloud point, plate heater provided with a test tube is used. Initially a 50 ml stock solution is prepared containing 100 millimoles of TX-100. From the prepared stock solution, solution of different concentration are made ranging from 10 millimoles to 30 millimoles . For each concentration, the cloud point is determined with help of plate heater. Beaker filled with water is placed on the plate heater. After the setup is arranged, test tube containing the prepared solution is placed and heating is started. Controlled heating is done, starting from the room temperature at a rate of 0.3^0C/min till the required cloud point temperature is obtained. Cloud point temperature of surfactant solutions was determined by the visual examination of the abrupt change in the appearance of the surfactant solutions as it occurs during the heating of the sample solutions.

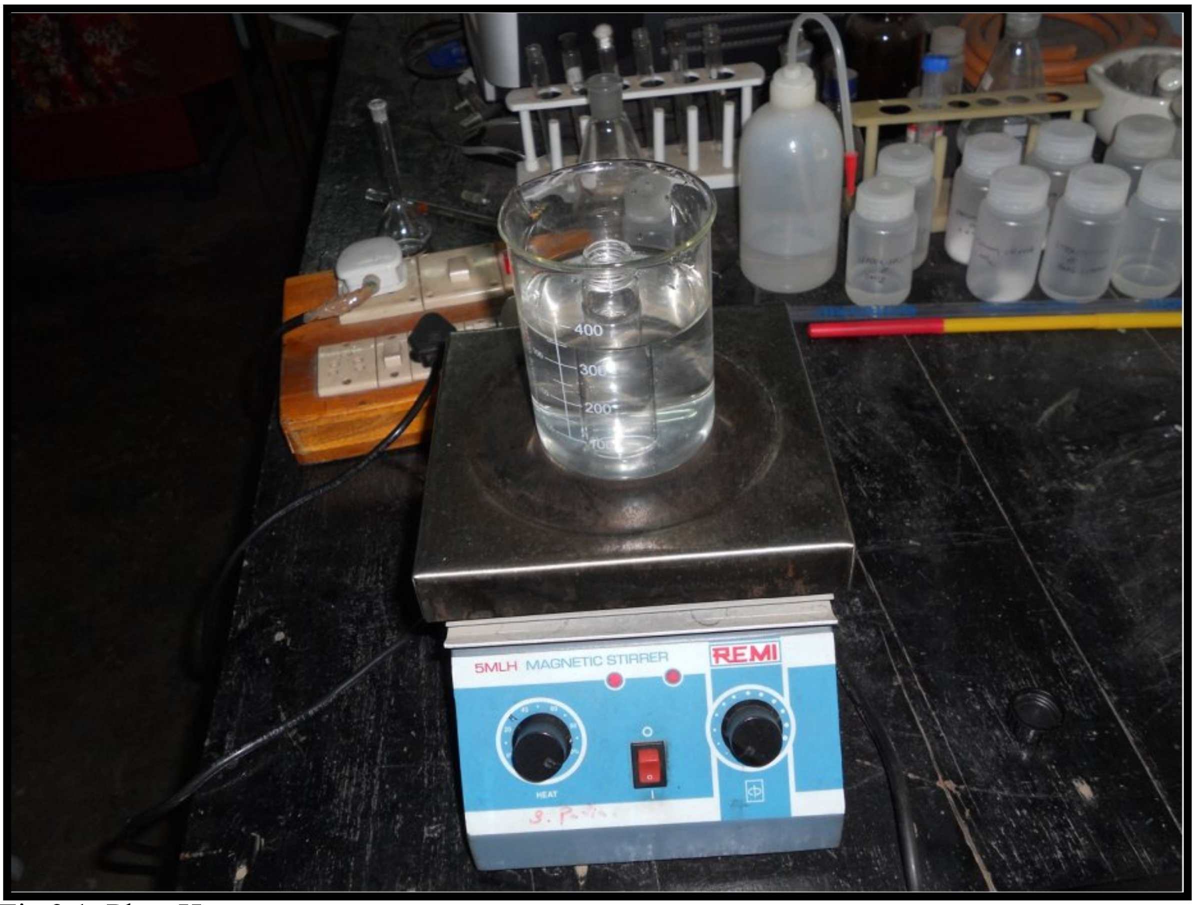

Fig.3.1: Plate Heater.

As well as for turbidity, the solution is put in the hole with clean of the test tube. No water should be there outside the test tube otherwise the instrument will be damaged. Digital temperature readings are also noted.

Fig. 3.2: Turbidity Meter.

After the temperature exceeds the cloud point, the solution should be cool down below the cloud point temperature and then it was heated again to check the reproducibility of the measurements. This procedure was repeated at least 2 times.

CHAPTER 4

RESULT AND DISCUSSION

Result and Discussion

4.1 Cloud Point of Surfactant

When the temperature increases gradually the turbidity value of the solution also increases. But at a certain temperature the cloudy appearance signifies the cloud point, and its corresponding turbidity is also very high (as shown in the Fig.).

The experiment was carried out with only a single concentration of the solution initially. Later various concentration of the same solution was tested for its cloud point. The results of various concentration of TX-100 were found out experimentally, and Fig. 4.1 depicts the results of one such experiment.

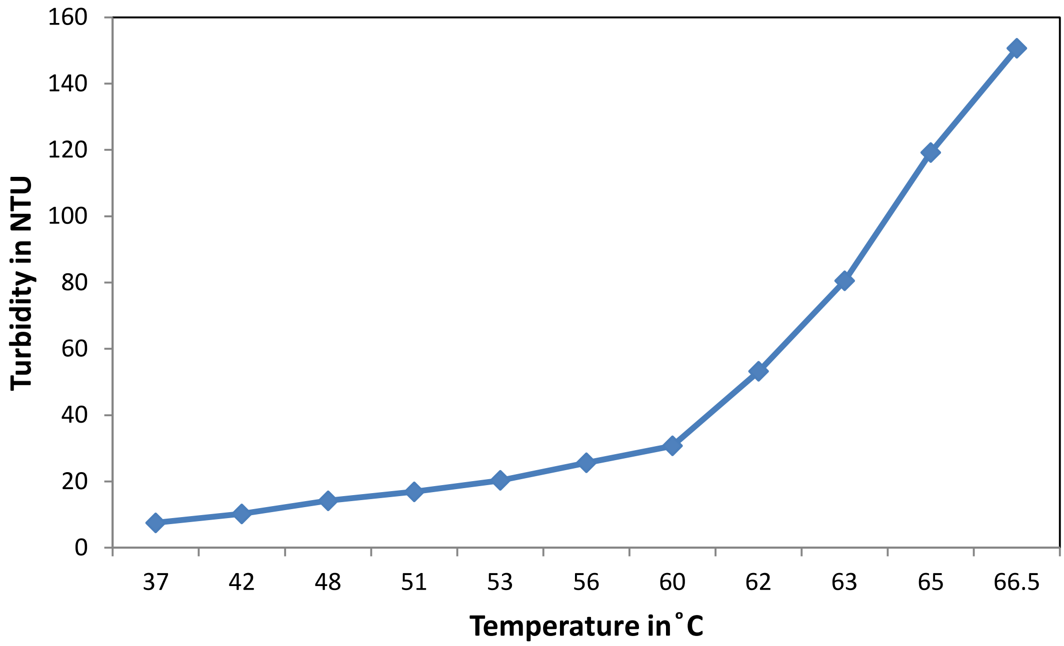

Fig. 4.1: Change in turbidity with temperature from 20 Mm solution using TX-100.

4.2 Effect of Concentration

The cloud point of TX-100 of different concentrations was determined by the experiments. The cloud point obtained from this experimental procedure was plotted in Fig. 4.2 . The cloud point is plotted as a function of concentration of TX-100. From Fig. 4.2 it can be determined that there is an increasing trend in the cloud point values with an increase in the concentration of the TX-100 concentration. The least value of cloud point for 10mM TX-100 is around 66 °C, and maximum being around 68.5 °C for 40 mM TX-100.

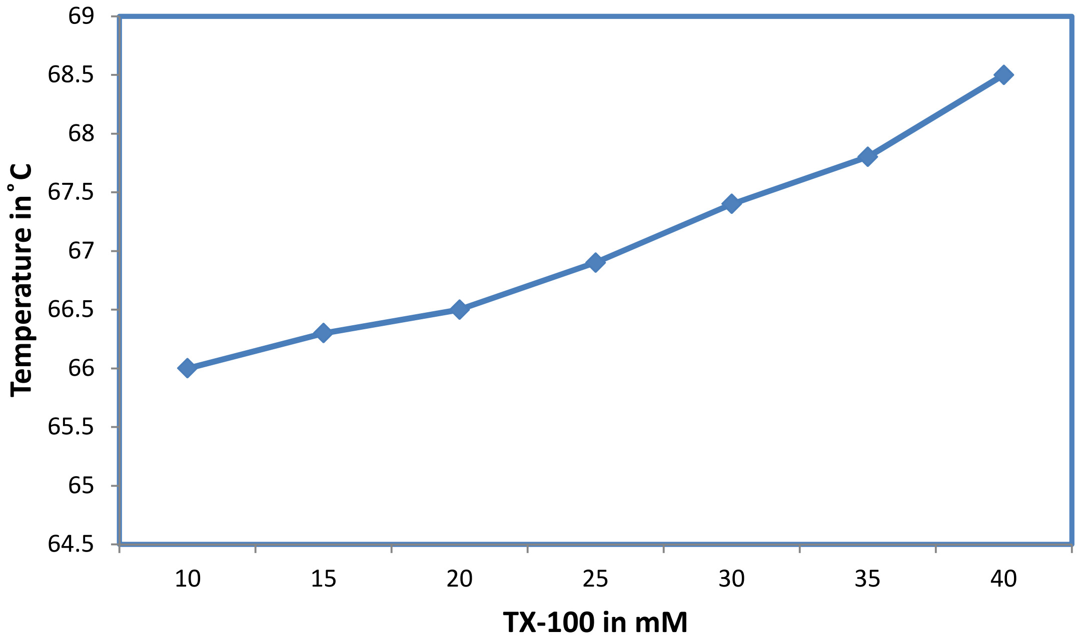

Fig. 4.2: Cloud point of aqueous solutions of Triton X-100 as a function of its concentration.

4.3 Effect of Mixed Surfactant

4.3.1 Mixing of TX-100 with CTAB

Mixing of surfactants induces a synergistic effect on the cloud point which may depend on the specific type of surfactants that have been used for the experiment. In this case the surfactants used are TX-100 and CTAB.

As it can be clearly detected, there has been a sharp increase in the cloud point values of the 10 mM TX-100 solution when mixed with CTAB. From Fig. 4.3 it can be noticed that the cloud point of 10 mM TX-100 is 66 °C. But when 10 mM TX-100 solution is mixed with CTAB, the cloud point tends to increase in values for increasing values of CTAB concentration. For 0.5 mM of CTAB mixed with TX-100, the mixture has a cloud point of 70 °C. The same trend of increase in cloud point is spotted for an increase in the CTAB concentration.

However, the cloud point of the mixture for fixed CTAB concentration and varying TX-100 yields that, 10 mM concentration of TX-100 has the highest effect compared to 20 mM and 30 mM. Hence mixing CTAB with TX-100 has greater effect at lower concentrations of TX-100 than higher concentrations.

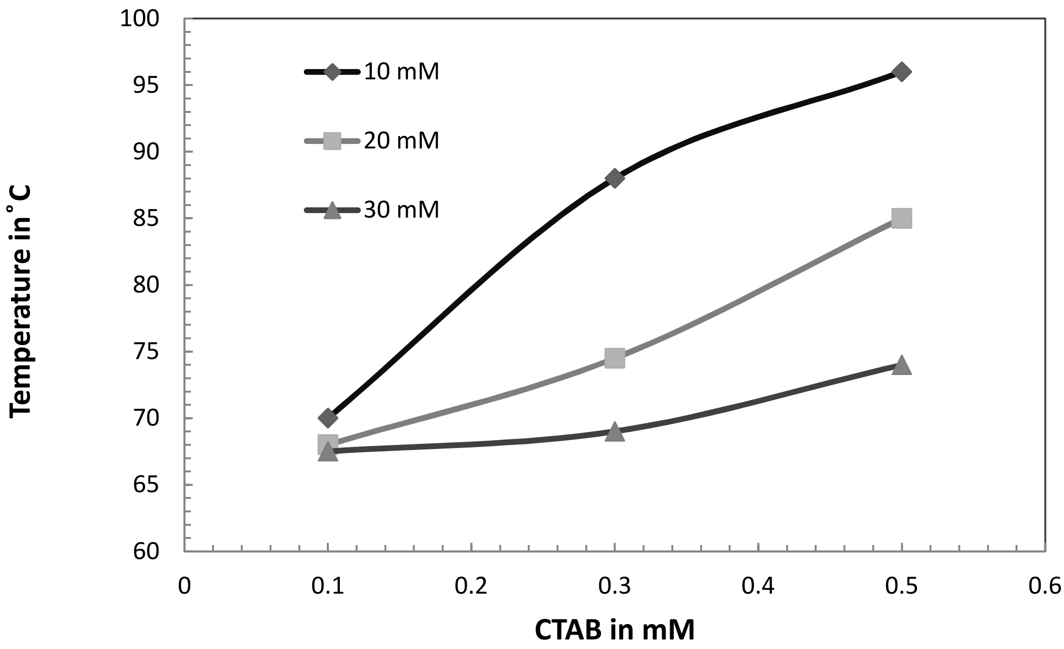

Fig. 4.3: Cloud point of TX-100 in the presence of CTAB.

Table 4.1. Linear equation for cloud point of TX-100 in the presence of CTAB

TX-100 Concentration (mM)	Equation	R^2
10	Y = 65x + 65.167	0.953
20	Y = 42.5x + 63.083	0.9819
30	Y = 16.25x + 65.292	0.9119

4.3.2 Mixing of TX-100 with SDS

Mixing of different surfactants has tremendous effects on the cloud point of the mixture. But since all the effects are due to the microscopic interaction of molecules present chemically in the mixture.

In this case TX-100 was mixed with SDS and its effect on cloud point was studied. From Fig. 4.4 and Fig. 4.4 it is evident that the cloud point of TX-100 solution is increased when mixed with SDS than its pure form. However, on increasing the concentration of the SDS that is being mixed, the cloud point of the solution tends to increase. But when a fixed value of SDS concentration is compared for a varying concentration of TX-100, it can be Fig.d that the lower the concentration there is better interaction of the system and hence better cloud point boosting characteristics. Thus from Fig. 4.4 it can be clearly noted that for a given SDS concentration highest cloud point is for the least value of TX-100 (here 10 mM TX-100).

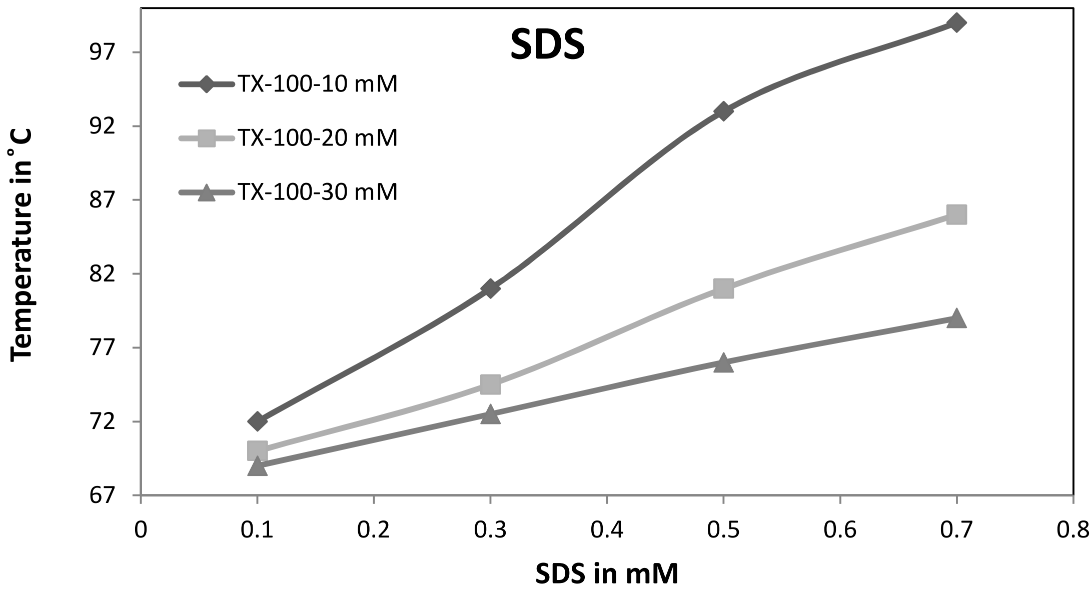

Fig. 4.4: Cloud point of TX-100 in the presence of SDS.

Table 4.2. Linear equation for cloud point of TX-100 in the presence of SDS.

TX-100 Concentration (mM)	Equation	R^2
10	Y = 46.5x + 67.65	0.9856
20	Y = 27.25x + 66.975	0.9955
30	Y = 16.75x + 67.425	0.9987

4.3.3 Comparison of CTAB and SDS

CTAB and SDS have very good effect of increasing the cloud point of TX-100 solutions. But both these surfactants have greater effect on the cloud point when TX-100 is present in lower concentrations and its effect keeps decreasing as concentration of the TX-100 increases. But comparing for a given TX-100 concentration and same mixing surfactant concentration (either CTAB or SDS) it can be noted that the cloud point of CTAB and TX-100 solution is higher than SDS mixtures. But this valid only when the concentration of TX-100 is very low, but for higher concentration of 30 mM TX-100 and 0.5 mM of mixing agent (CTAB and SDS), the effect of SDS as a cloud point booster is better than CTAB.

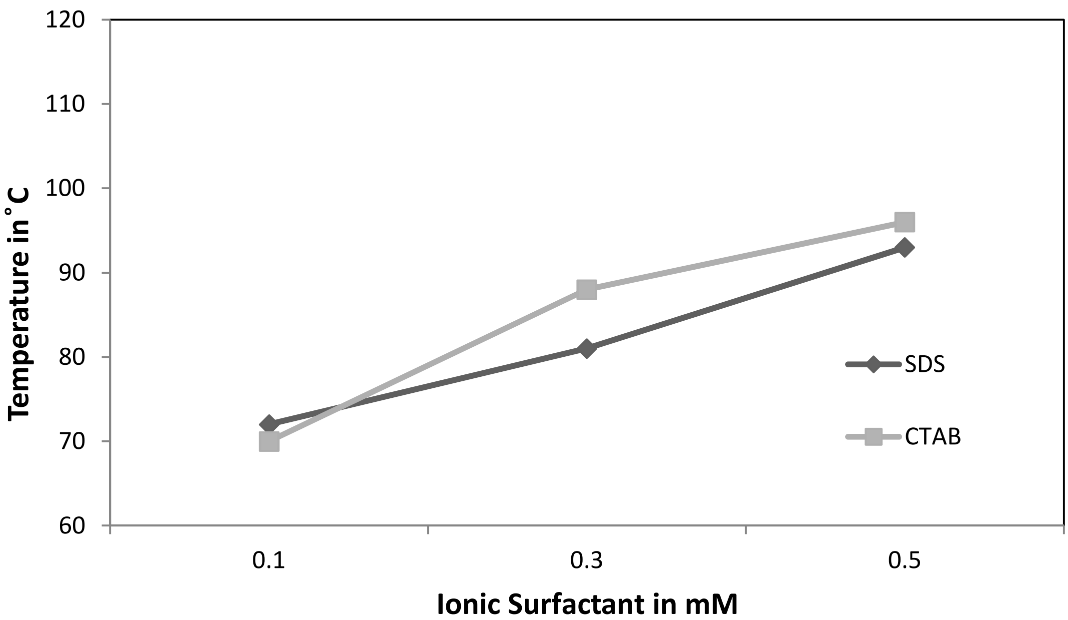

Fig. 4.5: Comparison between cloud points for the mixture of CTAB with TX-100 and SDS with TX-100.

Table 4.3. Comparison between the linear equations for cloud point of the mixture of CTAB with TX-100 and SDS with TX-100

Surfactant Concentration (mM)	**Equation**	**R^2**
CTAB	Y = 13x + 58.667	0.953
SDS	Y = 10.5x + 61	0.9932

4.4 Effect of Additives on Non- Ionic Surfactant

4.4.1 Effect of Na_2SO_4 on TX-100

Na_2SO_4 when mixed with TX-100 decreases the cloud point of the solution. It can be noted from the Fig. 4.6 that for a constant TX-100 concentration, increasing the Na_2SO_4 concentration, decreases the cloud point of the TX-100 solution. But when focused on a single Na_2SO_4 concentration it can be determined that the effect of decreasing the cloud point is strongly felt at higher concentrations of TX-100. In this case, the cloud point of 30 mM TX-100 and 100 mM Na_2SO_4 is 57 °C but for 10 mM TX-100 and 100 mM Na_2SO_4 the cloud point is 58 °C. Hence there is a greater activity of depressing the cloud point using Na_2SO_4 at higher concentrations of TX-100.

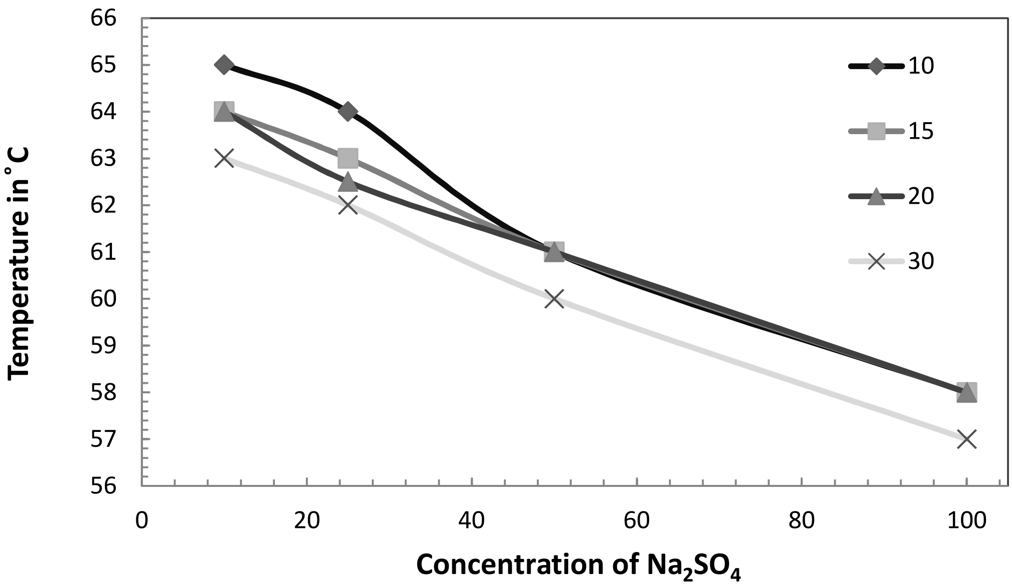

Fig. 4.6: Cloud point of TX-100 with different concentration of Na_2SO_4.

Table 4.4. Linear equations for cloud point of TX-100 with different concentration of Na_2SO_4.

TX-100 Concentration (mM)	**Equation**	**R^2**
10	Y= -0.0793x + 65.665	0.9774
15	Y= -0.0669x + 64.596	0.996
20	Y= -0.0647x + 64.365	0.9914
30	Y= -0.0669x + 63.596	0.996

As discussed previously, the cloud point and turbidity are interconnected. The cloud point is marked by a sharp change in the turbidity values and cloudy appearance.

For the effect of Na_2SO_4 on the cloud point of TX-100, its turbidity has also been studied and plotted in Fig. 4.7. The turbidity results too help to conclude that the cloud point has been achieved at lower temperatures for high concentrations of Na_2SO_4. At high concentrations of Na_2SO_4 it can be seen that the cloud point of TX-

100 are reduced. This implies that the turbidity has increased rapidly at lower temperatures to form cloud point. This is evident from Fig. 4.7 that for 100 mM Na_2SO_4 and 10 mM TX-100, there is a steeper change in turbidity compared to other concentrations, implying a greater change in turbidity at a lower temperature.

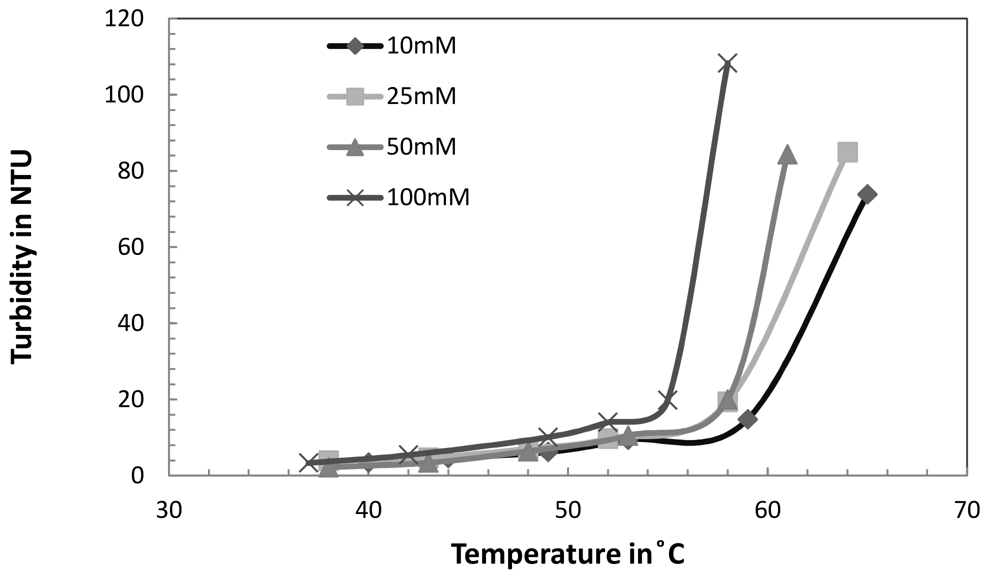

Fig. 4.7: Turbidity for 10mM of TX -100 mixed with different concentration of Na2SO4

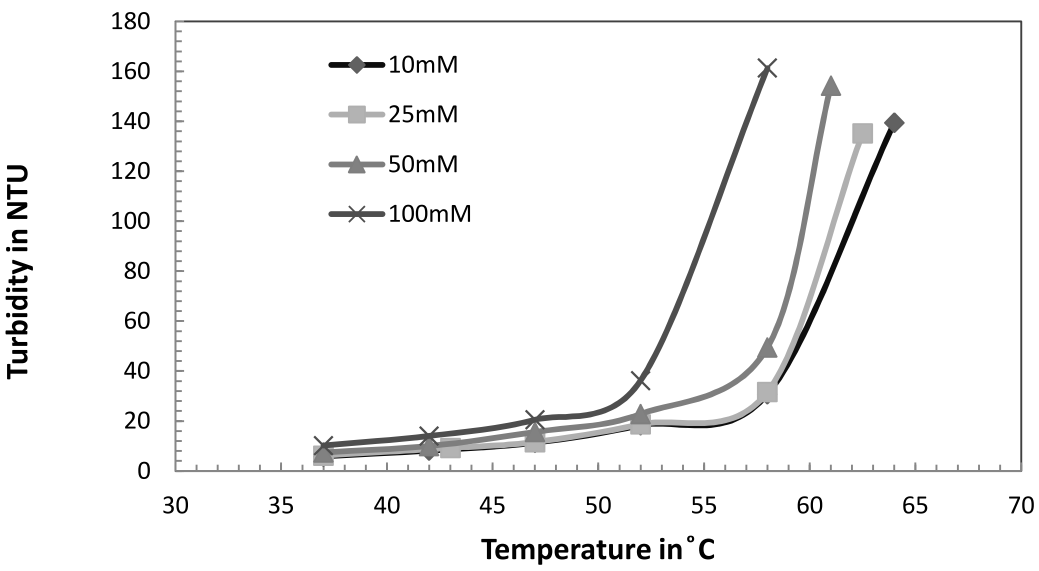

Fig. 4.8: Turbidity for 20mM of TX -100 mixed with different concentration of Na2SO4

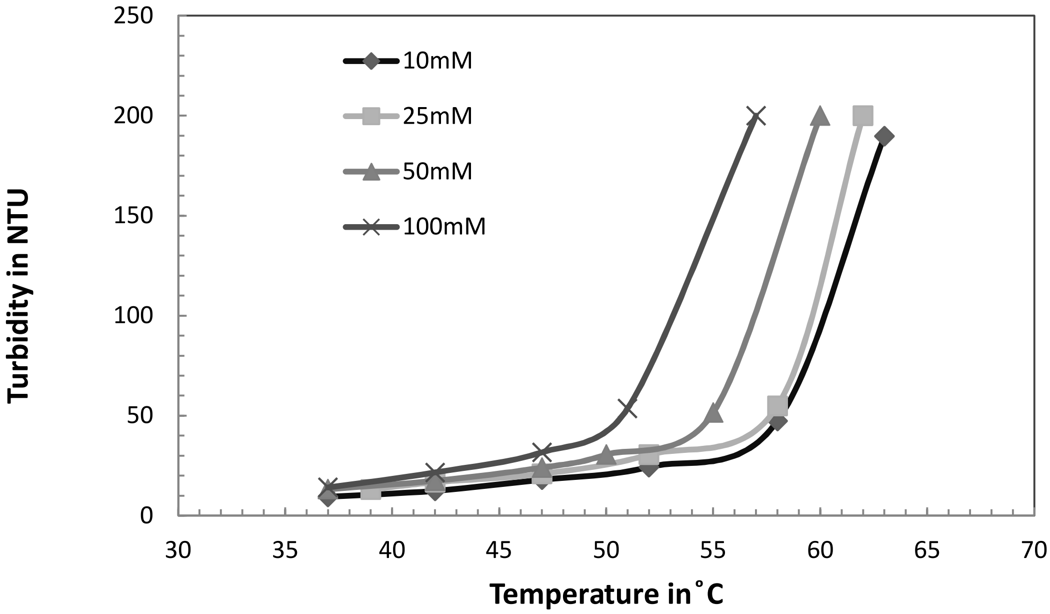

Fig. 4.9: Turbidity for 30mM of TX -100 mixed with different concentration of Na_2SO_4

Figs 4.7, 4.8, 4.9. show a similar pattern for a varying concentration of Na_2SO_4. However, as the concentration of TX-100 increases the curve gets steeper at lower temperature. This implies that the cloud point is being formed at a lower temperature for higher concentration of TX-100 that is mixed with Na_2SO_4.

4.4.2 Effect of $CaCl_2$ on TX-100

Fig. 4.10 denotes the effect of $CaCl_2$ on the cloud point of different concentration of TX-100. It can be noted that the cloud point depressing property of $CaCl_2$ can be effectively determined at lower concentrations of TX-100. For a fixed TX-100 concentration there is a decreasing trend of cloud point, for an increasing concentration of $CaCl_2$. But on comparing cloud point values at fixed $CaCl_2$ concentration of 100 mM, it was observed that for 30 mM TX-100 solution had maximum cloud point depression. Hence it may be recognized that $CaCl_2$ serves as an efficient cloud point depressing agent when used in high concentration along with high concentrations of TX-100.

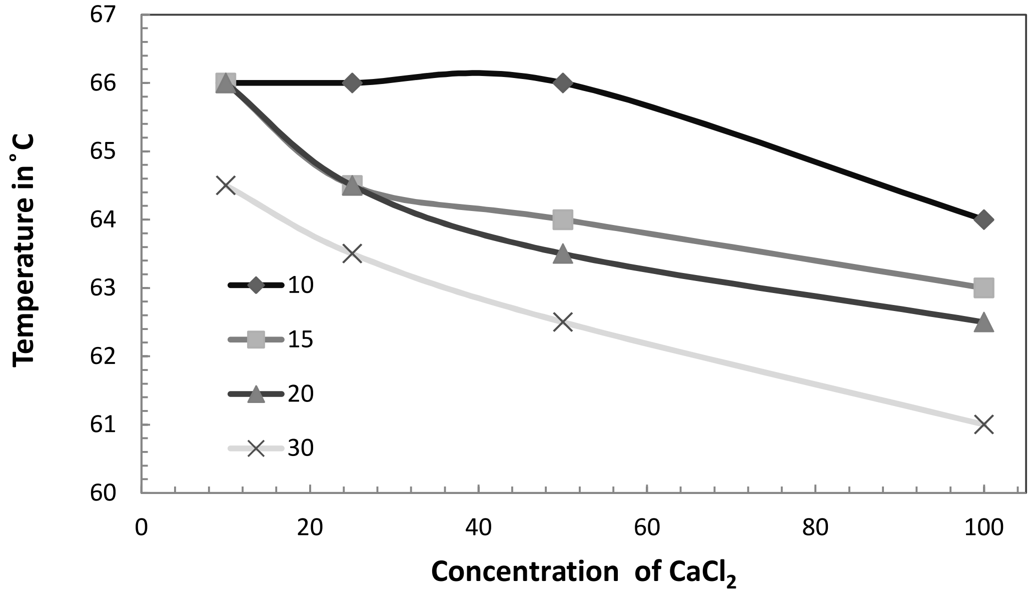

Fig. 4.10: Cloud point of TX-100 with different concentration of $CaCl_2$.

4.4.3 Effect of NaCl on TX-100

When NaCl was used as an additive for cloud point variation there was a cloud point depression observed. The values obtained experimentally were plotted and Fig. 4.11 was obtained. From Fig. 4.11 it can be noted that the cloud point of TX-100 (at fixed concentration) is drastically decreased for an increase in NaCl concentration. However for a fixed concentration of NaCl, the least cloud point can be noted for the highest concentration of TX-100. This implies that the NaCl acts as a good cloud point depressant for high concentration of TX-100.

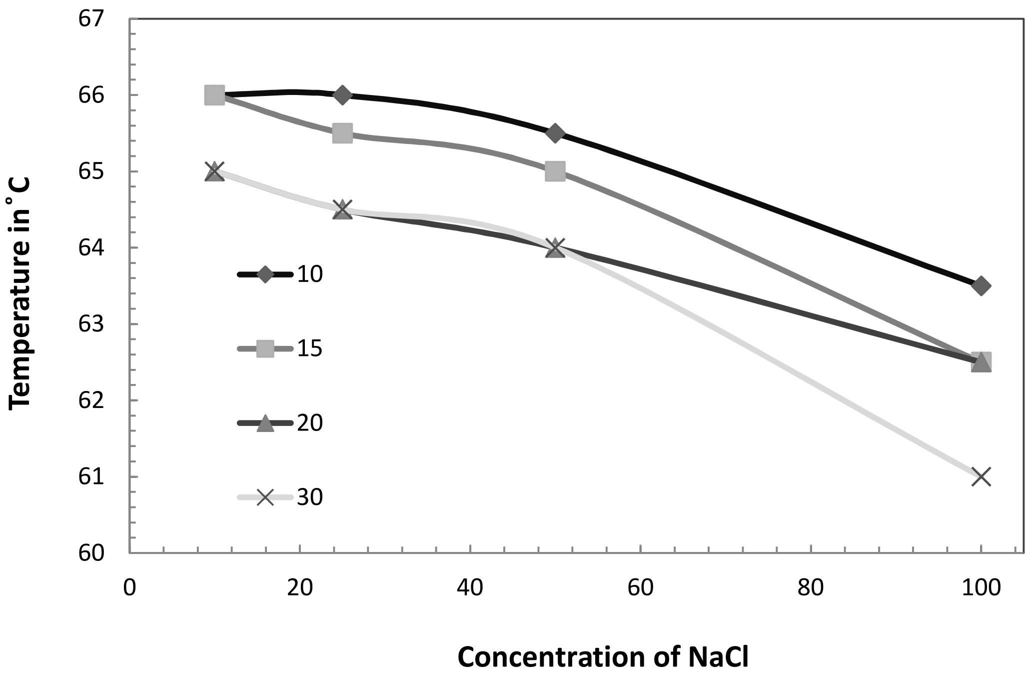

Fig. 4.11: Cloud point of TX-100 with different concentration of NaCl.

Table 4.5. Linear equations for cloud point of TX-100 with different concentration of NaCl.

TX-100 Concentration (mM)	Equation	R^2
10	Y= -0.0292x + 66.6	0.9356
15	Y= -0.0388x + 66.546	0.9705
20	Y= -0.0273x + 65.263	0.9948
30	Y= -0.0446x + 65.687	0.9577

4.4.4 Comparison of Additives

In general, all the additives used in our study have a cloud point depressant role. But our study gives us a general idea about the effect of various additives on the cloud point of TX-100. From these experiments we are able to come to a comparison that 100 mM Na_2SO_4 and 30 mM TX-100 has the maximum cloud point depression with a value of 57 °C. However corresponding 100 mM $CaCl_2$ and NaCl values are 61 °C. Hence Na_2SO_4 may be considered as a better cloud point depressing agent than $CaCl_2$ and NaCl.

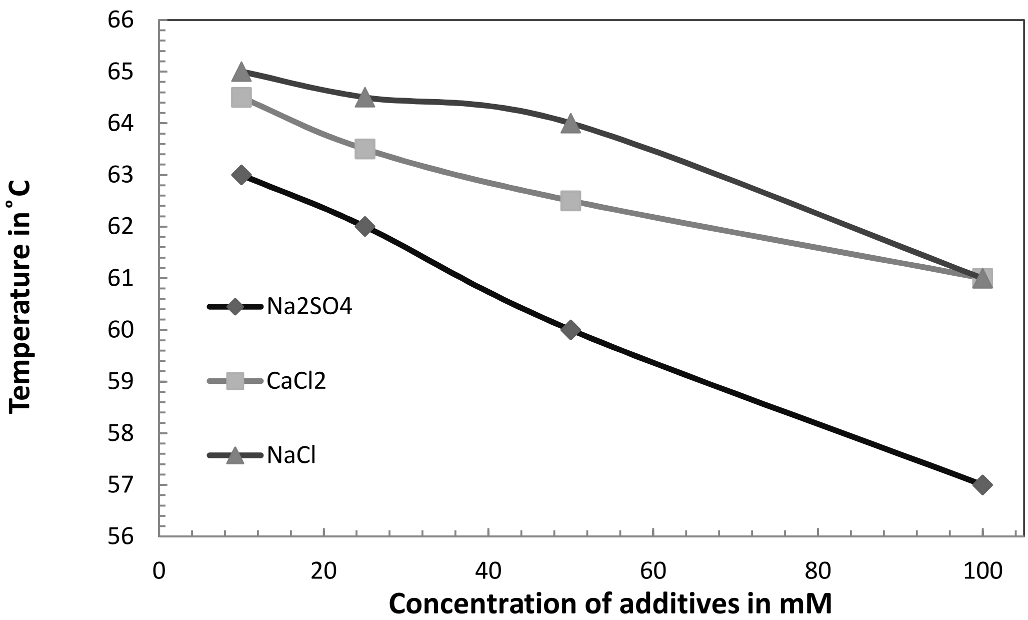

Fig. 4.12: Comparison of cloud point for mixtures of different additives with TX-100

Table 4.6. Comparisons among the linear equations for cloud point of mixture of different additives with TX-100

TX-100 Concentration (mM)	**Equation**	R^2
NaCl	Y = -0.0446x + 65.687	0.9577
$CaCl_2$	Y = -0.0373x + 64.602	0.9739
Na_2SO_4	Y = -0.0669x + 63.596	0.996

CHAPTER 5

CONCLUSION

Conclusion

It is observed that cloud point increases with increase in Triton X-100 concentration. For a fixed Triton X-100 concentration, the cloud point increase as the concentration of ionic surfactant increases.

For a fixed concentration of ionic surfactant, the cloud point decreases with increase in concentration of triton X-100. So an increase in concentration of TX-100 reduces the probability of SDS and CTAB at the surfaces which reduces the cloud point.

For CTAB solution cloud point temperature is higher as compare to SDS.

For a fixed Triton X-100 concentration, the cloud point decreases as the concentration of additives increases.

For a fixed concentration of additives, the cloud point negligibly decreases as the concentration of TX-100 increases.

For Na_2So_4 solution, decrease in cloud point temperature is more as compared to $CaCl_2$ and NaCl.

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