

## **“An electro chemical investigation on the corrosion behavior of ZA-27 alloy in 1M Na<sub>2</sub>SO<sub>4</sub> in the presence of cationic surfactants as inhibitors”**

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**Abstract:** The inhibition of the corrosion of ZA-27 in 1M Na<sub>2</sub>SO<sub>4</sub> by N, N-Dimethyl-N-(2-phenoxyethyl) dodecan-1-aminium bromide (DPDAB) and N,N,N-Trimethyldodecyl ammonium bromide (TDAB) has been investigated using weight loss, potentiodynamic polarization. Results obtained in weight loss studies show that these investigated compounds are good inhibitors and their inhibition efficiencies (IE %) increase with the increase of inhibitor concentration, whereas decreases with increase in immersion time and temperature. Potentiodynamic polarization studies demonstrate the inhibitors under investigation act as mixed type inhibitors and inhibitors changes the mechanism of hydrogen evolution. Effect of temperature is studied between 303 and 333 K differing by 10K. The mechanism of adsorption had been explained on the basis of chemical structure of the investigated inhibitors. It was found that there is a good agreement between the different tested techniques.

**Keywords:** Corrosion inhibition, surfactants, ZA-27 alloy, Na<sub>2</sub>SO<sub>4</sub> Potentio dynamic polarisation, Tafel extra polation.

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### **I. Introduction:**

Zinc and its alloys have been extensively used under different conditions in the chemical and allied industries for handling alkalis, acids and salt solutions and in power generating units, heat exchangers and cooling towers. Zinc is a metal which is mainly used for the corrosion protection of steel [1]. Therefore, zinc and its alloys are considered as industrially important materials. To address the increasing demand for high performance quality die casting, a family of hypereutectic Zn-Al alloys have been developed and are generically identified as ZA-8, ZA-12, ZA-27, where the numerical components designate the appropriate aluminum content. Zn-Al alloys can be used for manufacturing fittings exposed to steam or seawater, gears, bushings and other components subject to friction.

ZA-27 is ultra high performance material having the highest strength and elongation [2]. It has a whole range of applications. The high tensile properties of the alloy, coupled with its cast ability, enable the engineer to use it but at the same time reduce the overall material content of competitive materials. ZA-27 has good bearing properties and is very suitable for wear resistant applications. Therefore, zinc and its alloys are considered as industrially important materials. However, they are corroded by many agents, of which aqueous acids are the most dangerous [3].

The dissolution behavior of zinc and its alloys in acidic and nearly neutral media is known to be inhibited by nitrogen and sulphur containing organic compounds. Such compounds contain electron donating groups that decrease the corrosion rate by increasing the hydrogen overvoltage on the corroding metal [4]. Looking at its increasing use, the study of corrosion inhibition is of paramount importance. Most organic inhibitors are substances with at least one functional group that considered being a reaction centre for the adsorption of the compound on the corroding surface. Efficiency of compounds containing oxygen and nitrogen as inhibitors of corrosion for different metals in different corrosive environments has been studied by several workers [5-7] and their inhibition efficiency is due to the formation of a protective layer or film on the metallic surface.

### **II. Corrosion Inhibitors For Zinc Alloys:**

A number of substances ranging from inorganic to organic compounds investigated as corrosion inhibitors for zinc and its alloys in various corrosive media have been reported. Development of selective and environmentally acceptable corrosion inhibitors as alternatives of chromates [8-9], which are toxic and

carcinogenic, is desirable for inhibition of zinc and galvanized steel corrosion in a neutral chloride solution [10]. Various organic inhibitors have been studied for inhibition of zinc and galvanized steel corrosion in neutral, weak acid and alkaline solutions. They are 2-quinoline carboxylic acid [11], 8-quinolinol [12], salicyl alcohol [13], mercaptobenzothiazole [14], mercaptobenzoxazole [15], benzotriazole [16], 3-amino-5-heptyl-1,2,4-triazole [16], polythioglycolates [17-18] and 2-hydrazone-3-bromo- methylenedithiol [19].

Nitrogen-containing compounds are commonly applied as corrosion inhibitors. The dissolution behavior of zinc in acidic and nearly neutral media is known to be inhibited by nitrogen and sulfur-containing organic compounds. Studies of the effect of organic additives on the corrosion rate of zinc had been the subject of many investigators [20-25]. Hence, the study on corrosion of zinc based alloys and its control is an active area of research.

### **Cationic Surfactants as Corrosion Inhibitors for Zinc Alloys:**

The inhibitors which reduce corrosion of metallic materials are inorganic inhibitors, organic inhibitors, surfactant inhibitors and mixed type inhibitors. Organic inhibitors having multiple bonds in their molecules that mainly contain nitrogen, sulphur and oxygen atoms through which they get adsorbed on the metal surface [26-27].

Surfactants also called surface active agents, are molecules composed of a polar hydrophilic group, the ‘head’ attached to a non-polar hydrophobic group, the ‘tail’. In aqueous solution the inhibitory action of surfactant molecules may be due to physical (electrostatic) adsorption or chemisorption on the metallic surface, depending on the charge of the solid surface and the free energy change of transferring a hydrocarbon chain from water to the solid surface.

Surfactants have many advantages, for example, high inhibition efficiency, low price, low toxicity and easy production [28-29]. The investigation of surfactants adsorbed on metal surfaces is extremely important in electrochemical studies such as corrosion inhibition, adhesion, lubrication and detergency. The effective types of corrosion inhibitors for these applications are film forming inhibitors. Now a day, surfactants are widely used and find a very large number of applications in petroleum industry. This is attributed to their significant capability to influence the properties of surfaces and interfaces. The most important action of inhibition is the adsorption of the surfactant functional group on to the metal surface [30], adsorption being critical to corrosion inhibition. The ability of a surfactant molecule to adsorb is generally related to its ability to aggregate to form micelles.

In the case of Anionic surfactants, the anion is the surface active species. Most important reason for their popularity is the ease and low cost of manufacture. Sodium dodecyl sulfate (SDS) is by far the most important anion surfactant. On the other hand, Nonionic surfactants do not have any surface charge and have either a polyether or a polyhydroxyl unit as the non-polar group. In cationic surfactants, cation is the surface active species. The majority of cationic surfactants are based on nitrogen atom carrying the cationic charge. Both amine and quaternary ammonium based products are common. The amines only function as a surfactant in the protonated state, therefore they cannot be used at high pH. Quaternary ammonium compounds on the other hand are not pH sensitive. Non-quaternary cations are very much sensitive to polyvalent anions. However, Zwitterionic surfactants have two charged groups of different size. While the positive charge is almost invariably ammonium, the source of negative charge may vary, although carboxylate is by far the most common. Zwitterionics are often referred to as ‘amphoterics’. An amphoteric surfactant is one that changes from net cationic via Zwitterionic to net anionic on going from low to high pH. Neither the acidic nor the basic site is permanently charged i.e, the compound is only Zwitterionic over a certain pH range. The change in the charge with pH of the truly amphoteric surfactant naturally affects properties such as foaming, wetting, detergency etc.

All these properties strongly depend on the solution pH. Surfactants containing perfluorinated hydrophobic moieties are used in a wide variety of applications, ranging from fire extinguishing medium to electroplating additives and water repellent fiber coatings [31]. The promising potential application of surfactants as corrosion inhibitors has been studied widely over the past few years. It is well known that surfactants have a tendency to associate with one another at interfaces and in solution to form aggregates [32]. The adsorption is critical to corrosion inhibition and the primary action of the surfactant functional group is to get adsorbed on the metal surface. Adsorption of the surfactant molecules onto the metal surface was found to be responsible for the corrosion inhibition of the metal and in general directly related to its capability to aggregate forming micelles [32-35]. Consequently, a better understanding of the relation between the adsorption of the surfactant molecules onto the metal surface and corrosion inhibition is of great importance for both theoretical and experimental reasons. A number of studies have been carried out to reduce the zinc corrosion in acidic media by means of surfactants. Applications of cationic surfactants include softeners, cosmetic products and the stabilization of adhesive polymer latex as well as mining and paper manufacturing [36].

The present investigation is confined to the study of inhibiting action of non toxic and non carcinogenic

cationic surfactants on the corrosion behavior of zinc based alloy ZA-27. In this context, an extensive investigation on the corrosion inhibition of above said alloys in 1M Na<sub>2</sub>SO<sub>4</sub> has been done. The detailed investigation includes the effect of concentration of the inhibitors, temperature and also the immersion time on the corrosion rate of ZA-27 alloy.

### III. Materials and Methods

#### 2.1. Procurement and moulding of Zinc alloys:

ZA-27 alloys in the form of ingots were procured from M/S. Fenfee Metals, Bangalore, manufacturers of various kinds of quality metal alloys. The typical chemical composition in weight percentage of ZA-27 selected for the investigation is shown in Table 1.

**Table.1 Typical Chemical Composition of ZA-27**

Alloy	Al wt%	Cu wt%	Mg wt%	Fe wt%	Pb wt%	Cd wt%	Sn wt%	Zn wt%
ZA 27	26.0-28.0	2.0-2.5	0.01-0.02	Max. 0.075	Max. 0.006	Max. 0.006	Max. 0.003	Remaining

The alloy was melted by using electrical furnace (Fig 1a). The melt was thoroughly stirred using a mechanical stainless steel stirrer (Fig 1b) coated with alumina to prevent migration of ferrous ions from the stirrer material to the zinc alloy and subsequently degasified by the addition of degassifier. Castings were produced in permanent moulds in the form of cylindrical rods (Fig 1c) of dimensions 26 mm dia and 170 mm length by Gravity Die casting Method.



(Fig 1a)



(Fig 1b)



(Fig 1c)

#### 2.2. Specimen preparation for weight loss studies:

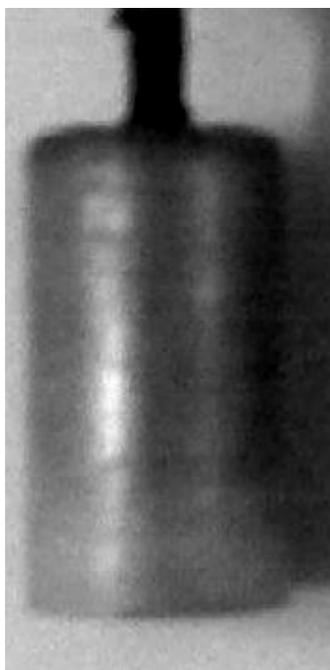
Cylindrical alloy rods were cut into 24 mm dia x 2mm height circular disc specimens using an abrasive cutting wheel and a 2 mm mounting hole (Fig 2) at the centre of the specimen was drilled for weight loss experiments. Before each experiment, the electrodes were abraded with a series of emery papers of different grades (600, 800, and 1200), washed with double distilled water, rinsed with acetone and dried at 353 K for 30 min in a thermostated electric oven and stored in a desiccator prior to use.



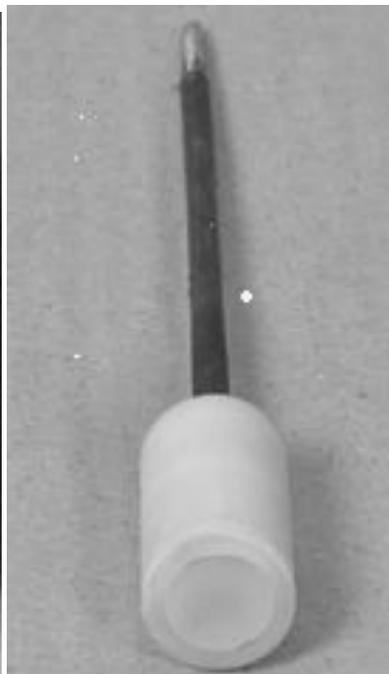
(Fig 2)

### 2.3. Specimen preparation for electro chemical measurements:

The cylindrical test specimens were moulded in cold setting acrylic resin (Fig 3a and 3b), thus a surface area of 1.0 cm<sup>2</sup> of alloy was exposed to corrosive medium in electrochemical measurements. Before each experiment, the electrodes were abraded with a series of emery papers of different grades (600, 800, and 1200), washed with double distilled water, rinsed with acetone and dried at 353 K for 30 min in a thermostat electric oven and stored in desiccator prior to use.



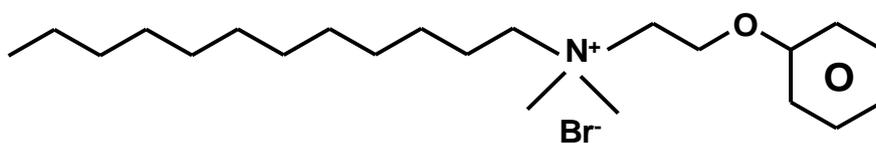
(Fig 3a)



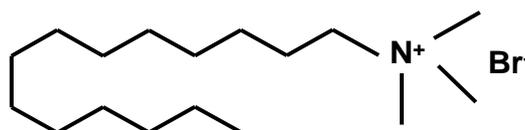
(Fig 3b)

## IV. Inhibitors

3.1 In the present study, N, N-Dimethyl-N-(2-phenoxyethyl) dodecan-1-aminium bromide (DPDAB) and N,N,N-Trimethyldodecyl ammonium bromide (TDAB) have been selected for the study and their structures are as follows.



N, N-Dimethyl-N-(2-phenoxyethyl) dodecan-1-aminium bromide (DPDAB)



N,N,N-Trimethyldodecyl ammonium bromide (TDAB)

### 3.2. Preparation of inhibitor solution:

All the solutions for the experiment were prepared using AR grade chemicals in double distilled water. The inhibitor concentrations such as 100,200,300 and 400 ppm were used and the temperatures being 303, 313, 323 and 333±1 K using thermostat water bath in all the experimental work. Fresh solutions were used for each experiment.

### 3.4 .Preparation of corrosion medium:

In the present work, 1M Na<sub>2</sub>SO<sub>4</sub> was used as the corrosive media which contained the desired quantity of the inhibitor (100ppm to 400ppm).The corrosive media selected for this study were prepared from analytical grade Merck chemicals in double distilled water.

## V. Experimental Methods:

As metallic corrosion is highly diverse in its occurrence, no universal testing procedure is found satisfactory to cover all aspects of corrosion. But for reproducible and informative evaluation, it is very essential to select a relevant method to correlate laboratory tests with actual service conditions. Detailed information regarding the suitable method to be adopted in corrosion testing is available in literature [37-42]. Though absolute reproducibility is rather impossible to achieve due to several factors, reproducibility within a reasonable degree of accuracy is of considerable importance. According to Evans [43] and Champion [38], this is possible by taking precautionary measures regarding the size and shape of the specimen, design of the set up, time of exposure and a careful control of experimental conditions such as temperature and stirring of the corroding medium. It is also desirable to perform the tests at least in duplicate or triplicate to minimize the error. The surface treatment of the test specimen prior to corrosion tests is another important factor. The exposed surface should be free from oxides, grease etc., for unambiguous results.

In the present work, a systematic and comprehensive approach to the understanding of the corrosion process during corrosion of ZA-27 alloys has been made as under.

### 4.1. Weight loss measurements

Weight loss measurements were performed on test specimens as per ASTM Method [44].The specimens were immersed in 100ml solution of corrosive medium in absence and presence of different concentrations of all the inhibitors at different temperatures and in thermostat water bath. The difference in weight for an exposed period of 2, 4, 6 and 8 hours was taken as the total weight loss. The weight loss experiments were carried out in triplicate and average values were recorded.

### Calculation of corrosion rate

The corrosion rate (CR) was evaluated as per ASTM Method using equation (1).

$$CR = \frac{K \times W}{DAT} \quad \text{-----} \quad (1)$$

Where, CR= Corrosion rate in mmpy,

K = a constant (8.76x 10<sup>4</sup>)

W = Weight loss in grams

D = Density in g/cm<sup>3</sup>

A= Surface area of test specimen in cm<sup>2</sup> and

T = Time of exposure in hours.

### Calculation of corrosion efficiency:

The percentage of inhibition efficiency ( $\mu_{WL\%}$ ) and the degree of surface coverage ( $\theta$ ) were calculated using the following equations(2) and (3).

$$\mu_{WL\%} = \frac{W_o - W_i}{W_o} \times 100 \quad \text{-----} \quad (2)$$

$$\theta = \frac{W_o - W_i}{W_o} \quad \text{-----} \quad (3)$$

Where  $W_o$  and  $W_i$  are the weight loss values of specimen in the absence and presence of the inhibitor and  $\theta$  is the degree of surface coverage of the inhibitor.

### 4.2. Potentiodynamic Polarization studies(Tafel Extrapolation)

The electrochemical experiments were carried out in a conventional three electrode cell(Fig 4). The specimen samples were welded with copper wire and embedded in teflon holder using epoxy resin with an exposed area of 1 cm<sup>2</sup> as working electrode, a platinum foil of 1cm<sup>2</sup> was used as counter electrode and the reference electrode was a saturated calomel electrode (SCE) with a Luggin capillary, which can be at close proximity to the working electrode to minimize ohmic drop. All potentials are measured with respect to the SCE. The polarization studies were carried in 1M Na<sub>2</sub>SO<sub>4</sub> as corrosive media without and with inhibitors using CHI Electrochemical workstation model 660C series from Sinsil International.



(Fig 4)

Tafel plots were obtained by polarizing the electrode automatically from -250 to + 250mV with respect to open circuit potential (OCP) at a scan rate 10mV s<sup>-1</sup>. The linear Tafel segments of anodic and cathodic curves were extrapolated to corrosion potential (E<sub>corr</sub>) to obtain corrosion current densities (I<sub>corr</sub>). Using Potentiodynamic Polarization parameters Corrosion Current (I<sub>corr</sub>), Corrosion Potential (E<sub>corr</sub>), Anodic and Cathodic Slopes (b<sub>a</sub> and b<sub>c</sub>) and Corrosion Rate (C.R.) were Evaluated. The inhibition efficiency (μ<sub>p</sub>%) was evaluated from the I<sub>corr</sub> values using the following relationship(4) .

$$\mu_p\% = \frac{I_{corr}^0 - I_{corr}}{I_{corr}^0} \times 100 \quad \text{-----(4)}$$

Where, I<sub>corr</sub><sup>0</sup> and I<sub>corr</sub> are values of corrosion current densities in absence and presence of inhibitor respectively.

## VI. Results And Discussion

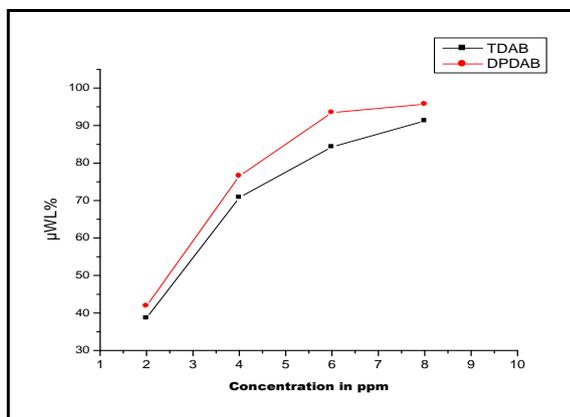
### 5.1 Weight loss measurements

Fig 5 shows the effect of increasing concentrations of surfactants DPDAB and TDAB on the corrosion of ZA-27 alloy in Na<sub>2</sub>SO<sub>4</sub> at 303K. The calculated values of the percentage inhibition efficiency (μ<sub>WL</sub>%) are listed in Table 2. Inspection of the values in the Table reveals that inhibition efficiency increased with increase in the concentration of inhibitor. Increase in inhibition efficiency at higher concentration of inhibitor may be attributed to larger coverage of metal surface with inhibitor molecules. The linearity obtained indicates that insoluble surface film formed during corrosion and that the inhibitors were first adsorbed onto the metal surface and therefore, impede the corrosion process[45]. Increase in inhibition efficiency at higher concentration of inhibitor may be attributed to larger coverage of metal surface with inhibitor molecules. The maximum inhibition efficiency was achieved at 400 ppm and a further increase in inhibitor concentration caused no appreciable change in performance. All the investigated cationic surfactants show a decrease in inhibition efficiency with increase in immersion time from 2 to 8 hours as shown in fig 6. The calculated values of the percentage inhibition efficiency (μ<sub>WL</sub>%) at different time of exposure are listed in Table 3. This indicates desorption of the inhibitor molecules over a longer test period and may be attributed to various other factors such as formation of less persistent film on the metal surface, and increase in cathodic reaction. The inhibition efficiency for the two inhibitors DPDAB and TDAB decreases with increase in temperature from 303 to 333±1K as shown in fig 7. The decrease in inhibition efficiency with rise in temperature were tabulated in table 4. The decrease in inhibition efficiency with rise in temperature may be attributed to desorption of the inhibitor

molecules from metal surface at higher temperatures and higher dissolution rates of zinc alloy at elevated temperatures. The variation of corrosion rate and surface coverage as a function of concentration of inhibitors are also shown in fig 8. The calculated values of corrosion rates and surface coverage are tabulated in table 5. It is observed that the surface coverage and % of inhibition efficiency is more in DPDAB than that of TDAB. This is attributed to the stronger adsorption of DPDAB on alloy surface due to the presence of more number of electronegative atoms and aromatic ring with high molecular mass when compared to that of TDAB.

**Table 2:** Weight loss parameters for ZA-27 in 1M Na<sub>2</sub>SO<sub>4</sub> in the absence and presence of various concentrations of DPDAB and TDAB inhibitors at 2 hours of exposure time

Inhibitor	Concentration (ppm)	CR (mils/year)	θ	μ <sub>WL</sub> %
TDAB	Blank	132.90 x10 <sup>2</sup>	---	---
	100	81.56 x10 <sup>2</sup>	0.38	38.63
	200	38.76 x10 <sup>2</sup>	0.70	70.80
	300	20.89 x10 <sup>2</sup>	0.84	84.28
	400	11.64 x10 <sup>2</sup>	0.91	91.24
DPDAB	Blank	122.22 x10 <sup>2</sup>	---	---
	100	71.04 x10 <sup>2</sup>	0.39	41.87
	200	28.64 x10 <sup>2</sup>	0.76	76.56
	300	7.98 x10 <sup>2</sup>	0.93	93.45
	400	5.25 x10 <sup>2</sup>	0.95	95.70



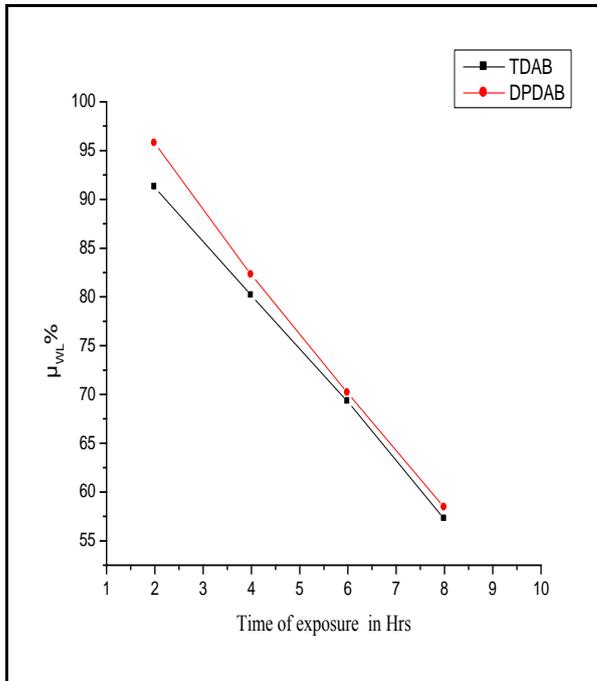
**Fig:5** Variation of inhibition efficiency with concentration of inhibitors DPDAB &TDAB

**Table :3** Inhibition efficiency of inhibitors With time of exposure

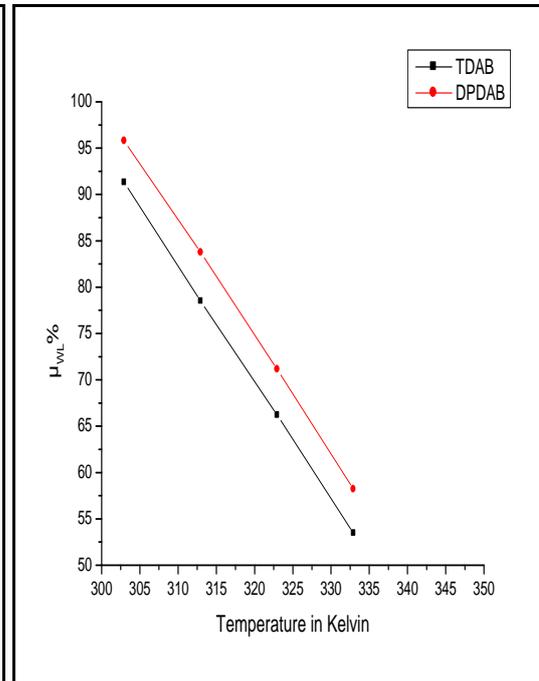
Inhibitor	Time in Hrs	μ <sub>WL</sub> %
TDAB	2	91.24
	4	80.12
	6	69.24
	8	57.23
DPDAB	2	95.71
	4	82.23
	6	70.14
	8	58.39

**Table :4** Inhibition efficiency of inhibitors with temperature

Inhibitor	Temperature in K	μ <sub>WL</sub> %
TDAB	303	91.24
	313	78.42
	323	66.12
	333	53.39
DPDAB	303	95.71
	313	83.68
	323	71.06
	333	58.14



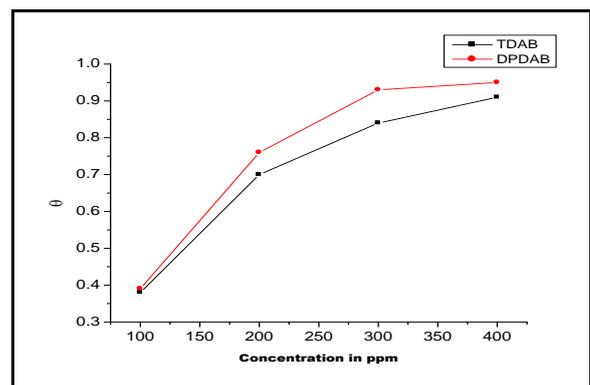
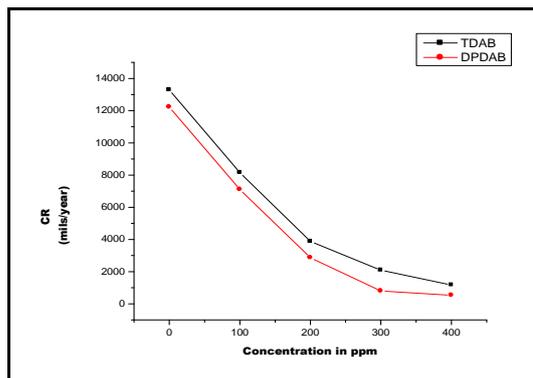
**Fig:6** Variation of inhibition efficiency with Time of exposure



**Fig:7** Variation of inhibition efficiency with temperature

**Table:5** Corrosion rate and Surface coverage in the presence and absence of inhibitors

Inhibitor	Concentration (ppm)	CR (mils/year)	θ
TDAB	Blank	132.90 x10 <sup>2</sup>	---
	100	81.56 x10 <sup>2</sup>	0.38
	200	38.76 x10 <sup>2</sup>	0.70
	300	20.89 x10 <sup>2</sup>	0.84
	400	11.64 x10 <sup>2</sup>	0.91
DPDAB	Blank	122.22 x10 <sup>2</sup>	---
	100	71.04 x10 <sup>2</sup>	0.39
	200	28.64 x10 <sup>2</sup>	0.76
	300	7.98 x10 <sup>2</sup>	0.93
	400	5.25 x10 <sup>2</sup>	0.95



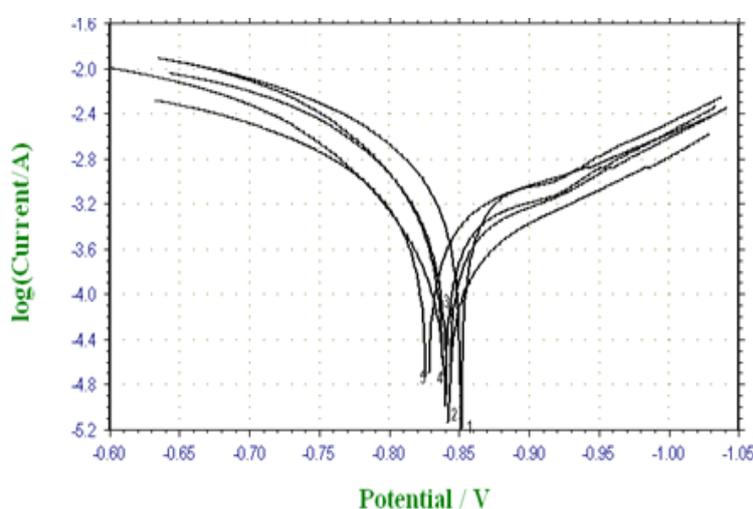
**Fig:8** Variation of corrosion rate and surface coverage with concentration of inhibitors TDAB & DPDAB

**5.4 Potentiodynamic polarization (PDP)measurements:**

The polarization measurements of ZA-27 specimens were carried out in 1M Na<sub>2</sub>SO<sub>4</sub> in the absence and presence of different concentrations (100 - 400 ppm) of DPDAB and TDAB at 303±1K in order to study the anodic and cathodic reactions. The Potentiodynamic polarisation curves (Tafel plots) of ZA-27 alloy in 1 M Na<sub>2</sub>SO<sub>4</sub> in the absence and presence of various concentrations of DPDAB and TDAB 303±1K were analysed. The electrochemical parameters i.e. corrosion potential ( $E_{corr}$ ), corrosion current density ( $I_{corr}$ ), cathodic and anodic Tafel slopes ( $b_a$  and  $b_c$ ) associated with the polarization measurements are recorded. The corrosion current densities were determined from the intersection by extrapolating the cathodic and anodic Tafel lines. The inhibition efficiency ( $\mu_p$  %) of inhibitors (at different concentrations) was calculated from the equation (4). It is observed from the PDP results, that the corrosion potential shifts to positive potential with respect to the blank but the displacement in corrosion potential is less than 35 mv for all inhibitors. According to Ferreria [46] and Li [47] if the displacement in corrosion potential is more than 85mV with respect to the corrosion potential of the blank, the inhibitor can be seen either as a cathodic or anodic type. The maximum displacement was less than 35 mV which indicates that the cationic surfactants acts as mixed type inhibitors [47]. It is also observed from the data that both anodic and cathodic slopes increases thereby suggesting that the inhibitor acts as mixed type inhibitors. It can be seen from polarization results, the corrosion current density decreases with increase in inhibitor concentration for DPDAB and TDAB inhibitors and inhibition efficiency increases with increase in concentration. From the polarization studies the order of inhibitor efficiency for ZA-27 alloy was found to be DPDAB> and TDAB.

**Table: 6** Potentiodynamic polarization parameters of ZA-27 alloy in 1M Na<sub>2</sub>SO<sub>4</sub> in the absence and presence of various concentrations of inhibitor TDAB at 303±1K.

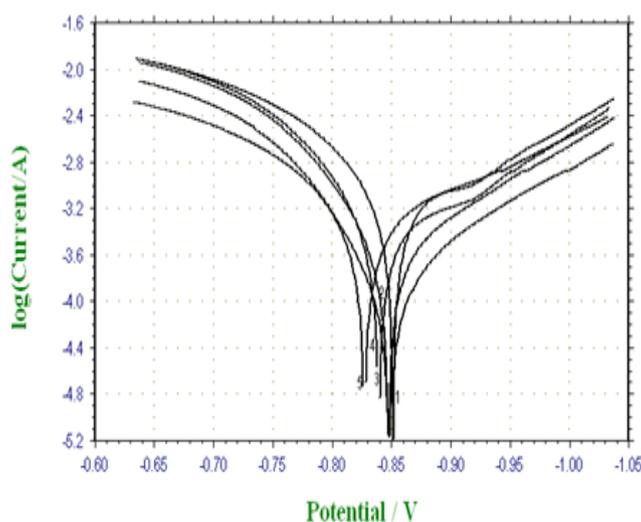
Tafel data						
Inhibitor	Concentration (ppm)	$-E_{corr}$ (mV vs. SCE)	$I_{corr}$ (mA cm <sup>-2</sup> )	$b_c$ (mV dec <sup>-1</sup> )	$b_a$ (mV dec <sup>-1</sup> )	$\mu_p$ %
TDAB	Blank	850	1.24	148.21	130.58	---
	100	840	0.69	154.67	142.59	44.35
	200	835	0.33	158.12	164.55	73.38
	300	827	0.19	226.91	177.05	84.67
	400	818	0.09	256.67	190.77	92.74



**Fig: 9** Potentiodynamic polarization curves (Tafel plots) of ZA-27 alloy in 1M Na<sub>2</sub>SO<sub>4</sub> in the absence and presence of various concentrations of TDAB at 303±1 K.

**Table: 7** Potentiodynamic polarization parameters of ZA-27 alloy in 1M Na<sub>2</sub>SO<sub>4</sub> in the absence and presence of various concentrations of inhibitor DPDAB at 303±1K.

Tafel data						
Inhibitor	Concentration (ppm)	-E <sub>corr</sub> (mV vs. SCE)	I <sub>corr</sub> (mA cm <sup>-2</sup> )	b <sub>c</sub> (mV dec <sup>-1</sup> )	b <sub>a</sub> (mV dec <sup>-1</sup> )	μ <sub>p</sub> %
DPDAB	Blank	852	1.24	148.30	104.49	---
	100	847	0.58	155.20	112.8	53.22
	200	836	0.28	160.59	161.89	80.64
	300	825	0.12	171.644	165.23	90.30
	400	816	0.03	177.809	169.28	97.58



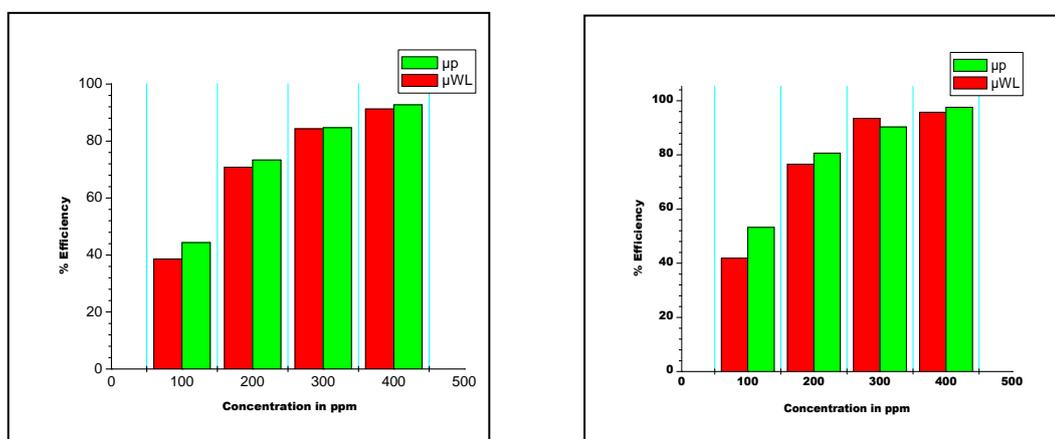
**Fig: 10** Potentiodynamic polarization curves (Tafel plots) of ZA-27 alloy in 1M Na<sub>2</sub>SO<sub>4</sub> in the absence and presence of various concentrations of DPDAB at 303±1 K.

**Table 8:** Surface coverage and inhibition efficiency of inhibitors at 303±1K for ZA-27 alloy in 1M Na<sub>2</sub>SO<sub>4</sub> in the presence of various concentrations of inhibitors by polarisation method

Inhibitor	Concentration (ppm)	I <sub>corr</sub> (mA cm <sup>-2</sup> )	θ	μ <sub>p</sub> %
TDAB	Blank	1.24	---	---
	100	0.69	0.44	44.35
	200	0.33	0.73	73.38
	300	0.19	0.84	84.67
	400	0.09	0.92	92.74
DPDAB	Blank	1.24	---	---
	100	0.58	0.53	53.22
	200	0.28	0.80	80.64
	300	0.12	0.90	90.30
	400	0.03	0.97	97.58

**Table 9:** Comparison of inhibition efficiency and surface coverage by weight loss and polarisation methods

Inhibitor	Concentration (ppm)	$\mu_{WL}\%$	$\mu_p\%$	$\theta_{WL}$	$\theta_{\mu_p}$
TDAB	Blank	---	---	---	---
	100	38.63	44.35	0.38	0.44
	200	70.80	73.38	0.70	0.73
	300	84.28	84.67	0.84	0.84
	400	91.24	92.74	0.91	0.92
DPDAB	Blank	---	---	---	---
	100	41.87	53.22	0.39	0.53
	200	76.56	80.64	0.76	0.80
	300	93.45	90.30	0.93	0.90
	400	95.70	97.58	0.95	0.97



**Fig:11** Variation of inhibition efficiency of TDAB and DPDAB on ZA-27 alloy in Na<sub>2</sub>SO<sub>4</sub> by weight loss and polarisation methods

### VII. Conclusions

Following Conclusions Can Be Drawn From The Above Experimental Results.

1. The cationic surfactants DPDAB and TDAB used as corrosion inhibitors for ZA-27 in 1 M Na<sub>2</sub>SO<sub>4</sub> act as an efficient inhibitors.
2. The inhibition efficiency increases with the increase of inhibitor concentration and decreases with rising of temperature.
3. The data obtained from all different techniques namely weight loss, potentiodynamic Polarization are in good agreement.
4. The inhibition efficiency of the investigated compounds decreases in the following order DPDAB > TDAB. This is attributed to the adsorption of cationic species on the alloy surface by electrostatic interaction via pi electrons of benzene ring with the surface of alloy.

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