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Inhibition Efficiency of Sodium Potassium Tartrate – Al^{3+} Mixed Inhibitors on Mild Steel in Ground Water

N. Parameswari [1], M.Karpagavalli [2] Angel.B.Ponmalar [3] Rane Caroleena Ganesh[4] and R.K.Seenivasan[5]

[1&2]. PG and Research Department of Chemistry, The Madura College, Madurai, Tamilnadu

[3] Department of Chemistry, PSN College of Engineering and Technology, Tirunelveli, Tamilnadu

. [4] Department of Chemistry, Sidharth College, Badlapur, University of Mumbai, India

[5] Department of chemistry, Government Arts College, Melur, Madurai-625007, Tamilnadu

ABSTRACT

This exploration means to examine the Corrosion hindrance conduct of Sodium Potassium Tartrate (SPT) in blend with Aluminium particle (Al^{3+}) on the consumption of carbon steel in ground water utilizing weight loss strategy. After effects of weight loss technique demonstrate inhibition efficiency (IE) expanded with expanding inhibitor fixation.

Key words: Carbon steel, Corrosion, synergistic impact, Sodium Potassium Tartrate

1. INTRODUCTION

Corrosion is a naturally occurring phenomenon which deteriorates a metallic material or its properties because of a reaction with its environment. Corrosion can cause dangerous and expensive damage to everything from pipelines, bridges and public buildings to vehicles, water and wastewater systems, and even home appliances. It is one of the most serious problems in the oil and gas industry. The uses of organic and inorganic inhibitors are the most widely practical methods for protection of metals and alloys against corrosion. The efficiency of an organic compound as a corrosion inhibitor is closely associated with the chemical adsorption [1-4]. Most well-known organic inhibitors contain nitrogen, sulfur, and oxygen atoms due to their ability to form an adsorbed protective film at the metal/ media interface. Studies report that the adsorption of organic inhibitors mainly depend on some physicochemical properties of the molecule, related to its functional groups, to the possible steric effects and electronic density of donor atoms: adsorption is supposed also to depend on the possible interaction of P-orbital of the inhibitor with d- orbital of the surface atoms, which induce greater adsorption of the inhibitor molecules onto the surface of carbon steel, leading to the formation of a corrosion protective film [5].

A survey of the available literature reveals that the Corrosion inhibition of 2-naphthalenesulfonic acid, 2, 7-naphthalenedisulfonic acid and 2-naphthol-3, 6-disulfonic acid on Armco- iron electrode in sulfuric acid has been investigated by Vracar and Drazic. The inhibition efficiency, changes with the number of functional groups substituted on the benzene ring and increases with concentration [6]. The inhibition action of 2-mercaptobenzoxazol, 2- mercapto benzimidazole, N-cetyl pyridinium bromide and propargyl benzene sulphonate on the corrosion of carbon steel in acid media has also been studied by Prakash Rajesh Kumar Singh and Ranju Kumar. The corrosion inhibitors are used to reduce corrosion damage in sub-surface equipments in oil well fields. The corrosion inhibition activity was studied by gravimetric and Potentiostatic polarization methods in presence of 20% HCl [7]. Manickavasagam, et al., has reported the corrosion inhibition of Poly (Styrene sulphonic acid) - doped poly aniline on carbon steel in acid media. The polymer acts as an anodic inhibitor. The adsorption of the compound on the metal surface obeys Temkin’s adsorption isotherm [8]. Aliev has described the influence of salts of Alkyl phenol Sulphonic acid on the corrosion of ST3 steel. The protective effect increases with temperature. The investigated compounds inhibit corrosion of ST3 steel as a result of chemical adsorption [9]. Shakthivel and Vasudevan have studied the effect of Acrylic acid-diphenylamine sulphonic acid copolymer as threshold inhibitor for sulphate and carbonate scales in cooling water systems. The results show that the polymer acts as a very good ant scaling inhibitor both in the carbo nate and sulphate brines. Copolymer of acrylic acid-diphenyl amine sulphonic acid can be used safely in cooling water systems [10]. Perusal of several literatures reveals that there is no information regarding the use of Sodium Potassium Tartrate (SPT) in combination with aluminium ion (Al^{3+}) as corrosion inhibitor. This paper focuses on the IE of SPT in controlling corrosion of carbon steel immersed in dam water in the absence and presence of Al^{3+}. The medium which is used in the present study is ground water collected from kanyakumari (near sea shore area) in the state of Tamil Nadu, India.

2. EXPERIMENTAL METHOD

The chemicals used in this study, Sodium Potassium Tartrate (SPT) and Al^{3+} ions (Aluminium sulphate $Al_2(SO_4)_3 .16H_2O$) co inhibitor were AR grade.

2.1.Preparation of the specimen

Carbon steel specimens of size 1.0 cm × 4.0 cm × 0.2 cm, (area 10 cm2) and chemical composition 0.026 % Sulphur, 0.06 % Phosphorous, 0.4 % Manganese, 0.1 % Carbon and the rest iron (density 7.87 gm/cm3), were polished to a mirror finish and degreased with trichloroethylene and used for the weight loss method and surface examination studies.

2.2. Weight–loss method

Carbon steel specimens were immersed in 100 ml of the medium containing various concentrations of the inhibitor (SPT) in the absence and presence of Al^{3+} for 3 days. The weights of the specimens before and after immersion were determined using a Digital Balance (Model AUY 220 SHIMADZU). The corrosion products were cleaned with Clarke's solution prepared by dissolving 20 gms of Sb_2O_3 and 50 gms of $SnCl_2$ in one litre of Conc.HCl of specific gravity (1.9) [11]. The corrosion IE was then calculated using the equation

$$\mathbf{IE = 100\ [1-(W2/W1)]\ \%} \text{ --------------- } \mathbf{(1)}$$

Where W_1 is the weight loss value in the absence of inhibitor and W_2 is the weight loss value in the presence of inhibitor. Corrosion rates were calculated using the following relationship.[12]

$$\text{Corrosionrate} = \frac{\text{Loss in weight (mg)}}{\text{Surface area of the specimen}(\text{dm}^2)\text{xPeriod of immersion}(\text{days})} \text{ ----- (2)}$$

The corrosion rate is expressed in mdd units [mdd = mgm/(dm^2) (day)].

2.3.Influence of Duration of Immersion on the IE

The power of duration of immersion on the IE of the SPT- Al^{3+} system has been studied for 1,3,5 and 7 days.

2.4. Influence of pH on the IE of SPT- Al^{3+} System

Influence of pH on the IE of SPT- Al^{3+} System has been analysed various from 6 to 12.

2.5. Synergism Parameters (S1)

The synergism parameter is calculated using the following equation:[12]

$$S_I = \frac{1 - I_{1+2}}{1 - I'_{1+2}}$$

Where;

S_I= synergism parameter

$I_{1+2} = (I_1 + I_2) - (I_1 . I_2)$

I_1= Inhibition efficiency of SPT

I_2= Inhibition efficiency of Al^{3+}

I'_{1+2} = combined inhibition efficiency of substance SPT and substance Al^{3+}

3.0. RESULTS AND DISCUSSION

The different boundaries of ground water are given in Table 1.The hindrance efficiencies (IE) of SPT in controlling consumption of carbon steel in ground water, for a time of three days in the nonattendance and nearness of Al^{3+} by weight reduction strategy are given in Tables 2 to 6. SPT alone has nearly 87.6% IE, while Al^{3+} has 7.6% IE. Without SPT, the pace of transport of Al^{3+} from the bulk part of the solution towards the metal surface is moderate [13].At the point when SPT is joined with Al^{3+} particles it is discovered that the their blend shows 97% IE. This proposes a synergistic impact among SPT and Al^{3+} particles; SPT can move Al^{3+} towards the metal surface.

Table I.THE PARAMETERS OF GROUND WATER WHICH IS USED FOR INVESTIGATION

Parameter	Value
pH	8.0
TDS	810 mg/l
Alkalinty	389 mg/l
Chloride	15 mg/l
Sulphate	17 mg/l
Calcium	82 mg/l
Magnesium	92 mg/l
Barium	14mg/l

Table 2.CORROSION RATE (CR) OF CARBON STEEL IN GROUND WATER IN THE PRESENCE OF INHIBITOR SYSTEM AND THE INHIBITION EFFICIENCY (IE) OBTAINED BY WEIGHT LOSS METHOD

Inhibitor system: SPT + Al^{3+} (0 ppm) Immersion period –3 days

SPT ppm	Al^{3+} ppm	CR mdd	IE %
0	0	19.52	-
50	0	6.54	66.5
100	0	15.95	18.3
150	0	2.39	87.76
200	0	8.58	56

Table 3. CORROSION RATE (CR) OF CARBON STEEL IN GROUND WATER IN THE PRESENCE OF INHIBITOR SYSTEM AND THE INHIBITION EFFICIENCY (IE) OBTAINED BY WEIGHT LOSS METHOD

Inhibitor system: SPT + Al^{3+} (50 ppm) Immersion period – 3 days

SPT	Al^{3+} ppm	CR mdd	IE %
0	50	7.26	62.80
50	50	4.88	75.0
100	50	4.05	79.26
150	50	7.97	59.14
200	50	2.5	87.19

Table4. CORROSION RATE (CR) OF CARBON STEEL IN GROUND WATER IN THE PRESENCE OF INHIBITOR SYSTEM AND THE INHIBITION EFFICIENCY (IE) OBTAINED BY WEIGHT LOSS METHOD

Inhibitor system: SPT + Al^{3+} (100 ppm) Immersion period – 3 days

SPT ppm	Al^{3+} ppm	CR Mdd	IE %
0	100	10.95	43.9
50	100	8.21	57.92
100	100	6.66	65.85
150	100	0.24	**98.78**
200	100	7.62	60.97

Table 5. CORROSION RATE (CR) OF CARBON STEEL IN GROUND WATER IN THE PRESENCE OF INHIBITOR SYSTEM AND THE INHIBITION EFFICIENCY (IE) OBTAINED BY WEIGHT LOSS METHOD

Inhibitor system:SPT + Al^{3+} (150 ppm) Immersion period – 3 days

SPT ppm	Al^{3+} ppm	CR mdd	IE %
0	150	15.83	18.90
50	150	7.38	62.19
100	150	11.42	41.46
150	150	7.86	59.75
200	150	0.47	97.56

Table 6. CORROSION RATE (CR) OF CARBON STEEL IN GROUND WATER IN THE PRESENCE OF INHIBITOR SYSTEM AND THE INHIBITION EFFICIENCY (IE) OBTAINED BY WEIGHT LOSS METHOD

Inhibitor system: SPT + Al^{3+} (200 ppm) Immersion period –3 days

SPT ppm	Al^{3+} ppm	CR mdd	IE %
0	200	13.53	30.67
50	200	3.93	79.87
100	200	2.35	87.80
150	200	4.99	74.39
200	200	0.59	96.95

The influence of duration of immersion on the IE of the SPT-Al^{3+} system is given in Table –7. It is found that as the duration of immersion increases with the inhibition efficiency found to decrease. When the immersion period is 1 day IE=73%, when the immersion period is 3 days IE =98%. When immersion period is 5 days IE=90%, when the immersion period is 7 days IE = 85%

TABLE 7.INFLUENCE OF DURATION OF IMMERSION ON THE IE OF THE SPT(150ppm) +Al^{3+} (100ppm) SYSTEM.

Immersion Period Day	**1**	**3**	**5**	**7**
SPT 0 ppm + Al^{3+} 0 ppm	**15.63**	**19.52**	**21.53**	**23.65**
SPT150ppm + Al^{3+} 100ppm	**1.58**	**0.24**	**0.36**	**0.28**
IE %	**73.2**	**98.78**	**90**	**85**

This may be due to the fact that as the period of immersion increases the protective film formed on the metal surface namely Fe^{2+} - SPT Complex is broken by the aggressive chloride ion present in ground water and hence IE decreases.

Lowering or raising the pH brings down the value of IE. The reduction in IE on decreasing the pH may be due to the inability of SPT to form a complex with Al^{3+} ions in the presence of acid. Hence, Al^{3+} ions are not in a position to transport the inhibitor to the metal surface. The added Aluminium ions form insoluble complexes with SPT and repair the protective porous oxide layer and prevent further corrosion. As a result, the rate of dissolution of iron is faster than the rate of transport of inhibitor to the metal surface. At higher pH, the low value of IE is attributed to the formation of $Al(OH)_3$. Hence, Al^{3+} ions are not free to carry the inhibitor from the bulk to the surface of the metal. At pH a marginal raise is noticed. The raise is due to the formation of soluble Aluminate ions.

Table 8. INFLUENCE OF P^H ON THE IE OF THE SPT(150 ppm) –Al^{3+}(100ppm) SYSTem.

pH	6	8	10	12
SPT 0ppm + Al^{3+} 0ppm	**12.56**	**13.85**	**14.23**	**12.58**
SPT150ppm + Al^{3+} 100ppm	**2.04**	**1.28**	**1.55**	**1.33**
IE %	**87**	**98**	**88**	**91**

It is found from Table 8 that when P^H is decreased from 8 to 6 (by addition of dil. H_2SO_4) the IE decreases from 98% to 87%. This is due the attack of H^+ ion of the H_2SO_4 on the metal surface and hence increases in corrosion rate and decrease in IE. When P^H is increased from 8 to 10 (by addition of dil NaOH) the IE decrease from 98% to 88%. This is due to the fact when NaOH is added Al^{3+} is precipitated as $Al(OH)_3$ in the bulk of the solution so the transport of inhibitor towards the metal surface decreases and hence the IE decrease when P^H is increased from 10 to 12 (by addition of dil. NaOH) the IE increases from 88% to 91% . This is due to the fact that further addition of NaOH converts $Al(OH)_3$ precipitate into soluble sodium Aluminates. Now the transport of inhibitors towards the metal surface is favoured. Hence the IE increases.

Synergism parameters are indications of synergistic effect existing between inhibitors [14, 15]. From Table 9 it is clear that % IE for SPT -Al^{3+} system inhibitor is higher than the % IE for single SPT and for single Al^{3+}inhibitor, which is synergistic in nature. S_1 approaches unity when there are no interactions between the inhibitor compounds, while $S_1 >$ 1 points to a synergistic effect; in the case of $S_1 < 1$, the antagonistic interaction prevails. This result clearly shows the synergistic effect between SPT and Al^{3+}

Table 9. SYNERGISTIC PARAMETERS (S_1) OF SPT-Al^{3+} SYSTEM.

Concn. of SPT ppm	I.E. % I_1	Concn. of Al^{3+} ppm	I.E. % I_1	Combined I'E. I_{1+2}	Synergism S_1
50	**66.5**	**100**	**58.5**	**57.92**	**66.15**
100	**18.3**	**100**	**58.5**	**65.85**	**15.30**
150	**87.76**	**100**	**58.5**	**98.78**	**50.99**
200	**56.00**	**100**	**58.5**	**60.97**	**52.69**

3.1. MECHANISM OF CORROSION INHIBITION

With these discussions, a mechanism may be proposed for the corrosion inhibition of carbon steel immersed in dam water containing 150ppm of SPT +50ppm of Al^{3+}.

When the formulation consists of 150ppm of SPT +50ppm of Al^3 in ground water, there is formation of SPT – Al^{3+} complex in solution

1.When carbon steel is immersed in this solution SPT– Al^{3+} complex diffuses from the bulk of the solution towards the metal surface.

2.SPT – Al^{3+} complex is converted into SPT –Fe^{2+} complex on the anodic sites of the metal surface with the release of Al^{3+} ion.

$$Al^{3+}\text{– SPT} + Fe^{2+} \longrightarrow Fe^{2+}\text{ – SPT} + Al^{3+}$$

The released Al^{3+} combines with OH– to form Zn(OH)2 on the cathodic sites of

the metal surface

$$Al^{3+} + 3OH^{-} \longrightarrow Al(OH)_3 \downarrow$$

3. Thus the protective film consists of SPT Fe^{2+} complex and $Al(OH)_3$

4. This account for the synergistic effect of SPT – Al^{3+} system.

IV. CONCLUSIONS

The present study leads to the following conclusions

- The inhibition efficiency (IE) of SPT controlling corrosion of carbon steel immersed in ground water in the absence and presence of Al^{3+} has been evaluated by weight loss method.
- The formulation consisting of 150ppm of SPT +100ppm of Al^{3+} has 97% IE.

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