

*REVIEW OF LITERATURE*

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## 2. REVIEW OF LITERATURE

Corrosion studies have become important due to the awareness of the world's metal resources. Though corrosion is unavoidable through better appreciation of its basic principles the losses can be considerably reduced. Extensive electrochemical investigations have been carried out on the corrosion behavior of brass and its inhibition in NaCl.

The present study on “**Substituted benzotriazoles as corrosion inhibitors for brass in 3% NaCl**” has been reviewed and presented under the followings

- ♣ Organic inhibitors for copper corrosion
- ♣ Organic inhibitors for brass corrosion. (NaCl medium)
- ♣ Organic inhibitor for mild steel corrosion (HCl H<sub>2</sub>SO<sub>4</sub> medium)
- ♣ Corrosion of brass in different medium (H<sub>2</sub>O, ammonia solution)
- ♣ Benzotriazole and its derivatives corrosion inhibitors

### ORGANIC INHIBITORS FOR COPPER CORROSION

\* Demonstrations given by **Petkova. G. et. al., (1998)** on the corrosion inhibition of copper in near neutral aqueous solutions by gamma pyridophenone ( $\gamma$ PD) revealed that high inhibitor efficiency (96.9) of  $\gamma$ PD suppresses active copper dissolution and oxygen reduction. Cathodic as well as anodic processes were effectively inhibited by  $\gamma$ PD.

\* **Walsh. et al., (1998)** studied the orientation of benzotriazole on Cu (100) by using near edge x-ray absorption fine structure (NEXAFS) at the 'C' and N K –edges and polarization. The monolayer adsorption of benzoimidazole was confirmed by polarization techniques and NEXAFS. The orientation of benzotriazole and 1- methyl benzotriazole on Cu have also been studied.

\* An evaluation of the effective performance of 5 hydroxy-1,2,4-triazole-3yl) butane compound D2 as corrosion inhibitors, for copper in 4.0 M HNO<sub>3</sub> solutions at 25°C by weight loss and galvanostatic polarization techniques was carried out by **EI-Nagar, M. M., et. al., (1999)**. The results showed that the predominant action of the inhibitors was cathodic. The maximum inhibitor efficiency of 5 hydroxy-(1, 2, 4-triazole-3yl) butane proved to be effective >99% with long term effectiveness.

\* **Ashis. k. et. al., (2002)** observed the effect of triazoles derivatives such as 1,2,3 benzotriazole 4-amino 1,2,4 triazole and 1,2,4 triazole on copper in dissolution in acid medium under various conditions. Potentio dynamic polarization, electro chemicals studies and weight loss measurement were carried out. The phenomenon of chemical absorption has been proposed from the negative  $\Delta G$  values. The data obtained from this study fits well into the Langmuir isotherm.

\* **Fox, P. G. et. al., (2003)** investigated the solution chemistry of 1:2:4 – triazole (TRZ) at different concentrations on copper. Photoelectron spectroscopic studies showed that although a surface layer of copper(I) complex is formed at low TRZ concentrations, wick is ineffective as an inhibitor until a critical concentration of Cu (II) complex appears which provides effective protection. It is suggested that the precipitation of Cu(II) hydroxychloride in which the TRZ is attached provides the protective layer.

\* Self assembled films of carbazole (CZ) and N-Viny- Carbazole (NVC) were prepared on copper surfaces by **Wang. T. et. al., (2003)** in  $\text{HNO}_3$ . FTIR and X ray photoelectron spectroscopy were used to characterize the film. The inhibition efficiencies of CZ and NVC determined by polarization measurements which were 91.1 and 93.4% respectively. Increased immersion time improved the quality of the self assembled films.

\* The effect of 5 chloro and 5 methyl benzotriazole on the corrosion of copper in acid solution was investigated by **A. Aranciba. et. al., (2005)**. Electrochemical polarization study was used to evaluate the corrosion resistance of copper. The IE obtained from tafel plots increased markedly with increase in the additive concentration. Benzotriazole and 5 methyl benzotriazole were found to be cathodic type while 5 chloro- benzotriazole was found to be a mixed inhibitor. The organic compounds are physisorped on the metal surface following a Langmuir adsorption isotherm

\* 2- Amino-5- ethyl-1,3,4-thiodiazole (AETDA) has been evaluated as a corrosion inhibitor for copper in 3% NaCl solutions using weight loss, potentiodynamic polarization, potentiostatic current time and electrochemical impedance spectroscopic measurements by **SU- Moon. et. al., (2006)**. EIS measurements revealed that the surface coverage and the charge transfer resistance increase upon increasing the AETDA concentration. Results together showed clearly that AETDA is a good mixed-type inhibitor for copper corrosion.

\* El – Sayed. et, al., (2006) studied the effects of 2- amino-5-(ethyl thio)-1,3,4-thiodiazole(ATD) on copper corrosion as a corrosion inhibitor in de- aerated, aerated and oxygenated 3% NaCl solutions using potentiodynamic polarization, potentiostatic current-time, electrochemical impedance spectroscopic (EIS), weight loss and pH measurements along with scanning electron microscopy (SEM) and energy dispersive x-ray (EDX) investigations. Weight loss measurements gave an inhibition efficiency of about 83% with 1.0 mM ATD, Increased to about 94% at the ATD concentration of 5.0mM. Results together are internally consistent with each other, showing that ATD is a good mixed- type inhibitor for copper corrosion with its inhibition efficiency increasing in the order of oxygenated > aerated > de-aerated 3% NaCl solutions.

\* The inhibition of corrosion of copper in hydrochloric acid by 2- mercapto-1-methylimidazole was investigated by dc polarization, ac impedance and weight loss techniques by Larabi. et. al., (2006). The degree of surface coverage obeys the Langmuir adsorption isotherm. The potentiodynamic polarization data indicated that the inhibitor was of mixed type, but the anodic effect is more pronounced. The slopes of the cathodic and anodic tafel lines are approximately constant and independent on the inhibitor concentration. Some thermodynamic data for the adsorption and dissolution process are calculated.

\* 5- (phenyl)-4H-1,2,4-triazole-3-thiol(PTAT)was synthesized and tested as a corrosion inhibitor for copper in stagnant and stirred 3.5% NaCl using potention dynamic polarization, potentiostatic current time, weight loss and pH measurements along with FT-IR investigation by EI-Sayed. et. al., (2007). The inhibition efficiency of 500ppm PTAT obtained by weight loss measurements is about 73% increasing to about 90% at its concentration of 1500ppm, As well as, the accompanied pH values were noticed to decrease with the presence of PATA and the increase of its concentrations. FT-IR investigations revealed that PTAT molecules are adsorbed strongly on the copper surface at an open-circuit potential.

\* The influence of the concentration of the purine (PU) and adenine (AD) on the corrosion of copper in 0.5M Na<sub>2</sub>SO<sub>4</sub> solutions (pH 6.8) was studied by Scendo. M. et. al., (2007). The investigation involved electrochemical polarization as well as electrochemical quartz crystal micro balance techniques. The inhibition efficiency increases with an

increase in the concentration of PU and AD. Adherent layers of inhibitors were postulated to account for the protective effect. The adsorption of inhibitors obeyed Langmuir isotherm.

★ Effects of 3-amino-1,2,4 triazole (ATA) on the inhibition of copper in 0.5 M HCl solutions have been studied using gravimetric, electrochemical and Raman spectroscopy by **Sherif. et. al., (2007)**. Weight loss measurements revealed that the dissolution rate of copper decreased to a minimum, while inhibition efficiency and degree of surface coverage increased with the presence of ATA and with the increase of its concentration. Potentiodynamic, chronoamperometric and EIS measurements showed that the presence of ATA molecules significantly decreased cathodic, anodic, corrosion currents and corrosion rates greatly.

### **ORGANIC INHIBITOR FOR BRASS IN NaCl MEDIUM**

★ The inhibiting effect of benzotriazole on the corrosion of alpha brass in 3.4% NaCl was effectively carried out by **Ahhour. et. al., (1995)**. The morphology of the alloy surface were monitored by SEM. Corrosion attack occurs very early in the absence of BTA leading to general and pitting corrosion, BTA was found to have a stronger inhibiting effect on the anodic dissolution of copper than on the cathodic reduction of oxygen.

★ Electrochemical characteristics of Al and-brass are investigated in both 3.5% NaCl and sea water using potentiodynamic polarization and cyclic voltammetric techniques by **Mosman. et. al., (2000)**. At higher applied anodic potential the active- passive transition leads to the formation of a thicker and more stable CuCl salt layer. With further increase in the anodic potential due to the formation of CuO and Cu (OH)<sub>2</sub> will take place. Studies were also carried out by adding SDBS, Dph(E0)<sub>9</sub> B and LAPACl as anionic , nonionic and cationic surfactants. It is found that the IE increases with increasing their concentrations. Order of the inhibitors are SDBS> LAPACl> Dph (E0)<sub>9</sub>.

★ **Asan. M. et. al., (2004)** carried out the effect of 2-[(E)-pyridine-2-ylamino) methyl] phenol and 2-[pyridine-2-ylamino) methyl] phenol, on the corrosion of brass in 0.10 M NaCl solution under various conditions by means of the potentiostatic polarization and AC impedance methods. The inhibiting efficiency increase with an increase in their concentrations. Self assembled film of these substances were also prepared on the brass surface. These films improved significantly the protecting ability of brass surface to

corrosion in 0.10M NaCl solution when the film was modified with benzotriazole (BTA), the quality and corrosion resistance of films improved markedly.

★ An evaluation of the effective performance of benzotriazole derivatives such as N,N-dibenzotriazol-yl methyl amine (DBMA) and 2-hydroxy ethyl benzotriazole on the corrosion and dezincification of brass in neutral medium by weight loss, potentiodynamic polarization, electro chemical impedance and solution analysis techniques was made. It was found that the benzotriazole derivatives behave as anodic inhibitors for brass in NaCl solution analysis revealed the decrease in dissolution of both copper and zinc in the presence of the inhibitors. (**Ranichandrane. et. al., (2004)**)

★ To appraise the inhibiting effect of N, N-dibenzotriazole-yl methyl amino methane (DBMM) and hydroxy propyl benzotriazole (HPBT) on corrosion of brass in artificial sea water studies were conducted. Corrosion rates were determined using cyclic voltametry, current transient techniques polarization and electrochemical impedance spectroscopy. The double layer capacitance and charge transfer resistance are related to adsorption of organic inhibitor on the metal surface, leading to the formation of a protective film, which grows with increasing exposure time. CV studies confirmed that the inhibitors effectively inhibit the corrosion of brass (**Ravichandran. K. et. al., 2005**)

★ Electrochemical behavior of Cu- 40 Zn alloy in 3% NaCl medium pure and polluted by 2ppm of  $S_2^-$  ions, has been studied in the absence and presence of the 3-amino 1,2,4 triazole (ATA) as corrosion inhibitor. Corrosion rate were determined using polarization curves, electrochemical and impedance spectroscopy. Electrochemical measurements showed that sulphides accelerats the alloy corrosion and the inhibitor behave like a mixed type. Scanning electron microscopy analysis (SEM) showed that the inhibitor acts by preventing the adsorption of  $S_2^-$  ions and formation of  $Cu_2S$  at the alloy surface (**Mountassir. et. al., 2007**).

★ Some triazole derivatives 4- amino-5-mercapto -3-methyl 1,2,4-triazole (AMMT),4- amino-5-mercapto-3-ethy 1,2,4- triazole (AMET) and 4-amino-5-mercapto -3-propyl 1,2,4-triazole(AMPT) were tested as corrosion inhibitor for brass in acidic and neutral solutions by **Nageh. et. al., (2007)**. The adsorption of these, compounds has been tested thermodynamically which was found to be a physisorption mode. Thermodynamic parameters such as  $\Delta H$ ,  $\Delta S$  and  $\Delta G$  have been estimated. In addition, a trial to find a

quantitative relationship between the inhibition efficiency and the electronic properties of the inhibitor molecule was carried out.

## ORGANIC INHIBITORS FOR MILD STEEL

✚ Investigation of 1, 3 bis (3'-chloro methyl-5'methyl-1 pyrazolyl) propane as corrosion inhibitors for mild steel in acid medium by weight loss and electrochemical polarization methods were done by **Aouniti. A. et. al., (1996)**. The result revealed that the inhibition efficiency as the function of the concentration of inhibitors and nature of the acids. It has been found that  $4 \times 10^{-4}$  % concentration offered 95% of inhibition efficiency in acid medium.

✚ **Kertit. S. et. al., (1996)** studied the inhibitive influence of 1 phenyl -5- mercapto- 1, 2, 3, 4- tetrazole (PMT) in molar HCl. Experiments were carried out through by weight loss and electrochemical steady state experiments. The result revealed the PMT is the best inhibitor and its IE becomes 98%  $2 \times 10^{-3}$ M. Polarization measurements showed that PMT is a mixed-type inhibitor. The adsorption of the compounds was found to follow Langmuir's adsorption isotherm.

✚ The corrosion behaviour of 3, 5 diphenyl -4 H- 1,2,4- triazole (DHT) on the corrosion of mild steel in hydrochloric acid were investigated by **Fouad Bentiss. et. al., (2000)**. The corrosion rate was calculated by using electrochemical, weight loss measurements and XPS. Polarization curves revealed that the organic compound act as mixed-type inhibitor and inhibition efficiencies up to 98% can be obtained. The surface coverage values were found to fit with Langmuir isotherm.

✚ The effective performance of hexyl amine and dodecylamine on the corrosion inhibition of mild steel in HCl at a temperature of 298 K was investigated by weight loss method and potential measurement techniques. Dodecylamine afforded higher inhibition efficiency compared to hexyl amine ( **Bastidas. et. al., 2000**)

✚ **Bentiss. M. et. al., (2001)** study assessed the corrosion inhibition effect of 2,5- bis (4-di methyl amino phenyl )- 1,3,4 thiadiazole (DAPT) on mild steel in 1M HCl and 0.5M H<sub>2</sub>SO<sub>4</sub>. DAPT showed a better performance in H<sub>2</sub>SO<sub>4</sub> than in HCl medium. The phenomenon of chemical adsorption has been proposed from the negative  $\Delta G$  values. The data obtained from that study fitted well into the Langmuir isotherm.

✚ **Lagreime. M. et. al., (2002)** attempted to study the inhibitive effect of N pyridyl substituted thiadiazoles on the corrosion of mild steel in 1M HCl, 0.5M H<sub>2</sub>SO<sub>4</sub> and 0.1M HClO<sub>4</sub> were made. The weight loss method (potentiostatic) electrochemical XPS and Quantum chemical studies revealed the effectiveness of the inhibitor due to the steel surface. Adsorption of thiadiazole derivatives on the surface of MS in acidic media followed a Langmuir isotherm model.

✚ Investigations of **Tamilselvi. S. et. al., (2002)** involving benzotriazole derivatives such as N-[benzotriazole -1-yl] alkyl aryl amine (BTM), N-1-benzotriazole 1-yl) aryl amine (TBA) hydroxy methyl benzotriazole (HBTA) as corrosion inhibitors for mild steel in acidic medium (1M H<sub>2</sub>SO<sub>4</sub>). A preliminary screening of the IE was carried out using weight loss and polarization techniques. Benzotriazole derivatives were found to act as mixed type inhibitors. The passive film characterization was done using FT-IR spectrum.

✚ **Yahyi. H. et. al., (2003)** studied the effectiveness of o- acrylate dipyrazole methane as corrosion inhibitor for pure iron in 1M HCl solution. Inhibition efficiency was determined by weight loss, potentiodynamic and polarization resistance measurements. The results showed that the inhibitor (OADPH) was well adsorbed on the metal surface and significantly repressed iron corrosion in M HCl medium. The data obtained from this study fitted well into the Langmuir isotherm and it also showed that the inhibitor acted as a mixed type inhibitor.

✚ An evaluation of the effective performance of indole-5- carboxylic acid towards corrosion of mild steel in deaerated 0.5 M sulfuric acid solutions were investigated using weight loss, potentiodynamic and spectrophotometric tests. The adsorption of this inhibitor was found to obey the Langmuir adsorption isotherm (**Quartarone. G. et. al., 2006**).

✚ **Abboud. V. et. al., (2006)** aimed to develop the inhibitive effect of 2,2- bis (Benzimidazole) on the mild steel in acidic medium (1M HCl). Weight loss, potentiodynamic, polarization were carried out. The result revealed that the compounds had fairly good inhibiting properties for steel corrosion and behaved like mixed type. The adsorption of 2-2'- bis (benzimidazole) on the surface of mild steel in 1M HCl obeyed a Langmuir isotherm adsorption.



✚ The use of some 4H-triazole derivatives, namely 3,5- diphenyl-4H-1,4- triazole (DHT),3,5-bis (4-pyridyl)-4H-1,2,4-triazole (4-PHT) and 3,5-bis(4- methyl tiophenyl)-4H-1,2,4-triazole(4-MTHT) for corrosion and dissolution protection of mild steel in HCl has been evaluated by **Bentiss. et. al., (2007)**. Weight loss measurements and electrochemical techniques were carried out. The inhibition efficiency increases with 4H-triazole derivatives concentration and attains the maximum value of 99.6% in the case of 4- MTHT at  $5 \times 10^{-4}$  M. Molecular modeling was used to get better insight, about structural and electronic effects in relative to the inhibition efficiencies.

## **CORROSION OF BRASS IN DIFFERENT MEDIUM**

❖ The effect of 1[-N,Nbis (hydroxyl ethyl) amino methyl] -benzotriazole {BTLY} on the corrosion of and dezincification of a 60/40 brass in aqueous  $H_2SO_4$  at 30C has been investigated by means of solution analysis, potentiodynamic and surface enhanced Raman scattering (SERS) techniques overall inhibition increased with increasing concentration up to  $5 \times 10^{-4}$  M level (63%). This was complex to that observed for benzotriazole (BTAH) under the same conditions. Solutions analysis indicated that BTLY is ineffective in preventing dezincification. Polarization studies showed that BTLY acted initially to suppress the cathodic and anodic corrosion reactions. The SERS spectra suggest that the adsorption with copper in the brass occurred through nitrogen in the azole ring of a protonated molecules BTLYH (**Otieno- Alego. et. al., 1996**)

❖ The corrosion inhibition behaviour of admiralty brass electrode in 0.1M  $H_2SO_4$  solution in the presence of four amino acid compounds (glycine, L- phenyl alanine) L- tyrosine and L- histidine) has been studied using weight loss and polarization studies. The IE of these compounds depends on their concentration and their chemical structure. The order of inhibition efficiency obtained as follows. Histidine > Tryosine > Phenyl > Alanine > Glycine (**Adallah. M. et. al., 1997**).

❖ **Tunc Tuken. et .al., (2004)** studied the effect of poly pyrrole film on brass and copper electrodes by using cyclic voltammetry techniques. The corrosion performance of PPY coated samples were investigated in 0.1M  $H_2SO_4$  solutions by using the electro chemical impedance spectroscopy (EIS) anodic polarization curves and open circuit potential curves. It was shown that PPY coating could provide important protection against the corrosion of copper and brass. The protective behaviour was coming from the barrier properties of the coating against attack of corrosive environment.

❖ The corrosion behaviour of Cu<sub>37</sub>Zn brass in a solution of sodium tetra borate, at pH 10 with the addition of chloride ions and benzotriazole (BTA) inhibitor were done by **Antonijevic. et. al., 2005**. Cyclic voltammetry studies have led to the conclusion that the anodic current densities increase with increase in immersion time in sodium tetra borate solutions.

❖ **Bazzaoui. M. et. al., 2006** analyzed the inhibitive effect of poly pyrrole (PPY) on copper and brass in sodium saccharinate and pyrrole aqueous medium and 0.1 M HCl medium. Electrochemical techniques such as cyclic voltammetry galvanostatic and potentiostatic were carried out. PPY has been characterized by SEM, XPS, IR and Raman spectroscopy and its quality has been confirmed. The results show that PPY coating electrodeposited from sodium saccharinate exhibits significant corrosion protection properties.

❖ **Chen Wang. et. al., (2006)** investigated the inhibitive effect of low phosphonic mult polymer and its corrosion IE of brass in synthesized water by weight loss and electro chemical tests. It showed that the synthesized inhibitor decreased corrosion of brass. Polarization curves indicated that the new inhibitor act as an anodic inhibitor and it reduces metal dissolution. The inhibition effect were due to the formation of a protective film of the inhibitor which was conformed by the energy – dispersive X ray analysis.(EDX)

❖ Investigation of 1 diethyl amino- propane-2- ol (EAP) and 1,3- bis-diethyl amino- propane-2-ol (DEAP) as inhibitor for brass in simulated, atmospheric water is evaluated by potentiodynamic curves and electrochemical impedance spectroscopy (EIS) by **Guo Gao (2006)**. The experimental results showed that the investigated compounds, retarded the anodic dissolution of brass and are found to be anodic inhibitors. From the result the inhibition efficiency of DEAP is higher than that of EAP for the same concentration.

### **BRASS CORROSION IN HNO<sub>3</sub> MEDIUM**

• An evaluation of the effective performance of BOC-PHE- MET-OCH<sub>3</sub> as corrosion inhibitor for 60 Cu-40 Zn in HNO<sub>3</sub> acid solution was performed through weight loss electrochemical polarization measurements. Polarization measurements indicate that BOC-PHE- MET-OCH<sub>3</sub> acted as cathodic inhibitors and the results obey Frumkin isotherms. And showed the inhibition occurred via chemisorptions of the inhibitor. (**Abed .et. al., 2004**)

- The effectiveness of 1-phenyl-5-mercapto-1,2,3,4-tetrazole (PMT), 1,2,3,4-tetrazole (TTZ), 5-amino-1,2,3,4-tetrazole (AT) and 1-phenyl-1,2,3,4-tetrazole (PT) on the corrosion of brass in nitric acid was studied by weight loss, polarization and electrochemical impedance spectroscopy (EIS) measurements. The explored methods gave almost similar results. Results obtained revealed that PMT is the best inhibitor and the IE follows the order  $PMT > PT > AT > TTZ$ . Polarization measurements also indicated that tetrazoles acted as mixed type inhibitors. The adsorption of PMT on the brass surface followed the Langmuir isotherm. (Ait Addi. et. al., 2006)

## AZOLE AND ITS DERIVATIVES ACT AS CORROSION INHIBITORS

- ◆ Stupniseklisac. et. al., (1995) investigated the efficiency of various imidazole derivatives as zinc corrosion inhibitors in HCl using electrochemical and gravimetric methods. A difference in efficiency was observed with the introduction of different substituents into the imidazole skeleton. These substituents increased the electron density and improved the corrosion inhibiting properties of the heterocyclic compound. A linear correlation between reaction kinetic data and the sum of the polar substituent constants was obtained.
- ◆ The effect of benzotriazole as an inhibitor for 304 stain less in 2M H<sub>2</sub>SO<sub>4</sub> has been studied using weight loss experiments, anodic and cathodic measurements, atomic emission spectrometry, optical and scanning electron microscopy by Rodrigues. et. al., (1996). The protective film was stable and adherent obeyed the Langmuir isotherm.
- ◆ Compounds such as 2-amino benzothiazole (ABT), 2-amino-6-chloro benzothiazole (ACLBT), 2-amino-6-methyl benzothiazole (AMBT)-amino-6-methoxy benzothiazole (AMEOBT) have been synthesized for which weight loss, Potentio dynamic polarization studies and hydrogen permeation measurements were done by Quraishi. et. al., (1996). All these compounds are found to reduce the permeation of hydrogen through mild steel in HCl and obeys Temkin's adsorption isotherm.
- ◆ Sizaya. et. al., (1996) investigated the inhibiting action of 1,2-diamyl-5, 6 - dihydroimidazo(2,1-b)thiazolium bromides on acid corrosion by correlation of the inhibition coefficients with the S-constants of Gammet. The result shared that the highest inhibition properties was shown by the compound with bromine substituent in phenylic ring.

- ◆ The influence of N- heterocyclis, viz; imidazole (IA) benzimidazole (BIA) and 2-methyl imidazole (MIA) on the corrosion and hydrogen permeation through mild steel in 1N H<sub>2</sub>SO<sub>4</sub> and in 1N HCl was investigated by **Muralidharan. et. al., (1997)**. IA and BIA inhibited the corrosion of mild steel in both the acid solutions but MIA accelerated the corrosion. They behave as cathodic inhibitors by influencing the cathodic polarization reaction. The adsorption of these compounds obeys Temkin's adsorption isotherm.
- ◆ Some new triazole derivatives have been synthesized by **Qurashi. et. al., (1997)**. The inhibiting action on the corrosion of mild steel in 15% HCl under boiling conditions has been studied by weight loss method. All the triazole derivatives tested showed an inhibitor efficiency of >98%.
- ◆ **Mernari. et. al., (1998)** investigated the effect of 3,5-bis(n-pyridyl) -4- amino 1,2,4,-triazole (n-PAT) on the corrosion of MS in 1M HCl using weight loss tests and electrochemical impedance spectroscopy. The electrochemical study revealed that these compounds were anodic inhibitors. The adsorption of (n-PAT) on the steel surface obeyed the Langmuir adsorption isotherm.
- ◆ **Bentiss. et. al., (1999)** inferred the inhibition of dissolution of MS in 1 M HCl by 2 (5-(2-pyridyl)-1, 2, 4- triazole-3-yl) phenol (PPT) using electrochemical studies, weight loss, SEM and XPS techniques and conformed that inhibitors were effective. The adsorption of 2 (5-(2-pyridyl)-1, 2, 4- triazole-3-yl) phenol on the MS surface was confirmed by SEM and XPS techniques.
- ◆ **Popova, (2005)** studied the corrosion inhibition effect of five heterocyclic compounds such as indole, benzimidazole, benzotriazole, benzothiazole and benzothiadiazole on mild steel in 1N HCl by electrochemical methods. All the inhibitors showed good inhibition efficiency.
- ◆ A new corrosion inhibitor namely 2-2'-bis (benzimidazole) has been synthesized and its inhibiting action on the corrosion of MS in acid bath (1M HCl) has been investigated by **Abboud. et. al., (2006)** by weight loss test and potentio dynamic polarization. The results of the investigation show that this compound has fairly good inhibiting properties for steel and is a mixed inhibitor in 1 M HCl. The adsorption of this inhibitor is found to obey Langmuir adsorption isotherm.

- ◆ The effect of benzotriazole (BTAH) added to a zinc phosphating bath on the corrosion resistance of a carbon steel was investigated by **Banczek. et. al, (2006)**. Anodic polarization curves and electrochemical impedance spectroscopy were used to evaluate the corrosion resistance of the phosphate steel with or without inhibitor (BTAH), in two solutions,  $0.1 \text{ mol l}^{-1} \text{ H}_2\text{SO}_4$  and  $0.5 \text{ mol l}^{-1} \text{ NaCl}$ . The result indicated better corrosion resistance for the steel phosphate with BTAH comparatively to that without BTAH.
  
- ◆ An evaluation of the effective performance of 2-5-bis (4-pyridyl) 1, 3, 4- thiadiazole (4-PTH) on the corrosion of mild steel in acid media (1 M HCl, 0.5 M  $\text{H}_2\text{SO}_4$ ) have been investigated using weight loss measurements electrochemical impedance spectroscopy and Potentiodynamic polarization these Studied that the compound is good inhibitor and best performances was seen in 1M HCl adsorption on mild steel follows Langmuir isotherm model (**Lebrini. et. al., 2006**).
  
- ◆ **Lin Wang, et. al., 2006** aimed to develop the inhibitive effect of triazole derivatives on the corrosion of mild steel in phosphoric acid medium. Weight loss, potentiodynamic, polarization studies were carried out. The results conformed that these compounds act as mixed-type inhibitors.
  
- ◆ (**Quraishi, et. al., 2006**) aimed to study the inhibitive effect of 2-amino-1,3,4-thiadiazoles(AT), 5-methyl-2-amino-1,3,4-thiadiazoles(MAT), 5-ethyl-2-amino-1,3,4-thiadiazoles(EAT) and 5-propyl-2-amino-1,3,4-thiadiazoles(PAT) on the mild steel in acidic medium ( $0.5 \text{ M H}_2\text{SO}_4$ ). Weight loss, potentiodynamic, and polarization studies were carried out. The result revealed that the compounds had fairly good inhibiting properties for steel corrosion and behaved like mixed type. The adsorption of the compounds on the surface of mild steel in 1M HCl obeyed a Langmuir adsorption isotherm.
  
- ◆ 3- alkyl-4- amino-5-mercapto 1,2,4-triazole(AAMT) has been evaluated as corrosion inhibitor for iron in  $0.1 \text{ M H}_2\text{SO}_4$  when the films of AAMT were self assembled on the surface of iron by **Xiuyu Liu. et. al., (2006)**. The film of AAMT inhibitor were characterized by electrochemical impedance spectroscopy, electrochemical polarization curves results revealed that AAMT performed excellently as a corrosion inhibitor for iron in  $\text{H}_2\text{SO}_4$  solution. Surface analysis was carried out using X-ray photoelectron spectroscopy and scanning electron microscope.
  
- ◆ The electrochemical behavior of bronze [Cu-8 Sn in wt %) was investigated in 3% NaCl aqueous solution, in presence and absence of a corrosion inhibitor, the 3- phenyl-1, 2,

4-triazole -5thione (PTS) by **Dermaj. et. al., (2007)**. The inhibiting effect of the PTS was evidenced for concentration as low as 0.1 mM for the cathodic process whereas its effect was clearly seen with a concentration as low as 0.1 mM for the anodic process. For voltammetry and electrochemical impedance spectroscopy experiments, the inhibiting efficiency of the PTS was found to be in the 94-99% range for 1mM concentration.

◆ The inhibition of the corrosion of carbon steel in 1M HClO<sub>4</sub> by 2- mercapto-1-methyl imidazole (MMI) has been investigated in relation to the concentration of the inhibitor as well as the temperature using weight loss and electrochemical measurements by **Benali. et. al., (2007)**. The inhibition efficiency of MMI is temperature independent but increases with the inhibitor concentration. Changes in impedance parameters were indicative of adsorption of MMI on the metal surface. The electronic properties such as highest occupied molecular orbital, lowest unoccupied molecular orbital energy levels and molecular orbital densities were calculated.

◆ The inhibiting properties of four azoles (indole, benzimidazole, benzotriazole, benzothiazole) were investigated for mild steel corrosion in 1M HCl at various temperatures. Impedance spectroscopy, polarization and gravimetric methods were applied. The generalization of the data obtained provide conclusions concerning the mechanism of the inhibition (**Popova, et. al., 2007**)