Electronic corrosion

Causes → Process related
→ Service related

Major Forms → Gas Phase (Ag_2S)
→ Galvanic (Au, Ni, Cu)
→ Voltaic Al, Al

Vapor phase Inhibitors

- Compounds with vapor press. $10^{-7} \rightarrow 10^{-2}$ mmHg
- Diffuse through gas phase & adsorbed onto the metal

⇓

involves metal-Inhibitor bond thro atoms like N (or) O → coordinate bond inhibitor Efficiency depend on

* ability to be adsorbed on metal's surface
* strength of adsorption
* Temperature dependence of V.P

→ dependence → chem. structure of inhibitor

V.P → critical parameter

↓

must be optimum

very low V.P → 10^{-6} Torr

↓

slow establishment of protective layer

V.P - too high (0.1 Torr)

insufficient protection

↓

limited to short duration

Preferable - less volatile inhibitors

↓

Long lasting, durable protection

over periods of 2 → 3 Years

<u>Some classes</u>

Aliphatic & Alicyclic } more efficient than aromatic

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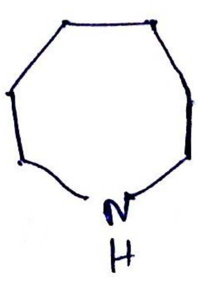
Straight chain Amines > Branched chain Amin

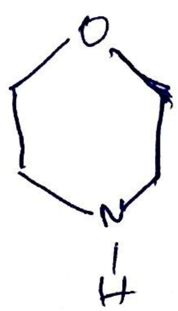
Farther branching →

closer to Amine group

More effective → Primary Straight chain Amines with even number of 'C' atoms

Heterocyclic Amines





Amino ketones

- adsorbed on metal thro
free e^- of NH_2 group.

$$O=\underset{\underset{CH_3}{|}}{C}-(CH_2)_n-N\begin{matrix} R \\ R \end{matrix}$$

$n=1 \Rightarrow$ (α - Amino ketones)

$n=2$ (β - ")

$n=3$ (γ - ")

α - Aminoketones - planar
Form densely packed layer
more effective

Steps taken to eliminate corrosion problems in electronic components include

- hermetic sealing of components in cavities
- use of protective coatings,
- encapsulation
- use of noble metal platings
- increased use of more corrosion resistant metal alloys
- and the use of moisture absorbing dessiccants

All these methods reduce corrosion, but not eliminate corrosion in electronic components. Volatile Corrosion Inhibitors or Vapour phase corrosion inhibitors (VCIs) can provide an effective means of protecting electronic components from corrosion.

VAPOUR PHASE CORROSION INHIBITORS

VCIs are organic compounds with vapour pressure about 10^{-7}-10^{-2} mm Hg . They are transported by diffusion through the gas phase and adsorbed onto the metal with a thickness of a few monolayers, thereby protecting it from corrosion.

The adsorption involves the formation of a metal-inhibitor bond (coordinate bond) through atoms like nitrogen or oxygen present in the inhibitor. The bond formation depends on the availability of electrons on heteroatoms, which are considered as reaction centers.

The ultra-thin protective layer does not interfere with conductivity or resistivity of the base metal. VCIs are especially useful for protecting metals in cavities and other hard to reach places.

The efficiency of an inhibitor depends on its ability to be adsorbed on the metal's surface, the strength of adsorption, and the temperature dependence of its vapour pressure. Each of these properties depends upon the chemical structure of the inhibitor.

VAPOUR PRESSURE OF INHIBITOR

Vapor pressure is a critical parameter in determining the effectiveness of a VCI. A VCI reaches the metal surface that it must protect through the vapour phase.

This transport mechanism requires the VCI to possess an optimum vapour pressure. Very low vapour pressure, e.g., on the order of 10^{-6} Torr at room temperature, leads to slow establishment of a protective layer which may result in insufficient corrosion protection. Further, if the space that houses the equipment and the VCI is not sealed, sufficient inhibitor concentration may not be reached.

On the other hand, if the vapor pressure is too high (approximately 0.1 Torr at ambient conditions), VCIs effectiveness will be limited to a short time period, as its consumption rate will be high.

Therefore, the VCI must not have too high or too low vapor pressure, but some optimum vapor pressure. For practical purposes, it is preferable to use less volatile inhibitors that provide long-lasting and durable protection over periods of 2 years to 3 years and protection of breathable enclosures and enclosures where changes of local atmosphere occur.

SOME CLASSES OF VCIs

AMINES

Aliphatic amines

Most of the volatile corrosion inhibitors that are used are amine derivatives. In general, aliphatic and alicyclic amines exhibit inhibiting efficiencies superior to those of the aromatic substances having similar vapour pressures.

The inhibition efficiency is higher for straight chain amines than branched chain in the case of aliphatic amines, Further, when the branching is closer to the amine group, the inhibition becomes lower.

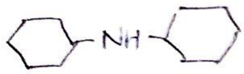
The most effective of the aliphatic amines are primary straight chain amines with an even number of carbon atoms.

Cyclohexylamine and dicyclo hexylamines are other inhibitors used. Dicyclohexyl ammoniumnitrite (DICHAN) is slightly volatile at atmospheric temperature.

$(C_2H_5)_2NH$ — Diethylamine

$H_2N-CH_2-CH_2-NH_2$ — Ethylene diamine

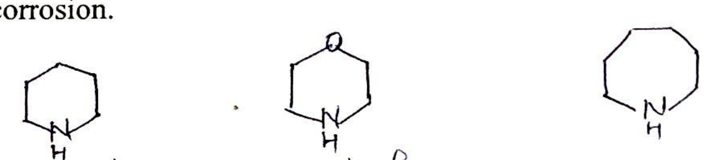
$HN(CH(CH_3)_2)_2$ — Diisopropylamine



Dicyclohexylamine

Heterocyclic amines

Some common heterocyclic amines that are used as VCI are hexamethylene imine, piperidine, and morpholine . Hexamethylene imine has a seven-membered ring structure and others are six-membered rings. Morpholine has a second heteroatom oxygen in addition to nitrogen. This second heteroatom present in the amine decreases the inhibition of steel corrosion.



Piperidine Morpholine Hexamethyleneimine

AMINO KETONES

Amino ketones have two heteroatoms with free electron pairs — one pair on the nitrogen atom and two pairs on the oxygen atom of the >C=O group. The nitrogen atom has a higher electron-donor capability than that of oxygen.The amino ketones get adsorbed on the metal surface through the free electrons of the amine nitrogen or >C=O group oxygen.

α-amino ketones, which are planar molecules, are adsorbed and form a densely packed layer unlike β- and γ -amino ketones, which are nonplanar. Thus, α-amino ketones are more effective inhibitors.

$$O=C(CH_3)-(CH_2)_n-NR_2$$

when n = 1 (α-aminoketone)

n = 2 (β-aminoketone)

n = 3 (γ-aminoketone)

NOTE:

VCIs that effectively prevent corrosion in ferrous materials do not always behave similarly on nonferrous materials. Some VCIs even accelerated the corrosion process on the nonferrous materials, e.g., some amines attack copper and copper alloys due to the formation of soluble complexes. Dicyclohexylamine, morpholine, and diisopropyl amine are recommended inhibitors for copper.