

# Prevention of Iron Materials by Vci Soaked Brown Paper in Wrapping Method

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**Abstract-** Corrosion was produced by vapours of acetic and formic acid when iron machinery is packed in wooden boxes. Prevention of iron materials (machinery tool and instruments made up of iron) can be prevented by wrapping. The paper used for wrapping is firstly treated with vapours produced by organic compounds. Organic compounds are heated to produce vapours which are absorbed in brown paper. Now this paper is used for wrapping of different machinery tools and instruments. This paper works as a barrier between environments and metal surfaces due to the passivity of the metal surface; rust cannot be formed (metal hydroxide). The organic compounds which are mainly used are meta-dinitrobenzene and Anthraquinone at 80%RH and 100%RH.

**Key words:** Anthraquinone, Meta-dinitrobenzene, Vapours, Materials, Machinery, Organic compounds.

## I. INTRODUCTION

Corrosion is a well-known problem worldwide. It is mainly an electrochemical process promoted by different types of processes such as differential aeration, accumulation of dirt, sand, scale, and other contamination because this part of metal is poorly oxygenated, hence anodic where corrosion takes place. The area becomes less accessible to air and more corrosion leads to the formation of deep cavities or localized pitting in the metal. Some time partial cover of metal by block of wood and piece of glass these are working as a screen part of metal from oxygen access. As a consequence, differential aeration and corrosion occurs. It can be some time prevented by passivation by which a metal or alloys show high corrosion resistance due to the formation of a high protective, very thin film (about 0.0004 mm thick) and quite invisible surface film but it can take place in different environments. Passivation tends to maintain a protective film on the surface as Ti, Cr, Al and Cr containing stainless steel alloys exhibit outstanding corrosion resistance in the presence of oxygen. This is due to the formation of a thin film on their surface; the rate of corrosion is less when the area of cathode is smaller, when the cathode area is smaller, the demands for electrons will be less and this results in the decrease rate of dissolution of metal at anodic regions. (1)

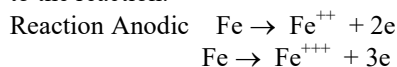
The concept of total corrosion control should be introduced in which corrosion control is more a daily activity at all stages of production than merely an afterthought. Good corrosion control. An inhibitor is a chemical substance, when added in small concentration to an environment, effectively decreases the corrosion rate. There are several classes of inhibitors conveniently designated as passivators. 1. Organic inhibitors 2. including slushing compounds and

pickling inhibitors, and vapour phase inhibitors. 3. The practice of corrosion inhibitors is greatly influenced by new regulations that have been developed because of toxicity in environment effect resulting from industrial effluents. There is a trend to replace some widely used inhibitors such as meta-dinitrobenzene, in application where toxicity, environmental damage, and pollution caused by these chemicals are important considerations. The extent of chemical reduction on initial contact of passivators with metal, according to this view point, must be at least chemically equivalent to the amount of passive film formed as a result of such reduction. From the passive film on iron this is in the order of 0.01 cm<sup>2</sup> of apparent surface. The total equivalent of chemically reduced Anthraquinone is found to be of this order and it is probably also the same for the other passivators acting on iron [1-3]. The amount of Anthraquinone reduced in the passivation process is arrived at from measurements [4]. In the type of vapour phase process various types of materials are widely used such as polyaniline [5-7], Polypyrrole [8] and polyacetylene [9]. Heavy effort has been deployed to find suitable corrosion inhibitors for organic compounds. Origin in various corrosive media. In acid media, nitrogen based materials and their derivatives, sulphur containing compounds, aldehyde, thioaldehydes, acetylene compounds and various alkaloids are used in corrosion prevention process. [10]

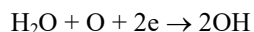
## II. MECHANISM OF CORROSION

Corrosion is the deterioration of a material as a result of reaction with its environment, especially with oxygen. Although the term is usually applied to metals, all materials, including ceramics, plastics, rubber, and wood, deteriorate at the surface to some extent when they are exposed to certain combinations of liquids and/or gases. Common examples of metal corrosion are the rusting of iron, the tarnishing of silver, the dissolution of metals in acid solutions and the growth of patina on copper. Most research into the causes and prevention of corrosion involves metals, since the corrosion of metals occurs much faster under atmospheric conditions than does the corrosion of nonmetals. The cost of replacing equipment destroyed by corrosion in the United States alone is in the billion-dollar range annually. Corrosion is usually an electrochemical process in which the corroding metal behaves like a small electrochemical cell. Since the corrosion of iron by dissolved oxygen is, from an economic standpoint, the most important redox reaction occurring in the atmosphere, it

will be used here to illustrate the electrochemical nature of the process. A sheet of iron exposed to a water solution containing dissolved oxygen is the site of oxidation and reduction half-reactions, which occur at different locations on the surface. At anodic areas, iron is oxidized according to the reaction.



At the same time, oxygen molecules in the solution are reduced at the cathodic areas. Reaction Cathodic



The two processes produce an insoluble iron hydroxide in the first step of the corrosion process: Generally, this iron hydroxide is further oxidized in a second step to produce  $\text{Fe}(\text{OH})_3$ , the flaky, reddish brown substance that is known as rust. Unfortunately, this new compound is permeable to oxygen and water, so it does not form a protective coating on the iron surface and the corrosion process continues. All metals exhibit a tendency to be oxidized, some more easily than others. A tabulation of the relative strength of this tendency is called the electromotive series of metals. Knowledge of a metal's location in the series is an important piece of information to have in making decisions about its potential usefulness for structural and other application

### III. MATERIAL AND METHODS

#### 3.1 Metal Studied

Iron panels of the size 7.5 cm × 1.25 cm (cut from single sheet) of pickled cold rolled closed annealed (18 SWG) were used in all experiments. The composition of the mild steel sheet was iron 99.74%, carbon 0.07%, silicon 0.07%, sulphur 0.044%, phosphorus 0.049%, manganese 0.023%. All panels were carefully polished with successive grades of emery paper for removing all surface defects. The final surface was brought to standard finish by polishing with 000 grade emery paper. All cuts, edges, corners and suspension holes were rounded off and smoothened.

After surface preparation panels were degreased with sulphur free toluene. This was followed by treatment with methyl alcohol to remove sweat residue and finger prints. The specimens were dried and then transferred to a vacuum desiccators in which they were allowed to remain for a period of 24 hours.

#### 3.2 Corrosion experiments:

After surface preparation panels were weighed (weighing was done with the help of single pan weighing machine). For the identification of panels all the panels were numbered and suspension holes were made.

Weighed metal panels, were exposed to synthetic atmosphere of different humidity or corrosive vapours. The samples were withdrawn after a specified time and the extent of corrosion was determined by weight gain or weight loss method. The de rusting was done by using appropriate de rusting solutions. The de rusting solution used was conc. HCl containing 5% stannous chloride and

2% Antimony trioxide at room temperature. After removal of corrosion product, the metal panels were washed with distilled water followed by immersion in absolute alcohol or acetone, drying with hot air, cooling in desiccators and weighing. The weight losses of specimens due to corrosion were determined by subtracting the weights of derusted panels from their original weights.

The specimens were suspended in sealed desiccators (one liter capacity) by glass hooks with the help of glass rod fixed tightly on the inner walls of the desiccators. Care was taken to put grease on the lid properly so that once closed, the system was fully sealed.

In order to make sure that the un corroded metal was not removed from the panels by the de rusting solutions, blank was run in each case to check the amount of metal removed in the process of de rusting. It was found that metal removed from the blank did not exceed 0.1% of the total corrosion value.

It has been reported by Evans if the rust consists of  $\text{Fe}(\text{OH})_2$  and no other compounds, the loss in weight should be 1.69 of that of the gain in weight. Since in our study, other compounds were likely to be formed the weight increments might not give the true picture, as in many cases where the corrosion product were not of adherent type or where leaching of the corrosion product could have been possible, the weight increments were not suitable as a method for assessment of the corrosion rate. The corrosion has been measure in  $\text{mg}/\text{dm}^2$  of the surface area.

Preparation of synthetic humid atmosphere:

The humid atmosphere of known RH was produced by using sulphuric acid of appropriate density, AR quality sulphuric acid was used for the purpose and the required dilution was done by distilled water. The concentration of acid for different RH was as follows:

For 20%RH  $\text{H}_2\text{SO}_4$  31.39 % by volume

For 40%RH  $\text{H}_2\text{SO}_4$  25.90 % by volume

For 60%RH  $\text{H}_2\text{SO}_4$  20.80 % by volume

For 80%RH  $\text{H}_2\text{SO}_4$  14.55 % by volume

For 100%RH  $\text{H}_2\text{SO}_4$  0.0 % by volume (Distilled water)

The amounts of dilute acid taken were 30cc in the desiccators of 1000 cc capacity. The sealed desiccators containing the solution were kept at room temperature for three days before the panels were introduced in them.

Preparation of other corrosive environments:

The acetic acid environment was created by taking 1cc of acetic acid of desired concentration soaked in cotton and hanging it inside the desiccators with the help of glass hooks. The environment of wood exhalations was created by hanging wet wood piece of size 1 inch ,2 inches with the help of cotton threads inside the desiccators for 7 days. Woods pieces were kept immersed in distilled water for 24 hours at room temperature before hanging.

#### 3.3 Volatile corrosion inhibitor:

Few volatile corrosion inhibitors reported by Rajagopalan as very good inhibitors were tested at different RH. Those found excellent were used to prevent corrosion by vapours

emitted by woods. They were also incorporated in ordinary brown paper to prepare VCI paper.

0.5 gm of VCI was taken in a glass plate and was kept inside the desiccators (IL) at required humidity with and without wood. The weight losses of the panels in the absence of VCI (W<sub>u</sub>) and in the presence of VCI (W<sub>i</sub>) were determined for different time durations. The inhibitor efficiency (I) was calculated by the following equation.

$$I = \frac{W_u - W_i}{W_u} \times 100$$

Majority of the state and Industrial standards, for evaluation of the performance of vapor corrosion inhibitors, used the Federal Standard No. 101C, Method 4031, (Corrosion inhibiting ability of VCI vapours). This test is applied for testing of the VCI films, papers and powders and is included in Japanese Industrial Standards JISZ 1519, JISZ 1535 JISK 2246. According to this test the VCI material is placed inside a Jar that serves as a test chamber. The Jar contains water glycerin solution of different strength, which produces different relative humidity. There is also a metal specimen inside the Jar. This specimen does not contact the VCI material. For non-VCI material this condition will cause corrosion. If the material contains an adequate amount of VCI, metal surface remains protected. According to German Military Standard TL 8135, Corrosion protection provided by the VCI material is graded by visual inspection of the metal specimen. Keeping in mind the above standard, we planned our experiment mild steel due to Anthracene for different RH.

**Table no 1: Corrosion of paper wrapped iron materials due to different concentrations of acetic acid for different time durations at different RH.**

S. No	Amount of Acetic acid(cc)	Wt loss(mg/dm <sup>2</sup> )			
		80%RH		100%RH	
		2 month	4 month	2 month	4 month
1	0.001	119	153	402	651
2	0.01	146	173	514	973
3	0.1	275	707	641	1254
4	1	1168	1615	1372	2475

**Table no.2: Protection of iron materials when wrapped with metadinitro benzene incorporated paper and exposed to acetic acid vapors of different concentration at 80%RH.**

S. No	Amount of acetic acid(cc)	Two month		Four month	
		Wt loss (mg/dm <sup>2</sup> )	Protection %	Wt loss (mg/dm <sup>2</sup> )	Protection %
1	0.001	24.4	79	28.1	81
2	0.01	87.0	40	94.2	45
3	0.1	119.5	56	200.0	71
4	1	331.8	71	349.5	78

**Table No 3: Protection of iron material when wrapped with met dinitrobenzene incorporated paper and exposed to acetic acid vapors of different concentration at 100%RH**

S.No.	Amount of acetic acid(cc)	Two month		Four month	
		Wt loss (mg/dm <sup>2</sup> )	Protection %	Wt loss (mg/dm <sup>2</sup> )	Protection %
1	0.001	48.8	87	46.3	92
2	0.01	114.6	77	229.2	76
3	0.1	268.5	58	305.4	75
4	1	429.0	68	424.0	82

**Table no. 4: Protection of iron materials when wrapped with Anthraquinone incorporated paper and exposed to acetic acid vapors of different concentration at 80%RH.**

S.No	Amount of acetic acid(cc)	Two month		Four month	
		Wt loss (mg/dm <sup>2</sup> )	Protection %	Wt loss (mg/dm <sup>2</sup> )	Protection %
1	0.001	0.0	100	2.9	98
2	0.01	0.0	100	1.4	99
3	0.1	12.2	95	34.0	95
4	1	9.76	99	30.5	98

**Table No 5: Protection of iron materials when wrapped with Anthraquinone incorporated paper and exposed to acetic acid vapours' of different concentration at 100 %RH.**

S. No	Amount of acetic acid(cc)	Two month		Four month	
		Wt loss (mg/dm <sup>2</sup> )	Protection %	Wt loss (mg/dm <sup>2</sup> )	Protection %
1	0.001	7.32	98	45.12	93
2	0.01	12.2	97	65.8	93
3	0.1	19.7	96	119.5	90
4	1	536.8	60	758.8	69

**IV. RESULTS AND DISCUSSION**

To study the effectiveness of VCI paper, iron panels wrapped with ordinary brown craft paper were exposed to acetic acid vapors of different concentration (0.001cc to 1.0 cc in one litre desiccators) for different time durations ( 2 months and 4 months) at different RH (100% RH and 80% RH) Result have been to table 1.Result show that corrosion at 100%RH is greater than 80% RH both during two and four month. The corrosion rate increased with concentration of acetic acid and also with time. In the presence of 0.001cc acetic acid during two months, the wt loss obtained was 119 mg/dm<sup>2</sup> at 80% Rh and 402 mg/dm<sup>2</sup> at 100%RH. During four months, wt loss obtained was 153 mg/dm<sup>2</sup> at 80 % RH and 651 mg/dm<sup>2</sup> at 100 % RH. In the presence of 1 cc acetic acid during two months. The wt loss obtained was 1168 mg/dm<sup>2</sup> at 800% RH and 1372 mg/dm<sup>2</sup> at 100%

RH, during four months the wt loss obtained was 1615 mg/dm<sup>2</sup> at 80% RH and 2475 mg/dm<sup>2</sup> at 100%RH. Thus, wt loss obtained with uninhibited paper wrapped iron panels was sufficiently higher.

Table No.2 depict the protection of iron panels wrapped with meta dinitro benzene incorporated paper and exposed to acetic acid vapors of different concentration (0.001 cc to 1.0cc ) at 80% RH for two months and four months. Results shows that at lower concentration (0.001cc) of acetic acid the percentage protection obtained was the order of 80% during entire time duration of two months and four months. At highest concentration (1.0cc) protection obtained during two months was 71 % and during four months was 78%.

Table No.3 depict the protection of iron panels wrapped with meta dinitro benzene incorporated paper and exposed to acetic acid vapors of different concentration (0.001 cc to 1.0cc ) at 100% RH for two months and four months. Results show that performance of metadinitro benzene was better at 100% RH than that at 80 % RH during entire exposure time of two months and four months. At lower concentration of acetic acid (0.001cc), the percentage protection obtained was 87% during two months and 92 % during four months at higher concentration (1.0 cc).The percentage protection obtained was 68% during two months and 82% during four months.

Table No.4 depict the protection of iron panels wrapped with Anthraquinone incorporated paper and exposed to acetic acid vapors of different concentration (0.001 cc to 1.0cc ) at 80% RH for two months and four months. Results show that anthraquinone is highly efficient volatile corrosion inhibitor even when incorporated in craft paper. It afforded 100% protection at lower concentration of acetic acid(0.001cc).wt loss obtained during two months is 0.0mg/dm<sup>2</sup>.and during four months was 2.9 mg/dm<sup>2</sup>.At higher concentration 0.1cc .The percentage protection obtained was 95%.

Table No.5 depict the protection of iron panels wrapped with Anthraquinone incorporated paper and exposed to acetic acid vapors of different concentration (0.001 cc to 1.0cc ) at 100% RH for two months and four months. Results shows that anthraquinone incorporated paper is highly effective at 100%RH also, in acetic acid concentration up to 1.0cc.The protection efficiency ranged between 96% to 98% during two months and 90% to 93% during four months. At higher concentration (1cc of acetic acid) percentage protection obtained was 60% during two months and 69% during four months.

## V. CONCLUSIONS

VCI derivative shows good inhibition efficiency of corrosion by the formation of physical barrier between metal and corrosive environment by the interaction. The volatile corrosion inhibitor of mild steel carried out by using meta dinitrobenzene, anthraquinone, wrapped craft brown paper soaked with these vapors producing organic compounds.

Investigation shows that VCI soaked paper provides very effective corrosion prevention processes for the iron materials such as boilers and feeders. VCI can apply in the powder form at the time of manufacturing of Iron materials equipment.

It is confirmed that VCI provides protection to the metal located at few centimeters from the VCI source. These experiments are done inside the desiccators

As per to the testing data. VCI is compatible. And it can also lower the corrosion rate.

All types of the inhibitors can used in incorporated with VCI materials soaked in brown craft paper.

## VI. ACKNOWLEDGEMENT

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