CHAPTER V

INHIBITION OF CORROSION OF 60/40 BRASS IN SODIUM HYDROXIDE SOLUTIONS
(1) CORROSION OF BRASS IN SODIUM HYDROXIDE

At ordinary temperature, in quiet exposure, rates range around to 1-10 mg/dm²/day (1).

Uhlig (2) reported that alkalies attack copper-zinc alloys at room temperature under stagnant condition to an extent of 0.002 to 0.02 ipy, but increased aeration and increased temperature enhance the rates from 0.02 to 0.07 ipy. Venator (2) observed that sodium hydroxide solutions attack brass only by preferentially dissolving zinc. Althof (3) studied the corrosion of brass in sodium hydroxide solutions and observed that the corrosion phenomena may be intercrystalline or intracrystalline. Craighead (4) studied the corrosion of brass in alkali in the temperature range 1000-1500°F. Dajjin (5) observed the corrosion of various types of brasses in sodium hydroxide solutions and reported that 70/30 brass offers highest resistance to corrosive attack of the alkali.


3. Intercrystalline and Intracrystalline Corrosion and Their Causes, F.C. Althof, Z. Metallkunde, 26 (1944), 177; C.A. 41 (1947), 2377.


Sodium rhodizonate, sodium chromotropate, quinellazinin, dithiooxamide, acriflavine, alocyanine have been used as inhibitors for the corrosion of copper (1-3), 63/37 brass (4-5), and 70/30 brass (6-7) in sodium hydroxide solutions.

Furfuraldehyde prevents the corrosion of zinc anodes in dry cells (8), the corrosion of metal containers and equipment by insecticides and weedicides (9), the corrosion of steel in water (10), and in acids (11), the corrosion of cadmium-antimony alloy in sulphuric acid (12), hydrochloric acid and nitric acid (13).

Takahashi (14) patented its use for the prevention of corrosion of metals by hydrochloric acid, sulphuric acid or phosphoric acid. Desai et al. reported that furfuraldehyde is an excellent inhibitor for the corrosion of brass in acids (15), and in alkali (16), the corrosion of aluminium in hydrochloric acid (17) as well as for the corrosion of copper in hydrochloric acid (19), sodium hydroxide (14) and potassium persulphate solutions (20). It has (21) also been used to prevent the corrosion of 63/37 brass in sodium hydroxide and potassium persulphate solutions. Turyk found that at 70°C, furfuraldehyde is an efficient inhibitor for the corrosion of boiler tubes in 8% hydrochloric acid (22).
Glucose has been used as an inhibitor of the corrosion of aluminium in alkali (23), of copper and in aqueous ammonia (24) and in sodium hydroxide solutions (1-3), the corrosion of 63/37 brass (4,5) and 70/30 brass (6,7) in sodium hydroxide solutions, during manufacture of furfural (25).

2,4-Pentanedione has been investigated as an inhibitor of corrosion of iron, zinc and cadmium in hydrochloric acid (26), and the corrosion of aluminium (27), copper (1-3), 63/37 brass (4,5) and 70/30 brass (6,7) in sodium hydroxide solutions. It has proved to be a satisfactory inhibitor for the corrosion of aluminium alloys 25 (26), 573 (18) and 653 (27) in hydrochloric acid.

Cyclopentanone has not been reported as a corrosion inhibitor so far.

Cyclohexanone has been used to retard the corrosion of steel in sulphuric acid at 70-100°C (28), the corrosion of copper (1-3) and 63/37 brass (4,5), 70/30 brass (6,7) in sodium hydroxide (8), potassium persulphate solutions (3).

Thiourea has been used to suppress the corrosion of iron in acidic media (29,30) of steel in hydrochloric acid (31-38) in sulphuric acid (39-45) and in nitric acid (46-48) and in mixtures of HCl, H₂SO₄ and HNO₃ (49). It was observed that thiourea affords simultaneous protection to iron and zinc in acid media (50). It has been also
suggested as corrosion inhibitor for various metals in hydrochloric acid (51-53), the corrosion of aluminium in hydrochloric acid (54-72), the corrosion of titanium in sulphuric acid (36), the corrosion of nickel in hydrochloric and sulphuric acid (36), and the corrosion of copper (3) in nitric acid and alkaline solutions. Thiourea also retards the corrosion of manganese electrodes (73), the corrosion of metals in steam generators (74, 75) and boilers (76) and in oil wells (77-79). It has been used as a pickling inhibitor (80). The cracking corrosion of aluminium (81) and steel (42) can be retarded by thiourea. It has been also tested as a vapour phase inhibitor (82). Its adsorption on mercury has been evaluated (83, 84). A synergistic action of thiourea with KI and urotropine has been noted (85). The uses of thiourea as corrosion inhibitor have been reviewed (86).

Phenylthiourea has been used as a corrosion inhibitor for metals (87), for iron in HCl (37, 38, 88-91) and for the corrosion stainless steel in HCl (92).

Horner evaluated sodium diethyldithiocarbamate as a corrosion inhibitor for iron (93). It has been studied as an inhibitor for the corrosion of carbon steel in dilute sulphuric acid (89). It affords excellent protection to copper (1-3), 63/37 brass (4, 5) and 70/30 brass (6, 7) in sodium hydroxide solutions.
Hydrazine has been used to prevent condenser tube corrosion(94), boiler corrosion(95-104), oil pipes corrosion(105-107), power station corrosion(108-110), the corrosion of steel in distilled water (111-113) in nitric acid(114), in hydrochloric acid(68) and alkalies(115), the corrosion of hydrocarbon fuel tanks(116), the corrosion of steam generators(117), the corrosion of copper in nitric acid(118) and as an oxygen scavenger(119). It has been observed to be an excellent inhibitor for the corrosion of copper(1-3), 63/37 brass(4,5), 70/30 brass(6,7) in alkalies, metals in water(120), and well casing corrosion(121).

Tannin retards the corrosion of steel in acids(123,124) in neutral solutions and in deuterium exchange systems(125), in presence of bacteria(126,127) in alkalies(128), the corrosion of aluminium in hydrochloric acid(129-133), the corrosion of copper in acetic acid(134), the corrosion of metals in water circulating systems(128,135), in boiler water(136), and the corrosion of lead in soft water(137).
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60/40 Brass is corroded to a greater extent in 0.5N sodium hydroxide solution than in 0.2N and 1.0N solutions of sodium hydroxide. The corrosion rates and efficiency of inhibitors is given in Table V-1, page 168-70.

The ratios of copper and zinc are given in Table V-2, page 171. In 0.2N and 1.0N sodium hydroxide, there is slight selective dissolution of zinc whereas in 0.5N sodium hydroxide, 60/40 brass dissolves as a whole unit.

**SODIUM RHODIZONATE**

In 0.2N sodium hydroxide solution, sodium rhodizonate accelerates the corrosion of 60/40 brass but with the increase in alkali concentration, the performance of sodium rhodizonate improves. Similar observations were made with 70/30 brass(4,5) and 63/37 brass(6,7) also. At 0.1% concentration, sodium rhodizonate affords 60% and 74% protection to 60/40 brass in 0.5N and 1.0N sodium hydroxide solutions respectively. Studies with copper(2,3) indicate that sodium rhodizonate is a satisfactory inhibitor in 0.2-1.0N sodium hydroxide solutions. It is to be noted that acceleration of corrosion in 0.2N sodium hydroxide in the presence of sodium rhodizonate is observed only in 70/30 brass(4,5) and 60/40 brass; with 63/37 brass(6,7) sodium...
rhodizonate is an unsatisfactory inhibitor, but corrosion is not accelerated. In the presence of sodium rhodizonate, in 0.5N and 1.0N solutions of sodium hydroxide, the metal specimens are covered with reddish film. In the presence of sodium rhodizonate there is a tendency of dezincification of 60/40 brass in 0.2N and 1.0N sodium hydroxide solutions but in 0.5N sodium hydroxide solution 60/40 brass dissolves as a whole unit. Sodium rhodizonate enhances the dezincification of 63/37 brass(6,7) but with 70/30 brass(4,6) there is a preferential dissolution of copper. Even though both hydroquinone(8) and sodium rhodizonate have quinonoid structure, there is a marked difference in their behaviour as corrosion inhibitors for 60/40 brass in sodium hydroxide solutions. In the presence of hydroquinone, the efficiency falls off beyond the optimum inhibitor concentration and hydroquinone is more effective in dilute alkali solutions. According to Welcher(9), sodium rhodizonate forms an orange red coloured compound with copper which can be represented by the following formula:

![Diagram of the compound formed by sodium rhodizonate and copper.](image)
Actually it is observed that at effective inhibitor concentrations, the specimens are covered with thin reddish yellow films. Probably, the better inhibition action of sodium rhodizonate is due to the formation of a protective layer of cupric complex which appears to be more stable with the increase in the concentration of sodium hydroxide.

**SODIUM CHROMOTROPATE (Fig. V-2, P-175)**

At lower concentrations, sodium chromotropate induces acceleration of 60/40 brass in 0.2-1.0N sodium hydroxide solutions, but with an increase in inhibitor concentration, it shows some inhibitive action. The efficiency of sodium chromotropate increases with the increase in sodium hydroxide concentration. The increase in inhibitive capacity with pH is also observed with copper(2,3) and 70/30 brass(4,5), whereas with 63/37 brass(6,7) there is a fall in efficiency. In the presence of sodium chromotropate, there is dezincification of 60/40 brass in 0.2N sodium hydroxide solution, but in 0.5N and 1.0N solutions of sodium hydroxide, 60/40 brass dissolves as a whole unit. With 70/30 brass(4,5) and 63/37 brass(6,7) a tendency of dezincification was observed. Probably, the protective action of sodium chromotropate is due to complex formation and the stability of the complex is relatively greater at higher concentrations of sodium hydroxide.
In 0.2N sodium hydroxide, 0.01% quinalizarin accelerates the corrosion of 60/40 brass, but with an increase in inhibitor concentration, its protective effect is felt. Quinalizarin is most effective in 0.5N sodium hydroxide solution. In the presence of quinalizarin, there is a tendency of selective dissolution of zinc. Similar results were obtained with 63/37 brass and 70/30 brass also. Quinalizarin is found to be a satisfactory inhibitor for copper(2,3), 63/37 brass(4,5) and 70/30 brass(6,7) also.

**FURFURALDEHYDE**

At 2.17 ml./l. concentration, furfuraldehyde completely arrests the corrosion of 60/40 brass in 0.2N and 0.5N sodium hydroxide solutions and in 1.0N sodium hydroxide also, it shows very good protection (97%). In the presence of furfuraldehyde, the metal specimens were covered with thin brown resinous films, which suggests that the inhibitive action of furfuraldehyde may probably be due to the fact that furfuraldehyde forms a resinous product in alkaline medium, which is adsorbed over the metal surface. In 0.2-1.0N sodium hydroxide solutions, furfuraldehyde affords more than 99% protection to 63/37 brass(6,7) and 70/30 brass(4,5), and completely arrests the corrosion of copper(2,3). The efficiency of furfuraldehyde improves with increase in alkali concentration, which is evident by comparing the results in 0.2-1.0N sodium hydroxide at 0.43
ml. concentration of furfuraldehyde. Such a behaviour is also observed with copper(2,3) and 63/37 brass(6,7). At 0.43 ml./l. concentration, there is a preferential attack on copper in 0.2N sodium hydroxide solution, whereas at higher concentrations of sodium hydroxide, 60/40 brass dissolves as a whole unit. With 70/30 brass(4,5) also a preferential dissolution of copper was observed.

**Glucose** (Figs. V-4, p. 177)

At 2% concentration, glucose completely arrests the corrosion of 60/40 brass in 0.2N and 0.5N sodium hydroxide solutions and affords 90% protection in 1.0N sodium hydroxide. At effective inhibitor concentration, the metal specimens are untarnished at the end of five days. The probable explanation for the excellent inhibitive action of glucose is that it removes the dissolved oxygen from the solution, cupric copper is reduced to cuprous copper by glucose and this cuprous copper is immediately oxidised to cupric state by dissolved oxygen so that the solution becomes oxygen free. Such an explanation was put forward by Redley(10) in explaining inhibition of the corrosion of copper in ammonia. With copper(2,3), 70/30 brass(4,5) and 63/37 brass(6,7) also, it was observed that 2% glucose completely arrests corrosion in 0.2-1.0N sodium hydroxide solutions. With an increase in sodium hydroxide concentration, the tendency of dezincification of 60/40 brass in the presence of glucose increases. Similar results were obtained with 70/30 brass(4,5).
2,4 PENTANEDIONE (Fig. V-5, p. 178)

In 0.2N sodium hydroxide, the optimum inhibitor concentration is 17.4 ml./l.; further increase in inhibitor concentration induces a considerable loss in its efficiency. In 0.5N and 1.0N solutions of sodium hydroxide, the efficiency increases with an increase in inhibitor concentration. In general, the efficiency of 2,4 pentanedione decreases with increase in sodium hydroxide concentration. In the presence of 2,4 pentanedione, there is a selective dissolution of zinc which becomes more notable with the increase in pH of solution. The increase in tendency of dezincification with an increase in sodium hydroxide concentration was noted with 70/30 brass and 63/37 brass also. 2,4 Pentanedione accelerates the corrosion of copper in 0.2N sodium hydroxide and is an unsatisfactory inhibitor for copper in 0.5N and 1.0N solutions of sodium hydroxide (2,3). With 70/30 brass (4,5) and 63/37 brass (6,7) it is observed that it is a good inhibitor in 0.2N sodium hydroxide, but its efficiency falls with an increase in sodium hydroxide concentration.

CYCLOPENTANONE

Cyclopentanone is a very good inhibitor for the corrosion of 60/40 brass in sodium hydroxide solutions. At 26.1 ml./l. concentration, it affords 94% protection to 60/40 brass in 0.2N sodium hydroxide solution and complete protection in 0.5N and 1.0N sodium hydroxide solution. The efficiency of cyclohexanone increases with an increase in
sodium hydroxide concentration which is quite evident by comparing the results obtained with 2.17 ml./l and 4.35 ml./l concentrations of cyclopentanone. In the presence of cyclopentanone, there is a tendency of dezincification of 60/40 brass. A comparison of results obtained with cyclopentanone and cyclohexanone shows that cyclopentanone is a better inhibitor than cyclohexanone.

**CYCLOHEXANONE (Fig. V-6, p. 179)**

In 0.2N sodium hydroxide solution, cyclohexanone is an unsatisfactory inhibitor for 60/40 brass. At lower concentrations, it accelerates the corrosion of 60/40 brass and the maximum protection afforded is 26.8%. In contrast, in 0.5N and 1.0N solutions of sodium hydroxide, cyclohexanone is an excellent inhibitor which affords very good protection to 60/40 brass even at as low a concentration as 0.43 ml./l. In 0.5N and 1.0N sodium hydroxide solutions, the metal specimens remain un tarnished at the end of five days. At low inhibitor concentrations, there is dezincification of 60/40 brass in the presence of cyclohexanone. The tendency of dezincification is more evident in 63/37 brass (6, 7). Cyclohexanone affords more than 90% protection to copper (2, 3), 70/30 brass (4, 5) and 63/37 brass (6, 7) in 0.2-1.0N sodium hydroxide solutions.
THIOUREA (Fig. 7, p. 180)

In 0.2N sodium hydroxide, the efficiency of thio­
urea decreases with an increase in inhibitor concentration,
but in 0.6N and 1.0N solutions of sodium hydroxide, with
the increase in inhibitor concentration, its efficiency
improves. Similar results are obtained with 70/30
brass (4, 5). In general, it can be said that the efficiency
of thio­urea increases with an increase in sodium hydroxide
concentration. Thio­urea accelerates the corrosion of
copper (2, 3) in 0.2N sodium hydroxide up to a concentration
of 0.6% and is an unsatisfactory inhibitor for copper in
0.2N sodium hydroxide. Even in 1.0N sodium hydroxide, the
efficiency of thio­urea for copper decreases with increase
in inhibitor concentration beyond 0.6%. In the presence of
effective concentrations of thio­urea, the specimens of
60/40 brass are covered with very thin black films. In the
presence of thio­urea, there is a selective dissolution of
zinc of 60/40 brass and 63/37 brass. Horner (11) suggests
that, thio­urea forms zwitter ions in sodium hydroxide
solution according to the reaction,

$$\begin{align*}
\text{H}_2\text{N} - \text{C} - \text{NH}_2 + \text{Na}^+ + \text{OH}^- &\rightarrow \left[ \begin{array}{c}
\text{Na}^+ + \text{S}^- + \text{OH}^- \\
\text{H}_2\text{N} - \text{C} - \text{NH}_2
\end{array} \right] \\
\text{and absorption of zwitter ions might be responsible for its inhibitive action for the corrosion of brass in sodium}
\end{align*}$$
hydroxide solutions, which explains the fact that the inhibitor efficiency increases with increase in alkali concentration.

PHENYL THIOUREA

The efficiency of phenyl thiourea falls with an increase in sodium hydroxide concentration. A comparison of results obtained with thiourea and phenylthiourea shows that in 0.2N and 0.5N sodium hydroxide solutions, phenyl thiourea is a better inhibitor than thio urea.

DITHIO-OXAMIDE (Fig. V-8, p. 181).

At low inhibitor concentrations, dithio-oxamide accelerates the corrosion of 60/40 brass in 0.2N and 1.0N sodium hydroxide, but at 0.2% concentration it is a very satisfactory inhibitor. The efficiency of dithio-oxamide increases with sodium hydroxide concentration. In the presence of dithio-oxamide, there is a selective dissolution of copper. Similar results were obtained with 70/30 brass (4, 5) and 63/37 brass (6, 7) also. Dithio-oxamide accelerates the corrosion of copper in 0.1N and 0.5N sodium hydroxide both at lower and higher inhibitor concentrations, however, in 1.0N sodium hydroxide the corrosion is accelerated at higher inhibitor concentrations only. At effective concentrations, dithio-oxamide gives nearly complete protection to 70/30 brass (4, 5), 63/37 brass (6, 7) and 60/40 brass in 0.2-1.0N sodium hydroxide solutions. The difference in
the behaviour of dithio-oxamide towards copper and brass may be due to the presence of zinc in brass and probably, the complex formed with zinc may not be susceptible to high alkalinity or to the high concentration of the inhibitor. The black copper complex of dithio-oxamide can be written as

\[
\begin{array}{c}
\text{HN} \\
\text{C} \\
\text{O} \\
\text{HN}
\end{array}
\]

It is insoluble in ammonia and dilute mineral acids. Formation of black films on the surface of 60/40 brass at the concentrations corresponding to effective inhibition suggests the formation of this complex.

**SODIUM DIETHYL DITHIOCARBAMATE** (Fig. V-9, P-182)

At 0.01% concentration, sodium diethyl dithiocarbamate is a highly satisfactory inhibitor for the corrosion of 60/40 brass in 0.2N and 0.6N sodium hydroxide solutions. In general, the order of efficiency is 0.5 > 0.2 > 1.0N. In the presence of sodium diethyl dithiocarbamate, there is a preferential dissolution of copper. With 70/30 brass also, decuprification of the alloy was observed but with 60/40 brass, a tendency of desincification prevailed. At effective inhibitor concentration, the specimens are covered with thin golden yellow films. Sodium diethyl dithiocarbamate affords
more than 98% protection to copper (2,3) in 0.2-1.0N sodium hydroxide solutions. With 70/30 brass (4,5) and 63/37 brass (6,7) it was observed that there is a fall in the efficiency with an increase in sodium hydroxide concentration. Sodium diethyl dithiocarbamate forms a brownish yellow coloured complex with copper salts,

\[
\begin{array}{c}
\text{C}_2\text{H}_5 \\
\text{N} \\
\text{C} \\
\text{S} \\
\text{C}_2\text{H}_5
\end{array}
\rightarrow \text{Cu}^{2+}
\]

and the formation of such complex on the alloy may be responsible for the protective action of sodium diethyl dithiocarbamate.

**HYDRAZINE SULPHATE** (Fig. V-13 p-186)

The performance of hydrazine sulphate is highly dependent on pH. In 0.2N sodium hydroxide, lower concentrations of hydrazine sulphate accelerates the corrosion of 60/40 brass, but with an increase in inhibitor concentration there is some improvement in its efficiency. However, in 0.5N and 1.0N solutions of sodium hydroxide, 0.1% hydrazine sulphate affords a very good protection to 60/40 brass and the specimens remain bright. In the presence of hydrazine sulphate there is a preferential dissolution of copper. Similar results were obtained with 70/30 brass (4,5) and 63/37 brass (6,7) also. Hydrazine sulphate affords nearly
complete protection to copper (2,3), 70/30 brass (4,5) and 63/37 brass (6,7) in 0.2-1.0N sodium hydroxide solutions.

**GALLOCYANINE** (Fig. V-10, p.183)

At lower concentrations, gallocyanine accelerates the corrosion of 60/40 brass in 0.2N sodium hydroxide solution, but with the increase in concentration its efficiency increases. The order of efficiency of gallocyanine is 0.5N > 0.2N > 1.0N. In the presence of gallocyanine, there is a selective dissolution of zinc. With 70/30 brass (4,5) and 63/37 brass (6,7) also a tendency of dezincification was noted. At effective inhibitor concentration, metal specimens were covered with reddish film. Gallo cyanine accelerates the corrosion of 70/30 brass (4,5) in 0.2N sodium hydroxide, but in 0.5N and 1.0N sodium hydroxide, it is a very satisfactory inhibitor. With copper (2,3) and 63/37 brass (6,7), gallo cyanine is a highly satisfactory inhibitor at all the concentrations of sodium hydroxide studied.

**ACRIFLAVINE** (Fig. V-11, p.184)

In 0.2N and 0.5N sodium hydroxide solutions, the efficiency of acriflavine decreases with increase in inhibitor concentration, but in 1.0N sodium hydroxide solution, the behaviour is reversed. Acriflavine is not a very satisfactory inhibitor for the corrosion of 60/40 brass in sodium hydroxide solutions. In presence of acriflavine, there is a tendency for selective dissolution of zinc which is more
evident in 0.2N sodium hydroxide. With 70/30 brass (4,5) and 63/37 brass (6,7) also a slight desincification was noted. With copper (2,3), 70/30 brass (4,5) and 63/37 brass (6,7) acriflavine was found to be a satisfactory inhibitor in 0.2N sodium hydroxide, but with the increase in sodium hydroxide concentration, a considerable reduction in its efficiency is observed.

TANNIN (Fig. V-13, p.185)

The optimum inhibitor concentration is 0.5%, further increase in concentration reduces the efficiency. Similar behaviour was observed with 70/30 brass (4,5) and 63/37 brass (6,7) also. In the presence of tannin, porous gelatinous films are formed on metal surface.

The inhibitive effect of tannin may be due to the absorption of oxygen by tannin with the resultant ring opening of the catechol and pyrogallol nuclei, which it contains to form aliphatic acids. Tannins have no tendency to absorb oxygen in acidic or neutral solutions, but excess alkalinity results in a rapid rise of absorption power which reaches a limiting value at higher alkalinitities. The darkening of solution occurs which is usually associated with the absorption of oxygen by tannins. It is reported in literature that copper reacts with tannin only upon the addition of alkali. Thus, in the present work in alkaline media, it is quite possible that the inhibitive action of tannin in sodium
hydroxide solutions is due to the formation of a thin film of the reaction product on metal surface as well as oxygen absorption by tannin. The stability of the film depends on the alkali concentration as well as on the concentration of the inhibitors.

A solution of tannin is an essentially a colloidal suspension of negatively charged particles. It is quite likely that colloidal inhibitors are transported to the cathodes or anodes by electrophoresis forming porous gelatinous films on the metal surface. As tannin is a colloidal solution of negatively charged particles it is transported to the anodes.

CONCLUSIONS

Sodium rhodizonate accelerates the corrosion of 60/40 brass in 0.2N sodium hydroxide solution, but with an increase in the concentration of sodium hydroxide, its efficiency improves. With sodium chromotropate, cyclopentanone, cyclohexanone, thiourea and hydrazine sulphate it was observed that the efficiency of the inhibitor improves with an increase in sodium hydroxide concentration. In contrast, with furfuraldehyde, glucose and phenyl thiourea it was observed that there is a slight fall in the efficiency with an increase in sodium hydroxide solutions. Quinalizarin, 2,4 pentandione, dithio-oxamid, sodium diethyl dithiocarbamate and galloycyanine are most effective in 0.5N sodium hydroxide solutions.
With sodium chromotropate, quinalizarine, glucose, cyclohexanone, dithio-oxamide, hydrazine sulphate and gallo cyanine the corrosion of 60/40 brass is accelerated at lower inhibitor concentrations, but with an increase in inhibitor concentration, the protective action of these compounds comes into play. 2,4 pentanedione and thiourea exhibit maximum protection in 0.2N sodium hydroxide at an optimum concentration, further increase in inhibitor concentration brings about a fall in the efficiency, however, such a behaviour is not marked at higher concentrations of sodium hydroxide. The optimum concentration of acriflavine, in 0.2N and 0.5N solutions of sodium hydroxide is 0.001%, at higher inhibitor concentrations, the efficiency falls. With tannin, maximum protection is given at 0.5% concentration.

Sodium rhodizonate, quinalizarine, furfuraldehyde, glucose, 2,4 pentanedione, cyclopentanone, cyclohexanone, thiourea, gallo cyanine, acriflavine enhance the preferential dissolution of zinc, whereas with dithio-oxamide, sodium diethyl dithiocarbamate, hydrazine sulphate and tannin the preferential dissolution of copper is evident.

At 4.35 ml./l. concentration, furfuraldehyde affords complete protection to 60/40 brass in sodium hydroxide solution. 2.0% glucose completely arrests the corrosion of 60/40 brass in 0.2N sodium hydroxide solutions. Cyclopentanone gives complete protection to 60/40 brass in 0.5N sodium hydroxide solution at 26.1 ml./l. concentration and
in 1.0N sodium hydroxide solution at 4.35 ml./l. concentration.

Sodium rhodizonate, sodium chromotropate, sodium diethyl dithiocarbamate, dithio-oxamide and 2,4 pentandione function as inhibitors for the corrosion of 60/40 brass in sodium hydroxide solutions due to their chelating capacity, thus their performance as corrosion inhibitors would depend on the stability, solubility, adhesivity and impenetrability of the film of the chelate formed on the metal specimens. Glucose and hydrazine sulphate function as inhibitors due to their reducing capacity, that is, by the capacity of removing the dissolved oxygen from sodium hydroxide solutions. The protection afforded by quinalizarine, acriflavine, gallo-cyanine, furfuraldehyde, cyclopentanone and cyclohexanone is due to the formation of the film over the specimen by adsorption of the inhibitor (or the reaction product of the inhibitor with the corrosive medium).

Tannin functions as an inhibitor by adsorption of colloidal particles over the specimen surface; whereas, the inhibitive action of thiourea is, probably due to the adsorption of zwitter ions formed by the reaction of thiourea with sodium hydroxide.
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<td></td>
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</tr>
<tr>
<td>Sodium rhodizonate</td>
<td>0.1 %</td>
<td>1.3</td>
<td>1.48</td>
<td>1.09</td>
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</tr>
<tr>
<td>Sodium chlorotropate</td>
<td>0.1 %</td>
<td>0.76</td>
<td>1.62</td>
<td>1.53</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quinalizarin</td>
<td>0.2 %</td>
<td>0.94</td>
<td>1.1</td>
<td>1.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Furfuraldehyde</td>
<td>0.43 ml/l</td>
<td>1.8</td>
<td>1.41</td>
<td>1.36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose</td>
<td>0.1 %</td>
<td>1.4</td>
<td>1.23</td>
<td>0.89</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,4 Pentanedione</td>
<td>26.10 ml/l</td>
<td>1.3</td>
<td>0.62</td>
<td>0.54</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyclopentanone</td>
<td>2.17 ml/l</td>
<td>0.92</td>
<td>0.75</td>
<td>0.30</td>
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<tr>
<td>Cyclohexanone</td>
<td>0.43 ml/l</td>
<td>0.92</td>
<td>0.71</td>
<td>0.78</td>
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<tr>
<td>Thiourea</td>
<td>0.2 %</td>
<td>1.2</td>
<td>1.35</td>
<td>0.97</td>
<td></td>
<td></td>
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<tr>
<td>Dithio-oxamide</td>
<td>0.1 %</td>
<td>1.62</td>
<td>1.89</td>
<td>1.76</td>
<td></td>
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<td></td>
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<tr>
<td>Sodium diethyl-dithio carbamate</td>
<td>0.001 %</td>
<td>1.59</td>
<td>1.94</td>
<td>1.84</td>
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<tr>
<td>Hydrazine sulphate</td>
<td>0.05 %</td>
<td>1.59</td>
<td>1.53</td>
<td>1.70</td>
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<tr>
<td>Galloxyanine</td>
<td>0.1 %</td>
<td>1.34</td>
<td>1.43</td>
<td>1.38</td>
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<tr>
<td>Acriflavine</td>
<td>0.05 %</td>
<td>0.98</td>
<td>1.05</td>
<td>1.43</td>
<td></td>
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<tr>
<td>Tannin</td>
<td>0.1 %</td>
<td>1.63</td>
<td>1.68</td>
<td>1.26</td>
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</tr>
</tbody>
</table>
REFERENCES


3. Inhibition of Corrosion of Copper in Sodium Hydroxide Solutions, Werkstoffe u. Korrosion, (1966), 870.

4. Inhibition of Corrosion of 70/30 Brass in Sodium Hydroxide Solutions, M.N. Desai, V.K. Shah, Under publication.


The figures given on the following pages give a graphical representation of performance of the investigated inhibitors for the corrosion of copper, 70/30 brass, 63/37 brass and 60/40 brass.

c-o indicate copper,
x-x indicate 70/30 brass,
indicate 63/37 brass, and
+-* indicate 60/40 brass.
Fig. 1.1

\[ \text{CONC. OF SODIUM RHODIZONATE, \%} \]

\[ \text{\% INHIBITION} \]
7. INHIBITION

Fig. V-5

<table>
<thead>
<tr>
<th>Conc. of 2,4 Pentanedione (m/l)</th>
<th>% Inhibition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Concentrations: 0.2N NaOH, 0.5N NaOH, 1ON NaOH
Fig V-6

INHIBITION

CONCENTRATION OF CYCLOHEXANONE, ml/

% INHIBITION

0.2 N NaOH  0.5 N NaOH  1.0 N NaOH

CONCENTRATION OF CYCLOHEXANONE, ml/
CONCENTRATION OF DITHIO OXAMIDE % in inhibition

Fig V-8
INHIBITION

CONCENTRATION OF SODIUM DIETHYL DITHIOCARBAMATE %

Fig. Y-5

0.2N NaOH 0.5N NaOH 1.0N NaOH

% INHIBITION

CONCENTRATION OF SODIUM DIETHYL DITHIOCARBAMATE
\[ \text{CONCENTRATION OF GALLOCYANINE, } \% \]
Fig. V-11

% INHIBITION

0.2N NaOH

0.5N NaOH

1.0N NaOH

CONC. OF ACRIFLAVINE, %
Fig. V-12

% INHIBITION

CONCENTRATION OF TANNIN γ.

0.2N NaOH
0.5N NaOH
1.0N NaOH