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"IMPROVEMENTS IN OR RELATING TO INHIBITION OF CORROSION  
OF STEEL IN COOLING WATER SYSTEMS"

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, Rafi Marg,  
New Delhi-1, India, an Indian registered body incorporated  
under the Registration of Societies Act (Act XXI of 1960 ).

The following specification describe the nature of this  
invention:-

This is an invention by Dr. NARAYANASWAMI SUBRAMANYAN,  
Scientist, KRISHNASWAMI BALAKRISHNAN, Scientist, BHAGAVATHI SATHIANAN-  
DHAN, Senior Scientific Assistant and MAHADEVA IYER KRISHNAN, Junior  
Scientific Assistant all of Central Electrochemical Research Institute,  
Karaikudi-3, Tamil Nadu, India. all Indian citizens.

PRICE Rs.2/-

This invention relates to improvements in or relating to the inhibition of corrosion of steel in cooling water systems.

Hitherto it has been proposed that chromates/<sup>phosphates</sup> and silicates alone or in combination are used as corrosion inhibitors for steel in coolingwater, particularly in recirculating systems.

This is open to the objection that chromates at concentrations generally employed (300-500 ppm) are toxic from the point of view of disposal and can give rise to dangerous localised corrosion, if used singly at lower concentrations. The chromate-phosphate combination can facilitate scale formation and also cause corrosion of any copper components in the cooling system, apart from favouring bacterial growth. Silicates are used in high concentrations.(3000-4000 ppm).

The object of this invention is to obviate these disadvantages by avoiding the use of chromates and phosphates and employing relatively lower concentrations of silicate.

To these ends, the invention broadly consists in combining silicate with organic amines like cyclohexyl amine, morpholine or triethanol amine and sodium citrate in the following ranges of concentrations, including benzotriazole (2 to 10 ppm) to take care of possible attack of copper or brass components wherever necessary.

Silicate : 250-1500 ppm  
 Amine : 100-500 ppm  
 Trisodium Citrate: 100-500 ppm

Though these chemicals are known to be corrosion inhibitors they do not give a high degree of inhibition except at high concentrations in water containing chloride ions as is evident from Table 1.

TABLE 1

Solution - 10 ppm NaCl		Temp. = 30 ± 2°C
Mild steel of size 3" x 1"		
S.No.	Inhibitor ppm	I.E.(%) for 10 days
1.	Triethanol amine (TEA) (250)	51
2.	TEA 250 + sodium citrate 250	60
3.	TEA (250) + sodium silicate(250)	42
4.	Sodium silicate (250) + sodium citrate(250)	52
5.	Morpholine (1000)	47

A suitable combination of these substances however can give a high degree of inhibition at comparatively lower concentrations under similar circumstances. This is brought out in examples I to III given below:

Example : 1

Temp. = 30 ± 2°C

Solution = 10 ppm NaCl

Mild steel of size = 3" x 1"

Inhibitive combination (in ppm)	I.E.(%) for 10 days	I.E.(%) for 30 days
1) T.E.A. (250) + Sodium citrate (250) + Sodium silicate (250)	99.9	68
2) T.E.A. (100) + Sodium citrate (100) + Sodium silicate (500)	100	74
3) T.E.A. (100) + Sodium citrate (500) + Sodium silicate (500)	100	99
4) T.E.A.(500) + Sodium citrate(500) + Sodium silicate(500)	100	95
5) Morpholine (250) + Sodium citrate (250) + Sodium silicate (250)	100	95
6) Morpholine(250) + Citrate (250) + Silicate(250) + Benzotriazole(10)	--	100
7) Morpholine(500) + Sodium citrate(500) + Sodium silicate(500)	100	100
8) Cyclohexyl amine (100) + Sodium citrate (500) + Sodium silicate(500)	100	96

Example:2

Temp. 30 ± 2°C solution = 100 ppm NaCl

Duration : 10 days

Mild steel of size 3" x 1"

Inhibition efficiency(%)

1) T.E.A. (100) + Sodium silicate(500) + Sodium citrate (500)	73
2) Cyclohexylamine (100) + Sodium silicate (500) + Sodium citrate (500)	73
3) Morpholine (100) + Sodium silicate (500) + Sodium citrate (500)	83

Example 3

Temp. = 80 ± 5°C

Duration = 10 days

Mild steel of size 3" x 1"

Inhibition efficiency (%)

	<u>10 ppm NaCl</u>	<u>100 ppm NaCl</u>
1) T.E.A. (100) + Sodium citrate (500) + Sodium silicate (500)	100	A few rust spots
2) Morpholine (100) + Sodium citrate (500) + Sodium silicate (500)	100	do
3) Cyclohexylamine (100) + Sodium citrate (500) + Sodium silicate (500)	100	do

Example 4

Metal = Copper 3" x 1"

Solution = 10 ppm NaCl

Duration = 30 days

Temp. 30 ± 2°C

<u>Inhibitor combination</u>	<u>Weight loss (m.gms)</u>
1) Control	2.4
2) T.E.A. (100) + Sodium silicate (500) + Sodium citrate (500)	3.3
3) Combination (2) + Benzotriazole (2 ppm)	2.7
4) Morpholine (250) + Sodium citrate (250) + Sodium silicate (250) + Benzotriazole (10 ppm)	nil
5) Morpholine (100) + Sodium citrate (500) + Sodium silicate (500) + Benzotriazole (10)	nil
6) Cyclohexylamine (250) + Sodium citrate (250) + Sodium silicate (250) + Benzotriazole (10)	nil

The following are among the main advantages of the invention;

1) It is possible to avoid completely the use of toxic substances like chromates in inhibiting the corrosion of steel in cooling water systems.

2) Even without chromate, a high degree of corrosion inhibition is achieved by suitable combination of amine, silicate and citrate.

3) The incorporation of benzotriazole in the inhibition combination makes it harmless to copper components in the system.

4) Pollution problem is considerably minimised by the avoidance of toxic chemicals.

Dated this 2nd day of July, 1974

Sd/-  
Asst. Patents Officer,  
Council of Scientific & Industrial Research  
ch

THE PATENT ACT 1970

COMPLETE SPECIFICATION

SECTION 10

IMPROVEMENTS IN OR RELATING TO INHIBITION OF CORROSION  
OF STEEL IN COOLING WATER SYSTEMS.

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, Rafi  
Marg, New Delhi-1, India, an Indian registered body ~~now~~  
incorporated under the Registration of Societies Act (Act  
XXI of 1860).

~~The~~

The following specification particularly describes and  
ascertains the nature of this invention and the manner in which  
it is to be performed :-

This is an invention by Dr. Narayanaswami Subramanyan,  
Scientist, Dr. Krishnaswami Balakrishnan, Scientist,  
Sri Bhagavathi Sathianandham, Senior Scientific Assistant,  
and Sri Mahadeva Iyer Krishnan, Junior Scientific Assistant  
all of Central Electrochemical Research Institute,  
Karaikudi-6, Tamil Nadu, India, all Indian citizens.

This invention relates to improvements in or relating to the inhibition of corrosion of steel in cooling water systems.

Hitherto it has been proposed that chromate, phosphates and silicates, alone or in combination are used as corrosion inhibitors for steel in cooling water, particularly in recirculating systems.

This is open to the objection that chromates at concentrations generally employed (300 - 500 ppm) are toxic from the point of view of disposal and can give rise to dangerous localised corrosion, if used singly at lower concentrations. The chromate-phosphate combination can facilitate scale formation. High concentration of phosphates can, in addition, cause corrosion of any copper components in the cooling system, while phosphate alone can favour bacterial growth. Silicates are used in high concentrations of the order of 3000 to 4000 ppm in water containing chloride basis.

The object of this invention is to obviate these disadvantages by avoiding the use of chromates and phosphates and employing relatively lower concentrations of silicate.



(1)	(2)	(3)
3. TEA (100) + Sodium citrate (500) + Sodium silicate (500)	100	99
4. TEA (500) + Sodium citrate (500) + Sodium silicate (500)	100	95
5. TEA Morpholine (250) + Sodium citrate (250) + Sodium silicate (250)	100	95
6. Morpholine (250) + Sodium citrate (250) + Sodium silicate (250) + Benzotriazole (10)	100	100
7. Morpholine (500) + Sodium citrate (500) + Sodium silicate (500)	100	100
8. Cyclohexyl amine (100) + Sodium citrate (500) + Sodium Silicate (500)	100	96

Example 2:

Mild Steel specimens of size 3" x 1"  
 Temperature : 30 ± 2°C      ::      Solution : 100 ppm NaCl  
 Duration : 10 days

	<u>Inhibition Efficiency (%)</u>	
1. TEA (100) + Sodium silicate (500) + Sodium citrate (500)		73
2. Cyclohexylamine (100) + Sodium silicate (500) + Sodium citrate (500)		73
3. Morpholine (100) + Sodium silicate (500) + Sodium citrate (500)		83

Example 3:

Mild Steel specimens of size 3" x 1"  
 Temperature : 80 ± 5°C      ::      Duration : 25 days\*

	<u>Inhibition efficiency (%)</u>		
	<u>10 ppm NaCl</u>	<u>100 ppm NaCl</u>	
1. TEA (100) + Sodium citrate (500)	98	97	
2. Morpholine (100) + Sodium citrate (500) + Sodium silicate (500)	98	81	30
3. Cyclohexylamine (100) + Sodium citrate (500) + Sodium silicate (500)	99	98	

\* The specimens were exposed to high temperature only for 8 hours each day and for the remaining period the solution was kept at room temperature.

Example 4:

Copper Specimen of size 3" x 1"  
Solution : 10 ppm NaCl     : Duration : 30 days  
Temperature : 30 ± 2°C

Inhibitor combination	Weight loss (m.gms)
1. Control	2.4
2. TEA (100) + Sodium silicate (500) + Sodium citrate (500)	3.3
3. Combination (2) + Benzotriazole (2 ppm)	2.7
4. Morpholine (250) + Sodium citrate (250) + Sodium silicate (250) + Benzotriazole (10 ppm)	nil
5. Morpholine (100) + Sodium citrate (500) + Sodium silicate (500) + Benzotriazole (10)	nil
6. Cyclohexylamine (250) + Sodium citrate (250) + Sodium silicate (250) + Benzotriazole (10)	nil

The following are among the main advantages of the invention:

1. It is possible to avoid completely the use of toxic substances like chromate in inhibiting the corrosion of steel in cooling water systems.
2. Inhibition of corrosion of steel greater than 90% for more than 30 days is obtained by any of the above mentioned combinations.
3. The incorporation of benzotriazole in the inhibitor combination makes it harmless to copper components in the system.
4. Pollution problem is considerably minimised by eliminating chromate.

We claim:

1. A composition for inhibition of corrosion of steel in cooling water system comprising a combination of silicate, aliphatic amines like cyclohexylamine and ~~hexamethylenetriethanolamine~~ triethanolamine and salts of polycarboxylic organic acids like citric acid with or without benzotriazole in the

concentration ranges of amine 50 to 250 ppm, silicate 250 to 500 ppm and citrate 250 to 500 ppm.

2. A composition as claimed in claim (1) in water containing chloride up to a concentration of 100 ppm and up to a temperature of 80°C.

3. A composition for inhibition of corrosion of steel in cooling water systems substantially as herein before described.

Dated this 20th day of September 1975

[GIPPP/(G.P & D.O.I)/79-80/150]

*R. Bhaskar Rao*

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