Research Journal of Biological Sciences 7 (8): 302-306, 2012
ISSN: 1815-8846

Formulation of an Anti-bacterial and Anti-corrosion Paint

[1]Seyed Ali Taheri, [2]Fatemeh S. Taheri and [3]Mohaddeseh Namjoo
[1]Golestan University of Medical Sciences, Gorgan, Iran
[2]Department of Chemical Engineering, Faculty of Engineering,
University of Sistan and Baluchestan, Zahedan, Iran
[3]Department of Paramedicine, Golestan University of Medical Sciences, Gorgan, Iran

Abstract: In this study, formulation of a paint which can resist the rough weather condition containing the water has been proposed. This type of paint can be useful for coating metal in port, ship structure, oil vessels and in agricultural and food safety applications. Also, usage of this paint for disinfection of veterinary environment such as aviculture space and walls and other places, inhibit the growth of pathogenic micro-organism, it can be used in generally for all positions and locations which are in clouding corrosion rough weather conditions. In this case additive materials and prime matters, the paint conditions shifted toward to a perfectly meet the above needs. The riched cine is such a two component paint based on resin epoxy polyamide. The second compound is the strengthener which the last part brought it as the catalyst and dryness of the film of the paint which has been responsible for hard duties. After physicochemical tests was found that due to the existence of proper percentage of zinc oxide and zinc phosphate pigments, the paint No. 10 had the best quality between other prepared paints.

Key words: Anti-corrosive pigments, anti-bacterial, zinc, epoxy coatings, corrosion, Iran

INTRODUCTION

Using organic coatings is an efficient means to protect metal surface against atmospheric corrosion. Existence of anti-corrosive pigments in organic coating prevent the corrosion. Some of the most used widespread inhibitive pigments are zinc oxide and zinc phosphate (Skale *et al*., 2008; Cechalova and Kalendova, 2007; Shao *et al*., 2009).

Usually the aging of protective film increase permeability property to water and some ions. The corrosion rate depends on the transfer of corrosion species through the film (Skale *et al*., 2008).

With negation of steel and prevention of iron ion which exist in steel can be arrest from iron oxidation greatly. Thus, if steel is connected to more active metal such as zinc or magnesium in this case the negative potential is induced to iron and from dissolving the iron ion to be prevented. Induction of negative potential can also be done by electricity. This method is known as cathodic protection. Also materials can be added to the paint to prevent iron ions move into the electrolyte and thus reduces corrosion in steel greatly. This method is called anode neutralization and relevant inhibitors called anode inhibitor.

Prevention of steel corrosion with Zn are used widespread in coatings by cathodic protection and also is applied in marine industrial. In this situation amount of Zn applied in pigments should not be <70% weight and only impediment of this way is usage of much more zinc (Jagtap *et al*., 2008; Munger and Vincent, 1999; Brodd *et al*., 1976).

In such paints organic and inorganic binders are used. Inorganic binders are applied when the withstand oil metal and organic solvent is important. Advantages of organic coatings into inorganic coatings are flexibility, cost and their rate of forming (Jagtap *et al*., 2008).

A set conventable coating with organic or inorganic metallic-zinc dust pigments is called zinc-rich primer which protect galvanic steel surface as oxidation and water inhibitor (Jagtap *et al*., 2008; Ahmad *et al*., 2005).

Generally, organic zinc-rich primers are formulated from epoxy ester and urethane vinyl as binders. Most of organic binders zinc-rich primers are based on chemical epoxy resins because the epoxy coatings with wonderful adhesion, good physical properties, extremely moisture and chemical resistance against high humidity of environment are known as a protective coating with verify and widely usage (Jagtap *et al*., 2008; Rousseau *et al*., 2009).

Corresponding Author: Sayed Ali Taheri, Golestan University of Medical Science, Gorgan, Iran

The rate of corrosion depends upon two factors of generation and growth corrosion rate. Epoxy resins can diminish the rate of corrosion in sub layer of steel as equal as generation rate (Shao *et al*., 2009). The high percentage of zinc metal in order that the electrical bond is established between the zinc particles and steel surface. Metal zinc oxidizes in anode and enters into solution.

In fact, surface is protected from corrosion with zinc oxide. In addition to zinc ions, hydroxyl ions are also found around the electrochemistry cell. So, binders used in this layer should be having sufficient resistance against alkali (Edavan and Kopinski, 2009).

Beside, materials contain zinc ions like zinc oxide or zinc phosphate due to their capability to release ions that prevent the growth of variety species of bacteria and micro-organisms and also widely use for clinical dentistry for disinfection of life environment (Boyd *et al*., 2006).

ZnO particles are effective anti-bacterial and anti-fungal agents both on gram-positive and negative bacteria and fungus and the potential to impact many aspects of food and agricultural systems and formulate a safe and cost-effective paint in controlling the spread of resisted pathogens in food processing environment (Emami-Karvani and Chehrazi, 2011; He *et al*., 2011).

MATERIALS AND METHODS

Construction of the first paint component: First, the amount of 214.3 g epoxy resin was transferred to the laboratory mixed reactor and the acetone solvent was added resin opens in a solvent. After 30 min, the amount of 600 g zinc powder was added gradually and the mixture was ground to reach an acceptable granulation.

Construction of the second paint component (hardener or catalyst): As previously mentioned earlier, the zinc-rich primer is two-component systems consisting of paint and hardener component. In this research, such as epoxy resin-based amide used, so its hardener should be based on polyamide. To build a second paint component, resin polyamide was mixed with various solvents to be chosen the best solvent. Including some hardener resin was mixed with a cyclohexane solvent that is a powerful solvent. It was observed that this solvent had not the properties of mixture of resin.

After various tests, hardener resin was solved in diethyl ether solvent that is solvent component group with the average hydrogen bond power. No detachment was observed in mixture after about 24 h. Then, two components made were mixed together and it was found that are not solved well. Among the tested solvents, xylene solvent was chosen for several reasons.

First, this solvent had miscibility properties with both paint components. Secondly, was more affordable economically. To form hardener component, the amount of 6 g hardener resin with 9 g xylene which is the best value that hardener resin will open in a solvent xylene.

Mixing the paint component with hardener: To find the best ratio between the two components paint; first they were mixed with different ratio and the optimal ratio is equivalent to one hardener component and two paint components was selected. In construction of completed two component paint in all of the flowing formulation, mixing ratio was observed.

RESULTS AND DISCUSSION

Regarding the paint quality control tests made, changes in formulation of physicochemical tests of paint was done after mixing the two components of paint together and results are shown in Table 1-19.

Table1: Physicochemical tests of full paint No. 1

Tests	Results
Appearance	Acceptable
Particles softness	30 micron
Viscosity (cup 4)	35 sec
Useful life of mixed paint	5 h
Drying time	100 min
Impact resistance	With cracking
Bending ability	With cracking
Adherence	4 B
Resistance to run	90 micron
Chemical resistance	Weak
Resistance to salt water spray	15 h
Moisture resistance	21 h

Table 2: Formulation of first component of paint No. 2

Materials	Values (g)	Percentage
Zinc powder pigment	600.00	60.00
Epoxy resin (70%)	214.30	21.43
Xylene	92.85	9.29
Acetone	92.85	2.29

Table 3: Physicochemical tests of full paint No. 2

Tests	Results
Appearance	Acceptable
Particles softness	30 micron
Viscosity (cup 4)	30 sec
Useful life of mixed paint	5 h
Drying time	100 min
Impact resistance	Is amount of crack
Bending ability	Minor amount of crack
Adherence	4 B
Resistance to run	120 micron
Chemical resistance	Weak and negative in all cases
Resistance to salt water spray	15 h
Moisture resistance	22 h

As is clear from Table 4, the acetone was half the value of one compared to previous formula and the amount of toluene was added.

On the other hand, the ratio of 1 and 2 for butanol and Xylene solvents to increase the dissolution rate variability has been considered.

Considering the Table 5, observed that the drying tests many changes and very much later than the film within acceptable limits were dried. The cause of which is the slow solvent evaporation.

Thus, it was observed that the formulation of the above paint remained too fluid and flowing. Therefore, to increase the paint formulation viscosity, paste Bentone were added. Dry Bentone (8/5% weight, solvent).

Because, the paint formulation viscosity problem in formulation paint No. 5 still existed, so the amount of Bentone in paint No. 6 formulation was increased and a new paste Bentone was made with the following properties there are still viscosity problems.

Due to viscosity problems remained in the paint No. 6 formulation, the amount Bentone of was increased and new paste the following features was made.

To make paint No. 6, 1st Bentone and solvent mixture were mixed for 20 min then the epoxy resin was added to it. After 15 min, the pigment also was added.

In the formulation of paint No. 6, the Bentone not only did not help the paint uniformity of the film but also increased the film resistance against the chemicals. Finally, after various preparations to increase the percentage of paint solid component and increasing viscosity, Bentone was prepared by combining the following percentage: Dry Bentone; 18.5% weight, solvent; 80.402% weight, methanol; 1% weight.

In formulation of paint No. 7 paint solid component was 75/24 weight% that this itself increase the paint viscosity as shown in Table 13.

In order to modify viscosity and improve the quality of paint, changes were made in the formulation of paint No. 8 and was prepared. First Bentone initially distributed in the solvent. Then the resin was added, the zinc pigment was added after 20 min and was mixed for 15 min.

Table 4: Formulation of first component of paint No. 3

Materials	Values (g)	Percentage
Zinc powder pigment	600.00	60.00
Epoxy resin (70%)	214.30	21.43
Butanol	30.95	3.10
Toluene	46.43	4.64
Xylene	61.90	6.19
Acetone	46.43	4.64

Table 5: Physicochemical tests of full paint No. 3

Tests	Results
Appearance	Acceptable
Particles softness	30 micron
Viscosity (cup 4)	about 40 sec
Useful life of mixed paint	5 h
Drying time	400 min
Impact resistance	Minor amount of crack
Bending ability	Minor amount of crack
Adherence	4 B
Resistance to run	120 micron
Chemical resistance	Weak and negative in all cases
Resistance to salt water spray	80 h
Moisture resistance	120 h

Table 6: Formulation of first component of paint No. 4

Materials	Values (g)	Percentage
Zinc powder pigment	600.00	60.00
Epoxy resin 70 (%)	214.30	21.43
Xylene	61.28	6.13
Toluene	41.78	4.18
Butanol	32.40	3.24
Methyl iso butyl keton	29.72	72.29

Table 7: Physicochemical tests of full paint No. 4

Tests	Results
Appearance	Acceptable
Particles softness	30 micron
Viscosity (cup 4)	40 sec
Useful life of mixed paint	5 h
Drying time	400 min
Impact resistance	Minor amount of crack
Bending ability	Minor amount of crack
Adherence	4 B
Resistance to run	120 micron
Chemical resistance	No resistance
Resistance to salt water spray	110 h
Moisture resistance	160 h

Table 8: Formulation of first component of paint No. 5

Materials	Values (g)	Percentage
Zinc powder pigment	600.00	60.00
Epoxy resin (70%)	214.30	21.43
Xylene	51.28	13.50
Toluene	41.78	4.18
Butanol	32.40	3.24
Butyl acetate	20.43	2.04
Metyl iso butyl keton	29.72	2.97
Bentone paste (8.5%)	10.00	1.00

Table 9: Physicochemical tests of full paint No. 5

Tests	Results
Appearance	Acceptable
Particles softness	30 micron
Viscosity (cup 4)	50 sec
Useful life of mixed paint	5 h
Drying time	390 min
Impact resistance	Is amount of crack
Bending ability	Is amount of crack
Adherence	5 B
Resistance to run	150 micron
Chemical resistance	Improved
Resistance to salt water spray	131 h
Moisture resistance	190 h

Table 10: Formulation of first component of paint No. 6

Materials	Values (g)	Percentage
Zinc powder pigment	600.00	60.00
Epoxy resin (70%)	214.30	21.43
Xylene	51.28	5.13
Toluene	38.78	3.88
Butanol	32.40	3.24
Butyl acetate	20.43	2.04
Metyl iso butyl keton	29.72	2.97
Bentone paste (10%)	13.00	1.30

According to the collected results in Table 5 at this stage, increasing of anti-corrosion properties of pigments like Litopone, various compound of lead, carbonate, sulphate and lead silicate and zinc oxide that had seemed necessary. ZnO demeans as a barrier to choloride-indused corrosion pores in primer and ameliorates the inhibitor properties (Jagtap *et al*., 2008).

Zinc oxide pigments in the paint No. 9 formulation were equal to 5% of total consumed pigments. This paint had high fluidity and its viscosity was better than previous paints. Percent of solid particle of paint was 75.52. To construct of this paint, first solvent and were transferred to mixed reactor and epoxy resin was added after 15 min. Then powder was added to mixture after some minutes and the reaction lasted for 25 min.

To increase film resistance against corrosion factor, another inhibitor pigment should be added to pigments group. One of the most important of anti-corrosive additive material is zinc phosphate.

Normally both zinc and phosphate ions can diminish the corrosion activity surfaces. Phosphate ions form low soluble iron phosphate anodic areas and zinc ions form low soluble zinc hydroxide on cathodic surfaces (Skale *et al*., 2008).

The absorbed phosphate on iron surface can prevent the cathodic de-adhesion process and by increasing the compactness of the iron oxide layers the inhibition properties of protect films were improved (Shao *et al*., 2009; Edavan and Kopinski, 2009).

So, the corrosion reaction became difficult or in other words the corrosion activity was stopped by the addition of zinc phosphate into epoxy resins.

On the other hand, zinc phosphate is a pigment with low coating that often used to make primers of stainless and could be enhanced its low coating by other coated binders. To obtain suitable zinc phosphate percent, different percentages of that was selected and optimum value was shown in Table 18.

Table 11: Physicochemical tests of full paint No. 6

Tests	Results
Appearance	Acceptable
Particles softness	30 micron
Viscosity (cup 4)	45 sec
Useful life of mixed paint	5 h
Drying time	380 min
Impact resistance	Is amount of crack
Bending ability	Little rupture
Adherence	5 B
Resistance to run	200 micron
Chemical resistance	Improved
Resistance to salt water spray	135 h
Moisture resistance	196 h

Table 12: Formulation of first component of paint No. 7

Materials	Values (g)	Percentage
Zinc powder pigment	600.00	60.00
Epoxy resin (70%)	214.30	21.43
Xylene	51.28	5.13
Toluene	38.78	3.88
Butanol	32.40	3.24
Butyl acetate	20.43	2.04
Methyl iso butyl keton	29.72	2.97
Bentone paste (18.5%)	13.00	1.30

Table 13: Physicochemical tests of full paint No. 7

Test	Results
Appearance	Acceptable
Particles softness	30 micron
Viscosity (cup 4)	48 sec
Useful life of mixed paint	5 h
Drying time	380 min
Impact resistance	Is amount of crack
Bending ability	With amount of rupture
Adherence	5 B
Resistance to run	200 micron
Chemical resistance	Improved
Resistance to salt water spray	170 h
Moisture resistance	240 h

Table 14: Formulation of first component of paint No. 8

Materials	Values (g)	Percentage
Zinc powder pigment	600.00	60.00
Epoxy resin (70%)	214.30	21.43
Xylene	51.28	5.13
Toluene	38.78	3.88
Butanol	32.40	3.24
Butyl acetate	20.43	2.04
Methyl iso butyl keton	29.72	2.97
Bentone paste (18.5%)	15.00	1.50

Table 15: Physicochemical tests of full paint No. 8

Tests	Results
Appearance	Acceptable
Particles softness	30 micron
Viscosity (cup 4)	52 sec
Useful life of mixed paint	5 h
Drying time	390 min
Impact resistance	Is amount of crack
Bending ability	Acceptable
Adherence	5 B
Resistance to run	200 micron
Chemical resistance	Acceptable
Resistance to salt water spray	180 h
Moisture resistance	260 h

Table 16: Formulation of first component of paint No. 9

Materials	Values (g)	Percentage
Zinc powder pigment	600.00	60.00
Epoxy resin (70%)	214.30	21.43
Xylene	51.28	5.13
Toluene	38.78	3.88
Butanol	32.40	3.24
Butyl acetate	20.43	2.04
Methyl iso butyl keton	29.72	2.97
Bentone paste (18.5%)	15.00	1.50

Table 17: Physicochemical tests of full paint No. 9

Tests	Results
Appearance	Acceptable
Particles softness	30 micron
Viscosity (cup 4)	58 sec
Useful life of mixed paint	5 h
Drying time	340 min
Impact resistance	Acceptable
Bending ability	Acceptable
Adherence	5 B
Resistance to run	200 micron
Chemical resistance	Improved
Resistance to salt water spray	230 h
Moisture resistance	336 h

Table 18: Formulation of first component of paint No. 10

Materials	Values (g)	Percentage
Zinc pigment	580.00	58.00
Zinc oxide	21.58	21.16
Epoxy resin (70%)	200.00	20.00
Xylene	49.50	4.95
Toluene	33.75	3.38
Butanol	32.40	3.24
Butyl acetate	17.25	1.73
Methyl iso butyl	15.00	1.50

Table 19: Physicochemical tests of full paint No. 10

Tests	Results
Appearance	Acceptable
Particles softness	30 micron
Viscosity (cup 4)	73 sec
Useful life of mixed paint	5 h
Drying time	310 min
Impact resistance	Without cracking
Bending ability	Without rupture
Adherence	5 B
Resistance to run	200 micron
Chemical resistance	Acceptable
Resistance to salt water spray	400 h
Moisture resistance	580 h

CONCLUSION

Attending to performed experiments, the following results have been obtained: The paint No. 10 with regard to physicochemical tests is shown in Table 19 and due to the having zinc phosphate that have a strong anti-corrosion properties and also having acceptable chemical resistance and other suitable properties has the highest quality among the other paints that is produced.

The prepared paint can make the very durable coating on steel plates in hard weather conditions.

This paint contains the anti-bacterial and anti-fungal activity of zinc compounds and powders (zinc oxide and zinc phosphate) which could be used in agricultural and food safety applications. Also, usage of this paint for disinfection of veterinary environment such as aviculture space and walls and other places inhibit the growth of pathogenic micro-organisms. And the made paint should be used on prepared and cleaned surface to have a maximum performance.

ACKNOWLEDGEMENTS

The researchers gratefully acknowledge financial support from Zahedan paint factory, Sistan and Baluchestan standard office and the Medical Sciences University of Golestan. All experts and technicians are appreciatively acknowledged for their support and help.

REFERENCES

Ahmad, S., A.P. Gupta, E. Sharmin, M. Alam and S.K. Pandey, 2005. Synthesis, characterization and development of high performance siloxane-modified epoxy paints. Progress Organ. Coat., 54: 248-255.

Boyd, D., H. Li, D.A. Tanner, M.R. Towler and J.G. Wall, 2006. The anti-bacterial effects of zinc ion migration from zinc-based glass polyalkenoate cements. J. Mater. Sci., 6: 489-494.

Brodd, R.J., V.E. Leger and A.J. Bard, 1976. Encyclopedia of Electrochemistry of the Elements. Vol. 6, Marcel Decker, New York, Pages: 35.

Cechalova, V. and A. Kalendova, 2007. Properties of ZnO in dependence on method of preparation and size distribution in coatings. J. Phys. Chem. Solid., 68: 1096-1100.

Edavan, R.P. and R. Kopinski, 2009. Corrosion resistance of painted zinc alloy coated steels. Corrosion Sci., 51: 2429-2442.

Emami-Karvani, Z. and P. Chehrazi, 2011. Anti-bacterial activity of ZnO nanoparticle on grampositive and gram-negative bacteria. Afr. J. Microbiol. Res., 5: 1368-1373.

He, L., Y. Liu, A. Mustapha and M. Lin, 2011. Anti-fungal activity of zinc oxide nanoparticles against *Botrytis cinerea* and Penicillium expansum. Microbiol. Res., 166: 207-215.

Jagtap, R.N., P.P. Patil and S.Z. Hassan, 2008. Effect of zinc oxide in combating corrosion in zinc-rich primer. Progress Organ. Coat., 63: 389-394.

Munger, C.G. and L.D. Vincent, 1999. Corrosion Prevention by Protective Coatings. 2nd Edn., National Association of Corrosion Engineers, USA., ISBN-13: 9781575900889, Pages: 524.

Rousseau, C., F. Baraud, L. Leleyter and O. Gil, 2009. Cathodic protection by zinc sacrificial anodes: Impact on marine sediment metallic contamination. J. Hazard. Mater., 167: 953-958.

Shao, Y., C. Jia, G. Meng, T. Zhang and F. Wang, 2009. The role of a zinc phosphate pigment in the corrosion of scratched epoxy-coated steel. Corrosion Sci., 51: 371-379.

Skale, S., V. Dolecek and M. Slemnik, 2008. Electrochemical impedance studies of corrosion protected surfaces covered by epoxy polyamide coating systems. Progr. Organ. Coat., 62: 387-392.