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Experimental Analysis of Physiochemicall Properties of Epoxy-Silicone based Heat Resistant Coating

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ABSTRACT

Now a days, faster, stronger, lighter, safer, durable with highly cost effective, these demands are constantly being pushed upon by today's researchers and manufactures. Heat reistant coatings are gaining popularity with the introduction of more sophisticated in Chemical Industries' Equipment Coating like Steam pipe, Heat exchanger, smoke stack, Reactor, furnace, evaporator, pipe, and boiler and also in automotive, aircraft exhaust equipment. Conventional organic coatings (like epoxy coatings) fail when used at high temperatures. A coating is a covering that is applied to the surface of an object, usually referred to as the substrate and coatings are applied to improve surface properties of the substrate, such as appearance, adhesion, wettability, corrosion resistance, wear resistance, heat resistant, and scratch resistance. Coating and printing processes involve the application of a thin film of functional material to a substrate, such as paper, fabric, film, foil, or sheet stock. Coatings may be applied as liquids, gases or solids.
Keywords: Coating, Pigment, Binder, Heat resistant etc

1. INTRODUCTION

Paint is one of the oldest synthetic substances known, with a history stretching back into prehistoric times. It was made more than 35 000 years ago by prehistoric man as they mixed clays and chalks with animal fats and used these paints to depict their hunts on cave walls. Index term: Coating, Pigment, Solvent, Additives, resin out any roughness or irregularities caused by the manufacturing process. Paint is a loosely used word covering whole variety of materials: enamels, lacquers, varnishes, undercoats, surfaces, primers, sealers, fillers, stoppers and many others. Is essential to grasp at once that these and other less obviously related products, such as plasters, concrete, tars and adhesives. The simplest form paint is whitewash and, when dry, whitewash is nothing more than a pigment-whiting (calcium carbonate)-sprayed over a surface. It decorates and to some extent it protects, but it rubs off. So, most paints contain the second ingredient, a resin polymer, film-former or binder, to bind together the pigment particl es and hold them on to the surface. Paint is a mixture of filmogen (film forming material, bi nder) and pigment. The pigments impart colours, and the filmogen, continuity; together, they create opacity. Most paints required volatile thinner to reduce their consistencies to a level suitable application.

Heat-resistant coatings are gaining popularity with the introduction of more sophisticated automotive and aircraft exhaust equipment, smoke stacks, stoves, furnaces, space heaters and incinerators. Conventional organic coatings (like epoxy coatings) fail when used at high temperatures. In order to improve the heat resistance of the epoxy resin, silicone resin is blended with epoxy resin because of the unique properties of silicones which arise from the inherent properties of the Si-O bond. The silicone structure is stable to oxidation, although it is susceptible to some rearrangement at elevated temperatures. Typical properties of silicone are • thermal stability due to excellent strength of the -Si-O-Si-bond; and • good solidity of the-Si-C-bond. The exact requirements are now met mostly by the use of silicone-based coatings. It is obvious that the high temperature environment indeed demands a special class of paints.

Heat Resistant Paint: High-temperature-resistant coatings are designed to withstand temperatures ranging from 150°C (300°F) to over 760°C (1,400°F) while providing protection against corrosion.

Composed of either organic or inorganic materials, high-temperature coating resins could either be an epoxy, epoxy phenolic, epoxy novolac, silicone, or a more specialized multi-polymeric matrix depending on the level of temperature resistance required.

2. MATERIALS AND METHODOLOGY

The main constituents of paints are made up of Binder, Pigments, Solvents and Additives. The raw materials for the preparation and analysis of coating are

1) Binder a) Epoxy Resin b) Silicone Resin c) Polyamide Resin as Hardener
2. Pigments a) Titanium Dioxide b) Carbon Black c) Aluminium Paste
3 Solvents a) Xylene b) Methyl Iso-butyl Ketone c) Acetone

Procedure

- A 50ml epoxy resin prepare by using a1:1:1 Mixture of xylene, Acetone and methyl iso butyl ketone solvent in the ratio 10:1 The above resin and the solvents are added to round bottom flask (Beaker) and to dissolve the resin. Stir it for 10 min
- A 50 ml silicone resin prepare by dissolving with xylene solvent in ratio 10:1
- Disperse the epoxy silicon resin continuously stir it for 10 min with the help of glass ball
- A 25ml of polyamide hardener is added to the mixture of epoxy-silicone resin.
- Above batch is 50:50 epoxy-silicone resin batch
- Similarly different composition batches were made such as 55:45 batch, 75:25 batch

Physical and Mechanical Properties of heat resistant paint

1. Dry film Thickness

In the present work, instrument based on magnetic function is used. Magnetic pull-off gages use a permanent magnet, a calibrated spring, and a graduated scale. The attraction between the magnet and magnetic steel pulls the two together. As the coating thickness separating the two increases, it becomes easier to pull the magnet away. Coating thickness is determined by measuring this pull-off force. Thinner coatings will have stronger magnetic attraction while thicker films will have comparatively less magnetic attraction. Magnetic thickness gauges are based on the principle that attractive force between a permanent magnet and a magnetic material is inversely proportional to the distance between them. Posit test is based on the above principal and it is used for measuring the thickness of the coating.

Magnetic pull-off gages are rugged, simple, inexpensive, portable, and usually do not require any calibration adjustment.

Table 1 – Dry Film Thickness for all batches samples

Test	**Observation**
Dry Film Thickness	Ranges from 80 to 100 micron

2. Adhesion Test:

In this method the assessment of adhesion is made by the area of film from the substrate. A coated film is cut through its thickness to the substrate by means of close parallel cuts and then another set of parallel cuts made at right angles to the former. An adhesive tape is pressed on to the surface of the cut film and sharply pulled off. The numbers of squares of film detached are counted and use as comparative measures of adhesion.

Table 2 – Adhesion test for Batch A - Epoxy- silicone resin

Test	**Observation**
Adhesion test	There is no detachment of film of coated panels

Adhesion test is performed on painted panels of all Batches shows following result in terms of performance of detachment of film of coated panels.

3 Water Absorption test - ASTM D570

Water absorption is used to determine the amount of water absorbed under specified conditions. For the water absorption test, the coated panels are dried in an oven for a specified time and temperature and then it is cooled at room temperature. Immediately upon cooling the coated panels are weighed and these panels are immersed in a water bath. After 24 hours, it is taken out and the excess water is removed by the filter paper and then weighed. This procedure is repeated till the identical values are obtained. From the amount of water absorbed the percentage of water uptake is calculated.

Table 3 – Water absorption percentages for all batches samples

% of Pigment		**50:50**	**55:45**	**75:25**
Tio2	**10%**	0.03%	0.12%	0.29%
	15%	0.02%	0.21%	0.32%
CB	**10%**	0.02%	0.22%	0.27%
	15%	0.12%	0.27%	0.32%
Al	**10%**	0.1%	0.18%	0.25%
	15%	0.14%	0.27%	0.29%

As silicone percentages increases the water absorption percentages decreases

3. Impact Resistant Test:

This was measured by falling weight method. In this test a tub of weight is allowed to fall over the painted specimen from a known height. The specimen is then examined for any damage to the film.

Photo 1 – Impact Resistant tester

The organic coatings under test are applied to four or more suitable thin metal panels. After the coatings have cured, a standard weight is dropped a distance to strike an indenter that deforms the coating and the substrate. The indentation can be either an intrusion or an extrusion. By gradually increasing the distance the weight drops, generally 1 inch (25 mm) at a time, the point at which failure usually occurs can be determined.

Table 4 – Impact resistant test for Batch A- Epoxy- silicone resin 50% - 50%

Test	Observation
Impact Resistant Test	No failure observed up to 1 kg load fall from 47cm height

4. Scratch Hardness:

In general, hardness measures the resistance of materials to permanent or plastic deformation. When testing coatings, scratch hardness refers to the force necessary to cut through the film to the substrate.

Placed the painted panels are kept under the test to a scratching motion of the brass rod, using a force of ½ kg and 1 kg. Panels coating are considered to be soft, if during the scratching process, a groove is made in them without deposition of metal from the brass rod, or if separate the coating film from the surface of the painted panels. The panels were loaded with different weight until a clear scratch showing the bare metal surface was seen.

Photo 2 – Scratch Hardness tester

Table 5– Scratch Resistant test for all Batches - Epoxy- silicone resin

Test	Observation
Scratch Hardness	No failure observed up to 1 kg load

B) Chemical properties of Heat resistant paint

Immersion Test

Painted panels are immersed in the following solution for 8 days in distilled water, with 5% sodium hydroxide solution, 5% sodium chloride solution and 5% hydrochloric acid. These painted panels are taken in separate three beakers with having a above solutions. The panels were taken out and washed in running water, dried and the performances of coated panels are examined as per ASTM standards. The paint was removed from the surface and the surface conditions were examined.

Photo 3– Immersion Test

Observations are noted on the basis of detachment of film from the panel, blistering, chalking, discoloration of film. If there is no detachment of film from panel, no blistering, no chalking and no discoloration which indicates the results are satisfactory.

Table 6– Immersion test for all batches of samples

IMMRESION TEST	BATCHES	TiO2	CB	AL
5% HCl, 5% NaOH, 5% NaCl	50% -50%	Satisfactory	Satisfactory	Satisfactory
	55% - 45%	Unsatisfactory	Satisfactory	Satisfactory
	75%- 25%	Satisfactory	Unsatisfactory	Satisfactory

Solvent Resistant

The painted panels are immersed in common solvents like xylene, acetone and toluene and kept for 24 hours and they are taken out, dried and examined for discoloration, chalking or detachment of the film.

Photo 4 – Solvent Resistant Test

Table 7– Solvent Resistant test for all batches samples

SOLVENT RESISTANT TEST	BATCHES	TiO2	CB	AL
Xylene, Toluene, Acetone	50% -50%	Satisfactory	Satisfactory	Satisfactory
	55% - 45%	Satisfactory	Satisfactory	Satisfactory
	75%- 25%	Satisfactory	Unsatisfactory	Satisfactory

Water Resistant Test

The painted panels are immersed in distilled water and kept for 8 days and they are taken out, dried and examined for discoloration, chalking or detachment of the film.

Table 8– Water Resistant test for all batches samples

TEST	BATCHES	TiO2	CB	AL
Water Resistant	50% -50%	Satisfactory	Satisfactory	Satisfactory
	55% - 45%	Satisfactory	Satisfactory	Satisfactory
	75%- 25%	Satisfactory	Satisfactory	Satisfactory

Salt Spray Test/Corrosion Resistant Test

The salt spray test is a standardized and popular corrosion test method, used to check corrosion resistance of materials and surface coatings. Usually, the materials to be tested are metallic and finished with a surface coating which is intended to provide a degree of corrosion protection to the underlying metal. Salt spray testing is an accelerated corrosion test that produces a corrosive attack to coated samples in order to evaluate (mostly comparatively) the suitability of the coating for use as a protective finish. The appearance of corrosion products rust is evaluated after a pre-determined period of time. Test duration depends on the corrosion resistance of the coating; generally, the more corrosion resistant the coating is, the longer the period of testing before the appearance of corrosion/ rust. The coated specimens are suspended in the salt spray test chamber from horizontal rods parallel to the flow of fog and the interface between the specimens and the direct impingement is avoided. The solution used is 5 percent sodium chloride. Clean compressed air is used for atomization. The atomized solution is continuously supplied to the test chamber and the temperature of the chamber is maintained at 30-35^{0}C. Periodic examinations of the specimens were made. The painted panels in triplicate are exposed in the salt spray chamber with and without scratch. After 5 hours of this test, the specimens are taken out and the corrosion spots are counted with the help of a magnifying lens.

Table 9 – Salt spray test for all Batches - Epoxy- silicone resin

Test	Observation
Salt Spray test	No rusting, No Detachment of film from the panel, No Blistering, no chalking, no discoloration observed.

Heat Resistant Test

The heat resistant test methods give the evaluation of the heat resistant properties of coatings designed to protect steel surface exposed to elevated Temperatures during their service life.

The painted Panels of five batches are kept in a muffle furnace maintained at the test temperatures. Thus, the painted panels are exposed to a muffle furnace is maintained at 200^{0}C and then increases the temperature to 370^{0}C for 4-5 hours. A visual inspection of the heated panels was made at the end of each temperature. The failure of the coating was assessed for chalking, blistering, cracking and colour change. Good adhesion and absence of cracking or chalking indicate heat resistant and high thermal stability.

Table 10– Heat Resistant Test for all batches samples

% of Pigment		50:50	55:45	75:25
Tio2	10%	280°c	270°c	310°c
	15%	260°c	260°c	290°c
CB	10%	350°c	350°c	390°c
	15%	320°c	330°c	360°c
Al	10%	510°c	530°c	560°c
	15%	480°c	490°c	530°c

APPLICATION OF HEAT RESISTANT PAINT

High-temperature coatings are often found in the following industries:

- Aerospace
- Power
- Manufacturing
- Petrochemical
- Military

Specific examples of applications for high-temperature coatings include:
Jet Engines, Power, Chemical plants Refineries, Offshore assets, OEM applications,
Corrosion Under Insulation, Fireproofing, Buildings and Construction

RESULTS AND DISCUSSION

The experimental observation of mechanical, chemical and solvent resistance properties is given in Table II, which shows that:

(1) The mechanical properties of the epoxy silicone paint were found to be good.

(2) The chemical resistance character of the paint was good in a corrosive environment such as sodium chloride.

(3) Resistance to solvents like xylene, toluene and trichloroethylene was found to be very good. This behaviour shows that the coatings after drying contains only very little amounts of organic matter and mostly the inorganic pigments and also TiO2. Therefore, the organic solvents do not attack the coatings.

(4) A heat resistant paint prepared from the epoxy and silicon resins BATCH 50:50 10% & 15% Al paste pigment can withstand temperature 510°c & 480° C up to 370 °C as campare to the other batches it less but physical, and chemical along with solvent resistant and corrosion resistant properties were tested and found satisfactory result.

(5) However, the silicone-based paints have many intrinsic disadvantages because of the high-cost factor and therefore the search for some alternatives is relevant. In this concern above investigation plays a vital role in improving the heat-resistant properties on the basis of cost / benefit Ratio.

CONCLUSION

It is concluded that the investigation done in the present work conformed that the new hybrid coating Epoxy – Silicone Resin based Heat Resistant Paint **Batch 50:50** not only gives the durability but also **gives best cost / benefit** along with good Physical Properties, Mechanical properties, Chemical Resistant Properties, Corrosion Resistant Property and heat resistant Property. It also increasing demands in the areas of health, safety and environmental protection.

REFERENCE

[1] Arthur A. Traction, "Coating Technology Handbook", Third Edition, Taylor and Francis Publication, Page no. 31-144
[2] J.A. Brydson, "Plastic Material". Seventh Edition, Elsevier Publication, Page No Page no. 693-720
[3] G.P.A Turner, "Introduction to Paint Chemistry", Second Edition, Chapman and Hall Publication, Page No .85-198
[4] Oil and chemist's Association Australia, "Surface Coatings", Vol .1, Page no.120,344
[5] Di eter Stoye, Werner Frecitag, "Paint, Coating, and Solvents" (1998), Willey Publication, 2nd Edition, Page No 56-91
[6] Zeno W. Wicks, "Organic Coating", Science and Technology, 3rd Edi ti on, Page.No.271,326
[7] S.D. Dawande, Principles of Heat Transfer and Mass Transfer, Central Techno Publicati on, 1st Edi ti on. Page no, 95-125
[8] L. Mathivanan, S. Radhakrishna" Heat Resistant paint from epoxy-silicone vehicles" Emerald Article Anti -Corrosion Methods and Materials, Vol. 44 Iss: 6 pp. 400 – 406
[9] S. Ananda Kumar, T.S.N. Sankara Narayanan "Thermal properties of siliconeized epoxy interpenetrating coatings", Elsevier Publication, 10 April 2002
[10] Norman R. Mowrer, "Polysiloxanes Coatings Innovations" Ameron International, November, 2003
[11] Christopher Howard and Markus Hallack "Novel High Solids Systems Based on Silicone-
[12] Epoxy Resins" by the University of Southern Mississi ppi Department of Polymer Science, October 2008.
[13] PHIL PHILLIPS "High heat resistant coating systems" Business Corner, STRATEGIES & NALYSIS, MAY 2009.
[14] Hiroshi Kimura, US patent No. 4354013 "Process for Epoxy-Modified Silicone Resin: Oct. 12,1982
[15] Kaoru Mi yahara, US Patent No. 8084528 B2"Heat Resistant Paint", Dt:27,2011
[16] Firdous Habib and Madhu Bajpai "UV Curable Heat Resistnt Epoxy Acrylate Coatings" by dept of Oil and Chemical Tech. Harcourt Butler Technological Institute (HBTI) Kanpur, Vol. 4, No. 3, 2010
[17] A broucher by Wacker of, "Coating ideas for paints" Wacker Metroark Chemicals Pvt. Li mited.
[18] Paint India Magazine, India only Journal for Coating, Volume VII, No.1 Jan 2007