

**EXPERIMENTAL INVESTIGATION OF EPOXY BASED COATINGS
BLENDED WITH NANO-BORON NITRIDE**K.VAHINI¹, N.RAMESH², K. R. SATYANARAYANA³¹ Assistant professor, Department of mechanical engineering,
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Abstract- In the present study, the modification in the epoxy based coatings was studied with the addition of 1%, 3%, 6% & 12% of Boron Nitride Nano powder (~70 nm). Corrosion (Particularly Pitting Corrosion to the ship's hull) performance of the nano composite coatings were evaluated by applying these nano coatings on mild steel substrates of size (120x100x10 mm³) and exposing them to polarization technique for one week. The results obtained suggest that with an increase in the concentration of Boron Nitride Nano powder, there was improvement in the corrosion resistance and some mechanical properties. Further, it is observed that the mild steel specimens can expose to the sea water for testing the antifouling properties.

Keywords- epoxy based coatings, Boron Nitride Nano powder, Pitting Corrosion, mechanical properties

1. INTRODUCTION

In the broad sense, corrosion may be defined as “the destruction of a material by chemical, electrochemical, or metallurgical interaction between the environment and the material”. Generally it is slow but persistent in character. Corrosion is essentially an electrochemical process resulting in part or all the metal being transformed from the metallic to the ionic state.

Pitting corrosion is a localized form of corrosion by which cavities or “holes” are produced in the materials. Pitting is considered to be more dangerous than uniform corrosion damage because it is more difficult to detect, predict and design against. Corrosion products often cover the pits. A small, narrow pit with minimal overall metal loss can lead to the failure of an entire engineering system. Pitting corrosion, which, for example, is almost a common denominator of all types of localized corrosion attack, may cause different shapes of metals. Experimental study of mechanical properties of Epoxy based Composites filled with B₄C & WS₂^{1,2} discussed. Incorporated micro-silver flakes and nano-hexagonal boron nitride (BN) particles into a matrix resin to prepare electrically conductive adhesives (ECAs)³. Three aluminium metal matrix composites (MMCs) containing 15 vol.-%B₄C particles⁴ discussed. Pitting corrosion is localized accelerated dissolution of metal that occurs as a result of a breakdown of the otherwise protective passive film on the metal surface⁵. the experiments performed during the last few decades which enhance knowledge of the pitting of aluminum⁶. work nano-CaCO₃ modified powder coatings were prepared using epoxy resin/nano-CaCO₃ composites obtained through in situ and inclusion polymerization and the nano-CaCO₃ can be well dispersed⁷. This studies the mechanical properties including traction, flexion, compression, and hardness characteristics of a composite made from the combination of epoxy resin and granitic stone powder from the fold-and-thrust belt located in the municipality of Nossa Senhora da Glória⁸. The effects of the particle size, dispersion degree, filling interface, and filling volume have also been studied⁹⁻¹².

2. MATERIALS**Materials used:****BORON NITRIDE (BN) NANOPOWDER**

Hexagonal Boron Nitride (HBN) is also known as ‘White Graphite’, has similar (hexagonal) crystal structure as of Graphite. This crystal structure provides excellent lubricating properties.

A-Grade Mild Steel plate samples (120x100x10 mm³)

Epoxy based paints (Sigma Cover 280, Sigma Cover 525, Sigma AlphaGen 680)

3. EXPERIMENTAL PROCEDURE**PROCEDURE FOLLOWED**

- A. Preparation of 5 A-Grade Mild Steel plate samples (120x100x10 mm³)
- B. Procurement of Boron Nitride nano powder.

- C. Procurement of Epoxy based paints (Sigma Cover 280, Sigma Cover 525, Sigma AlphaGen 680)
- D. Improving the corrosion resistance by using the Boron Nitride nano powder.
- E. Investigation of rate of corrosion through polarization technique.
- F. Preparation of report.

STEP 1: Surface preparation & Zinc Silicate coat

Five plate samples (120x100x10 mm³) of A-Grade Mild Steel were used in this study. The samples were first prepared with sharp edges by using grinding machine. Grinding is the process of removing the metal by the application of abrasives which are bonded to form a rotating wheel. After preparation of mild steel specimens with proper dimensions, we have to expose them to the surface treatment method called sand blasting. Sandblasting is a blast of air carrying sand at high velocity to clean metal surfaces.

It is a method of surface preparation using abrasives, propelled through nozzles or by centrifugal wheels, to remove mill scale, rust, rust scale, old paint, laitance and other foreign contaminants that would interfere with the adhesion of the subsequent coating. Sand and Mineral Abrasives Produce a Fine / Angular Surface Profile.

After the process of sandblasting within one hour we have to apply Zinc Silicate coat of 75 microns by using spraying gun. The purpose of Zinc Silicate coat is to avoid the corrosion before application of protective coatings to the particular metal. It can protect the metal for maximum one day

Curing Mechanism of Zinc Silicate

These coatings cure by hydrolysis or reaction with moisture following the evaporation of solvent. These coatings are typically resistant to rain showers in one hour or less

STEP 2: Primer Coat

Primer coat should be applied to the specimens within 24 hours after the application of Zinc Silicate coat.

Paint type : SIGMACOVER 280
Description : Two component poly amide cured epoxy primer
Principle Characteristics : General purpose epoxy primer in protective coating systems for steel metals.
Good adhesion to Mild steel metals, Good flow and wetting properties, Good water and corrosion resistance

STEP 3: Intermediate Coat

Intermediate coat should be applied to the specimens within 24 hours after the application of Primer coat.

Paint type : SIGMACOVER 525
Description : two component polyamine cured epoxy tiecoat

STEP 4: Top/ Finish Coat with the addition of Boron Nitride

Paint type : SIGMA ALPHAGEN 680
Description : high performance TBT-free self polishing antifouling for coastal Operating ships with cuprous oxide and organic biocides for aggressive fouling conditions

Final coat is applied by mixing Boron Nitride nano powder with Epoxy AlphaGen 680 to the specimens randomly with different proportions of 1 wt%, 3 wt%, 6 wt% & 12 wt% . Initially, First piece of specimen is coated with 100 gm of Epoxy AlphaGen 680 with Xylene which is used as thinner to have a good viscosity when applied to the specimen using air spray gun. After the specimen is dried for 4 to 5 hours, the thickness of the coat is checked by dry film gauge and it should be around 75 to 80 microns.

Next, Second piece of specimen is coated with 100 gm (i.e.; combination of 99 gm of Epoxy AlphaGen 680 + 1 gm of Boron Nitride nano powder) of paint sample and was stirred by using an electric paint mixing machine around 2 to 3 hours. After the solution is mixed properly, it is applied to the specimen and allow it to dry for 2 to 3 hours. After the specimen is dried, the thickness of the coat is checked by dry film gauge and it should be around 75 to 80 microns.

NOTE ::

- After the application of nano coating to the specimen it should be dried naturally instead of artificially drying in an oven.
- Stirrer speed should be around 300 to 400 rpm.

The same procedure is followed for all the next three specimens as following

Third specimen : 100 gm of solution (i.e.; combination of 97 gm of Epoxy AlphaGen 680 + 3 gm of Boron Nitride nano powder) of 75-80 microns.

Fourth specimen : 100 gm of solution (i.e.; combination of 94 gm of Epoxy AlphaGen 680 + 6 gm of Boron Nitride nano powder) of 75-80 microns.

Fifth specimen : 100 gm of solution (i.e.; combination of 88 gm of Epoxy AlphaGen 680 + 12 gm of Boron Nitride nano powder) of 75-80 microns.

SPECIMEN TESTING

POLARISATION STUDIES

A wide range of electrochemical polarization techniques are used to study the corrosion process of metals which involve imposing a potential on a metal from an external source and determining the current variation at either constant or changing potential, or varying the current and determining the associated potential changes. The controlled current technique involves passing a predetermined current between the test electrode and an inert auxiliary electrode and following the corresponding test electrode potential changes with a reference electrode and a high independence voltmeter.

POTENTIODYNAMIC POLARIZATION TESTING AS PER ASTM G 59 STANDARD

A software based PAR electrochemical corrosion testing system was used to carry out potentiodynamic polarization tests to study corrosion behavior of coated mild steel samples. The basic electrochemical system with Electrochemical flat cell used in this work was given in Fig. A Saturated Calomel Electrode (SCE) and carbon electrode were used as reference and auxiliary electrodes respectively.

All experiments were conducted in aerated 3.5% NaCl solutions with pH adjusted to 10 by adding potassium hydroxide. The potential scan was carried out at 0.166 mVs^{-1} with the initial potential of -0.25 V , SCE to the final pitting potential. The exposure area for these experiments was 1 cm^2 . Polarisation curve is a plot between potential (mV) and current density (mA/cm^2) which is having anodic and cathodic branches. Potential at which anodic and cathodic branches meet is taken as Corrosion potential (E_{corr}). Typical polarization curve is shown in Fig. Specimens exhibiting relatively more positive corrosion potential (or less negative potentials) were considered to have better corrosion resistance.

4. RESULTS AND CONCLUSIONS

1. From the experimental procedure very clearly we can observe that, Boron Nitride nano powder is playing a major role to improve the corrosion resistance.
2. From the Fig(1); it is observed that pure specimen (without adding nano powder) is having poor corrosive resistance when Compared to the Fifth specimen (epoxy alphagen 680 + 12 % of boron nitride nano powder).

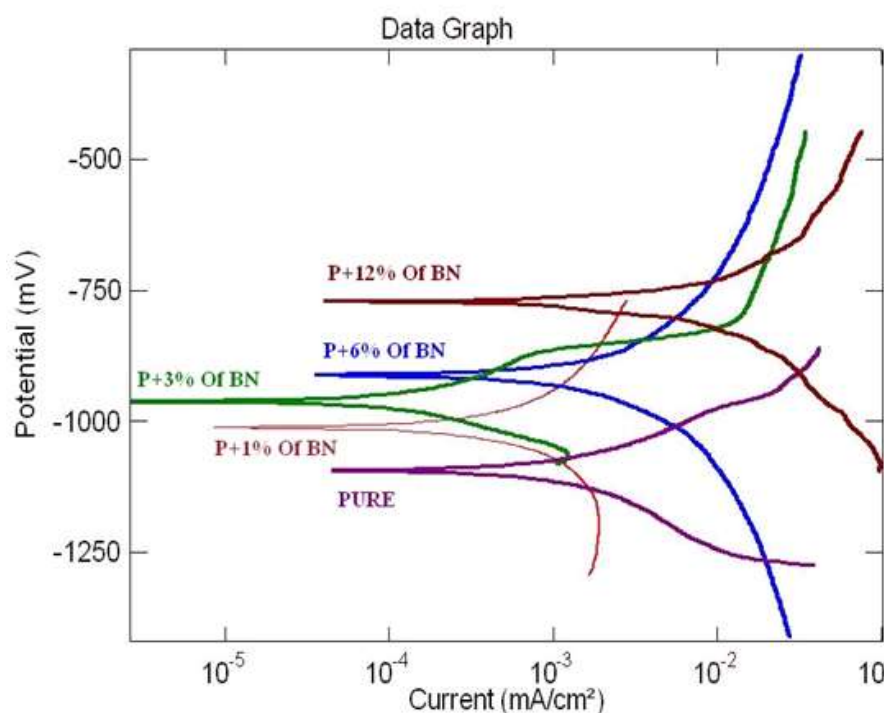


Fig (1)

3. Always corrosion rate depends upon the value of potential. Means, Specimens exhibiting relatively more positive corrosion potential (or less negative potentials) were considered to have better corrosion resistance.
4. While adding Nano powders to the particular coated sample we should take care that, the mixture should not get agglomeration condition.
5. As Like TiO_2 , ZrO_2 and Al_2O_3 , it is proved that we can get better result by adding Boron Nitride Nano powder to the antifouling paints in the proper proportions.

PROPERTIES TABLE					
S.NO.	Type of specimen	Corrosion Potential (mV)	Surface Finish	Agglomeration Of Nano Particles	Drying Time
1	PURE SPECIMEN	-1094.4	Good	-----	More (~24 hours)
2	99 gm of Epoxy paint + 1 gm BN	-1010.7	Good	Low	More (~24 hours)
3	97 gm of Epoxy paint + 3 gm BN	-962.31	Good	Low	Less (~12 hours)
4	94 gm of Epoxy paint + 6 gm BN	-911.37	High	High	Less (~12 hours)
5	88 gm of Epoxy paint +12 gm BN	-771.59	High	Very High	VeryLess(~3 hours)

Despite of increasing in proportional levels in 1 wt%, 3 wt%, 6 wt% and 12% of Nano Boron Nitride, there was a tremendous improvement in different properties such as ,

Decrease in permeability to corrosive environment and hence better corrosion properties.

1. High surface finish.
2. Optical clarity.
3. Better surface appearance.
4. Easy to clean surface.
5. Anti-reflective in nature.
6. Better retention of gloss.

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