

A Review on Composite Mixture with Nanoparticles for Corrosion Inhibition

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ABSTRACT: Corrosion is the decay of a material with respect to time, due to atmospheric and environmental factors. This deterioration rate is however faster in a marine environment which leads to loss of time, energy and materials. So measures are taken to reduce the rate of corrosion. The conventional methods used commonly are painting, varnishes, coating, sacrificial method etc. which are ineffective for preventing marine corrosion. In this paper, study of composite polymer along with nanoparticles is done for the improvement of corrosion inhibition in marine environment. The mixture of composite material is prepared and fiberglass nanoparticles are synthesized. The product is coated by special means on the material. Different tests are conducted on the specimen for checking the corrosion rate. There are certain safety procedures that are to be followed for risk free atmosphere. Use of gloves, goggles and mask are recommended for personal hygiene.

KEYWORDS: Barcol hardness, Fabrication, Thermodynamics, Lacquers, Fiberglass Nanoparticles, Static Current, x-rays, Ferromagnetic materials, Toxicity, Resuscitation, Incinerator.

I. INTRODUCTION

Corrosion is an undesirable process, which leads to limitation of progress in many areas. The cost of replacement of materials and equipment lost through corrosion is unlimited. Metals and alloys are used as fabrication or construction materials in engineering. If the metals or alloy structures are not properly maintained, they deteriorate slowly by the action of atmospheric gases, moisture and other chemicals. This phenomenon of destruction of metals and alloys is known as corrosion. It is the spontaneous destruction of metals; in the course of their chemical, electrochemical or biochemical interactions with the environment. Thus, it is exactly the reverse of extraction of metals from ores.

The concept of fibre glass nanoparticle for the use of corrosion prevention was first introduced by Butt L.T. in a paper published in 1982 titled as INTERNATIONAL DEVELOPMENTS IN FIBRE REINFORCED PLASTICS FOR ANTI CORROSION USES [1]. The use of polymers for coating was introduced and studied by William R. Slamain in paper [2] POLYESTER AND VINYL ESTER COATINGS published in 1996. The usage of reinforced polymer using nano particles showed improvement in barrier protection in test conducted by M.R. BAGHERZADEH, and F. MAHDAVI in [3]. The tests conducted by M. Nematollahi, M. Heidarian, M. Peikari, S.M. Kassiriha, N. Arianpouya and M. Esmaeilpour in 2010 [4] helped in deciding the use of fibre glass in corrosion prevention test. A comparison between the use of fibre glass nanoparticles and layered silicates where done in [5]. The use of fiberglass nanoparticle in marine environment was found to be compatible, when the test run by the authors in [6] was successful. The use of composite polymer compound in combination with acids resulted in reduced degradation in [7]. Degradation levels in chemical environments were found to be lower in [8]. All the subsequent papers [9], [10], [11], [12] relating to this topic were pointed to the same direction in terms of approving the context, which were used in analysing the various working conditions.

The work in this review paper is divided into five different sections. The section 1 is about introduction to marine engineering, section 2 deals with the different methods for corrosion prevention, section 3 deals with the basic idea of

the method used and different materials used for the synthesis of the polymer compound. Section 4 deals with the experiment conducted and different types of test done for the evaluation of the compound used, the section 5 deals with the safety and control measures required for the safety and personal hygiene of the workers.

II. MARINE CORROSION

For marine applications, mild steel remains the number one metal for constructional purposes by virtue of its relatively low cost, mechanical strength and ease of fabrication. Its main drawback is that it corrodes easily in seawater and unless adequately protected, rapidly loses strength which may result in structural failure. In general terms corrosion can be defined as the spontaneous reaction between a material and its environment which results in the degradation of that material. The majority of metals in nature are found in their mineral state, i.e. in their stable oxidised condition as oxides, chlorides, carbonates, sulphates, sulphides, etc. The extraction of a metal from the appropriate mineral involves a reduction process in which a great deal of energy is absorbed. As a consequence of this large energy input the metal is in a high energy condition and will endeavour to return to its former stable, oxidised, low energy state as quickly as environmental conditions will allow. It is the energy difference between the pure metal and its oxidized forms which is the driving force for corrosion.

Effect of Corrosion

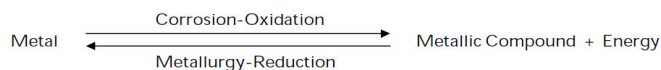
The economic and social consequences of corrosion includes

- i) The efficiency of the machine gets reduced leading to plant shut down, by the formation of corrosion product over the machinery,
- ii) The products contamination or loss of products
- iii) Replacement of corroded materials
- iv) Preventive measures like metallic coating or organic coating is required.
- v) Corrosion releases toxic products, leading to health problems.

Metallic Corrosion

The metals are extracted from their metallic compounds (ores). During the extraction, ores are reduced to their metallic states by applying energy in the form of various processes. In the pure metallic state, the metals are unstable as they are considered in excited state (higher energy state). Therefore as soon as the metals are extracted from their ores, the reverse process begins and form metallic compounds, which are thermodynamically, stable (lower energy state). Hence, when metals are used in various forms, they are exposed to environment, the exposed metal surface begin to decay (conversion to more stable compound). This leads to metallic corrosion.

Although corroded metal is thermodynamically more stable than pure metal; useful properties like malleability, ductility, hardness, luster and electrical conductivity are lost.



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III. CORROSION PREVENTION

The prevention of corrosion requires the elimination or suppression of the chemical reaction between the environment and the metal. Key factors in prevention of marine corrosion are design, selection of materials, construction, use and maintenance. Prevention of corrosion can be done by isolation of the corroding metal from the sea water by painting or other coating, changing the potential of the metal to a point where corrosion ceases by impressed voltage or coupling to a sacrificial anode, by making the metal passive using corrosion inhibitors by changing the pH of the local environment by chemical dosing and finally by making a change to a more corrosion resistant material.

Different methods of prevention are:-

- Protection by painting
- Cathodic protection
- Inhibition
- Galvanic corrosion
- Using corrosion resistant alloys

IV. DISCUSSIONS

In this paper, we are preparing a composite polymer which consists of a parent polymer, curing agent, static current conducting material and nanoparticle for corrosion inhibition. The polymer bonding of the parent polymer being weaker is strengthened using the curing agent. The nanoparticles are mixed uniformly using suitable mechanism for the purpose of corrosion inhibition. A static current conducting material is added to the mixture for preventing the removal of the polymer coating from the surface of the parent metal due to static current build up. The proposed polymer is prepared and is applied on the surface of the parent metal and various tests are done.

Fiberglass Nanoparticles

The commercial availability of fine, consistent glass fiber; coupled with the development of low pressure composite polymers marked the birth of the fiber reinforced composites industry over fifty years ago. Glass is an ideal reinforcing fiber for plastics. It is one of the strongest of materials (the ultimate tensile strength of a freshly drawn single filament of 9 - 15 microns diameter is about 3.5 GPa). Its constituents are readily available, it is non-combustible and also chemically resistant. Glass fiber is produced by drawing and rapidly cooling molten glass and is available in a variety of types and formats. Its final format will depend on how the drawn glass is further processed. Fiberglass nanoparticles are effective between a temperature range of -30°C to 540°C . Fiberglass is the trade name for a man-made fiber that also may be called fibrous glass or glass wool. A fiber particle is three times as long as it is wide. The main fiber-forming substance in fiberglass is glass.

Fiberglass was first used in the 1930s for home furnace filters and insulation. Fiberglass also is used to insulate pipes and appliances, for sound control in aircrafts and automobiles, and in curtains, roofing material and some plastics. Fiberglass substrates are electrically non-conductive and therefore, eliminate galvanic corrosion, including concerns connected with coastal environments.

Composite Polymer

A composite material is material made from two or more constituent materials with significantly different physical or chemical properties that, when combined produce a material with characteristics different from individual components. The individual components remain separate and distinct within the finished structure.

Curing Agent

Curing is a term in polymer chemistry and process engineering that refers to the toughening or hardening of a polymer material by cross-linking of polymer chains, brought about by electron beams, heat or chemical additives. When the additives are activated by ultraviolet radiation, the process is called UV Cure. In rubber, the curing process is also called vulcanization.

Static Current Reducing Agent

Static electricity is an imbalance of electric charges within or on the surface of a material. The charge remains until it is able to move away by means of an electric current or electric discharge. A static electricity can be created whenever two surfaces contact and separate, and at least one of the surfaces has a high resistance to electric current. The effects of static electricity are familiar to most people can feel, hear, and see the spark produced between dry hair and palm during cold climatic conditions.

Static current generation is one of the major drawbacks faced in oil pipelines. Static current conducting materials must be added in the mixture so as to prevent corrosion inhibition due to removal of the applied coating from the surface of the metal.

Experimental Setup

Experiments will be conducted in chloride solution, sulphate solution, marine water and marine environment on base metal with and without coating at various temperatures and concentrations. These experiment results will be evaluated and compared with an existing technology.

V. TEST CONDUCTED

- Visual inspection
- Radiography
- Scanning Electron Microscope
- Magnetic Particle Inspection
- Pulsed Eddy Current test

Visual Inspection

Visual inspection in the simplest form can be performed without any accomplishing aids when there is physical access to the object. The experienced inspector can often determine the type of corrosion, such as general corrosion, pitting corrosion, crevice corrosion, weld and heat affected zone corrosion from visual inspection. The degree of corrosion can be measured and described and documented by the use of sketches or photograph.

Radiography

Radiography makes use of the penetrating quality of short wave electromagnetic beams, which may be X-rays generated by X-ray equipment or γ -rays from radioactive isotopes. These beams are similar to light but are not visible. The wavelengths are much shorter and the energy much higher. These beams are able to penetrate solid materials including metals, which produces impressions on a photonic film upon being eradicated by beams. When the beam passes through a test specimen, some energy is absorbed in the material. The thicker the material, the larger the amount of energy absorbed. As a result, a photonic film is produced using the data interpreted for the analysis of the test conducted.

Scanning Electron Microscope

A scanning electron microscope is a type of microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the samples surface topography and composition. The most common SEM mode is detection of secondary electrons emitted by atoms excited by the electron beam. The number of secondary electrons that can be detected depends upon the topography and other things. An image is created using the data interpreted by the secondary emitted electrons.

Magnetic Particle Inspection

Magnetic particle inspection method is a non-destructive testing process for detecting surface and slightly subsurface discontinuities in ferromagnetic materials such as iron, nickel, cobalt, and some of their alloys. The process puts a magnetic field into the part. The piece can be magnetized by direct or indirect magnetization. Direct magnetization occurs when the electric current is passed through the test object and a magnetic field is formed in the material. The presence of a surface or sub surface discontinuity will disrupt the magnetic field resulting in leakage.

Pulsed Eddy Current test

Eddy current testing is one of the many electromagnetic testing methods used in non destructive testing making use of electromagnetic induction to detect and characterize surface and sub surface flaws in conductive materials. Conventional ECT uses sinusoidal alternating current to excite the probe. Pulsed eddy current technique uses step function voltage to excite the probe. The advantages if using step voltage is that such a voltage contains a range of frequencies.

Barcol Hardness

The barcol hardness test characterises the indentation hardness of materials through the depth of penetration of an indenter, loaded on a material sample and compared to the penetration in reference material. It is an inexpensive and quick method for testing the thickness of the coating. Barcol hardness test is not valid test for round surfaces.

VI. SAFETY

Safety is very important in this field as most of the chemicals used in this process are not compatible to human body. The inhalation of fumes developed during various processes may result in adverse health conditions. Measures must be taken in order for the efficient working by providing protection gears like mask, gloves, goggles, protective clothing, etc..

Health Risks and Symptoms of Exposure

INHALATION: Vapours can be harmful in high concentrations. It can cause irritation to upper respiratory tract and can cause narcosis.

SKIN: Prolonged exposure to skin may cause irritation. Not likely to be absorbed at harmful levels.

EYE: Vapours may irritate and cause tears in the eyes. Liquid can cause some corneal injury.

INGESTION: Oral toxicity is low. However, if liquid enters lungs it may be absorbed and cause damage to other organs.

Emergency and First Aid Procedures

EYES: Flush with potable water immediately for 15 minutes. If irritation develops, get medical attention.

SKIN: Remove with soap and water.

INGESTION: Do not induce vomiting. Get immediate medical attention.

INHALATION: Remove to fresh air. If unconscious, apply mouth to mouth resuscitation. Get medical attention immediately.

Precautions For Safe Handling and Use

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Flammable material. Isolate from all sources of ignition. Protect personnel involved in clean-up from vapors of styrene. Soak up spill with absorbent material such as clay and sand.

WASTE DISPOSAL METHOD: Place in containers for disposal. Residual resin may be removed by steam cleaning or with the use of non-flammable solvent. Burn in an approved incinerator or bury in an approved landfill.

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING: Keep containers tightly closed when not in use. If mixtures of A and B are allowed to remain in the mixing vessel past pot life deadline, heat and a strong reaction will result.

Control Measures

VENTILATION: Provide ventilation to keep the material below the exposure guideline value.

PROTECTIVE GLOVES: Wear protective gloves.

EYE PROTECTION: Wear protective goggles.

OTHER PROTECTIVE CLOTHING OR EQUIPMENT: Wear protective body covering clothing when handling.

WORK/HYGIENIC PRACTICES: Practice good industrial hygiene. Wash hands thoroughly after use, before eating or smoking.

VII. CONCLUSION

This article reviews the theory behind fiberglass nanoparticle reinforcement in polymers for corrosion protection. The fiberglass nanoparticle form a lamellar barrier structure which reduces the area available for diffusion and increases the diffusing pathways of corroding agents within the polymer coating or lining. Diffusion models are suggested in the literature to describe the reduced transport in fiberglass nanoparticle filled permeable media. A number of experimental methods have been applied in recent studies to measure the corrosion protection capability of fiberglass included polymers. The metal without coating reacts directly with NaCl solution, the coating with glass fiberglass nanoparticle does not react with NaCl as glass flakes have no reactivity. Hence, coatings with fiberglass nanoparticle are much better than conventional methods. The use of static current conducting materials in the polymer compound showed increased durability and decreased rate of erosion due to static current build up. The decrease in susceptibility due to diffusion by adding nanoparticle eliminated the primary chance for corrosion by providing a barrier between marine environment and parent metal.

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