Study of graphene coating with metals and metal Nano composites

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Abstract—This paper is a study about the graphene coating and their properties so far done. At first, graphene was synthesized a few decades ago with graphene-based devices like supercapacitors transistors and microelectromechanical systems are made. We aim to make a graphene composite that exhibits optimized properties and characters that meet the requirement of the industry field. This paper is a study about properties of graphene when coated with other metals and the application study of graphene with Nanotechnology.

Keywords— Graphene coating, graphene oxide, corrosion resistance, Nanocomposites, Graphene synthesis.

I. INTRODUCTION

Generally, carbon has four allotropes of carbon. They are carbon nanotubes, charcoal and graphite fullerenes. Graphene structure is made of four allotropes of carbon. Graphene has peculiar properties that make it different from other forms of carbon. Though some properties like density are lower in graphene, it's thickness is stronger when compared with steel. Graphene has properties like thermal conductivity. Graphene carbon atoms are packed in the hexagonal structure.

The structure of graphene is studied by electron microscopy transmission by suspending the graphene sheets between the metal bars. The composition of chemical in graphene can generally be modified by oxygen and nitrogen –containing functional groups which are tested using X-ray photoelectron spectroscopy and infrared spectroscopy. Graphene can be synthesized by several methods. They are top -down and bottom -up approaches.[1]

Graphene has several material applications used in several products like solar cells, the light emitting diode(LED), touch panels, smartphones etc...Graphene is often made in powder made of polymer matrix which can be used in advanced composites, batteries, capacitors, thermal management

II. CORROSION PROTECTION PROPERTIES WITH MILD STEEL

The resistant to corrosion property of Mild Steel can be improved by developing GO nanosheets filled with epoxy coatings the factor which is very essential that influences the performance of coating with graphene oxide in polymer matrix GO to polymer of 0 1% with lower viscosity is added to give required properties like good adhesion properties good quality of dispersion and protection of corrosion under sodium chloride electrolyte[1]

A. Properties of Epoxy coatings:
• Low cost
• Good chemical resistance
• Dimensional stability

B. Drawbacks:
• Britteness
• Low resistance in crack propagation [2]

C. Composition of epoxy coating:
Epoxy resin is made of hydrophilic hydroxyl groups which make them more permeable to corrosive agents. Nanocomposite coating is a promising method for increasing corrosion resistance in epoxy coating. Graphene increases the corrosion resistance and the barrier properties in the polymer of the matrix are improved. Graphene has strong Vander Waal’s force and pi -pi interaction between graphene sheets and high specific surface area.[2]
**D. Materials used:**
Graphite powder (<20 micrometers), KMnO₄, Sulphuric acid, Hydrogen peroxide and HCl are used for graphene oxide preparation. Epoxy resin and polyamide hardener are used for epoxy coatings. Mild carbon steel plates (ST-12) are used as a substrate for the epoxy coating. Sandblasting of mild steel and degreasing on acetone is done before the coating of spray-on mild steel [3]

**E. Characterization:**
The characters for the graphene oxide are analyzed by several tests. • The GO crystal structure is characterized by X-ray diffraction • The chemical grafting the polymer of the matrix is found by the Fourier transformation infrared spectroscopy [3] Graphene oxide morphology, quality of dispersion in nanocomposite of GO is found by scanning electron microscope. The adhesion of nanocomposite is found out by the pull-off method. [3]

**III. MECHANICAL ENHANCEMENT OF AN ALUMINUM LAYER BY GRAPHENE COATING**
The properties of aluminium coated with the graphene are tested by doing various experiments by numerical tensile methods by dynamics of molecules simulations[4]. Based on the results obtained from the results, the aluminium layer coated with the graphene enhances young’s modulus, toughness of the material. The loading rate on coating is tested. Though the hybrid coat structure is mostly of the aluminum core[4]. A high loading rate makes structure as amorphous. So, the loading effect and the amorphization temperature are found out by performing various simulations[4].
Among many carbon nanocomposite materials, graphene has many mechanical, chemical and electrical properties. The chemical bonding of graphene is also similar to other carbon nanotubes. The characteristics of Graphene along with several other composites are also studied. Graphene added with several metals like iron, copper -nickel will enhance the strength of those metals [5]. The graphene metal composites have many applications. The metal generally used is aluminum in the composite and it is made to make with several methods. Difficulties in conducting nanoscale experiments are overcome by conducting numerical experiments with graphene metal composites through the atomistic modeling of these materials. Molecular dynamics simulations are applied for studying the chemical and mechanical properties and its behaviour of nanocomposite materials[6]. MD simulations of graphene -nickel and graphene -TiO₂ are studied and their mechanical properties are investigated[6]

**A. Atomistic modeling and simulation details:**
The atomistic model is created by placing the graphene sheet of dimensions 20*20 nm on the free surface of 10 nm thick aluminum block, permitting a gap of 0.224 nm which is found to be the bond length between aluminum and carbon atoms. For finding the atomic interactions between the metal atoms, the embedded atom method is used. A formula is also used for finding the atom’s total energy. The tensile stress -strain curves of coated as well as uncoated aluminum layer are drawn at a temperature of 300 K[7]. The applications of boundary conditions of the planar direction (X, Y, Z axes) is done. The thermalization is done at a different temperature. The application of Tensile loading in Y direction is done by applying different strain rates [7]. During loading, viral stress is calculated using the formula.

**B. Observation of the coating process:**
It is observed that coating the graphene on aluminum sheets will enhance several important properties like young’s modulus, yield strength. The graphene is coated with the uncoated aluminum surface and so density of the aluminum material increases [8]. Tensile characteristics of aluminum sheet is tested by high loading and graphene plays role in enhancing the properties is also discussed and their results are plotted as graphs[8]. The loading rates have been tested for different temperatures and increasing the loading rate improved the density. The undefined stackings are formed due to the enhancement of loading rate[8].

**C. A suitable method to coat graphene nanoparticles on an aluminum composite:**
Graphene coating is done on the composite. Antibacterial activity, microstructure are investigated[9]. The graphene is coated uniformly. Researchers have developed the graphene -coated aluminum composite to avoid all the limitations of organic coatings. [10]

**Properties:**
Excellent bonding strength, superior corrosion resistance, weather resistance [11] The graphene silver
coating is experimentally prepared by a suitable method and sprayed on the mild steel plate using a cold spray method. X-ray diffraction, scanning electron microscopy, energy dispersive spectroscopy are some of the methods to check the graphene coating on the composite. The antibacterial activities were studied in the bacteriostatic experiment[12]. Through scanning electron microscopy, the graphene’s microstructure which is to be coated has been studied and several curves were drawn through Raman spectroscopy. On the whole, the aluminum matrix composite coated with graphene is chemically synthesized and cold spray. It is also tested using testing methods[12].

IV. ELECTROPHORETIC COATING DEPOSITION ON COPPER

Graphene coated composite is synthesized using suitable methods and its application is done on the copper through electrophoretic deposition. By this method, a minimum thickness of 40 nm at 10 V and at a deposition time of the 30s. By means of electron microscopy the morphological characteristics are studied in copper which describes the distribution of oxides of graphene which is of few nanometers[13].

A. Raw materials

Initially, before the synthesis of the coating, all the necessary raw materials like copper flat sheet, Polymeric isocyanate crosslinked with hydroxy-functional acrylic like adhesive (PIHA) are used. Specific surface charges are measured by particle charge detector (PCD) and the optimum concentration of PIHA is also checked prior to the synthesis of the composite[14].

B. Synthesis of GO and suspension of GO, PIHA:

Then the graphene oxide is prepared by a method called modified hummer. After the synthesis of GO, GO and PIHA are made to suspend each other by using a stirrer.

C. GO-PIHA composite coating:

The EPD setup is set up using two fixed parallel plates. EPD from the GO-PIHA suspension was conducted at constant DC code using source meter. On successful completion of coating, the samples were taken from the setup. Then the GO composite coating is chemically reduced using some chemicals[15].

D. Tests to be carried out and characterization:

Initially, the electrochemical corrosion test is conducted on copper plate coated with the graphene composite coating. Then the graphene composite’s microstructure which is to be coated is found out using scanning electron microscopy. Therefore, physical and chemical characteristics of the composite coating will also be understood from the tests being carried out[16].

V. ENHANCEMENT OF SEAWATER CORROSION RESISTANCE

Acetone derived graphene coating enhances the efficiency of the copper corrosion in the seawater environment. Copper and alloys of copper are used as components of the seawater system due to enhanced corrosion resistance and biofouling. It not only depends on the inherent cathodic nobility of metal but also naturally from positive layers[17].

Layers-Cu2O

Corrosion rate rely upon parameters like seawater, temperature, the velocity of water flowing to the metal surface and degree and kind of pollution. Many physical barriers are added for preventing corrosion of copper like alloy polymer organic layer but it will change their physical and chemical properties[18].

Graphene has a strong thin metal coating which is protective with considering structural, chemical, thermal stability. Acetone derived from graphene films effectively protect metallic copper growth from corrosion[18].

A. Corrosion level checking upper graphene added

By physical methods like XPS and ATR, F-Diacetone from the graphene layer acts as large cathodic reduction barriers against dissolved O2 and chloride diffusion. It not only helps Cu but also other several metals from corrosion[19].

B. Methods of corrosion checking and graphene level checking:

ATR FT-IR –Used to record reflectance spectra of Cu coil samples which has already undergone annealing using germanium ATR crystal prior and undergone acetone deposition Raman spectroscopy using water project software data analysis is done afterward Field emission (FE-SEM)-energy dispersive X-ray spectrometer mechanically test for acetone work before and after corrosion[19]. Acetone drops (Cu foil) on heated at 1000-degree Celsius gives graphene which is an anti-corrosion barrier as corrosion resisting coatings in the marine atmosphere.
Graphene with copper as single layer acts as a large cathodic reduction barrier against dissolved O2 and chloride diffusion into underlying Cu in a seawater. Since partial active oxidation did on the single-layer graphene is powerful so that the multilayered graphene will also effective[19].

Full forms:
RTA-Rapid thermal anneals
XPS-X-ray photoelectron spectroscopy
ATR FT-IR-Attenuated complete reflectance of transforms of Fourier infrared.

VI. METAL NANOCOMPOSITES: SYNTHESIS, APPLICATIONS AND THEIR CHARACTERIZATION

In recent times nanocomposites found much attention in scientific research due to their improvement in properties when compared with single metal in nanoparticles[20]
The range of nanocomposites will be 1-100nm Nanocomposites are classified based on
- Continuous phase
- Discontinuous reinforcing phase

The basic method of preparation of nanocomposites are
- Metals
- Ceramics
- Polymers.

A. Metal Oxide Nanocomposites (MONC)
The main focus on MONC structure and function is explained by the above three basic methods.

Synthesis:
Synthesis is based on optical, magnetic, electrical, biological which helps to determine the properties based on size and dimensions[21].
Another method of approach to synthesis is
- Top-Down approach (physical methods)
- Bottom-up approach (wet methods)

There are different wet methods for synthesis of nanocomposites and metal nanoparticles but primarily hydrothermal co-precipitation and sol-gel methods are less costly when compared with others[21].

Co-precipitation:
We use a co precipitation method for the synthesis of nanoparticles mixed with metal ceramics or metal. The precipitate is produced by Nanocomposites that are separated from the solution. MgO-Al2O3, Mgo-cuo.

1) Sol-gel method:
The sol-gel method is used for the synthesis process of nanomaterials by mild reaction and building the molecular variation on properties and material Nano and microstructures can be produced by sol-gel methods[21].

\[ \text{TiO}_2-\text{Fe}_2\text{O}_3 \text{Ag-TiO}_2 \]

2) Hydrothermal methods:
This method involves a chemical reaction in an aqueous solvent or no aqueous solvent occurring at more than room temperature at 1atm pressure in a closed system The properties and size can be modified based on requirements[21].

\[ \text{ZnO-kaolinite Co-MgO} \]

B. Characterization of Metal Oxide Nanocomposites (MONC)
By different techniques, the Nanoparticles are characterized to analyze the morphology, particle size, phase, composition, thermal stability, optical, magnetic, electrical and thermal properties.

X-ray Diffraction:
Powder X-ray Diffraction (XRD) is used for phase determination and unit cell information of the nanocomposites under investigation

\[ D = K \lambda \cos \theta \]

D (nm) crystalline domains mean size. K is the shape factor value in which K is near unity and dimensionless.
C. Thermal Applications of Metal Oxide Nanocomposites (MONC)

1) Application in Environment

The MONC are frequently used as adsorbents, photocatalysts, and sensors to tackle environmental pollution problems[21].

2) Application in Agriculture and Food

The MONC is widely used in the packaging of foodstuff provides strength as a filler material (silicates, clays, TiO2). While in the agriculture sector, MONC used as Nanosensor for pesticide and pathogen detection in plants and source for delivery of genetic material for the improvement of crops[21]

D. Application in Health and medicine

The MONC has many applications in medicine, for delivery of drugs and imaging, diagnosis and screening of diseases, DNA sequencing, in gene therapy and tissue culturing and in cancer treatment. Metal oxide nanocomposites have proven themselves as the materials in the 21st century with the range of applications in every industry sector. The wet chemicals methods mark the easy route for their fabrication that makes them cost-effective as well. The complex matrix which is based on MONC VI is formed by co-precipitation by simple routing[22]

VII. CONCLUSION

In this paper, the aluminium sheet properties with the graphene is studied by MD simulations for enhancing properties like tensile strength, toughness, yield strength, etc. The loading rates have been tested for different temperatures. The undefined stackings are formed due to the loading rate. It is observed that coating the graphene with metals will enhance several important properties like young’s modulus, yield strength. The graphene is coated with the uncoated aluminum surface and the aluminum material density increases. The aluminium sheet’s tensile characteristics are studied using high loading and graphene role in enhancing the properties is also discussed.

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