Application of Natural Nano Silicate-Aluminum Powder in Advanced Smart Nanocomposite Coating †

EL-SHEIKHY Refat* , AL-SHAMRANI Mosleh* and KOBAYASHI Akira**

Abstract

Applying nano technology in smart coatings is a new field of interest for industry and technology. A smart coating using nano materials has been applied using different types of metallic materials such as Zirconia or Metal glass. It has been applied using different technologies such as plasma spray tunnelling systems or nowadays microwave coating technologies. The current research studies a new advanced material with super properties based on the powder of nano silicate-polymer nanocomposite. This new material can produce sustainable and durable coatings with super properties and low cost in addition to good maintenance and environmentally green performance. It can be applied as hot coating or cold coatings. The efficiency of this type of coating material is very high for corrosion resistance, impact resistance, wear resistance, fracture resistance, thermal stability, impermeability for gas and water, hardness,…..etc. This research introduces it as a new technology for coating industries.

KEY WORDS: (Smart coating), (Nanotechnology), (Nanocomposite), (Silicate powder), (Fracture mechanics)

1. Introduction

Nowadays, recent advanced technology in material science and industry is depending on the development of nano science. Nano technology is making significant changes in all fields of life. The products of conventional materials and conventional industries have developed from the challenge and competition of the new products of this new technology direction. Nano science could develop new materials and produce new products which have not been found before. One of these fields is coating technology. A nano coating can produce high quality with super properties in the coating layers. It can produce sustainable products with super ability to resist the stresses and loads for different applications. The current research introduces a new application of the nano silicate/polymer nanocomposite for application in coating technology.

In current research, we developed a new material which is a pure natural material developed in Saudi Arabia at the Bughshan Research Chair and Center of Excellence for Research in Engineering Materials at Civil Engineering Department at King Saud University. The material can be mixed with other materials to improve the properties such as nanocomposite polymers. The material is a natural nano silicate –aluminum powder. It can be used for cold coating and hot coating for metallic and non metallic substrates. It can be added to some other materials like Polyethylene PE, or polypropylene PP to produce nanocomposite coatings suitable for different applications. The previous studies of smart coating technology depended on metallic powders, ceramic powders and metal – glass powders [1-17]. The previous studies [1-17] depended on thermal spray technology like the plasma technique which needs very special precautions devices, very high temperatures and very expensive equipment. The previous coating has many different problems.

The previous research or technology [1-17] had many difficulties and problems. Until now they could not produce ideal materials with ideal coatings capable of resisting different types of stresses and loads [1-17]. For example, the impact, thermal stability, wear resistance, water resistance, hardness, stiffness, flexibility, ductility, fracture resistant, …etc. This research introduces a new idea of application with a new material for producing high quality nano coatings.

2. Materials (The Nano Silicate Powder and Nano Silicate / Polymer Nanocomposite)

The material can be represented as the basic of generation of cold smart coating which may replace smart

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Transactions of JWRI is published by Joining and Welding Research Institute, Osaka University, Ibaraki, Osaka 567-0047, Japan

hot coating. There are several types of silicate particles. Few types only of it are suitable for producing nanocomposites which can be used in coating applications with good stability and color [1-17]. In the current study the materials are natural clay (Saudi Arabian Montimorillonite MMT) shown in **Figs 1- 5** and domestic Saudi polymers high density Polyethylene (HDPE) or low density Polyethylene LDPE as in **Figs. 6, 7**, and nanocomposite of Silicate-aluminum/LDPE as shown in **Figs. 8-10** .

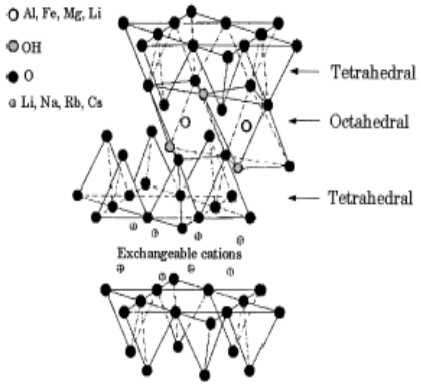

Fig. 1 Silicate-aluminum structure.

Fig. (2.a) Fig. (2.b)

Fig. 2 Silicate-Aluminum / polymer nanocomposite structure with local orientation (a) Dispersed agglomerated , (b)Dispersed exfoliated.

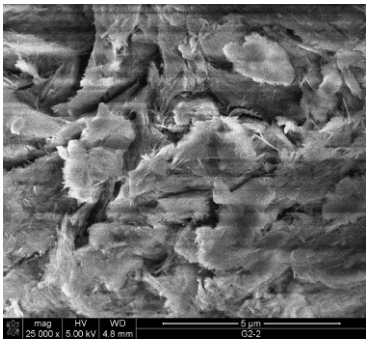

Fig. 3 SEM analyses of Saudi Arabian natural agglomerated nano silicate- aluminum.

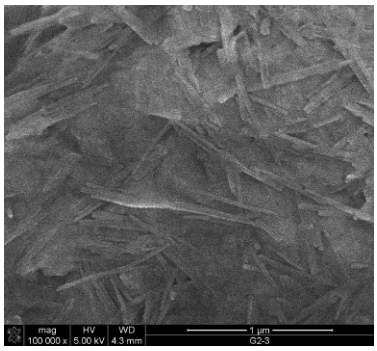

Fig. 4 SEM analyses of Saudi Arabian natural nano silicate-aluminum fibers.

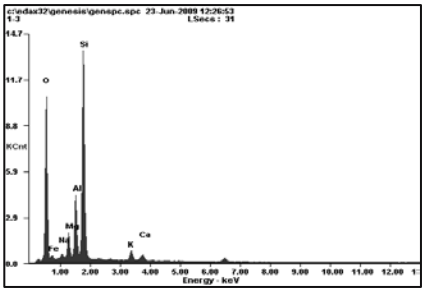

Fig.5 EDAX chemical analysis of Saudi Arabian natural MMT nano silicate- aluminum.

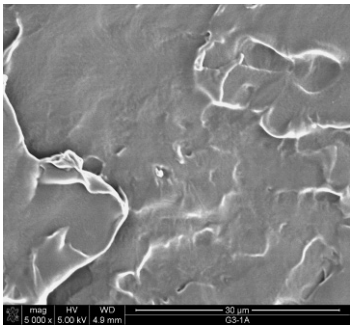

Fig.6 SEM analysis for HDPE polymer produced by SABIC in Saudi Arabia indicating that it is amorphous material.

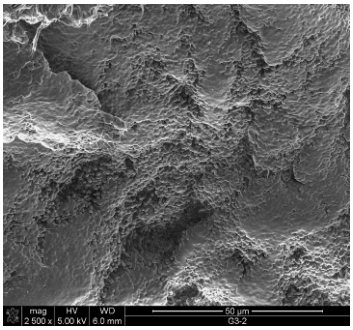

Fig.7 SEM analysis for LDPE polymer produced by SABIC in Saudi Arabia indicating that it is crystalline material.

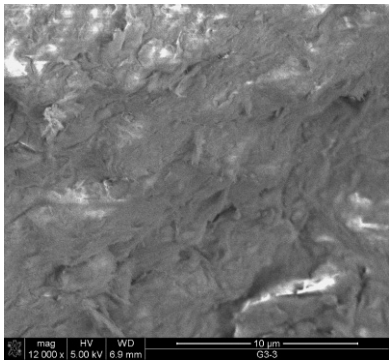

Fig. 8 SEM analysis for nanocomposite of natural Saudi aranian Silicate aluminum MMT based Saudi HDPE polymer.

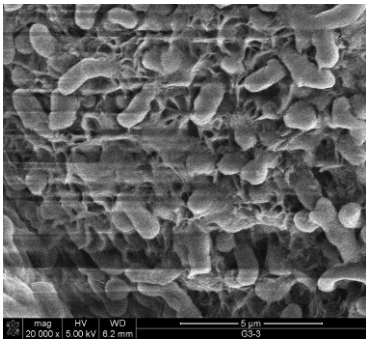

Fig.9 SEM analysis for nanocomposite of natural Saudi aranian Silicate aluminum MMT based Saudi LDPE polymer showing both nano silicate fibers and polymer crystals.

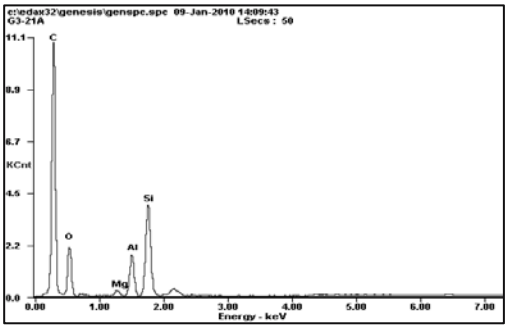

Fig.10 EDAX analysis for nanocomposite of natural Saudi aranian Silicate aluminum MMT based Saudi LDPE polymer.

3. The Nanocomposite and Nano Silicate

Nano silicate powder and its nanocomposite a with polymer matrix have many advantages which make it very convenient for producing nanocomposites for coating purposes and other applications. The properties of the nano silicate such as aspect ratio, surface area, chemical composition, strength, toughness, low cost, environmentally green, ability for modifications to be organophilic or hydrophobic by surface treatment and thermal stability make it suitable for producing good nanocomposites if it is used as reinforcement material or filler material in other weak matrix material like polymers. The nano silicate/polymer nanocomposite represents a very good example of application. The manufacturing of such composites pass through several technical steps until it can become a final product. These steps can be concluded as material selection, materials preparation and processing (mixing, Extruding). Figures (8-10) show MMT / LDPE nanocomposite.

4. The Idea of the Application

The idea of using the nano silicate for coating technology arose for two reasons. The first reason is the high quality of silica properties. The second reason is the difficulties and problems of the other coating materials such as zirconia, ceramics and metal glass. Therefore, the current research idea is based on improving the coating quality by using the good properties of the silicate material. Then, based on the information and knowledge on the nano silicate and nanocomposite adantages and properties, it was decided to apply it in the field of smart coating.

There are three methods of applications of nanosilicate and nanocomposite for coating industry. The first application depends on using the nano silicate powder for coating layers as liquid cold coating. The second method is based on using the dry silicate powder with the plasma spray technique. The third one, which is completely new is using the silicate as a filler material or reinforcement for some other materials for advanced coating materials such as Zirconia, alumina, metal glass, ...etc or with polymers such as epoxy, PP, PE, to produce silicate polymers nanocomposite coatings.

5. Techniques and Methodology

Each type has certain methods for installation and production of the application with suitable technique. The second and third types can be applied through the plasma technique. The first and third types can be applied by liquid coating technique.

For cold types, the nano silicate can be used alone by adding any suitable solvent and water or with polymers to produce nanocomposites which can be liquified by any suitable solvent. Then it can be used as spray. The nanocomposite coating can be produced after several steps with some complicated procedures to produce nanocomposite. The procedures go through some steps of preparation, mixing, processing and final production of the nanocomposite. The final product can be prepared for the coating process by adding some solvents and necessary colors before spraying it on to the substrate. The following steps explain the manufacturing procedures.

1. Preparation
2. Mixing
3. Processing
4. Final coating material
5. Coating processing

6. Characterization and Testing

The natural nano silicate materials are tested and charecterized using the microscopy techniques of each of SEM, TEM and XRD in addition to calculations of the surface area. The results are shown in the figures (3-10).

7. Conclusion

This research introduces a new application in the field of coating technology. It introduces a new material developed and produced in Saudi Arabia by the author. This material is pure natural nano silicate. It can be used for several purposes and fields of applications. Coating technology is one of the most important applications. It can produce high thermal stability, corrossion resirtant material, impact resistant material, resistance for wear, resistance for fracture and cracking, good bond, ...etc. It has another important aspect environmentally since it is a green material. This new application will help in producing sustainable and durable products in all fields of industries.

Acknowledgements

This work is a part of nano technology research project supported by Center of Excellence for Research in Engineering Materials CEREM, Faculty of Eng., King Saud Univ., Saudi Arabia.

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