Chapter 1
Coating Materials: Nano-Materials

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ABSTRACT

The ever-growing interest in nanocoating and its enthralling protective properties makes it a very capable candidate for next generation protecting systems. The future of these special nanocoating markets will be expanding in different industries such as marine, building, and defense. The main purpose of coatings involves the use of thin films (nanoscale dimensions) that are applied to the surface of materials, which improve the material functionalities. Some of the improved functionalities include anti-corrosion, easy-to-clean (anti-graffiti), anti-icing, anti-fogging, anti-fouling, etc. Some of the common techniques used for nanocoating are chemical vapor phase deposition, physical vapor phase deposition, Sol-gel methods, electro-spark deposition, electrochemical deposition, and laser beam surface treatment. Commercial application of nanocoating nanotechnology includes self-cleaning coatings, depolluting coatings, ultra-violet (UV) light protective coatings, anticorrosion coatings, thermal resistance, anti-fouling coatings, and anti-graffiti coatings.

INTRODUCTION

Nanotechnology is an emerging branch of science and technology that deals with the study of matter at dimensions roughly in the range of 1-100 nm (1 nm = 10^{-9} m). (Joshi & Adak, 2019) Materials in nanometer scale possess specific physical, chemical and biological properties that differ in fundamental and valuable ways from properties of bulk matter. (Kim, 2010) Potential application of nanotechnology includes its use in catalysis, scientific tools, textile industries, electronics, biomedical application, agriculture, environmental remediation etc. (Joshi & Adak, 2019) Recently, reports have been found which explains the use of nanotechnology in solving various problems that are persisting in various develop-

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ing countries. One of the important industrial applications includes the use of nanostructured coating where nanotechnology has been extensively used is the coating. (Achanta *et al*., 2011) It is therefore now possible to use nanomaterials and nanostructures in the coating industry for its application in various fields. (Dubbert *et al*., 2014)

Nano-Coating

"A coating is defined as a coherent layer formed from a single or multiple application of a coating material to a substrate" (DIN EN ISO 4618; 2.52). According to the existing standard (DIN EN ISO 4618; 2.53) "a coating material is a material in liquid, paste or powder form which, when applied, forms a protective and decorative coating." (Dubbert et al., 2014)

Coating materials mainly consists of following four types of ingredients (Dubbert et al., 2014):

a) **Binders:** They help in forming a coherent film during drying and hardening.
b) **Pigments and extenders:** Pigments are usually used as colourant and mainly comprises of insoluble color particles. While extenders are used to modify the physical properties.
c) **Solvents:** Solvents are single liquids or mixture of liquids that dissolve other substances to form solutions without reacting with the substance to be coated.
d) **Additives:** Very small quantities of additives when added to the coating material considerably modify its properties. Some of the properties include its flow behaviour, surface tension, gloss, structure, UV and weather resistance. (Dubbert *et al*., 2014)

The main purpose of coatings involves the protection and decoration of materials, and its use has been widened with increasing social and industrial development. (Makhlouf, 2011)

There are thousands of coating systems, ranging from simple systems to multilayers systems and complicated instruments. Most of these systems have an adverse effect on the environment. To combat with this problem continuous research and development work has been undergoing in coatings science and surface technology. The main driving forces are:

Increase in industry supplies at relatively low cost for high performance coatings;

To reduce the hazardous waste produced during coating processes (such as hexavalent chromate and volatile organic compounds (VOC)) which results in environmental pollution. (Makhlouf, 2011)

Nanocoating are one-phase solids structures that are applied onto the surface which dimension is lesser than 100 nm, thereby adding a specific property to the surface. These coatings are made up of layers or by combination of particles thinner than 100 nm, which enhances the surface properties or improves the material functionalities. Properties of nanocoating are greatly dependent on the constituent nanostructures. Small particle size of nanoparticles offers more surface area per unit mass that improves its application with low production costs. Enhanced surface properties encompass improved mechanical properties, wetting properties, thermal and chemical properties, electronic and magnetic properties, biological properties and optical properties. Improved properties may considerably alter the reactivity and capacity that is highly desirable depending upon the applications. (van Lente and van Til, 2008)

Some of the applications of nanocoatings include its use in medicine industry, electronics, food packaging, soft material industries (such as polymers, wood, textiles, leather, etc.), automotive industries, solar cells etc. (van Lente and van Til, 2008)