Innovations

Characterization of the Microstructural Properties of Polymer- Calcine Kaolin Clay Mineral Concrete- A review

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Abstract
With the contemporary swift increase in population, the demand for infrastructure development likewise increased exponentially. As the cities experiences evolution, built-up areas temperature also increases the chemical reactions which in turn generate smog and rise in pollution. These increase demand for innovative infrastructure such as Polymer and nano concrete or polymer – photocatalysaconcrete that can feed the global demand for building materials.Polymer concrete is a composite or multifarious material in which the aggregate is joined together in a matrix with a polymer binder.While photocatalyst, titanium dioxide (TiO_2) and calcium oxide (CaO), is a naturally occurring compound that can decompose gaseous pollutants with the presence of sunlight. Combination of both can tackle or substitute Portland cement that has shortened service life,causesCO_2emission, organic synthesis and durability problems during construction, though widely utilized man-made material, mostly when serving in nonideal environment and suffering internal or external assaults. Moreover, Nitrogen oxides (NO_x) from dirts threating quality of air breath in and huge cost of cleaning due to uneven stains resulting from murky and dirty on building or structures exterior surfaces like roofs, kerbs and facades especially in tropical regions. Hence, there is need for innovative concrete or construction materials that support the sustainability aspects of construction, besides has rapid setting characteristics, high strength-to-weight ratio, ability to withstand a corrosive, aquatic environment, save natural resources, protecting the environment, besides solve environmental problems and energy catastrophethrough only consuming solar energy.Also serves as possible method to make the municipality cleaner by decreasing the air pollutants as well as tackle CO_2 emissions challenges. The use of this contemporary concrete composite in urban and interurban areas can reduce maintenance cost, removes pollutants from the air and ensure a cleaner environment.

Keywords: *1.Polymer; 2.Dirt;* 3. CO_2*emission; 4.Synthesis; 5.Heterogeneous photocatalysis.*

1.0 Introduction

With the contemporary swift increase in population, the demand for infrastructure development likewise increased exponentially (Zhou et al.2017). As the cities experiences evolution, built-up areas temperature also increases the chemical reactions which in turn generate smog and rise in pollution. This increase demand for innovative infrastructure feeding the global demand for building materials.For instance, ordinary Portland cement (OPC), which serve as the main binding constituent for producing concrete. Currently, the global demand of the OPC is around 4 billion tons (Gherardi et al. 2018; Adnan et al. 2016), which is second most required material after water and it is expected that this figure will increase by 8–10% in the coming years (Garcia et al. 2018; Arum et al. 2013).

The production of cement is a highly energy intensive process which releases one-tonne of carbon dioxide CO_2 for every tonne production of cement (Bergamonti et al. 2016; Graziani et al. 2016a). It is estimated that by the year 2020, theCO_2 emission will rise by 50% from the current levels. To overcome these challenges, researchers have recently worked on the development of Polymer concretes (PC) as a good alternative to traditional cementitious materials in the field of new construction. It is believed that PC will exhibit high compressive strength and ultimate compressive strain values due to their good chemical resistance property. In order to address cities pollution problems there is need to use nanotechnology materials for example heterogeneous photocatalysis that remain cool in sunlight besides have a solar contemplative index (Baviskar et al. 2018; Buyukozturk et al. 2014). Heterogeneous photocatalysis embroils usage of a semi-conducting material which might be excited through absorption of light. The photocatalysis applications include water treatment, air treatment, purification, and 'self-cleaning' surfaces. The most frequently employed photocatalyst material for research as well as industrial applications is titanium dioxide (TiO_2), because it is photostable, non-toxic, chemically stable, photoactive, and relatively inexpensive. Titanium dioxide (TiO_2) nanomaterials have been deliberated as the most promising photocatalyticsemiconductor for contagion or pollutant removal as well as energy generation owing to their relatively good photocatalytic deed, slightly economical, nontoxicity, and high stability since the discovery of hydrogen evolution thoughthe photoelectron chemical water splitting on TiO_2 electrode (Prasittisopin and Trejo 2015; Djongyang et al. 2009). Meanwhile, photocatalysishypotheticallymight be an ideal resolution to current environmental problems and energy crisis through consuming solar energy only.

2.1 Impact of population expansion

Rise in population lead to increment of infrastructural development, which in turn generate a lot of wastes categories that pollute the environs and inhabit soil surfaces thereby leading to environmental pollution. Best way for consuming wastes is to obtain green materials and produce polymer concrete. Though, most infrastructures like buildings, rigid pavement, kerbse.t.c, are exposed to various organic contagionssubstances from bird residue to diesel fumes. Besides, all built-up buildings are constantly exposed to organic material that makes their façadeslook dirty (Baviskar*et al*. 2018; Aldoasri et al. 2017). Building surface dirt is commonly not seen as a key problem since it does not significantly impede the safety except deterioration sign concealments. Nevertheless the dirt is perceptible hence it is expedient to examine what consequence the dirt has on the building (Garcia *et al*. 2018; Gherardi*et al*., 2018). There are three causes of construction exterior messiness; Dust, dirt and biological evolution, but another category of organic material which constantly bombarding or barraging buildings that is harder to see is nitrogen oxides (NO_x). As the primary component of smog, NO_x not only makes buildings dirty, but it also threatens the quality of the air we breathe (Aprianti et al. 2015; Davies 2011). A variety of air pollutants have known or suspected harmful effects on human health and environment (Bergamonti et al. 2016; Colangiuli et al. 2015). Polymer concrete (PC) is aninnovative composite material which is used in construction industry as a result of its superior properties in comparison with ordinary Portland cement concrete for example: mechanical strengths and chemical resistance. Likewise, Figure 1, showing dirt and water marks on the buildings in Nigeria andPhotocatalysts concrete unit pavers in Japan.Since, it is extremely significant to achieve a better understanding of the deterioration mechanisms as well as reliable prediction methods for durability properties and/or long-term performance of concrete. Modern molecular simulations and modeling are favourable for bringing innovative solutions to above issues and thus developing durable polymer-calcine kaolin clay based materials or concrete structures.

Figure 1. Dirt and water marks on the offices buildings in Nigeria.

Figure2. Examples of Photocatalysts concrete unit pavers in Japan. (Source: Adnan *et al*. 2018)

2.2 Reason for stand-in materials

Due toCO_2emission, organic synthesis and durability problems that shortened service life of Portland cement concretethat is widely used man-made material, mostly when serving in nonideal environment and suffering internal or external assaults. Moreover, Nitrogen oxides (NO_x) from dirts threating quality of air breath in and huge cost of cleaning due to uneven stains resulting from murky and dirty on building or structures exterior surfaces like roofs, kerbs and facades especially in tropical regions. Hence, there is need for innovative concrete or construction materials that support the sustainability aspects of construction, besides has rapid setting characteristics, high strength-to-weight ratio, ability to withstand a corrosive, aquatic environment, save natural resources, protecting the environment, besides solve environmental problems and energy catastrophethrough only consuming solar energy.

3.0 Polymer as a concept

Polymer concrete is a composite or multifarious material in which the aggregate is joined together in a matrix with a polymer binder (Hughes and Howind2016; Gunes et al. 2013). According to Luvidi*et al*. (2016) Polymer concrete is an aggregate mixture that utilizes some kind of epoxy binder to cure as well as harden into place.The composites do not compriseof hydrated cement phase, thoughPortland cement can be utilized as an aggregate or filler. Polymer concrete might be used for innovative construction or renovating of old concrete. The adhesive properties of polymer concrete permit repair of both polymer as well as conventional cement-based concretes (Luvidi et al. 2016; Lau and Buyukozturk2010).Construction materials modified through polymers were being in used since 2000～3000 B.C. Likewise, since 1950's, there has been increasing interest in concrete-polymer composites as new construction materials in the construction industry, andfor improving the properties of concrete through polymer based concrete studied was explored after 1966. In fact from the past few decades, many nations engaged aggressively in development of polymeric materials in mortar as well as concrete. Polymer concrete (mortar) is presently being used in Japan as prevalent construction material owing to its high performance, multi-functionality as well as sustainability as likened to conventional cement (Jindal *et al*. 2017; Lau *et al*. 2014). Different types of fillers can be used, considering especially the industrial wastes are: fly ash, slag, micro silica, cinder, phosphogypsum, etc. (Garcia *et al*. 2018; Barbuta and Lepadatu2008; Russaa, Natalia, Monica, Cristina, Antonino, Gino and Silvestro2016). Studies on polymer concrete with different types of resin such as: epoxy resin (Aggarwal *et al*.2007; Reis2004), polyester resin (Gorninski*et al*. 2007; Jo *et al*. 2008, Varughese and Chaturvedi1996), furan resin (Muthukumar and Mohan 2005), poly (methylmethacrylate) (Blaga and Beaudoin1985) show the uneasiness or preoccupation in this field. For rising the properties of polymer concrete numerous fiber reinforcements are utilized (glass, PVA,carbon fibers, etc.) (Reis2004; Yuksel et al. 2010).The low permeabilityand corrosive resistance of polymer concrete permits it to be used in sewer structure applications, drainage networks, swimming pools, electrolytic cells for base metal retrieval, as well as other structures that contain liquids or corrosive chemicals. It is specifically suited for construction, and rehabilitation of manholes owing to their capability to withstand toxic, corrosive sewer gases and microbes commonly found in sewer structures. It can likewise be used as a bonded wearing course for asphalt pavement, for higher durability and higher strength upon a concrete substrate (Graziani et al.2016b; Buyukozturk and Hearing 1998). More so, polymer concretes were categorized through measuring the density, studying its microstructure through scanning electron microscope, besides determination of experimental strength tests,for examples compressive strength, flexural strength as well as split tensile strength. The sustainability importance increase around the globe has led to a greater concern of the environmental effect of using concrete in construction, but Polymer and nano concrete such as Polymer-calcine kaolin clay concrete which is a possible method to make the municipality cleaner by decreasing the air pollutants as well as tackle CO_2 emissions challenges. The use of this contemporary concrete composite in urban and interurban areas can reduce maintenance cost, removes pollutants from the air and ensure a cleaner environment (Adnan *et al*. 2016).Nanotechnology materials from heterogeneous photocatalysis, a semi-conductor materialsfor instanceTitanium dioxide (TiO_2) is one of the most capable light scattering pigments known to mankind, and as a result it is extensively utilized to deliver opacity and brightness because they have the ability to scatter light. More in detail, the benefit of the use of photocatalytic coatings is to avert massive adhesion of dirt or filth deposits, lessening the necessary cleaning operations in terms of both intensity as well as frequency (Gherardi*et al*. 2018). This decrease denotes economic benefits for landlords and estate managers, conversely contributes to a more sustainable administration of the built environment (Kapridaki et al. 2014). The incorporation of self-cleaning photoactive functional materials is an effective precautionary maintenance strategy that permits consistent savings as well as reduces environmental effects of cleaning operations all through the whole building or structures service life (Franzoni*et al*. 2016). Photo catalysis is, thus, an accelerator for oxidization processes that already occur in nature. Indeed, it stimulates faster decomposition of contagions as well as prevents them from accumulating on the surfaces. Hence, because of increasing demand for titanium dioxide, its costvice versa has been increasing. For illustration Titanium dioxide price rose almost 35% in 2011 and 2015 and is projected to increase at an average annual rate of approximately 7% for the near future (Jay et al. 2017; La-Russa et al. 2016). For this reason, the search for an alternative to substitute titanium dioxide as photocatalysts is desirable. Besides, cost of TiO_2 challenges, others are: dwindling resources, as well as an energy exhaustive manufacturing process which creates objectionable by-products, replacements are required to sustain a source of white pigment in the future and to conform to fluctuating sustainability legislation. Many substitutes exist, including calcium oxide and calcine kaolin clay. The photocatalyst, titanium dioxide (TiO_2) and calcium oxide (CaO), is a naturally occurring compound that can decompose gaseous pollutants with the presence of sunlight (Hughes 2016; Yang and Liu 2014). Kaolin is a soft white mineral that has a large array of uses, which is normally referred to as

"China clay". Sources of this mineral can be located all over the world, its uses are multiple as well as diverse. Likewise, is a mineral belonging to the set of alumino-silicates with the chemical composition $Al_2Si_2\,O_5\,(OH)_4$.

3.1 Polymer Concrete Materials

According to Munafo et al. (2015); Naidu and Scherer (2014), A polyester, vinyl ester, or normal epoxy mixture is frequently utilized, but polymer concrete could be made with numerous kinds of polymer resins that permit the concrete to be poured or troweled and then hardened. It cures through a chemical reaction with the polymer material like traditional concrete, besides it also has water, sand, gravel or crushed stone as principal ingredients.Polymer materials which alsotitledas resins play significant role in binding the organic substrate like concrete or aggregates to each other owing to their inherent adhesive nature. Liquid resins used for the polymer concrete include unsaturated Polyester (UP), Polyurethane, Epoxy, Vinyl ester (VE), and Polymethyl methacrylate (PMMA).

3.1.1 White Pigments

Frequently used white pigmentsconsist of Zinc White, Barytes,Titanium Dioxide, Zinc Sulfide, Lithopone, China Clay,Alumina Hydrate, Calcium Carbonate, Blanc Fixe, talc, and silica.

Several types of ink pigments used for either printing opaque whites (called opaque pigment) or for tinting, extending, or reducing the strength of other color pigments (called transparent pigment). Commonly used white pigments include Zinc White, Titanium Dioxide, Zinc Sulfide, Lithopone, Alumina Hydrate, Calcium Carbonate, Blanc Fixe, Barytes, talc, silica, and China Clay.

3.1.2 Post-transition metals

These are a kindofmetallic elements in the periodic tableplaced between the transition metals to their left, as well as the metalloids to their right. Based on where these adjacent or contiguous groups are judged to begin as well as end, there are at least five (5)contending proposals for which elements to include: the three (3) most common contain six, ten as well as thirteen elements, respectively. All proposals include gallium, indium, tin, thallium, lead, and bismuth (Ozkaynak et al. 2010; Macmullen et al. 2011).

3.1.3 Metal-based pigments

Inorganic pigments:such as; Cadmium pigments: cadmium yellow, cadmium red, cadmium green, cadmium orange, cadmium sulfoselenide; Chromium pigments: chrome yellowandchrome green (viridian); Cobalt pigments: cobalt violet or blue, cerulean blue, and aureolin or cobalt yellow; Copper pigments: like Azurite, Han purple or blue, Egyptian blue, Phthalocyanine Blue BN,Malachite or Paris green, Phthalocyanine Green G, andverdigris; Iron oxide pigments: sanguine, caput mortuum, oxide red, red ochre, Venetian red, Prussianblue; Lead pigments: for illustration lead Naples yellow,white, cremnitz white, red leadandlead-tin-yellow; Manganese pigments: manganese violet, Mn blue; Mercury pigments: vermilion; Titanium pigments: like titanium yellow, black or beige, and titanium white; Zinc pigments: such as zinc white, ferrite, andzinc yellow and Aluminum pigment: for example Aluminum powder.

Other inorganic pigments:for instances; Carbon pigments: for examples carbon black (together with vine black and lamp black), and ivory blackor bone charcoal; Clay earth pigmentsoriron oxides: like yellow ochre, raw sienna or burnt sienna, raw umber, and burnt umber and Ultramarine pigments: for instance ultramarine, andultramarine green shade.

3.1.4 Biological and organic

Biological origins: for examples cochineal red,Indianyellow,alizarinoralizarin crimson that is synthesized, gamboge, rose madder, indigo, andTyrian purple.

Non biological organic: like quinacridone, magenta, phthalogreenand blue, pigment red 170, and diarylide yellow.

4.0 Nanotechnology concept

Nanotechnology is an embryonic field that covers comprehensive range of technologies which are currently under development at nanoscale (Palkoric et al. 2018; Rhim and Buyukozturk1998). Behavior of materials at the nanoscale as likened to macroscale frequently found to be highly desirable properties which are created because of size confinement, the dominance of interfacial phenomena, as well as quantum impacts. These innovative and unique properties of nanostructured materials, nanoparticles, and other related nanotechnologies lead to enhanced properties for instances catalysts, tunable photoactivity, improved strength, with many other fascinating characteristics. Thisfocus on the different kindsof nanomaterials utilized in photocatalysis in terms of their synthesis approach, microstructure, as well as their optical and magnetic properties (Russaa et al. 2016; Samnath2015). Environmental applications of nanotechnology address the development of solutions to the prevailing environmental issues, preventive measures for future problems ensuing from the interactions of energy and materials with the environment, and any possible hazards that may be posed through nanotechnology itself (Quagliarini et al.2017; Palkoric et al.2015).Use of pesticides, herbicides, dyes, solvents, etc., rapidly in agriculture and large scale industrial development activities are causing much trouble, concern for the scientific communities and environmental regulatory authorities around the world. These organic pollutants harmfully affect the environment, besides they are a key source of aesthetic contamination, eutrophication as well as ecological disturbance in aquatic life owing to their toxicity and persistence. To safeguard our environs, it is very vital to detoxify these risky organic pollutants. Among numerous proposed approaches for wastewater treatment: photocatalytic oxidation process offers a route for the detoxification of numerous toxic, hazardous pollutants and remedies water (Muhammad et al. 2017; Naidu et al.2016). In this contemporaneous scenario all the researchers as well as scientist are getting more and more fascinated towards the metal oxide (MO) nanostructures because of their technology significant applications in electronic and optoelectronic devices, sensors, medicines as well as renewable energy sources. Decreasing materials size of metal oxide to nano-level imparts properties which are diverse from the bulk or crystalline kind and these nanoparticles exhibit behavior like an isolated atoms and molecules.

4.1 Various Categories of Nanotechnology

4.1.1 Biosensor

A biosensor is a unified reducedtool that employs a biological element for examples nucleic acid, antibody, enzyme, receptor protein, whole cell or tissue segment, as a sensing element combined to a transducer for signal detection. A biosensor operates the selectivity or fussinessof the biomolecule as well as the processing power of modern microelectronics and optoelectronics and is thus a powerful analytical device with applications in medical diagnostics as well as other areas. Owing to their specificity, movability, rapid response time and low price, biosensors are proposed to play a critical part in both clinical and non-clinical applications (Zhou et al. 2017; Lau et al. 2014). Nanostructured metal oxides (NMO) have recently become significant as materials, besides,it is found to display interesting nano-morphological, efficient biocompatible, non-toxic and catalytic properties, specifically those of zinc, zirconium,iron, cerium, tin, titanium, metal and magnesium. These materials also heightened electron-transfer kinetics and tough adsorption ability, providing appropriate micro-environments for the restriction of biomolecules, ensuing in the enhanced electron transfer and improved biosensing attributes as biosensors. To scrutinize the impact of optical and electrochemical properties of NMO, solid–liquid interfaces, proscribed media, and nano-bio-interfaces are being performed for biosensor applications (Tuakta and Buyukozturk2019; Thanh et al. 2015).The predominant reduceddevices allow packing of several microscopic electrodes together with transducers into a minor footprint of a biochip instrument, leading to the design of high-density bio arrays. Numerous biosensors relied on different detection for diverse analytes for instances: hydrogen, ammonium and sodium ions and urea, butyrylcholine,creatynine, triglycerides, acetylcholine, pesticides as well as heavy metal ions were presented.Biosensors helps in discovering emerging contagionsfor examples pharmaceuticals, xenoestrogens,personal care products, steroids, and other endocrine disturbing compounds (EDCs), algal toxins, giardia i.e, other pathogens, and a variety of mixt chemicals for instance caffeine, cholesterol, etc.To manufacture an efficient biosensor, it is vital to select an NMO that is appropriate for immobilization of the preferred biomolecule.

4.1.2 Photo-catalysis: essentials, methods and mechanism

Catalysts are employed for speeding up the chemical reaction, or they are a photocatalyst employ for speeding up chemical reactions in the presence of UV light. In this way, light absorption creates electron–hole pairs that permit chemical transformations of the reaction contributors as well as regenerate its chemical composition after each cycle of such interfaces. Though, there are two kinds of photocatalytic reactions, that is, homogeneous photocatalysis and heterogeneous photocatalysis. Substantial attributes of the photocatalytic systems are: proper band gap, material morphology, more exposed exterior area, stability and its reusability (yang and Liu 2014; Yuksel et al. 2010). Photocatalysis is extensively being practiced for the degradation with mineralization of risky organic compounds ofCO_2andH_2O and hence leads to the lessening of toxic metal ions into non-toxic states, deactivate and destruct all the water borne microorganisms, decomposes the air pollutants such asNO_2, CO and NH_3, degraded the waste plastics and green synthesis of industrially important chemicals (Palkoric et al. 2017b; Macmullen et al. 2011).

5.0 Concepts of Nanotechnology leading to Nanomaterials

Nanotechnology is the study and control of material which has one or more dimensions in the Nanoscale i.e. in the size range between approximately 1-100 nm (Chen 2012). Nanotechnology is a very multifaceted technology ranging from the extensions of conventional physics to the new approaches and the developing of new materials and devices that have at least one dimension in the Nanoscale. Nanotechnology also deals with the exploration of whether material in the Nanoscale can be directly measured. Nanomaterials are not a homogenous group of materials but encompass a magnitude of various types and forms of materials (Chen 2012; Hofmann 2009).

Nanomaterials are the keystones of nanoscience and nanotechnology. Nanoscience and Nanotechnology is a widearea of research and development activity that has been growing explosively worldwide from the last few years. It has thepotential for developing the ways in which materials and products are generated and the range and nature of functionalitiesthat can be accessed. It is already having a significant commercial impact, which will definitely increase in the future.Nanoscale materials can be defined as a set of substances where at least one dimension is less than aroundhundred nanometers (Pawan and Manish 2013; Chen 2012). A nanometer is one millionth of a millimeter approximately one lakh times smaller than the diameterof a human hair. Nanomaterials are of interest because at this scale unique optical, magnetic, electrical, and otherproperties emerge. These emergent properties have the potential for great impacts in industrial machinery and other fields (Gaurav et al. 2016; Soboley et al. 2006). Nanomaterials are being used in an ever-increasing number of products and applications. Nanotechnology is rapidly developing, which leads to the need for safety assessment with regard to both human health and environmental impacts. Materials in the Nanoscale can behave differently from larger materials, even if the basic material is the same. Nanoscale Materials can have different chemical, physical, electrical and biological properties. The nanotechnologyindustry is experiencing challenges in both environmental effects assessment and therefore risk assessment (Chen 2012; Hofmann 2009).

5.1 Nanomaterials concept

Nanomaterials are a diverse class of small-scale substances that have structural components smaller than 1micrometer (1000 nanometers (nm)) in at least one dimension. Nanomaterials include nanoparticles which are particleswith at least two dimensions between approximately 1 and 100 nm in the Nanoscale (Thanh et al. 2015; Chen 2012). Nanomaterials can be categorized intothree types according to their source: natural, incidental, and engineered.

5.1.2 Occurrence of Nanomaterials

Some Nanomaterials occur naturally, but of particular interest are engineered Nanomaterials, which are specially designed for, and are used in many commercial goods and processes (Marineta et al.2016). These are found in such things as stain-resistantclothing, cosmetics, sunscreens, electronics, sporting goods, tires, as well as many of real life daily items, and are used inmedicine for purposes of diagnosis, imaging and drug delivery. Nanomaterials are commercially using with some havingbeen available for several years or decades. The commercial products are available today at a very broad range (Zegardlo et al. 2018; Chen 2012).

5.1.3 Advances in Nanomaterials

The Nanomaterials are in use immediately after the big bang when Nanostructures were designed in the early timeperiod. Nature later evolved many other Nanostructures like seashells, skeletons etc. Nanoscale smoke particles were formed, when the fire used by early humans.Today Nanophase engineering growing rapidly in a number of structural materials, both inorganic and organic,allowing to manipulate the mechanical, catalytic, electrical, magnetic, optical and electronic functions.The production of Nanophase or cluster assembled materials is generally based on the generation of separatedsmall clusters which then fused into a solid matrix materials as illustrated in Figure 3.

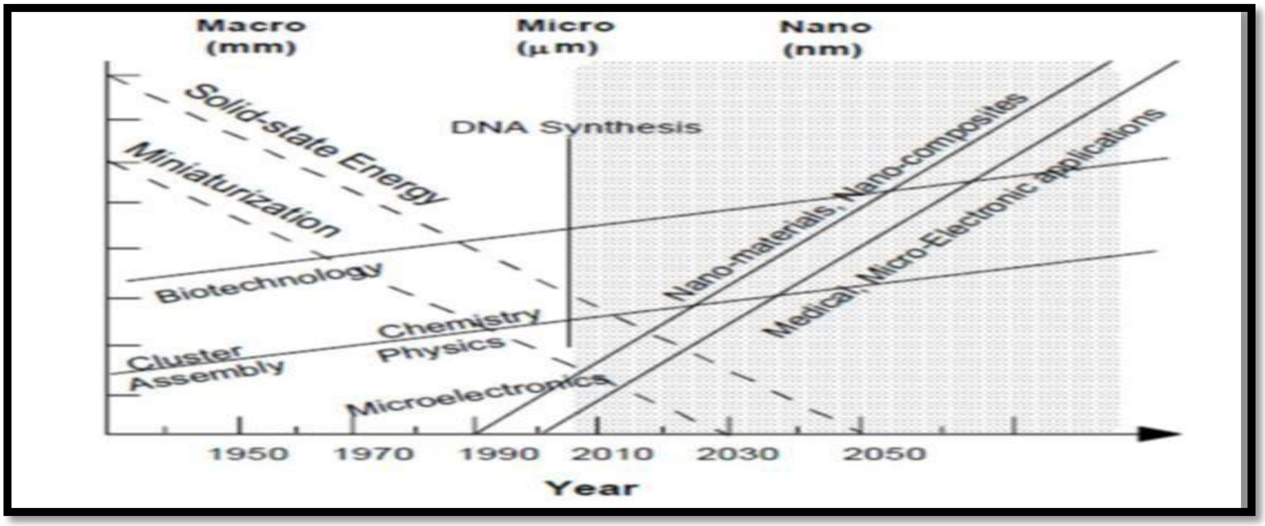

Figure 3:Evolution of Science and Technology and the Future. (Source: Pawan and Manish 2013).

5.1.4 Classification of Nanomaterials

Nanomaterials have extremely small size which having at least one dimension 100 nm or less. Nanomaterials can be Nanoscale in one dimension, two dimensions, or three dimensions. They can exist in single, fused, aggregated or agglomerated forms with spherical, tubular, and irregular shapes (Gherardi et al. 2018; Hofmann 2009). Common types of Nanomaterials include nanotubes, quantum dots and fullerenes. Nanomaterials have applications in the field of Nanotechnology, and displays different physical chemical characteristics from normal chemicals (i.e., Silver Nano, Carbon Nanotube, Fullerene, Photo Catalyst, Carbon Nano, and Silica). On the Basis of Dimension, Nanomaterials are Classified as: zero dimensional nanostructures (e.g. Spheres and Clusters etc.), one dimensional nanostructure (e.g. Film. Coatings, Multilayer's etc.), two dimensional nanostructures (e.g. Tubes, Fibers, Wires, Platelets etc.), three dimensional nanostructures e.g. Particles, Quantum Dots, Hollow Spheres etc. as illustrated in Figure 4 (Pawan and Manish 2013).

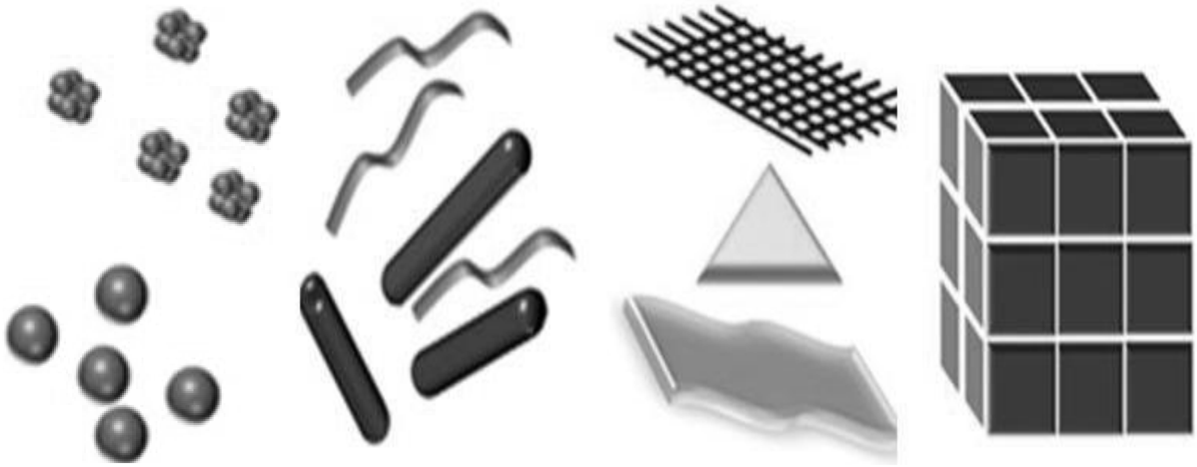

Figure 4: 0D Spheres and Clusters, 1D Nanofibers, Wires, and Rods, 2D Films, Plates, and Networks and 3D Nanomaterials (Source: Pawan and Manish 2013).

5.1.5 Properties of Nanomaterials

The chemical and physical properties of Nanomaterials (such as optical absorption and fluorescence, meltingpoint, catalytic activity, magnetism, electric and thermal conductivity, etc.) are typically differ significantly from thecorresponding coarser bulk material. A wide range of material properties can be adjusted by structuring at the Nanoscale as displayed in table 1.

Table 1: Adjustable Properties of Nanomaterials

Properties	Examples
Catalytic	Better catalytic efficiency through higher surface-to volume ratio.
Electrical	Increased electrical conductivity in ceramics and magnetic Nano composites, increased electricresistance in metals.
Magnetic	Increased magnetic coactivity up to a critical grain size, super paramagnetic behavior.
Mechanical	Improved hardness and toughness of metals and alloys, ductility and super plasticity of ceramic.
Optical:	Spectral shift of optical absorption and fluorescence properties, increased quantum efficiency ofsemiconductor crystals.
Sterical:	Increased selectivity, hollow spheres for specific drug transportation and controlled release.
Biological:	Increased permeability through biological barriers, improved biocompatibility.

5.1.6 Characteristics and samples of Nanomaterials materials

Nanomaterials have structure sizes smaller than 100 nm in at least two dimensions. These Nanomaterials can havevarious shapes and structures such as spherical, needle-like, tubes, platelets, etc. Chemical composition is anotherimportant parameter for the characterization of Nanomaterials, which comprise nearly all substance classes e.g. metals/metal oxides, polymers, compounds as well as biomolecules. Under ambient conditions nanoparticles tend to stick togetherand form aggregates and agglomerates.These aggregates/ agglomerates have various forms, from dendritic structure to chain or spherical structures withsizes normally in the micrometer range. The properties of nanoparticles can be significantly altered by surface modification (Hofmann 2009). For the characterization of Nanomaterials it is further important in which medium the nanoparticles are dispersed e.g.in gaseous, liquid or solid phase. Figure 6summarizes relevant parameters for the characterization ofNanomaterials.Nanomaterials are materials which are characterized by an ultra-fine grain size (< 50 nm) or by a dimensionalitylimited to 50 nm. Nanomaterials can be created with various modulation dimensionalities. Zero (atomic clusters, filamentsand cluster assemblies), one (multilayers), two (ultrafine-grained over layers or buried layers), and three (Nanophasematerials consisting of equiaxed nanometer sized grains), as demonstrated in Figure 7& 8.

a. **On the Basis of Phase Composition, Nanomaterials are classified as:** single Phase Solids (e.g. Crystalline, Amorphous Particles and Layers etc.), multi-Phase Solids (e.g. Matrix Composites, Coated Particles etc.) and multi-phase System e.g. Colloids, Aerogels, Ferro fluids etc. (Pawan and Manish 2013).

b. **On the Basis of Manufacturing Process, Nanomaterials are classified as:** gas Phase Reaction (e.g. Flame Synthesis, Condensation, CVD etc.), liquid Phase Reaction (e.g. Sol-Gel, Precipitation, Hydrothermal Processing etc.) and mechanical Procedures (e.g. Ball Milling, Plastic Deformation etc. (Pawan and Manish 2013; Soboley*et al.* 2006).

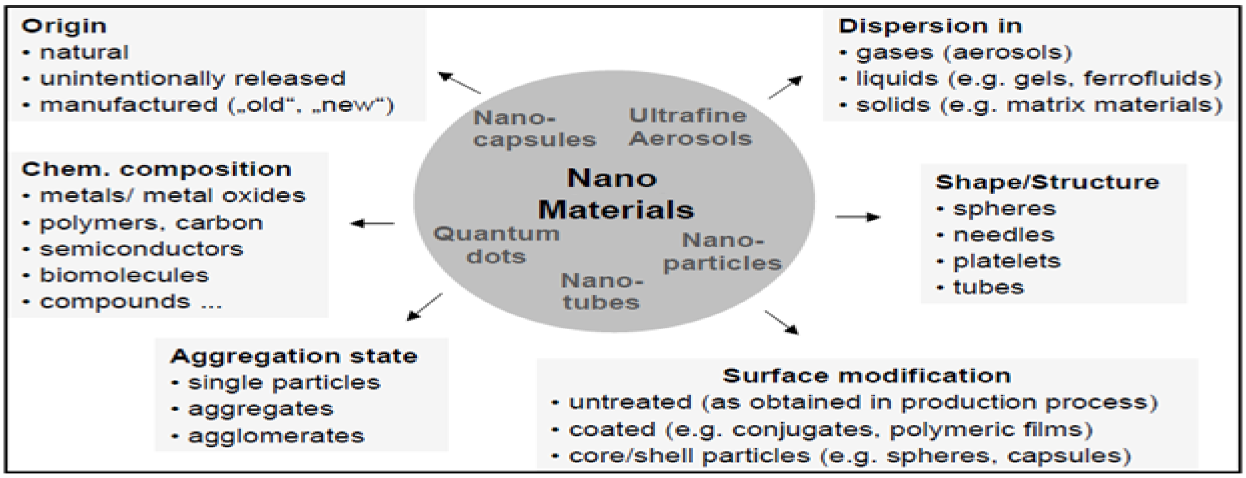

Figure 6: Characterization Parameters of Nano Particulate Materials.(Source: Pawan and Manish 2013).

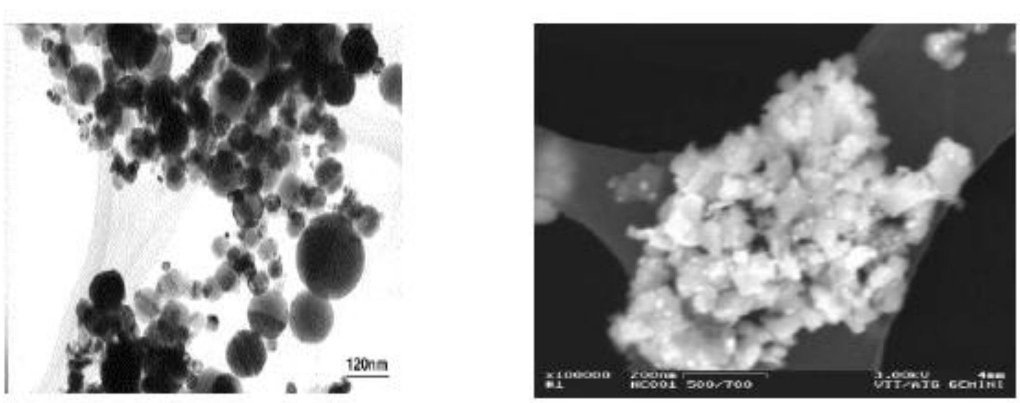

Figure 7:Nanostructured $Al_2O_3 - Ni$Composite Powder and Nickel Nanoparticles (Keskinen 2003; Grozaet al. 2003)

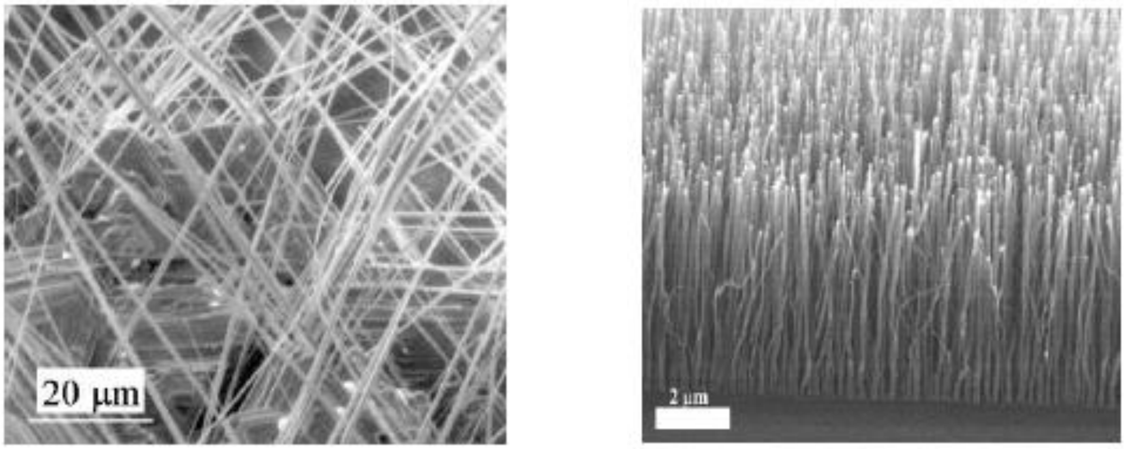

Figure8:Needle Like Crystals Ag-(Nbs4) xI and Multiwalled Carbon Nanofibres (Remskar 2002; Meyyappan et al. 2003).

6.0 Meritsand Applications of Nanomaterials

Nanomaterials have a number of advantages due to its chemical, physical, mechanical and some other properties:Tunable chemical, mechanical, and physical properties due to extremely fine grain size (1-100 nm), superior formability and potential super plasticity, possess high strength, toughness, and ductility, possess enhanced activity (extremely large specific surface area), reduced thermal conductivity, dispersoids can be utilized to further increase strength and reduced energy costs (Zulhuf et al. 2018; Chen 2012).Nanomaterials have unique, beneficial chemical, physical and mechanical properties and these properties are usedfor a wide range of applications in the industrial environment (Allahyarr et al. 2019; Soboley et al. 2006). These applications (Figure 9) include, but are not limited to thefollowing:

a. **Photovoltaic Applications (Solar Cells):** Solar cells are generally constructed using two electrodes with a semiconductor layers between them.TiO2nanoparticles can be transparent and function in solar cells as the electrons acceptor. In organic solar cells, solarradiation photo excites the organic semiconductor layer which then emits electrons as shown in Figure 2.6. These emitted electrons transfer to thesemiconductorTiO2Nanomaterials. To increase solar cell efficiency a patterned TiO2 thin film containing numerous pores,a few nm in diameter, can be used (Chen 2012).
b. **Automotive Industry:** Nanomaterials have a wide range of applications in the automotive industry. Nanomaterials are used forlightweight construction, painting (fillers, basecoat, and clear coat), catalysts, tires (fillers), and sensors, coatings forwindscreen and car bodies in the automotive industry.
c. **Chemical Industry:** Nanomaterials are used as fillers for paint systems, coating systems based on Nanocomposites, impregnation ofpapers, switchable adhesives and magnetic fluids in the chemical industry.
d. **Engineering:** Nanomaterials are used for wear protection for tools and machines (anti blocking coatings, scratch resistantcoatings on plastic parts, etc.) and lubricant-free bearings in the Engineering.
e. **Electronic Industry:** Nanomaterials are used for data memory (MRAM, GMR-HD), displays (OLED, FED), laser diodes, glass fibers,optical switches, filters (IR-blocking), conductive and antistatic coatings in the electronic industry.
f. **Construction Industry:** Nanomaterials are used for construction materials, thermal insulation, flame retardants, surface-functionalized,building materials for wood, floors, stone, facades, tiles, roof tiles, etc., facade coatings and groove mortar in theconstruction.

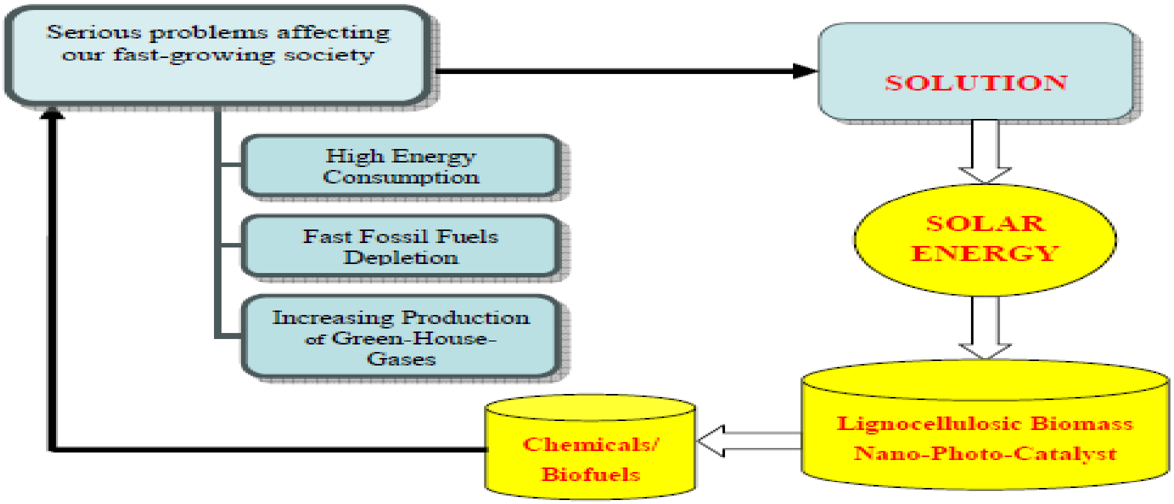

Figure 9:The efficient use of solar energy and biomass is considered a potential solution for energy and environmental challenges. (Source: Juan et al.2009).

g. **Medicine Industry:** Nanomaterials are used for drug delivery systems, active agents, contrast medium, medical rapid tests, prosthesesand implants, antimicrobial agents, coatings and agents in cancer therapy in the medicine industry.
h. **Textile/Fabrics/Nonwovens Industry:** Nanomaterials are used for surface-processed textiles and smart clothes in the Textile/fabrics/nonwovens industry.
i. **Energy:** Nanomaterials are used for fuel cells, solar cells, batteries and capacitors in the power industry.
j. **Cosmetics:** Nanomaterials are used for sun protection, lipsticks, skin creams and tooth paste in the cosmetics industry.
k. **Food and Drinks:** Nanomaterials are used for package materials, storage life sensors, additives, clarification of fruit juices in thefood and drinks industry.
l. **Household:** Nanomaterials are used for ceramic coatings for irons, odors catalyst, cleaner for glass, ceramic, floor andwindows in the household.
m. **Sports /Outdoor:** Nanomaterials are used for ski wax, antifogging of glasses/goggles, antifouling coatings for ships/boats,reinforced tennis rackets and balls in Sports /outdoor.
n. **Electronic, Optoelectronic Magnetic Applications:** Nanomaterials have a wide range of applications in Chemical–mechanical polishing, Electro conductive coatings,Magnetic fluid seals and recording media, Multilayer capacitors, Optical fibers, Phosphors and Quantum optical devices.
o. **Biomedical and Pharmaceutical Applications:** Nanomaterials have a wide range of applications in Antimicrobials, Bio-detection and labeling, Bio-magneticseparations, Drug delivery, MRI contrast agents, Orthopedics/implants, Sunscreens and thermal spray coatings.
p. **Energy, Catalytic Structural Applications:** Nanomaterials have a wide range of applications in automotive catalyst, Membranes, Fuel cells, Photo catalysts,Propellants, Scratch-resistant coatings, Structural ceramics and Solar cells.
q. **Kinetic Energy (KE) Penetrators with Greater Lethality:** Nanocrystalline tungsten heavy alloys provide themselves to such a self-sharpening mechanisms because of theirunique strain characteristics, such as grain boundary sliding.
r. **Better Insulation Materials:** Nanocrystalline materials synthesized by the sol-gel technique result in foam like structures called "aerogels".These aerogels are porous and extremely lightweight; yet, they can loads

equivalent to 100 times their weight. They are also being used as materials for "smart" windows, which darken when the sun is too bright and they lighten themselves,when the sun is not shining too brightly.

s. **Low-Cost Flat-Panel Displays:** Flat-panel displays represent a wide level of market in the laptop computers industry. The flat-panel displaysmade out of Nanomaterials possess much higher brightness and contrast than the conventional, ones owing to their betterelectrical and magnetic properties.
t. **Tougher and Harder Cutting Tools:** The cutting tools made by Nanocrystalline materials, such as tungsten carbide, tantalum carbide, and titaniumcarbide, are much harder, much more wear resistant, erosion resistant, and last longer than their conventional counterparts.
u. **Elimination of Pollutants:** Nanocrystalline materials have very large grain boundaries relative to their grain size. Hence, Nanomaterials havea very good activeness in their chemical, physical, and mechanical properties. Due to their better chemical activity,Nanomaterials can be used as catalysts to react with such noxious and toxic gases as carbon monoxide and nitrogen oxidein automobile catalytic converters and power generation equipment to preclude the environmental pollution arising fromburning gasoline and coal.
v. **High Energy Density Batteries:** Conventional and rechargeable batteries are generally used in all applications that need electric power. Theseapplications include automobiles, laptop computers, electric vehicles, next-generation electric vehicles to decrease theenvironmental pollution, personal stereos, cellular phones, cordless phones, toys, and watches.
w. **High-Power Magnets:** Nanomaterials have broad range of applications in high-power rare-earth magnets include general submarines,automobile alternators, land-based power generators, and motors for ships, ultra-sensitive analytical instruments, andmagnetic resonance imaging in medical diagnostics.
x. **Automobiles with Greater Fuel Efficiency:** A conventional spark plug is not applicable to burn the gasoline fully and efficiently. This problem iscompounded by defective, or worn out, spark plug electrodes. Since Nanomaterials are stronger, harder, and much morewear-resistant and erosion-resistant, they are envisioned presently to be used as spark plugs. These electrodes provide thespark plugs longer lasting and combust fuel far more efficiently and completely.

y. **Ductile, Machinable Ceramics:** Ceramics are very brittle and hard to machine. These features of ceramics have discouraged the potential usersfrom exploiting their valuable properties. However, with a reduction in grain size, these ceramics have increasingly beenused.

Conclusion

This paper scrutinized causes and means of tacking various oxides emission, organic synthesis and durability problems that shortened service life of Portland cement concrete. Concrete man-made material, mostly utilized in non ideal environment and as a result suffers internal or external assaults, needs to be innovatively remanufactured. Hence, innovative concrete or construction materials like polymer concrete that support the sustainability aspects of construction, besides has rapid setting characteristics, high strength-to-weight ratio, ability to withstand a corrosive, aquatic environment, save natural resources, protecting the environment, besides solve environmental problems and energy catastrophethrough only consuming solar energy is reviewed. Further concept of polymer concrete as nanomaterials, the chemical and physical properties of Nanomaterials like optical absorption and fluorescence, melting point, catalytic activity, magnetism, electric and thermal conductivity are highlighted.

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