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Chemistry And Applications Of Nano Composites: An Update About Recent Developments

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Abstract

Nano materials can be defined as materials possessing, at minimum one external dimension measuring 1-100nm. They include Nano particles, nano fibers, nano suspensions, nano emulsuions, quantum dots and nano composites. Nanocomposite is a multiphase solid material where one of the phases has one, two or three dimensions of less than 100 nanometers or structures having nano- scale repeat distance between the different phases that make up the material. Nano composites are of two types: polymer-based nanocomposites and non-polymer-based nanocomposites.Polymer nanocomposites (PNC) consist of a polymer or copolymer having nanoparticles or nanofillers dispersed in the polymer matrix.Non-polymer-based nanocomposites are also known as inorganic nanocomposites. They can be further classified into metal-based nanocomposites, ceramic-based nanocomposites, and ceramic-ceramic-based nanocomposites. Nano composites can be prepared by in situ polymerization, melt mixing, solution mixing, precipitation, sol-gel process and electrospinning. They can be characterized by scanning electron microscopy, transmission electron microscopy, X- ray diffraction, Fourier-transform infrared spectroscopy and thermogravimetric analysis. Nanocomposites have been growing with a speedy rate so as their large number of applications. In the next 10 years, the worldwide production will exceed 600,000 tons in the following regions: Superior strength fibers and films, UV protection gels, drug delivery systems, new fire-retardant materials, anti-corrosion barrier coatings, lubricant and stretch paints.

Keywords: Chemistry And Applications Nano Composites

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INTRODUCTION

The scientific community is fascinated by the topic of nanoscience. Hence nanotechnology has received the majority of contemporary discussions, definitions, and attention. As a result, it stands for a holistic concept that perfectly captures man's unquenchable thirst for information that may be put to use. Any technology that acts on the nanoscale and has practical applications, such as building things out of isolated atoms and molecules, is called nanotechnology.The development and application of synthetic, physical, and biological processes with structural parameters that range from a single molecule or atom to submicron dimensions, as well as the incorporation of the related to structural into larger systems, are all included in the field of nanotechnology. "Technology at the nanoscale" is the shorthand definition of nanotechnology. Numerous interpretations of nanotechnology have developed as a result (Wang & Kaskel, 2012).

This initial definition requires more work, such as an explanation of what nanotechnology entails. Consequently, we cannot effectively describe nanotechnology without initially understanding "nanoscale" or a scale of 1-100 nanometers. Atomically precise technology or atomic precision engineering are two definitions of nanotechnology. Nanotechnology, according to the definition, is "the exact and controlled manipulation, precise arrangement, modeling, measurement, and manufacture of materials on the nanoscale to produce things, systems, and devices with basically unique qualities and functionalities (Nasrollahzadeh et al., 2019).

Studies in nanoscience include those that primarily focus on the following properties in materials and systems:

- Has a minimum of one dimension under 10 nm.
- Use techniques that show complete control of molecular-scale formations' physical and chemical properties (process).
- Permit the creation of more substantial buildings (building block property).

In the body, bio entities, including DNA, enzymes, sugars, proteins, RNA, and viruses, are the building blocks for cellular components often synthesized using nanotechnology. Several molecular structures in life are nanoscale, with sizes ranging from 1 to 100 nm. Hence nanoscience is truly representational of nature in the biological sciences (Nasrollahzadeh et al., 2019).

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Applications

The subject of nanotechnology started to expand around 1958. One of the most significant scientific topics today is nanotechnology, which gathers knowledge from the realms of physics, informatics, biology, medical, chemistry and engineering. It's a new technology sector with a lot of promise for big advances that can be used in real life. Nanotechnology techniques and tools that explore and adjust the characteristics, responses, and activities of biological and inanimate substances at sizes less than 100 nm are created and controlled by different nano biomaterials and nanodevices. The application and utilization of nanomaterials in electronic and mechanical gadgets, optical and attractive parts, quantum figuring, tissue designing, and different biotechnologies, with littlest highlights, widths well under 100 nm, are presently and apparently soon the most financially significant pieces of nanotechnology (Che Marzuki et al., 2019).

The diversity of nano products is growing quickly as more and more materials that have undergone nanoengineering are available on the global market. The continuous revolution in nanotechnology will lead to the creation of nano-materials with properties and functions that will improve the lives of our population in a variety of areas, including health, the environment, electronics, and other fields. The problem of energy generation calls for the promotion of alternative sources of renewable power based on cutting-edge technologies. The development of nanometrology tools and strategies to characterize and work with nanostructures must keep pace with improvements in nanomaterials. In the near future, revolutionary new methods for nanometrology will be needed, and those that now exist will need to be enhanced in terms of higher sensitivity and resolution for atoms and molecular species.

The following are the several industries where nanotechnology may find use:

- Health and Medicine
- Electronics
- Transport
- Environment and Energy
- Exploration of space (Madkour, 2019).

Nanomaterials

Nanomaterials are referred to as at least one exterior dimension between 1 and 100 nm. Nanomaterials can be developed intentionally through engineering for a specific purpose or emerge naturally as byproducts of combustion processes. These materials may have different

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physical and chemical characteristics than their bulk form equivalents. They include nano particles, nano fibers, nano suspensions, nano emulsuions, nano composites and quantum dots (Abraham et al., 2017).

Nanoparticles

The diameter of a nanoparticle, which ranges from one to hundred nanometers, is extremely small. Although undetectable to the human eye, nanoparticles' physical and chemical properties are notably different from those of their larger material counterparts. According to the definition provided by the European Commission, a numerical size distribution must contain at least 50% of particles with a particle diameter of 100 nm or smaller. Most nanoparticles contain just a few hundred atoms.

Due to their very tiny size, nanoparticles have a comparatively high ratio of surface area to volume as compared to bulk materials like powders, plates, and sheets. Nanoparticles can exhibit surprising optical, physiological, and chemical properties because they are tiny enough to confine their electrons and create quantum effects. For instance, copper is regarded as a flexible material because bulk copper may bend due to the clustering of its atoms at the 50nm scale. Due to this, copper nanoparticles smaller than 50 nm are regarded as being very hard materials with far less ductility and flexibility than solid copper. Similar to how bulk gold melt at 1064 °C, gold nanoparticles likewise melt differently depending on their size; for 2.5 nm size, they dissolve at 300 °C. Furthermore, materials made of nanoparticles absorb solar energy far more effectively than thin films made of consecutive sheets of the same substance (Silva et al., 2019).



Figure. 1 Types of Nano particles (Ranjan & Kumar, 2022)

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Uses and Applications of Nanoparticles

Nanomaterials can be created artificially, organically, through by-products of combustion processes, or specially tailored to perform a specific function. Due to their ability to generate materials precisely to accomplish a definite purpose, nanomaterials are employed in a broad range of sectors, from medicine and beauty products to environment protection and air refinement (Guo et al., 2013).

In the healthcare sector, nanomaterials are applied in several ways, including medicine delivery. The creation of nanoparticles to help in the administration of cancerous drugs exactly to virulent tumors and to apply them to injured parts of arteries to battle cardiovascular disease are two examples of this technology. Additionally, carbon nanotubes are being studied for applications such as mixing nanotubes and antibodies to create bacteria sensors. Zinc oxide nanowires are being designed to be utilized in elastic solar cells and for use in the purification of contaminated water.

The cosmetics industry uses mineral nanoparticles like titanium oxide in sunscreen since conventional chemical UV protection has limited long-term durability. Similar to the bulk substance, titanium oxide nanoparticles offer higher UV protection, with the added benefit of lessening the unsightly whitening associated with sunscreen due to their nano-size (Guo et al., 2013).

Nanosuspension

Nano suspensions are colloidal dispersions containing drug particles that are stabilized by surfactants. They may also be described as a biphasic system with pure drug particles distributed in an aqueous medium and smaller than 1 m in particle diameter. Because of the increased surface area and saturated solubility, drug particles that are reduced to the nanometer range have a faster suspension rate (Jassim & Rajab, 2018).

A growing number of recently produced medications are badly soluble; in many cases, drugs are badly soluble in both organic and aqeous environments, obviating established ways of addressing such solubility variables and leading to bioavailability issues. To solve these issues, the creation of drug nanoparticles (i.e. nano suspensions) is an alternate and promising technique. Because of their versatility and specific characteristics, an effective method for delivering hydrophobic medications has emerged: nano suspensions. Due to their specific qualities, nano suspensions may be employed in a wide range of tablet formulations, including customized delivery systems like muco-adhesive hydrogels. This technology's key benefits are its broad application to a wide range of medications and its ease of use. Nano suspension is easy

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to make and can be used with any medicine that is water insoluble.

Melt emulsification, high pressure homogenizer, supercritical fluid processes, wet mill, and emulsion solvent evaporation are used to make nano-suspensions. Oculr, parenteral, pulmonary, and oral routes can all be used to deliver nano-suspensions. When included in ocular insects and muco-adhesive hydrogels, nano suspensions can be employed for targeted drug delivery. The expansion of their uses in site-specific medicine administration is now being worked on. Nanosuspensions have been delivered by parenteral, preoral, ophthalmic, and pulmonary routes with great success (Geetha et al., 2014).

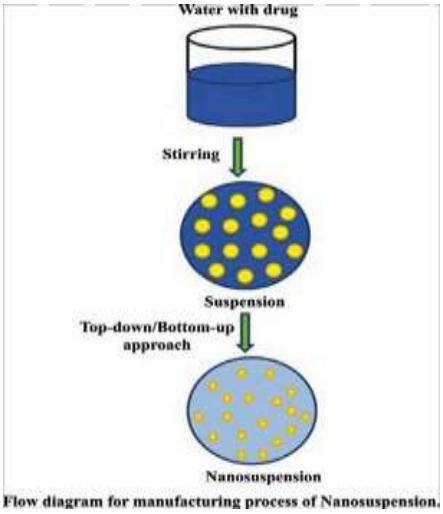


Figure 2 Preparation of Nano-suspension (Ali et al., 2009)

Nano-emulsions

The morphology of nano-emulsions can be used to classify them. An "oil-based" or water-in-oil (W/O) emulsion contains water as the continuous liquid phase and oil as the dispersed phase, in contrast to a "water-based" or oil-in-water (W/W) emulsion. Nano-emulsions enable for homogeneous deposition and penetration of active substances through the skin's surface because of their small droplet area. Because of the large surface area and low surface tension of the entire emulsion system, nano-emulsions have better ingredient penetration efficacy, needing just 3–10% surfactants during production. Surfactant concentrations of 20% or more are required in microemulsions, on the other hand. As a result, nano-emulsions appear more fluid (at low oil concentrations), with appealing physical qualities and skin feel, particularly when thickeners are not used. Creaming or sedimentation, flocculation, and coalescence, which commonly damage emulsions, are also prevented as a result of significant steric stabilization between the sub-micrometric droplet sizes (Che Marzuki

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et al., 2019).

Properties and Application

We examine the literature on the characteristics and uses of nano-emulsions in this section. Small droplet size, excellent stability, transparency, and tunable viscoelasticity are only a few of the special qualities of nano-emulsions. Due to these characteristics, nano-emulsions are a desirable choice for use in the food, cosmetic, pharmaceutical, and drug delivery industries.They can also be used as the foundation for creating advanced materials with special features.

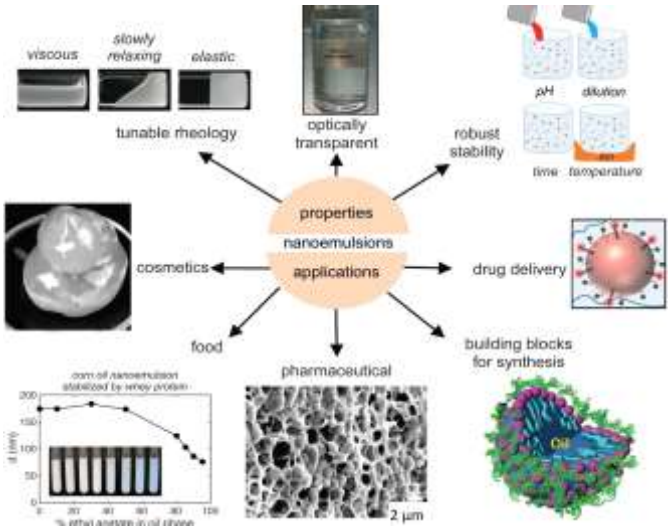


Figure. 3 Properties and applications of nano-emulsions(Gupta et al., 2016)

Nanofiber

Fibers with a diameter of less than 100 nm are referred to as nanofibers. This category is frequently expanded in the textile industry to include microfibers, which are fibers with a diameter of 1,000 nm or smaller. In general, there are many methods to make fibers, including melt processing, anti-solvent induced polymer precipitation, electrospinning, interfacial polymerization and electrostatic spinning. Carbon nanofibers, on the other hand, are graphitized fibers made through catalytic combining.

Intriguing noble nanoscale fibers are used for a variety of doping in significant functions like battery storage, fuel cells, aircraft, diodes, capacitors, transistors, medication delivery devices, and information technology. Different inorganic precursors were converted into metal oxide nanofibers using various standard processes. TiO2, SiO2, Al2O3, titanium nitride, or

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platinum are the most frequently referenced ceramic semiconductor materials with a surface morphology similar to nanofibers (Nasrollahzadeh et al., 2019).

Due to their fascinating properties that their bulk or nanoparticle counterparts do not exhibit, one-dimensional magnetic nanostructures have recently received a lot of attention. As active chemical elements for exceptionally high information storage in the development of selective and sensitive detectors and photoelectric chips or devices, these metal oxide nanoparticles are also particularly helpful. A good method for creating polymer materials with small dimensions, from nano to micrometers, is electrospinning.

Under the influence of the altered electric field, these nanofibers with noticeably reduced diameters fold away towards that grounded conductor and can eventually be aggregated as lengthy threads. Nonwoven mats with an increased surface were covered, and relatively small pore diameters are typically created when nanofibers are placed on a conductor's surface. By altering the design of an accumulator, it is possible to aggregate the thin nanofibers into uniaxially aligned nano-arrays (Padron et al., 2013).

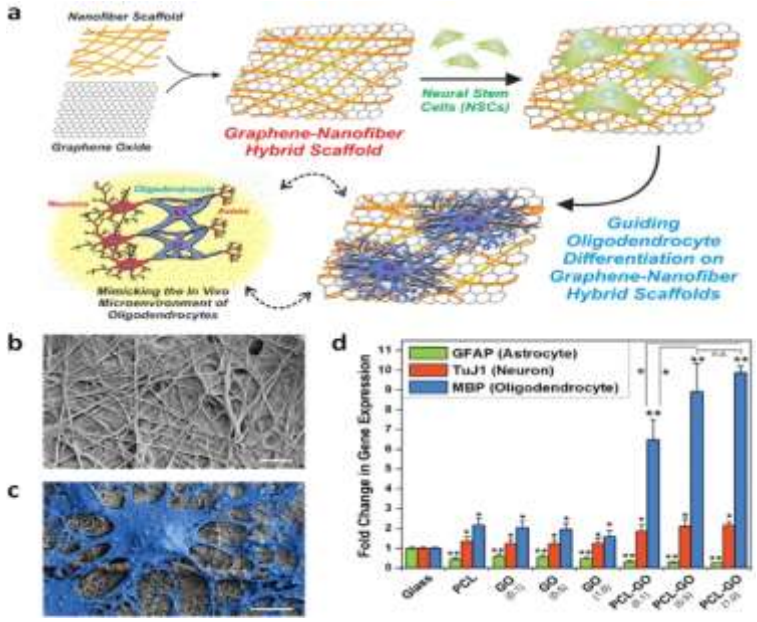


Figure 4 Different types of nano-fibers (Lim, 2017)

Due to their distinctive physicochemical qualities, nanofibers have become intriguing one-dimensional nanomaterials with applications in a variety of scientific fields and industries. Nanofibers are a family of nanomaterials that have cross-sectional dimensions between tens and hundreds of nanometers, and they have a veryhigh surface area-to-volume ratio and specific surface area. They are a desirable option for a variety of cutting-edge applications

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becausethey have extraordinary interconnectedness between their pores, allowing them to build networks of extremely porous mesh.In fact, it is possible to trace the significant impacts of nanofiber technology by looking at the wide variety of basic materials that may be utilized to create them. These include techniques, particularly the electrospinning technique, and natural polymers (Lim, 2017).

Quantum Dots

Man-made nanoscale crystals called quantum dots (QDs) have the ability to carry electrons. These semiconducting nanoparticles can release a range of colored light when exposed to UV radiation. These manufactured semiconductor nanoparticles are used in fluorescent biological labels, solar cells, and composite materials. Quantum dots, semiconductor nanoparticles, were first created in the early 1980s after being postulated in the 1970s. If semiconductor particles are produced small enough, quantum phenomena will restrict the energies at which holes and electrons (particles without an electron) may exist. Because power and wavelengths (or colour) are related, the optical properties of the substance may be precisely changed in accordance with its size. Therefore, particles may be designed to release or absorb definite light wavelengths by simply changing their size (colors).

Depending on their substance and shape, quantum dots are artificial nanostructures that can have a wide range of different properties. For instance, they could be employed as dynamic materials in single-electron transistors due to their unique electrical properties. A quantum dot's attributes are influenced not just by their size but also by their composition, structure and shape such as whether it is solid or hollow. For a broad range of applications in photonics, electronics, catalysis, information storage, sensing, medicine, or imaging, a trustworthy manufacturing process that makes apply of the properties of quantum dots must be able to produce large amounts of nanocrystals with each batch being produced using the exact same specifications.

Nanocrystals may also have a key role in the self-assembly of well-designednanodevices since some biological molecules have the ability to recognize and assemble other molecules. The atom-like excitation states of QDs also contribute to their distinctive optical characteristics, such as a fluorescence wavelength that depends on particle size. This phenomenon is employed to create optical probes for imaging in biology and medicine.

Colloidal QDs have found the most varied uses thus far in the field of bio analytics. Even though the first batch of quantum dots had already shown promise, more research was necessary to improve their core properties, notably colloidal durability in salt-containing fluids.

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Since these droplets would have readily precipitated in "real" samples like blood, quantum dots were first only used in highly artificial environments. These issues have been resolved, and several practical uses of QDs now exist. Due to their small particle size and variable energy levels, quantum dots are used in solar cells, fluorescent biological markers, and composite materials (for example, to follow a biological molecule).

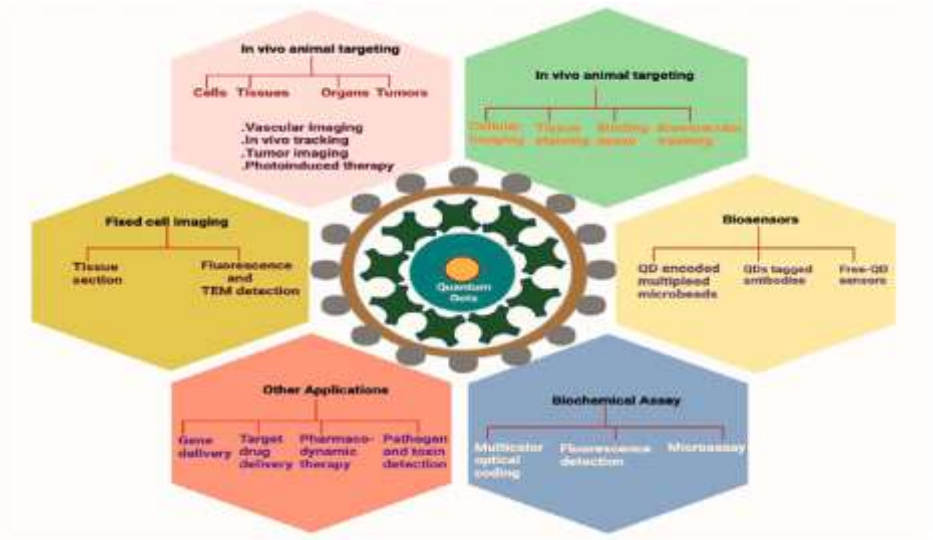


Figure 5 Quantum dots applications (Bera et al., 2010)

Composites

When two or more separate integral elements are merged to produce a new substance with superior qualities to the original materials in a certain completed structure, each of which has its own distinct attributes (physical or chemical), the result is a composite, which can be artificially created or naturally occur (Shin et al., 2012).

They are typically praised for having a variety of attributes, among which are the following:

- Strength and stiffness
- Low expansion coefficient
- Resistance to exhaustion
- Simpler to produce complicated shapes
- Efficient restoration of damaged structures
- Corrosion protection (Liu & Antonietti, 2014).

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Nanocomposites

When each of the phases in a multiphase solid material has one, two, or three dimensions less than 100 nanometers, or when the structures between the phases that make up the material have nanoscale repeat distances, the substance is referred to as a nanocomposite.

When a composite material has a phase with nanoscale morphology, such as nanoparticles, nanotubes, or lamellar nanostructure, the material is said to be a nano-composites. They are multiphase materials because they have many phases, and at least one of those phases should have diameters between 10 and 100 nm. Nanocomposites have evolved as useful alternatives to engineering materials that currently have limitations in order to overcome them. According to their scattered matrix and dispersion phase components, nanocomposites can be categorized (Wang & Kaskel, 2012).

Modern synthetic techniques have made it feasible to produce a variety of intriguing new materials with unique qualities thanks to this quickly developing discipline. The so-called founds traits were heavily influenced by the originals' interfacial and morphological qualities in addition to their own properties. The fact that occasionally a newly developed property of a substance is unaware to its parent constituent materials must be accepted (Wang et al., 2015). Using components with nanoscale dimensions as building blocks, nanocomposite seeks to create novel materials with extraordinary elasticity and improvements in their substantial qualities.

Benefits of Designing Novel Nanocomposites

A bulk matrix and a nano-dimensional phase that have different properties due to chemical and structural variations are hard fused to form nanocomposites.

Characteristics that have shown significant development include:

- Mechanical characteristics (toughness, withstands limit, bulk modules, etc.)
- Thermal resiliency
- Suppresses fire and lowers smoke production
- Reduced gas, water, and solvent permeability
- Greater outward appearance
- Enhanced electric conductivity
- Enhanced chemical defense
- Better optical clarity than traditionally filled plastics

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Areas where nanocomposites may provide a risk are:

- Molten production
- Problem to health and the environment
- Social dangers
- Development of nanocomposites
- Molecular manufacturing

To make nanocomposites, different organic polymers, enzymes, biological molecules organic and organometallic compounds and sol-gel produced polymers can be mixed with inorganic nanocrystals, clays, oxides, fullerenes, metals, oxides or semiconductors.

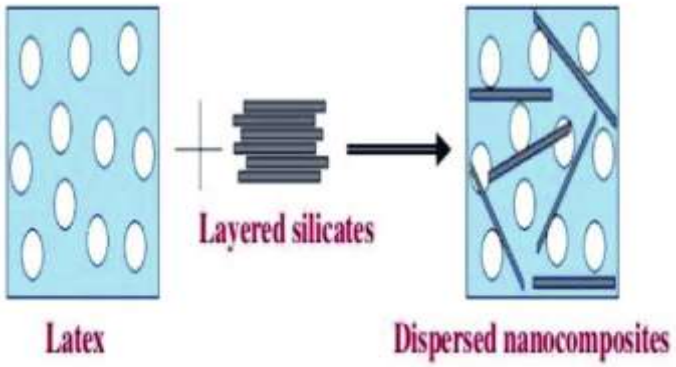


Figure .6 Formation of nanocomposites (Xu et al., 2020)

The unusual features of nanocomposite materials, which are created by combining two or more different building blocks into one substance, are most likely because of their, huge surface area, tiny size and of course, the interfacial contact between the phases. They have successfully used their extraordinary potential to improve the biological performance of numerous medications, biomaterials, catalysts, and high-value added materials.

Polymer-based nanomaterials seem to be the most advanced ones currently being explored and developed among a range of nanocomposites. For polymer-based nanocomposites, dimensional variety, active functions, and film-forming capabilities are all huge advantages (Al-Johani& Salam, 2011).

Applications of Nanocomposites

Nanocomposites and the numerous uses they offer have both been expanding quickly. The following locations will see output rise beyond 600,000 tonnes during the coming ten years:

- Extra-strength films and fibres

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- Gels for UV protection
- Drug delivery techniques
- New materials that resist fire
- Barrier coatings that prevent corrosion
- Stretch and lubricant paints

By improving features, particularly the mechanical ones, nanocomposites have drawn interest from the automotive and industrial sectors. Timing belt covers, engine covers, and door covers are just a few examples of the several vehicle kinds where they can be used or applied. Vacuum cleaner blades, mower hoods, mobile phone coverings, and other uses are examples of further applications (Huang et al., 2003).

➢ *Types of Nanocomposites*

Based on whether or not the composite contains polymeric material, the following categories of nanocomposite materials could be created.

Non-polymer-based nanocomposites are those in which there are no polymers or components generated from polymers in the compositions. Inorganic nanocomposites are another name for non-polymer-based nanocomposites. They may also be divided into three categories: ceramic-based, nanocomposites with metal and ceramic components (Khandoker et al., 2011).

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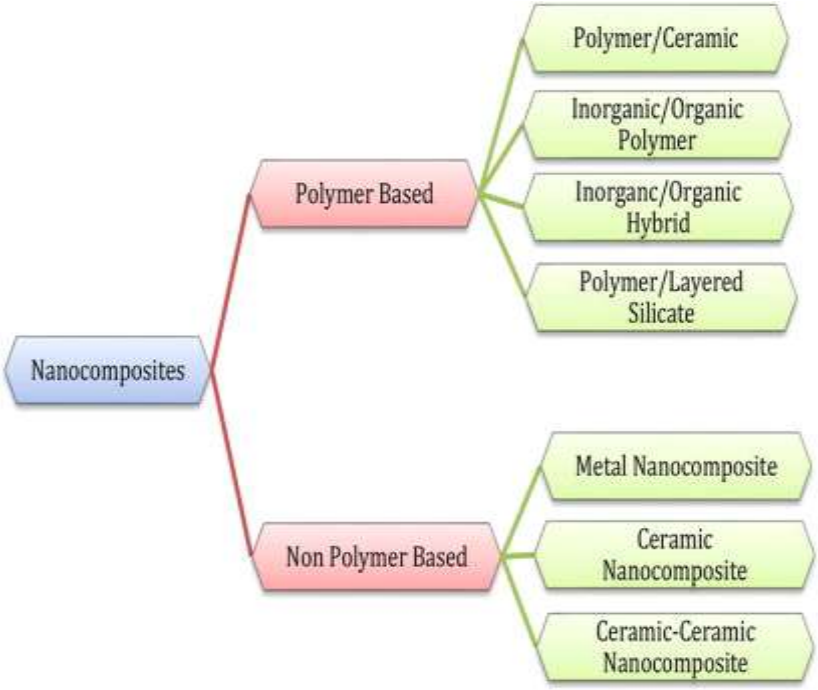


Figure 7 Types of Nanocomposites (Pandey et al., 2007)

Nanocomposites Based on Metals

Due to their improved catalytic properties and improvement in the optical features associated with particular and differentiated metals, bimetallic nanoparticles-whether in the style of alloys or core-shell structures are intensively explored.

They can be identified by their:

- Intense plasticity
- Less extreme melting points
- Enhanced hardness and strength
- Better magnetic characteristics,
- A rise in electrical resistance, etc.

Nanocomposites based on ceramics

Ceramic-based nanocomposites are described as composites comprised of at least one solid phase with a diameter of between 50 and 100 nm, as well as more than one solid phase. These composites incorporate the magnetic, mechaical, optical, and chemical characteristics of both phases, such as in hydroxyapatite/titanium nanocomposites (Pandey et al., 2005).

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These can be identified by their:

- Increased ductility
- Enhanced hardness and strength

Ceramic-Ceramic-Based Nanocomposites

The ceramic or ceramic nanocomposites can also be characterised as non-polymer-based nanocomposites. These materials can be used as artificial joint implants for fractures failures, which might drastically reduce surgical expenses and improve patient mobility. The longevity of bones might be increased by 30 years with the effective usage of implants made of zirconia-toughened alumina nanocomposite materials. Another example of ceramic-ceramic nanocomposites is calcium sulfate-biomimetic apatite nanocompositesn(Thostenson et al., 2005).

Polymer-Based Nanocomposites

Poly nanocomposites are polymers or copolymers with nanoparticles or nanofillers scattered throughout the polymer matrix. One dimension (1D) must have a range of morphologies, such as platelets, fibres, spheroids, etc., and be within 1 and 50 nm in size. Multiphase Systems (MPS), which encompasses composites, blends, and foams, include poly nanocomposites. Close to 95% of the plastic production may be salvaged by these materials. Because of this, these system needs controlled mixing, stable dispersion, directed dispersed phase, and essentially identical compounding processes for all MPS, comprising polymeric nanocomposites (PNC) (Fischer, 2003).

The intricate interfacial areas between the polymer matrices of polymer nanocomposites (PNCs) pose the greatest challenge because of their formation at such a small scale, which highlights the importance of interactions between polymer and nanoparticles(Fedullo et al., 2007).

A form of reinforced polymer known as polymer nanocomposites is known to include extremely little, or less than 5%, of clay-based polymer nanocomposites. These chemicals attracted a lot of interest from the educational community as well as the manufacturing sectors, particularly in the field of nanocomposites. This is essentially because they have far better or enhanced thermal, mechanical, and barrier qualities than micro- and prevalent composites. These materials could be distinguished, in particular, by their enhanced fire retardant, recyclability, barrier characteristics, and thermal stability(Ray &Bousmina, 2005).

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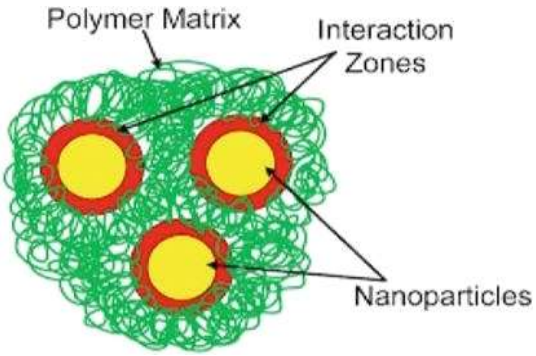


Figure .8 Uniform dispersion between the filler and matrix in the nanocomposites (Supova et al., 2010)

Bio- Nanocomposites

Since they are regarded as natural nanocomposites, they are known to as "Bio-nanocomposites". In order to be aware of their vital roles in natural systems, biologists investigate their constitution and characteristics. In order to assure the sustainability of the linked species, bio-nanocomposites were developed to meet both the demands of the environment and the necessities of life. However, the construction of bio-nanocomposites requires that biological molecules be considered as synthetic basic building block, which is very different from the viewpoint of their own natural function. This is true even when the structure and chemical composition of natural materials vary.

They are made of inorganic particles with diameters range from 1 to 100 nm and biopolymers. Due to their diverse characteristics, which include, biodegradabilitybiocompatibility, and, anti-bacterial activity they have a wide variety of uses. The significant decrease in the use of fossil fuels is the effective result of the increased demand for bio-based polymers. Bio-nanocomposites have quickly taken the place of traditional, petroleum-based plastic that is not biodegradable because of their low weight and environmental friendliness. As a result of their development, they are now a durable material that can be used in high-performance applications.They are advantageous for biological applications and suited for cosmetic and biotechnology uses since they are biocompatible. They will be of utmost importance as eco-friendly sustainable materials in the future(Verma et al., 2013).

Bio-Nanocomposites: Uses

1. Bio-nanocomposites are utilized to make implants, scaffolds, diagnostics, and medical technology in addition to in the cosmetics industry.

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2. They are also excellent as gas-separation membranes, catalysts, and contact lenses.
3. Through tissue regeneration, biopolymer-based nanocomposite can be used to treat osteomyelitis.
4. To manage load-bearing bone grafts, artificial bone implants employ nanostructured organic/inorganic nanocomposites.
5. Controlled electrophoretic synthesis of bioinorganic composites is carried out using living cells of functionalized particles.
6. They are particularly useful for tissue production, medication administration, and diagnostics.
7. They are used as actuators in several sectors. They are also employed in the production of biodegradable bags because to their environmental friendliness.

Bio-nanocomposites will be utilized in place of the petroleum-based polymers now in use (Xu et al., 2020).

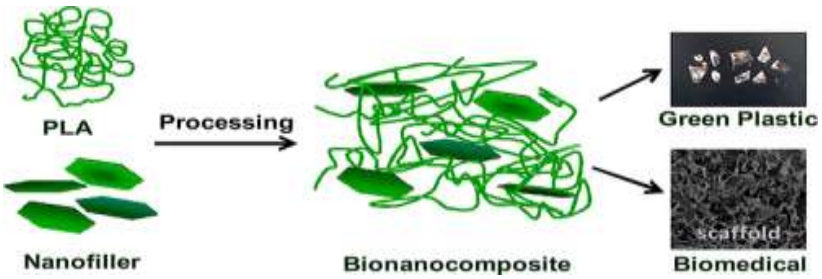


Figure 9 Formation of Bio nanocomposites(Sinha Ray, 2012)

CarboxymethylCellulose

Carboxymethyl cellulose is a linear polysaccharide of anhydro-glucose that is an anionic, water-soluble cellulose derivative (CMC). The repeating units are linked together by 1,4-glycosidic connections. The only anionic carboxymethyl groups (i.e., -CH2COOH) that replace some of the hydroxyl groups present in the original cellulose architecture in the CMC structure are the main molecular differences between CMC and cellulose. CMC synthesis was started in 1918. However, the first illustration of the production of these essential polymeric materials for commercial use was created in Germany in the early 1920s (Heinze & Pfeiffer, 1999).

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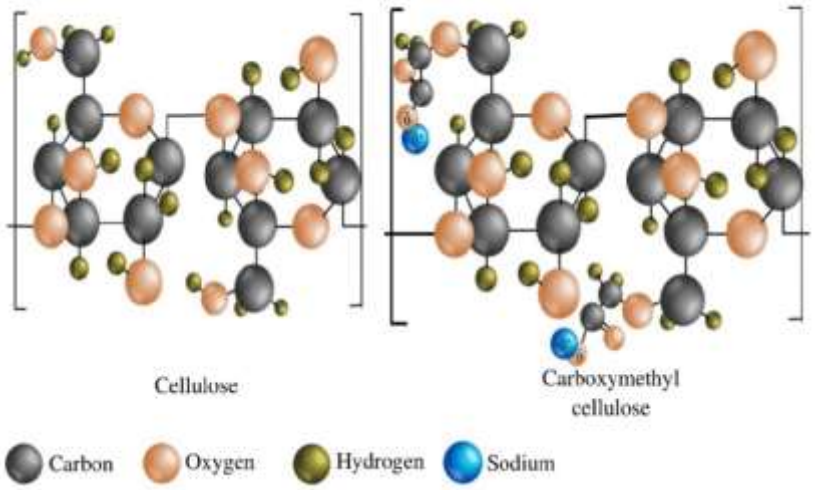


Figure 10 The fundamental structural difference between cellulose and carboxymethyl cellulose(Rahman et al., 2021)

Characteristics of CMC

The key defining factor to describe the nature of CMC is the response that CMC gives when applied in a range of situations or applications. This section highlights the characteristics or variables, such as viscosity, rheology and DS that have a direct impact on CMC uses or the actions of the CMC-produced finished products. Contrarily, rheology describes the physical properties as well as the stream and fracture behavior of the final products of the CMC (under different pressures). The most significant impact on the rheological properties, including stress-strain flow behavior, pseudoplasticity, viscoelasticity, and thixotropy, is exerted by viscosity. Viscosity and the DS of CMC are also connected. Thus, the recommended three major parameters can be used to identify the general properties of CMC for a variety of application objectives (rheology, viscosity, and DS).

Rheological Properties

In between discussion of the characterization of matter and the research of the flowing behavior of matter and its distortion under application, rheology plays a critical role in merging these two fields of study. The rheological study of materials also offers a general understanding of the flow system, involving thixotropy, pseudoplasticity, viscoelasticity, and stress-strain flow behavior. After all, this behavior or set of rheological characteristics is intimately related to the structure of polymer systems, such as morphology, particle size, concentration, form, or surface characterization, etc. The analysis of structure reveals that under the action of stress-strain, CMC exhibits certain complicated and intriguing flow behaviors that have a direct bearing on

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the numerous application objectives of CMC, such as food packing, layer production, or coating of materials, etc.(Abraham et al., 2017).

Viscosity

Viscosity is a measure of a fluid's resistance to flow and describes the internal friction of a flowing fluid. Due to its great solubility in water, CMC, a polymeric substance, produces a viscous solution in an aqueous media. The viscosity parameter is essential for describing the fluid behaviors, characteristics (such as thickness and emulsifying), and property-based applications of aqueous Na-CMC (or H–CMC). In contrast, the synthesis circumstances (intensity of NaOH, reaction temperature, and pH of solution) and supply factors (such cellulose particle size, molecular weight, and DS) also affect or depend on the CMC's viscosity property. This is due to the applied medium's lower or higher viscosity being maintained when the CMC content goes up or down, accordingly (Rachtanapun et al., 2021).

Degree of Substitution

The most important factors in determining cellulose's chemical activity in chemistry are its reactive groups. With the DS, three hydroxyl (-OH) reactive groups were added to the cellulose anhydroglucose units. Usually, the DS range from 0 to 3 is provided for each device. The formal definition of the DS value is the average number of replacements of a reactive group by the other active molecules with in polymer chain. The value of DS depends on the number of substituent groups (carboxymethyl) linked to each anhydroglucose unit during the creation of CMC from cellulose. The DS value is a crucial element for determining the solubility, thickening characteristic, stability, acid resistance, viscosity, and salt tolerance of CMC, among other features (Casaburi et al., 2018).

As an illustration, the CMC polymer is completely soluble but expandable below the 0.4 degree of substitution value. CMC, however, is completely soluble beyond 0.4 (DS). The macromolecular chain's carboxymethyl substitution and substitution uniformity have both risen due to the compound's increasing solubility in DS (Fleming et al., 2001).

Synthesis of CMC from Its Various Sources

CMCs from Various Plant-Based Precursor Materials

The terrestrial antecedents of cellulose have been employed the majority of the time since CMC manufacture began. However, the simultaneous presence of additional compositional elements including minerals, pectin, hemicellulose, and lignin without the

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desired extent of cellulose necessitates an excessive energy input and financial outlay for their removal through a number of extra pre-treatment procedures. Because of their scarcity and costly pre-treatment processes, typical terrestrial cellulosic precursors are being used less and less in the manufacturing of CMC. It has been demonstrated that a variety of agricultural by-products and wastes, such as fruit peels, cobs, maize straws, leaves, etc., have a moderate amount of cellulose percentage (i.e., 31–60 percent) (Huang et al., 2014).

Due to this, there has been an increase in demand in present years for these materials to be used in the production of valuable CMC for a range of uses, depending on the CMC produced. The physiochemical or morphological characteristics of the synthetic CMCs produced from different plant- or animal-based precursors could not be the same, which is an essential point to remember (e.g., DS, rheological properties, water, viscocity, and oil retaining capacity, etc.). Their intended uses may therefore vary from one another. To improve or increase the properties of cotton fibres, which contain around 95% cellulose, CMC has been produced from them (Easson et al., 2017).

Production of CMCs from Non-Conventional Precursor Materials

In addition to the conventional plant-based cellulose precursors, CMCs may be made from a variety of waste materials, including offices waste textile, paper sludge, waste papers, and by-products from the home and workplace (such as knitted rag and cotton linters). The use of these waste materials in the production of CMC and its different composites reduces the cost of production and is crucial in limiting environmental pollution. There are numerous applications for CMC and its different composites. For instance, cotton cleaning plants produce waste called cotton linters. Cotton linters, which have a high cellulose content (i.e., around 90%) when they are in their unprocessed condition, are created from wasting 3-5 percent of cotton fibres, which was found in 1954. They may thus produce different levels of CMC products for a range of purposes (Ott et al., 1954).

Synthesis Route of CMC

The alkylation-etherification procedure is the traditional technique for making CMC. Since the very start of CMC production from various cellulosic precursors, this unusual method has been used in all research investigations relevant to its manufacturing. The only changes between these experiments are the applied ratios of the affined chemicals to the cellulose extents of the sources and changes in reaction parameters, such as temperature, reaction time, pH, etc. It is important to note that not all naturally occurring and synthetic cellulosic precursors

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(such as leaves, stems, pulp, paper waste, microbial, and different textile-based sources like cotton linters and knitted rags have the same compositional properties that can consistently produce a fixed amount of cellulose extract. In addition to the cellulosic percentiles, the majority of precursors also contain sizeable amounts of ash, pectin, lignin, and other minerals (such as phosphorus, calcium, potassium etc.). Delignification, dewaxing, defatting, acid washing, bleaching, defatting, dewaxing, defatting, proteolysis (remedy with protease enzyme), inhibition of different enzymes of the plant-based precursors (such as disablement of pectic enzymes found in orange peels), deactivation of pectic enzymes, treatment with some essential chemical compounds (such as methanol, ethanol, chloroform, etc.), and removal of hemicellulose are carried out for the extraction of pure α-cellulose from natural sources (Saputra et al., 2014).

Application of CMC

Application in Textile Industries

Numerous polysaccharide-based thickeners, including legume, tamarindus, maize starch, tcassava starch, etc., have been used extensively over time in textile printing with a variety of colours and fabrics. Because of its superior water-absorbing ability,CMC has recently been discovered as a highly efficient thickening component for paints and textile varnishes. In vat dyes for textile printing, for instance, CMC made synthetically from lignocellulosic waste was employed as a thickening (Sheikh et al., 2015).

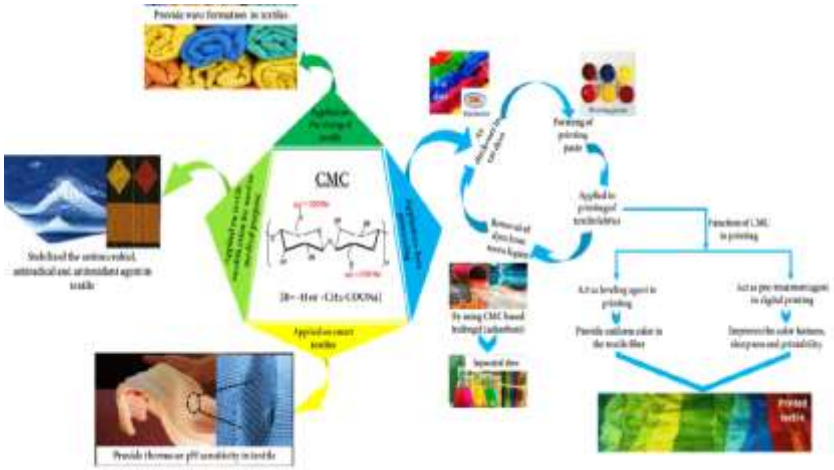


Figure11 Schematic illustration of the textile-based CMC application(Rahman et al., 2021)

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Application in Food Industries

The provision of food for human society is a crucial function of the food industry. Various polysaccharide (agar, gums, alginates, some pectin and galactomannans, modified celluloses, modified starches, CMC, etc.) and hydrocolloids like), xanthan gum powder, sugar beet pectin (SBP), and soluble soybean polysaccharide (SSPS are among the many auxiliary ingredients used in the food industry as a emulsifying, thickener, fixing agent, and blinder (Lee & Yoo, 2020). These CMC characteristics aid in enhancing food standard and the required pleasant texture to guarantee food protection. CMC is typically employed in the food sector as a variety of auxiliary agents, including emulsion, thickeners, moisture binders, stabilizers, additives, suspending and texture-boosting agents, water retention (or dewatering) agents, etc. The rheological properties, appearance, flavor, and structure of products as well as their pseudoplastic characteristics are also fine-tuned using CMC. In order to certify the long-term protection of food goods, it is also employed as a coating or packaging material (Mirhosseini et al., 2008).

Application in the Water Treatment Process

Water contamination is one of the most important concerns facing the globe today. Every day, a huge number of contaminants from diverse businesses and household activities enter the aquatic environment and cause a variety of illnesses in numerous living things, including people. The number of different pollutants that could be found in sewerage that has originated from various manufacturing or other home activitiesare not strictly capped. However, to the author's knowledge, CMC-based materials have primarily been used up to this point for the removal of various organic-inorganic colours, inorganic ionic pollutants (both anions and cations), as well as different radioactive organisms from polluted waters in various experimental circumstances (Janarthanan et al., 2020).

Wound Dressing

CMC is frequently used to enhance the properties and efficacy of various wound dressing and wound healing materials in various clinical applications due to its exceptional binding strength to internal body cells, bio - compatibility (i.e. with skin, bone, and mucous membranes), and strong hydrophilic property (bcause of presence of anionic carboxylic and hydroxyl groups in internal network surface and structure as well) (Lan et al., 2018).

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Application of CMC in Pharmaceutical Industries

In recent years, the pharmaceutical and nutraceutical sectors have shown a great deal of interest in certain naturally derived substances. Examples include red palm oil, an essential oil with numerous fitness advantages and medicinal potential, CMC, antioxidant chemicals, etc. Many people are interested in the properties of CMC and its derivatives (composite/copolymer) for usage in pharmaceutical products, such as biocompatibility, extended half-life in vivo, excellent stability and drug binding capacity, and pH-sensitivity (for the appearance of carboxy group) (Sorokin et al., 2021).

Other Applications

There are many various forms of paper accessible today, including writing paper, tissue paper, newspaper, food packaging, paper or paperboard, etc. To improve mechanical strength (MS) as well as other properties, coating formulations typically use CMC and its derivatives as sizing or consolidation agents. For instance, CMC works as both an internal and a surface sizing agent when employed as a size agent to increase the coating feature and paper strength. Increased hydrogen bonding among CMC and regularly spaced fibres caused by CMC made the paper more robust and long-lasting (Baker, 1982).

METHODS FOR THE PREPARATION OF BIO-NANOCOMPOSITES

A modified Hummers procedure was used to create graphene oxide (GO), which was then modified with carboxymethyl cellulose (CMC) and a Zn-based metal-organic framework using the solvothermal method (MOF-5)

Synthesis of CMC/MOF-5/GO Bio-Nano-Composites

From graphite powder, GO was produced using the modified Hummers technique. A 46 mL flask containing 98 percent H2SO4 was placed in an ice bath. The flask was then shaken vigorously while being filled with 2.0 g of graphite. After that, the solution temperature was kept under 20°C in an ice bath for approximately 30 minutes before 6.0 g of KMnO4 was progressively added to the flask. The reaction mixture was then added to each flask containing the reaction mixture after being heated in a water bath to 35°C and stirring for approximately 45 minutes. After addition of 46 mL of water to the flask, the reaction temperature was increased to 90°C, and the mixture was then stirred for around 30 minutes.

Then, 280 mL of water and 10 mL of 30% aq. H2O2 were gently added to the mixture.

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The mixture was periodically washed with deionized water up to pH 7, then dry under vacuum (50°C) for around 24 hours to remove any leftover salt.

To create a DMF emulsion of GO, 0.33 g of GO was sonicated into a solution of DMF. The solvothermal method was used to prepare the CMC/MOF-5/GO bio-nanocomposite with certain changes to MOF-5. In a typical process, GO/DMF of 35 ml solution was combined with 5.2 g of zinc nitrate hexahydrate, 1 g of BDC, and 0.33 g of CMC. The mixture underwent a 25-hour solvothermal treatment at 120°C. Finally, a vacuum drying process employing a desiccator fitted with a heater at 80°C was used to produce CMC/MOF-5/GO after the resulting solid sample had been cleaned with DMF and CHCl3. The same process was used to synthesize pure MOF-5, but without the use of CMC or GO (Karimzadeh et al., 2019).

Green Synthesis and Characterization of Carboxymethyl Cellulose Fabricated Silver-Based Nanocomposite for Various Therapeutic Applications

Using Syzygiumaromaticumethanolic buds extract (SAEE) as a reducing and coating agent, a green synthesis of AgNPs was disclosed. However, plant extract and CMC-based silver nanoparticles (CMC-AgNPs) were produced using the previously reported technique, with a few changes.

To generate CMC-AgNPs, dropwise solutions of SAEE (10 mg/mL) and CMC (5 mg/mL) were combined with an aqueous solution of AgNO3 (1 mmol/L). Additionally, CMC was utilized in the manufacture of AgNPs as a stabilizing and reducing agent. The culture that was created was centrifuged for thirty min at 10,000 rpm to separate the supernatant, washed in deionized water, and tested for the presence of CMC-AgNPs using a UV spectrophotometer.

The substance's change in color from silver to greenish-black indicates that AgNPs were synthesized using CMC. The produced nanocomposite was then dried for a further 12 hours at 65 °C in a hot air oven to eliminate any leftover free biological elements in order to get pure CMC-AgNPs. To evaluate the degree of substitution (DS), value of CMC in the created nanocomposite, however, potentiometric titrations were applied (Asghar et al., 2021).

Synthesis of Greener Silver Nanoparticle-Based Chitosan Nanocomposites and their Potential Antimicrobial Activity Against Oral Pathogens

Both Milli-Q water and tap water were used to properly wash the leaves of Cissusarnottiana. The plant was then dried in the shade for 3–4 days. A fine powder was made from the dried plant and stored in ansealed container. 100 mL of double-distilled water were combined with 1 g of the desiccated, powdered plant. After that, the mixture was cooked for 15

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minutes at 70°C using a heating mantle. All of the phytochemicals included in the Cissusarnottiana plant are diffused in the aqueous solution using this method. The percolate leaf extract from this final mixture was kept in the refrigerator for later usage after being filtered through Whatman No. 1 filter paper.

Nanoparticle Synthesis

To 90 mL of deionized water, 1 mM of precursor silver nitrate (AgNO3) was added. The addition of 10 mL of Cissusarnottiana purified plant extract. For 48 hours, the mixture was stirred at 600–700 rpm using a magnetic stirrer. At regular intervals beginning at the start wavelength of 360–500 rpm, the synthesis of AgNPs was examined using a UV–Vis–double beam spectrophotometer (revolutions per minute). Biosynthesized AgNPs were centrifuged at 8,000 rpm for 10 min to separate the pellet from the aqueous reaction mixture. The pellet was rinsed three times with ethanol and then deionized water before being held in a hot air oven at 70°C for two hours. The supernatant was then discarded. Additionally, AgNPs in powder form were kept in airtight Eppendorf tubes for characterisation experiments.

Preparation of Nanocomposites

To 90 mL of deionized water, precursor silver nitrate (AgNO3) at 1 mM was added. Extract from the filtered plant Cissusarnottiana was added in 10mL. For 48 hours, the mixture was stirred at 600–700 rpm using a magnetic stirrer. At regular intervals beginning at the start wavelength of 360–500 rpm, the synthesis of AgNPs was examined using a UV–Vis–double beam spectrophotometer (revolutions per minute). The pellet of biosynthesized AgNPs was separated from the aqueous reaction mixture by centrifugation at 8,000 rpm for 10 min. The pellet was rinsed three times with ethanol and then deionized water before being held in a hot air oven at 70°C for two hours. The supernatant was then discarded. Additionally, AgNPs in powder form were kept in airtight Eppendorf tubes for characterisation experiments(Rajeshkumar et al., 2021).

Synthesis and Characterization of Silver/Montmorillonite/Chitosan Bio Nanocmposites by Chemical Reduction Method and their Antibacterial Activity

Synthesis of Ag/MMT/Cts BNCs using $NaBH_4$

In order to make soluble Cts (100 mL, 0.5 wt percent), each sample was independently dissolved for 45 minutes while being constantly stirred in a solution that contains 1.0 wt percent acetic acid (pH 3.53). According to the usual method for preparing AgNPs, AgNO3 solutions were

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added to each soluble Cts sample and continuously mixed to form AgNO3/Cts solutions. The dilute Cts-acetic acid mixture thickened with the addition of AgNO3 solution. Ag concentrations in the samples ranged from 0.5 (A1) to 1.0 (A2) to 1.5 (A3) to 2.0 (A4) and 5.0 g Ag/100 g MMT, respectively.

The AgNO3/MMT/Cts suspensions were created by combining soluble Cts and continuous amounts of MMT in different volumes of a 1 103 M AgNO3 solution for a whole day at room temperature. To keep the AgNO3/NaBH4 molar ratio constant, newly made NaBH4 (4 102 M) solution was introduced while the suspensions were continually stirred (1:4). The reducing agent was then added, and stirring continued for one further hour. The Ag/MMT/Cts BNC suspensions were centrifuged to remove any remaining silver ions, and then they were washed with double-distilled water four times before being dried at 40°C in vacuum for the whole night. The experiments were all carried out at room temperature (Shameli et al., 2011).

Synthesis and Characterization of CarboxymethylChitosan/Fe_3O_4 and $MnFe_2O_4$ Nanocomposites Hydrogels for Loading and Release of Curcumin

Preparation of Carboxymethyl Chitosan (CMCS)

A 20 percent NaOH solution (100 mL) was added to chitosan (88 percent of deacetylation, Mw = 2.0 105) in a 5 g solution for 15 minutes with a solvent of 1 percent (v/v) acetic acid. Slowly adding 15 g of monochloroacetic acid to the mixture, it was heated for 2 hours at 40 °C. A solution of 10% acetic acid was used to neutralize the reaction solution. As a result, the product underwent two rounds of methanol washing and filtering before being vacuum dried at 55 °C for eight hours.

Preparation of Fe3O4

Deoxygenated distilled water (200 mL) was combined with FeCl36H2O (16.25 g) and FeCl24H2O (6.35 g) and agitated for 60 minutes.Then, at 30 °C, add N2 gas and 2 M NaOH solution while stirring vigorously, chemical precipitation was achieved. For five hours, the reaction system remains at 70 °C. At a pH of 8 to 12, the precipitation process should be complete. The precipitates were isolated by a permanent magnet, rinsed using distilled water until pH neutral, and then dried in an oven at 60–70 °C after cooling to 25 °C.

Preparation of MnFe2O4

In a typical synthesis technique, 100 mL of an aqueous solution was vigorously agitated while 0.05 mol of iron (III) chloride (FeCl3.6H2O) and 0.25 mol of manganese chloride

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(MnCl2.4H2O) powders were dissolved. After that, 15 mL of a 25% ammonia solution and 0.2 g of PVP as a stabilizer were added to the aforementioned solution. The mixture was kept at 25 °C while being stirred vigorously for one hour. The mixture was then put into a 100 mL autoclave that was Teflon walled and heated for 16 hours at 180 °C. The system was allowed to cool to ambient temperature, and the product was cleaned two times with distilled water and ethanol. Then, it was dried in a vacuum oven for 8 hours at 80 °C.

Preparation of Magnetic (MnFe2O4 and Fe3O4)/Carboxymethyl Chitosan Hydrogels

The 50 mg of CMCS solution and 1 percent NaOH was mixed with 50 mg of Fe3O4 nanoparticles or MnFe2O4 and heated to 25 °C for two hours while being exposed to ultrasonic radiation. 22 L of epichlorohydrin are then added. Under ultrasonic irradiation, the resulting solution is neutralised with 300 mL of 0.1 M NaOH. To convert the product's gel form to film, it is desiccated in the oven at 60 °C for an entire night. The film was washed twice with distilled water and numerous times with acetic acid. It is then desiccated in the oven at 60 °C for the entire night (Naderi & Azizian, 2018).

CHARACTERIZATION

Fourier Transform Infrared Spectroscopy

The interferogram's raw data is converted into the true spectrum in Fourier transform infrared spectroscopy (FTIR) via a mathematical process (Fourier transform). To ascertain if a fuel sample is transmitting or absorbing infrared light, the FTIR method is utilized.To determine if the sample contains any organic or inorganic substances, FTIR is utilized. The specific chemical groups prevailing in the sample will be identified using spectrum data from the computer-controlled spectroscopy program and the fourier transform infrared frequency range of 600–4000 cm1.

This chapter presents a novel method for characterizing the fuel stability variability of diverse biodiesel/antioxidant samples: FTIR(Mohamed Shameer& Mohamed Nishath, 2019).

Principle of FTIR

FTIR spectrometers, like NDIR analyzers, work under the assumption that different gases absorb IR light at frequencies particular to each species. However, because FTIR spectroscopy uses a dispersion method, measurements are made over a broad spectrum rather than a limited frequency range (Undavalli et al., 2021).

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Working of FTIR

All of the light source's spectrum components are simultaneously measured in Fourier transform infrared (FTIR) spectroscopy. The entering light's spectral makeup must be permanently altered in order to produce an FTIR spectrum. As a result, the FTIR detector's signal detection is time-dependent. The well-known FTIR spectrum is produced by transforming the detector signal through a process known as Fourier transformation from the time domain to the frequency domain (finally shown in wavenumbers, cm^{-1})(Berthomieu & Hienerwadel, 2009).

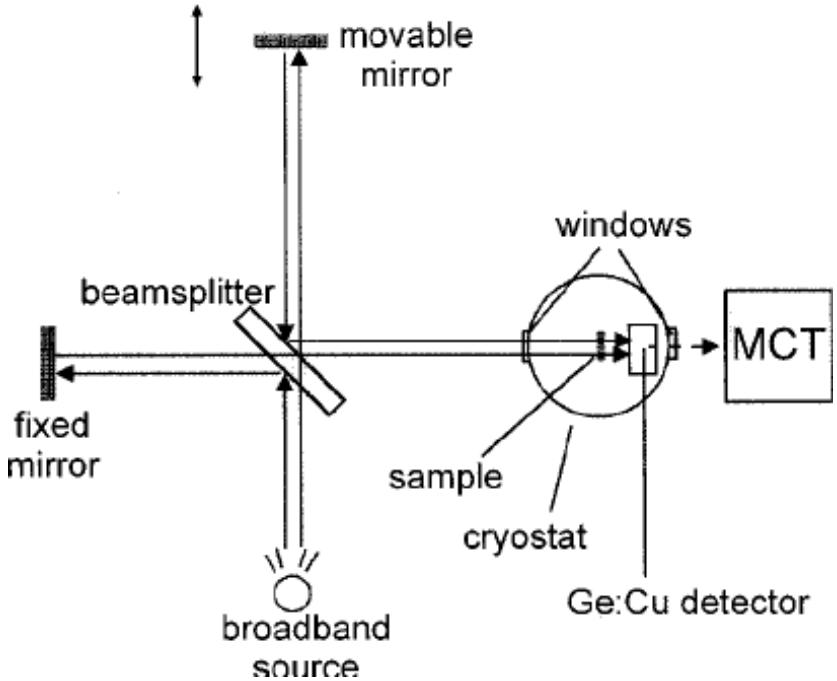


Figure.12 Systematic diagram of FTIR (McCluskey, 2000)

Instrumentation

A Michelson interferometer is used in FTIR spectroscopy. A semi-transparent mirror and two reflectors—one permanent and the other movable are employed. After being collimated and directed toward the interferometer, the light from the light source is incident obliquely on the semitransparent mirror, where it is divided into transmitted and reflected beams. The two beams are rejoined in the semitransparent mirror because of being reflected by the moving mirror and the stationary mirror. This results in an interference pattern.A moving mirror's position (optical path difference) will affect the types of light interference patterns that are created. The Fourier transform may be used to determine the intensity of light for each wavenumber.

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Transmission Spectrum

A single beam instrument is an FTIR spectrophotometer. To determine a sample's transmission spectrum, two measurements must be made: one with the sample within the chamber and the other without (background). After a Fourier transform is performed on the background interferograms and sample to create a single beam spectrum (SB), the transmission spectrum is calculated using the formula shown below:

Transmission spectrum = (Sample SB) / (Background SB) 100.

The impacts of absorption by H2O and CO2 as well as the energy characteristics for other elements can be rectified in the transmission spectrum (Perkins, 1986).

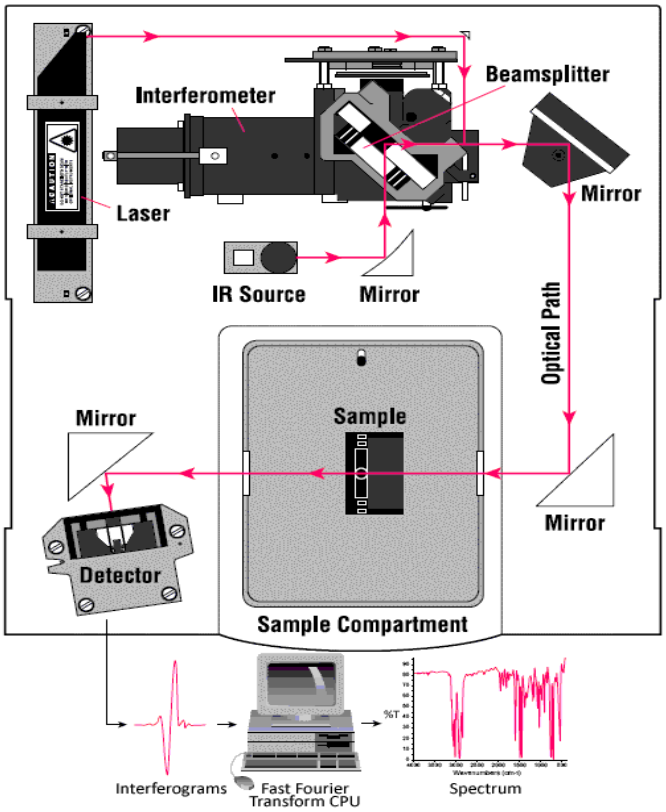


Fig. 13 Working diagram of FTIR (Lozeman et al., 2020)

Scanning Electron Microscopy

Principle of Scanning Electron Microscopy (SEM)

The scanning electron microscope uses emitted electrons as opposed to transmitted electrons, which are used by the transmission electron microscope. The operational principle for scanning electron microscopy states that signals are produced from electron interactions

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using kinetic energy. For the investigation of crystalline elements and photons, secondary electrons, diffracted backscattered electrons, and backscattered electrons—are employed. A image is made using backscattered and secondary electrons. The major function of the secondary electrons released from the specimen is to identify its shape and topography, whereas the backscattered electrons demonstrate contrast in the elemental composition of the specimen (Akhtar et al., 2018).

Working of SEM

SEM is anapparatus at which indiscernible worlds of micro space and nano-space could be seen. SEM may show details and complexity that are unavailable by light microscopy:

- A high-energy electron beam between and will be used to conduct the study (100-30,000 electron volts). Usually, a heat source is used for electron emission.
- Because the gun's spot size is too large to provide a sharp image, a SEM with lenses to compress the spot and focus the electron on the specimen is utilized. The signals required to form an image are created when the electrons that were caught in the majority of SEMs, the light from the last lens interacts with the object and descends to a depth of 1 m.
- Unless a rectangular raster is produced on the specimen's surface, the electron beam is transported to discrete spots in the pattern of straight lines, at which time the electron beam moves point by point to create the image of the specimen. The required magnification determines the entire operation. The scan coils cause the beam to deflect across a smaller area in the event that the user desires a greater magnified image. It is significant to remember that the magnification rely on the working interval, or the distance between the surface of the specimen and the last lens. In the current SEM, this problem is resolved automatically.
- The purpose of an electron detector is to pick up signals that the scanned material has emitted as electrons. Each signal produced as a result of the interaction between the the electron beam and sample’s surface can produce an image on its own in the absence ofdetectors, which is unfathomable. Both backscattered electrons (BSE) and secondary electrons (SE) are utilized to create SEM pictures. When a higher voltage is given to the collector screen, SE and BSE will both be collected. Only BSE will be gathered if a negative voltage is applied to the collector screen.
- The operator will then manage the brightness and intensity until a reasonable clear image is obtained after the signals are presented on the viewing screen. Magnification

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over (10,000x) should be used when the specimen has to have small details. f- The electron voltage mode (emitted by the gun) affects the information presented. Low accelerating voltages utilized less than will result in the scanned image having a wealth of surface information (5 kV).

- In contrast, faster voltages that pierce below the surface and range between (15 and 30 kV) will cause the reflected light from the surface to be marked and send information about the sample's inside. SEM images that are partially three-dimensional rely on how well the sample's topography can be seen in terms of (size, shape and surface texture). And this is based on the BSE and SE numbers. Surprisingly, the topographic difference is directly impacted by the inclination angle of the sample surface, which increases both of the aforementioned figures. A tilt angle greater than 50o up to 70o causes the numbers of BSE and SE signals to reach their maximum (Mohammed & Abdullah, 2018).

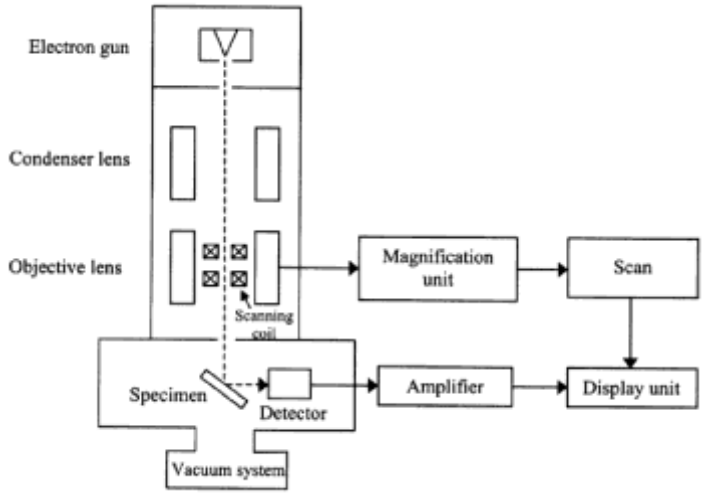


Figure 14 Systematic diagram of SEM(Nagarathnam&Komvopoulos, 1993)

Instrumentation of SEM

Crucial components of all SEMs comprise the following:

- Electron Lenses
- Sample Stage
- Electron Source ("Gun)"
- Detectors for all interest-related signals
- Devices for displays and data output
- Infrastructure needs include:

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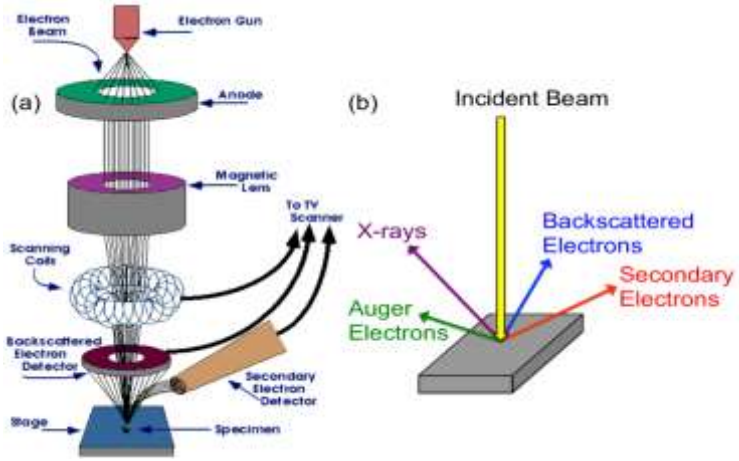
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- Power Source
- Vacuum Equipment
- Cooling mechanism
- A non-vibrational floor
- A space without background magnetic and electric fields

SEMs are equipped with many detectors, usually including at least one secondary electron detector. Which detectors an instrument can accommodate has a significant impact on its specific capabilities (Venables et al., 1974).



Figufre 15 Illustration of working of SEM(Sutton et al., 2007)

Transmission Electron Microscopy

Principle of Transmission Electron Microscopy

The fluorescent screen is used to create a picture when electrons are forced through the specimen, either utilizing the transmitted beam or the diffracted beam.

Working of TEM

In TEM, a tungsten filament (cathode) is heated electrically to produce a high-voltage electron beam, which is then dragged toward an anode (magnetic lenses) and passes through an aperture. The beam passes through the aperture, an electromagnetic condenser, an objective lens, an intermediate lens, and finally a projector lens. A very thin specimen is passed through the intense electron beam loaded on a grid placed in the route and controlled by a goniometer. The specimen is 50 nm in size, transparent to electrons, and contains structural information. The portion of the beam that was scattered, absorbed, and transmitted via the

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objective aperture before being adjusted by intermediate lenses and projected by the projector lens onto the fluorescent screen.With the aid of an optical binocular attached to its viewing glass, the image is examined.

The spatial change in the "image" is eventually recorded by striking a fluorescent screen or light detector, like a CCD (charge-coupled device) camera located either on the side or bottom of the photographic plate, after being magnified by a succession of magnetic lenses. Contrast in the image is created by TEM electron scattering as opposed to variations in absorbance. The specimen's atoms and the illumination beam's electrons interact to cause scattering.Electrons are attracted to the negatively charged electron clouds surrounding atomic nuclei, which scatters them. As electrons approach specimen atoms, these effects intensify. High atomic number nuclei, such those found in heavy metal atoms like those of lead and uranium, produce the widest dispersion. Images created by transmission electron microscopes are two-dimensional and monochromatic. Structures like the ribosome, microtubules, microfilaments, and big molecules like proteins are easily resolved by the TEM. Under the unique operating conditions, even photographs of a single heavy metal atom have been created (Shi, 2016).

Instrumentation of TEM

A part of the TEM is an emission source, which might be a tungsten filament or an origin of lanthanum hexaboride (LaB6). For tungsten, it will manifest as a microscopic hairpin- or spike-shaped filament. Small single crystals are utilized in LaB6 sources. This weapon is compatible with high voltage sources (usually 100–300 kV), and with enough current, it will start to spew electrons into the vacuum via thermionic or field emission. A Wehnelt cylinder is typically used to facilitate this extraction.The TEM's higher lenses make it possible to create an electron probe that is the proper size and position for subsequently interacting with the material once it has been removed. The electron beam can be controlled by two physical processes. Electromagnets can regulate the electron beam because when electrons contact with a magnetic field, they travel according to the right-hand rule. With the use of magnetic fields, a magnetic lens with changeable focusing power can be created, with the lens's shape resulting from the division of magnetic flux.

Electrostatic forces may also cause electrons to be deflected through a defined angle. A shift in the beam path can be produced by joining two deflections in opposite directions with a tiny intermediate gap. Through the use of six coils as opposed to four, this technique is employed in TEM to enhance the lens symmetry. There are typically three steps involved in lensing for a TEM. The projector lenses, condenser, and objective make up the stages.

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Condenser lenses create the primary beam, while objective lenses concentrate the beam that passes through the sample (in STEM scanning mode, there are also objective lenses above the sample to make the incident electron beam convergent). Onto the phosphor screen or other image medium, such as film, the projector lenses disperse the beam. The ratio of the distances between the specimen and the objective lens's picture plane determines the TEM's magnification (Vernon-Parry, 2000).

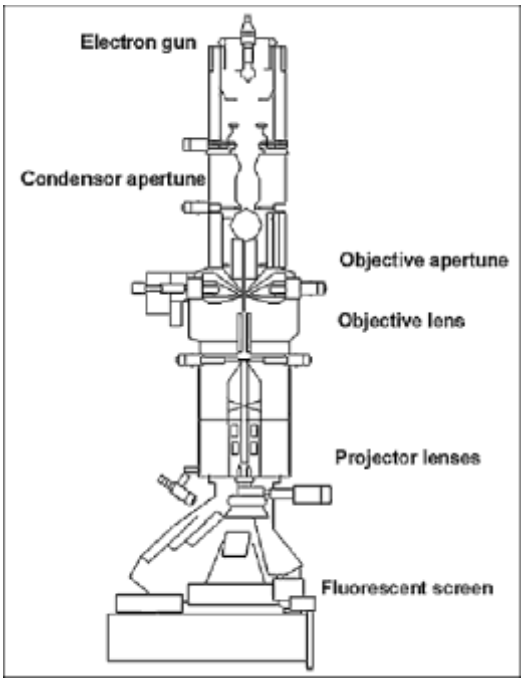


Figure 15 Systematic diagram of TEM(Alqaheem&Alomair, 2020)

X- ray Diffraction

Principle of X- ray Diffraction

The use of XRD for studying materials and thin films is common. To function properly, it must be composed of a crystalline material. Despite being bulk-sensitive, the approach may be used in the correct circumstances to provide information regarding surface changes. For instance, using XRD to assess how significantly a carbon system's surface treatment has altered the bulk of the material can be useful. XRD must normally be treated as a bulk structural approach even if some surface information may be obtained from it in a thin-film mode utilizing extremely modest take-off angles (Sherwood, 2001).

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Working of XRD

X-rays are electromagnetic radiation waves, whereas crystals are regular collections of atoms. Crystal atoms generally react with the electrons to deflect incoming X-rays. The scattering of the electron is a component of this process, known as elastic scattering. A uniform array of spherical waves results from a regular array of scatters. These waves intrude destructively in the vast majority of directions, but in the following few, according to Bragg's rule, they add constructively:

$$2d\sin\theta = n\lambda$$

Where:

d is the distance between diffracting planes, θ is the incidence angle, n is an integer, and λ is the lengthening of beam

The diffraction pattern indicates reflection if certain directions appear as dots. Consequently, X-ray diffraction patterns originate from electromagnetic waves intruding on a continuous sequence of scatterers.

Due to their wavelength, which typically coincides with the distance, d, between the crystal surfaces, X-rays produce the diffraction pattern (1-100 angstrom).

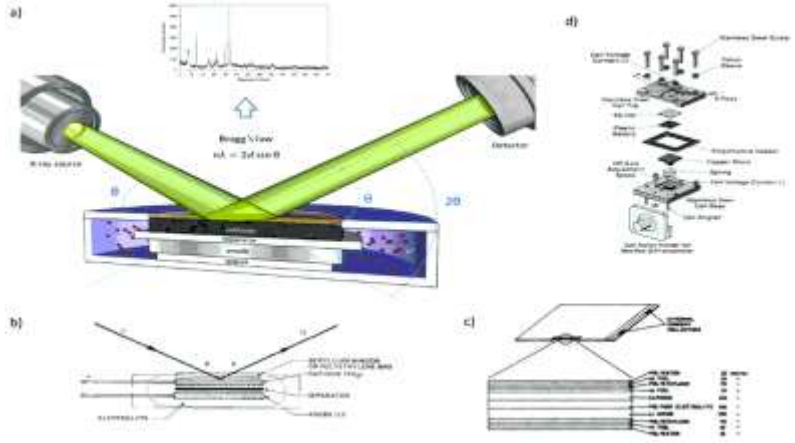


Figure 16 Working diagram of XRD (Llewellyn et al., 2020)

Instrumentation of XRD

Equipment for measuring particle diffraction hasn't changed much since it was created in the late 1940s. The employment of the minicomputer for control, information gathering, and data processing distinguishes modern instrumentation from previous varieties as the key distinction. Figure depicts a typical diffractometer setup with the system source F, PR and soller

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slits D,slit RP, reception slit R and sample S divergence. The goniometer's axis is located at A. The Bragg-Brentano parafocusing system is created when a line source F generates a diverging beam that strikes a sample S, is diffracted, and then passes through a monitoring slit R to the detector. The length of both AR and FA is the same. The effective focal length of the origin and the divergence slit's aperture, D, define how much divergence there is.

To regulate axial divergence, two simultaneous plate collimators (Soller slits) are utilized. They are situated, respectively, between both the specimen and the scatter slit and between the focus and the specimen. If the sample has a broader apparent aperture, using the narrow divergence slit will allow for smaller diffraction angles since there will be fewer specimen coverage at a certain diffraction angle.

The only way this is accomplished is at the expense of intensity loss. The range of angles that must be covered determines the choice of the divergence slit and its corresponding scatter slit. The intensity that is available will determine whether or not the slit size must be raised at a specific angle.

Behind the scatter slit, a photon detector—typically a scintillation detector—converts the diffracted X-ray photons into voltage pulses. These pulses can be concatenated to create an analogue signal for an x/t recorder using a rate meter.

When the recorder and goniometer's scanning speeds are synchronized, a diffractogram—a plot of degrees 2u against intensity—is produced. For quantitative work, a timer/scaler is also available, and it is utilized to compute the cumulative peak intensity of one or more selected lines from each analyte phase in the sample. Additionally, signal-to-noise qualities can be enhanced by using a diffracted beam monochromator. A "powder diagram," or graph of intensity as a function of diffraction angle, is the output of the diffractometer and may be generated from a computer graphics program or shown as a strip chart (Perkins, 1986).

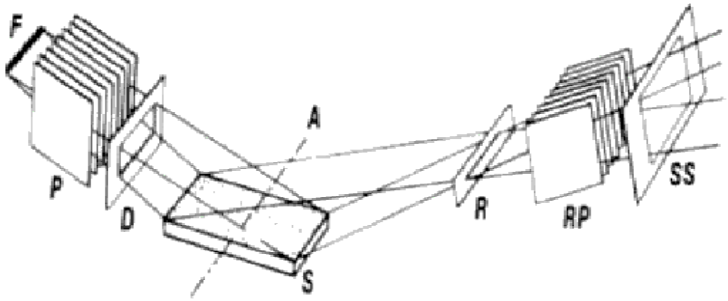


Figure 17 Systematic diagram of XRD(Llewellyn et al., 2020)

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Thermal Travimetric Analysis

Principle of Thermal Gravimetric Analysis

One more typical technique for characterizing of polymers is thermogravimetric analysis (TGA). The weight change of the substance is determined as a function of time or temperature when a sample specimen is subjected to a temperature-controlled program in a controlled environment (Inan, 2017).

Working of TGA

Using a change in mass, a variety of analytical chemistry lab procedures known as gravimetric analysis can be utilized to ascertain a substance's properties. Thermogravimetric analysis measures the weight change in proportion to temperature change in a controlled setting. In TGA, heat is utilized to accelerate chemical reactions and other material changes. A trustworthy method to identify exotherms, endotherms, solvent residues, measure oxidation processes, thermal stability, explosive decomposition points, polymer properties,the amount of organic and inorganic components in a mixture, degradation temperatures of a material and the absorbed moisture content of materials is thermogravimetric analysis (TGA). Explosives, petroleum, chemicals, biological samples, polymers, composites, plastics, adhesives, coatings, organic materials, and other materials can all be evaluated using thermogravimetric analysis(Camuffo, 2019).

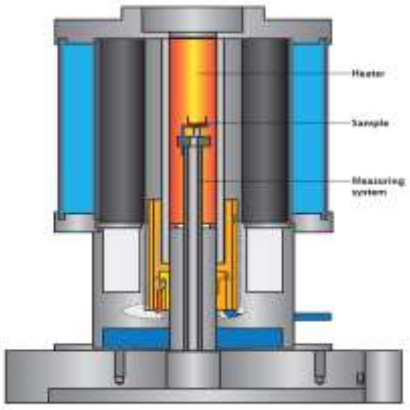


Figure 18 Illustration of working of TGA(Jang et al., 2016)

Instrumentation of TGA

Typically, the thermogravimetric analysis tool comprises of a sample pan and high-precision balance. In a furnace or oven that is heated or cooled throughout the experiment, the

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pan that contains the sample material is situated. The temperature within the oven is precisely controlled and measured using a thermocouple. Throughout the analysis, the sample's mass is continuously tracked. An environment can be cleaned and controlled using an inert or reactive gas. By progressively increasing the temperature and charting the substance weight versus temperature, the analysis is carried out. The equipment is managed by a computer, which also processes the temperature vs. weight output curves (Prime et al., 2009).

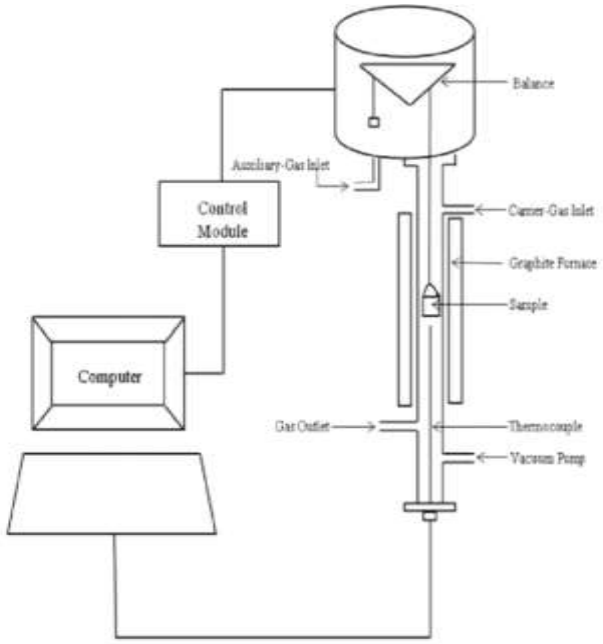


Figure 19 Systematic diagram of TGA (Yang et al., 2012)

APPLICATIONS OF NANOCOMPOSITES

Applications

The number of uses for nanocomposites has been expanding quickly. In the next five to ten years, the following major areas are expected to be covered by the predicted global output, which is estimated to exceed 600,000 tons;

- Drug delivery systems
- UV protection gels
- Anti-corrosion barrier coatings
- Paints and lubricants that are scratch-resistant.
- New materials that resist fire
- New materials that resist scratching and abrasion

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- Extra-strength films and fibers

Due to advancements in mechanical characteristics, nanocomposite has attracted substantial interest in a range of general/industrial and automotive applications. Door handles, the capacity to serve as mirror housing on different vehicles kinds, timing belt covers, intake manifolds, and engine covers are some examples of these potential applications. More broad uses are also being researched, including power tool housings, impellers, and blades, vacuum cleaners, mower hoods, and coverings for portable digital devices like mobile phones and pagers (Huang et al., 2003).

Environmental Protection

Water-rich situations are among the most hazardous ones that polymeric materials may encounter. Therefore, the capacity to reduce the amount of water absorption can be a huge benefit.

According to the information that is now available, adding Nano clay could significantly reduce the amount of water that a polymer absorbs. Polyamide-based nanocomposites could likewise produce a similar result (Pandya et al., 2013).

Nanocomposites in Active Packaging

Silver, zinc oxide, and magnesium oxide are a few nanofillers that exhibit antibacterial or antioxidant properties. These nanofillers have an action that inhibits or delays the growth of microbes in polymer or biopolymer matrices, which lowers the risk of food deterioration.

The extension of the product's shelf life is the primary objective of active packaging solutions. They can be created to decrease food waste by enhancing food quality and safety. Due to their natural anti-microbial agents' inherent anti-microbial characteristics and their adequate structural integrity, which comes from the barrier qualities produced by the nanocomposite matrix, anti-microbial nanocomposite films are valuable (Rhim& Ng, 2007).

Nanoscale materials are more efficient because they can connect to a greater variety of biological molecules due to their larger surface-to-volume ratios than their microscale counterparts. Nanocomposites may be used as growth inhibitors, bactericides, and antibiotic carriers, according to earlier reports.

Nanocomposites can be employed as delivery systems in addition to being used as packaging materials since they facilitate the migration of useful additives like vitamins, probiotics, and minerals into the food. These controlled-released packaging are one more illustration of an active packing application for nanomaterials. Silver is a common component of the anti-

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microbial nanocomposites used in food packaging. Silver is very poisonous to a wide range of microbes. The anti-microbial activity of silver nanoparticles has been attributed to a variety of processes, including membrane pitting and increasing cell permeability through adhesion to the cell surface (Sondi&Salopek-Sondi, 2004).

DNA damage is followed by the release of Ag after nanoparticles have entered a bacterial cell. Active nanocomposites are cutting-edge substitutes for active plastic or active sachet technologies for extending the quality and safety of packaged food goods. A plastic composite (i.e., a mixture of polymers) that contains an active, nanostructured material that gives the plastic matrix an activity is referred to as an "active nanocomposite" in general.At least one of the active nanostructured material's dimensions must be under 100 nm in size. The active agent may be carried by Nano clays. Because the active ingredient is highly disseminated in the polymeric matrix and is thus exposed to the substance on which it is required to work more effectively, its effectiveness is increased(Honarvar et al., 2016).

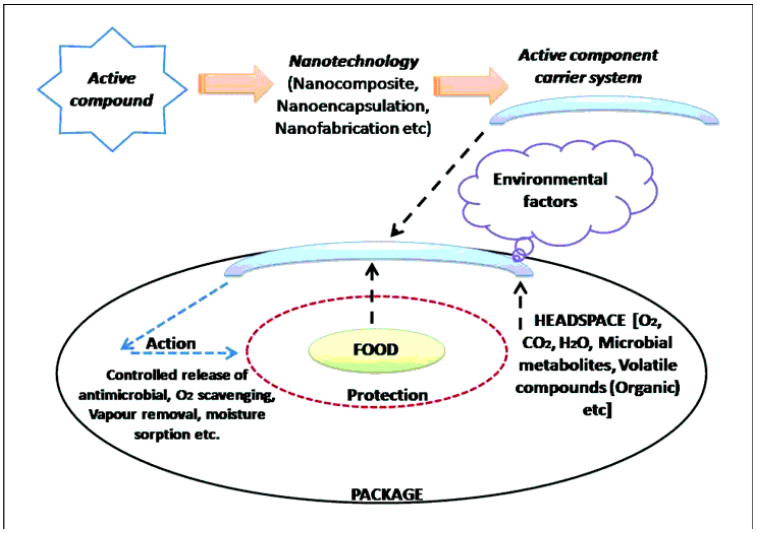


Figure .20 Nano composites in food packaging (Sharma et al., 2017)

Applications in the Aerospace Industry

Numerous uses for nanocomposites can be found in the aerospace sector. Nanocomposites made of Al2O3 nanoparticles and nickel matrix was tested for temperature and corrosion resistance (Hussain et al., 2009).

Because the nanocomposite coating on jet engine turbine blades prevented grain formation

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even at extremely high temperatures, they were used as overlay coatings in a variety of aerospace applications. For aerospace applications, a tough nanocomposite covering was created. A PU matrix was used to scatter conductive CNTs, and a little increase in the CNT weight percentage significantly increased the thermal diffusivity. For de-icing applications in the aircraft industry, it was discovered that the coating had a lower surface resistance and excellent flexibility.The evaluation of 10-Dihydro-9-oxa-10-phosphaphenanthrene-10-oxide-based phosphorus tetra glycidyl epoxy nanocomposites revealed that they possess flame retardant qualities, making them suitable for use in aerospace. Utilizing a nanocomposite system made of silica nanoparticles in a polymer matrix, surface degradation brought on by UV light was evaluated(Yagnamurthy et al., 2013).

In its lower earth orbit, the International Space Station is vulnerable to a high level of UV light that can have detrimental effects on its structure. The erosive yield of the polymer epoxy generated by the AO was found to be decreased by the silica particles, and they were regarded as trustworthy substitutes for other polymer-based systems. The structural components of a space rocket were shielded during launch by a thermally resistant nano silica-ethylene propylene diene monomer (EPDM) rubber nanocomposite (Singh et al., 2013).

The nanocomposite was found to have a low rate of erosion and an excellent thermal expansion coefficient through physical testing. As an alternative to aluminum and copper, which are prone to galvanic corrosion under specific climatic circumstances, nanocomposites were considered as the material to give lightning protection (Zhang et al., 2013).

Indium and graphene were combined to form a coating, and experimental examination revealed that the coating had good electrical conductivity (Bhat et al., 2021).



Fig.4.2 Applications of nano composites in air space (Tsach et al., 2012)

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Applications in Biomedical

One of the subfields of nanotechnology that is expanding fast is the use of nanocomposites in biomedical applications. One area of ongoing study is the production of bio-repairable nanofiber scaffolds by electrospinning. Using electrically conductive nanofibers made of conjugated polymers, nerve growth in a biological system may be regenerated. Silver oxide, silver salts, and nanoparticle silver have all been added to polymer matrices to give antibacterial action. For bone healing and implantation, studies have been done on hydroxyapatite-based polymer nanocomposites (Ca10(PO4)6(OH)2). When used directly, hydroxyapatite, a key component of hard tissue, has unfavorable mechanical characteristics; as a result, polymer-based matrix nanocomposites are preferred. Methods investigated for bone repair systems include poly-2-hydroxyethyl methacrylate/poly (3-caprolactone) nanocomposites and gelatin generated from collagen. A common technique for creating nanofiber scaffolds for tissue engineering purposes is electrospinning of biodegradable polymer solutions. Salt leaching and gas foaming were done after electro spinning solutions of salt, exfoliated montmorillonite clay, and poly(L-lactic acid). Applications involving drug delivery and release have been suggested for polymer matrix nanocomposites. Applications for iron oxide nanoparticles include medication administration, cellular treatment, improving the contrast in magnetic resonance imaging, and immunoassay. It has been reported that polydimethylsiloxane-encased iron and cobalt nanoparticles can treat retinal detachment problems (Vaia& Wagner, 2004).

Electronics

The design of cutting-edge devices for electrical and optoelectronic applications is heavily influenced by nanotechnology. Electronic gadget dimensions have now dipped into the nano range. Polymer-based nanocomposites have a wide range of applications in various fields. Conjugated carbon nanotubes are used in one particular type of nanocomposite. Its possible uses include sensors, field effect transistors, superconductors, photodiodes, photovoltaic cells, and light-emitting diodes. Photovoltaic systems built on silicon have a validatedcommercial utility, high efficiency and great stability. Organic-polymer-based PV systems have promise for more affordable and adaptable manufacturing, but they could yet benefit from advances in long-term stability and efficiency. The discovery of carbon nanotubes led to the emergence of interest in graphene for use in electronics. Research has been done on conjugated polymers that include different nanoscale filler inclusions for use in biosensors, gas sensors, chemical sensors, and other sensor applications. A SWCNT nanocomposite's gas sensor sensitivity was on par with SWCNT by itself.Based on changes in conductivity brought on by chemical or gas

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interactions between nanofiller and the conjugated polymer., these nanocomposites' sensing abilities can be used in a variety of applications (Sadasivuni et al., 2015).

Prospects of nano-Composites

Nanocomposites provide an extraordinarily wide range of potential applications, including those in novel materials, electronics, optical communications, and biological systems. Several devices and methods, as well as numerous potential applications, have been examined. New devices and other possible applications are being suggested. Evidently, it is difficult to recap all of the technologies and uses that have been investigated. It is interesting to notice that different fields' applications of nanocomposites clearly have different requirements, which lead to different obstacles and call for different strategies(Ates et al., 2020).

SUMMARY

Nanotechnology can be defined as "atomically precise technology" or "atomic precision engineering." Nanotechnology is related to materials and systems with parts and structures that are new and significantly better in terms of their physical, chemical, and biological properties, processes, and phenomena. According to the dictionary definition of nanotechnology is "the careful and meticulous handling, precise placement, modeling, testing, and manufacture of materials at the nanoscale to produce products, systems, and technologies with basically novel characteristics and capabilities.

The use of materials having at least one outside dimension between 1 and 100 nm are referred to as nanomaterials. Nanomaterials can be developed intentionally through engineering for a specific purpose or they can emerge naturally as byproducts of combustion processes. Compared to their equivalents in bulk form, these materials may have differing physical and chemical characteristics. They include nano particles, nano fibers, nano suspensions, nano emulsuions, nano composites and quantum dots.

When each of the phases in a multiphase solid material has one, two, or three dimensions less than 100 nanometers, or when the structures between the phases that make up the material have nanoscale repeat distances, the substance is referred to as a nanocomposite. When a composite material has a phase with nanoscale morphology, such as nanoparticles, nanotubes, or lamellar nanostructure, the material is said to be a nano-composites. Nanocomposites have evolved as useful alternatives to engineering materials that currently have limitations in order to overcome them.

There are two categories of nano composites: those based on polymers and those not.

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Polymer nanocomposites are composed of a polymer or copolymer with nanoparticles or nanofillers dispersed throughout the polymer matrix (PNC). Inorganic nanocomposites are another name for non-polymer-based nanocomposites. They can also be broken down into three different categories: ceramic-based, ceramic-based and metal-based nanocomposites.
In situ polymerization, melt and solution mixing, precipitation, the sol-gel method, and electrospinning may all be used to create nano composites. Scanning and transmission electron microscopy, X-ray diffraction, fourier-transform infrared spectroscopy, and thermogravimetric analysis can all be used to identify them.

Nanocomposites and the numerous uses they offer have both been expanding quickly. The following locations will see output rise beyond 600,000 tonnes during the coming ten years: New fire-retardant materials, UV protection gels, medicine delivery systems, anti-corrosion barrier coatings, stretched and lubricant paints, as well as fibers and films with superior strength.

Due to advancements in mechanical characteristics, nanocomposite has attracted substantial interest in a range of general/industrial and automotive applications. Door handles, the capacity to serve as mirror housing on different vehicles kinds, timing belt covers, intake manifolds, and engine covers are some examples of these potential applications. More broad uses are also being researched, including power tool housings, impellers, and blades, vaccum cleaners, mower hoods, and coverings for portable digital devices like mobile phones and pagers.

REFERNCES

Abraham, J., Sharika, T., Mishra, R., & Thomas, S. (2017). Rheological characteristics of nanomaterials and nanocomposites. In R. K. Mishra, S. Thomas & N. Kalarikkal (Eds.), *Micro and nano fibrillar composites from polymer blends* (1st ed., Vol.2, pp. 327-350). Amsterdam: Elsevier.

Akhtar, K., Khan, S. A., Khan, S. B., & Asiri, A. M. (2018). Scanning electron microscopy: Principle and applications in nanomaterials characterization. In S. K. Sharma (Eds.), *Handbook of materials characterization* (2nd ed., Vol. 1, pp. 113-145). Chambridge: Springer.

Ali, H. S. M., York, P., & Blagden, N. (2009). Preparation of hydrocortisone nanosuspension through a bottom up nanoprecipitation technique using microfluidic reactors. *International Journal of Pharmaceutics, 375*(1), 107-113.

Al-Johani, H., & Salam, M.A. (2011).Kinetics and thermodynamic study of anilineadsorption by multi-walled carbon nanotubes from aqueous solution.*Journal of Colloid and Interface*

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Science, 360(2), 760-767.

Alqaheem, Y., &Alomair, A.A. (2020).Microscopy and spectroscopy techniques for characterization of polymeric membranes.*Membranes, 10*(2), 33-38.

Asghar, M. A., Yousuf, R. I., Shoaib, M. H., Asghar, M. A., Zehravi, M., Rehman, A. A., Khan, K. (2021). Green synthesis and characterization of carboxymethyl cellulose fabricated silver based nanocomposite for various therapeutic applications. *International Journal of Nanomedicine, 16*(2), 5371-5379.

Ates, B., Koytepe, S., Ulu, A., Gurses, C., & Thakur, V. K. (2020). Chemistry, structures, and advanced applications of nanocomposites from biorenewable resources. *Chemical Reviews, 120*(17), 9304-9362.

Baker, C. (1982). Methylcellulose & sodium carboxymethylcellulose: Uses in paper conservation. *Journal of the American Institute for Conservation, 1*(4), 16-19.

Bera, D., Qian, L., Tseng, T.-K., & Holloway, P. H. (2010). Quantum dots and their multimodal applications: A review. *Materials,* 3(4), 2260-2345.

Berthomieu, C., & Hienerwadel, R. (2009). Fourier transform infrared (FTIR) spectroscopy. *Photosynthesis Research, 101*(2), 157-170.

Bhat, A., Budholiya, S., Raj, S. A., Sultan, M. T. H., Hui, D., Shah, A. U. M., & Safri, S. N. A. (2021). Review on nanocomposites based on aerospace applications. *Nanotechnology Reviews, 10*(1), 237-253.

Camuffo, D. (2019). Measuring time of wetness and moisture in materials. In P. Raghavendra & T. Pullaiah (Eds.), *Microclimate for cultural heritage* (2nd ed., Vol. 3, pp. 450-482). Amsterdam: Elsevier.

Casaburi, A., Rojo, Ú. M., Cerrutti, P., Vázquez, A., & Foresti, M. L. (2018). Carboxymethyl cellulose with tailored degree of substitution obtained from bacterial cellulose. *Food Hydrocolloids, 75*(10), 147-156.

Che Marzuki, N. H., Wahab, R. A., & Abdul Hamid, M. (2019). An overview of nanoemulsion: Concepts of development and cosmeceutical applications. *Biotechnology & Biotechnological Equipment, 33*(1), 779-797.

Easson, M., Villalpando, A., & Condon, B. D. (2017). Absorbent properties of carboxymethylated fiber, hydroentangled nonwoven and regenerated cellulose: A comparative study.*Journal of Engineered Fibers and Fabrics, 12*(4), 155-160.

Fedullo, N., Sorlier, E., Sclavons, M., Bailly, C., Lefebvre, J.M., & Devaux, J. (2007). Polymer based nanocomposites: Overview, applications and perspectives. *Progress in Organic Coatings, 58*(2), 87-95.

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Fleming, K., Gray, D. G., & Matthews, S. (2001). Cellulose crystallites. *Chemistry–A European Journal, 7*(9), 1831-1836.

Fischer, H. (2003). Polymer nanocomposites: From fundamental research to specific applications.*Materials Science and Engineering: C, 23*(8), 763-772.

Geetha, G., Poojitha, U., & Khan, K. A. A. (2014). Various techniques for preparation of nanosuspension: A review. *International Journal of Pharma Research & Review, 3*(9), 30-37.

Guo, D., Xie, G., & Luo, J. (2013). Mechanical properties of nanoparticles: Basics and applications. *Journal of Physics D: Applied Physics, 47*(1), 13001-13009.

Gupta, A., Eral, H. B., Hatton, T. A., & Doyle, P. S. (2016). Nanoemulsions: Formation, properties and applications. *Soft Matter, 12*(11), 2826-2841.

Heinze, T., & Pfeiffer, K. (1999). Studies on the synthesis and characterization of carboxymethylcellulose. *Die Angewandte Makromolekulare Chemie, 266*(1), 37-45.

Honarvar, Z., Hadian, Z., & Mashayekh, M. (2016). Nanocomposites in food packaging applications and their risk assessment for health. *Electronic Physician, 8*(6), 2531-2538.

Huang, J.Y., Li, X., & Zhou, W. (2015). Safety assessment of nanocomposite for food packaging application. *Trends in Food Science & Technology, 45*(2), 187-199.

Huang, R., Cao, M., Guo, H., Qi, W., Su, R., & He, Z. (2014). Enhanced ethanol production from pomelo peel waste by integrated hydrothermal treatment, multienzyme formulation, and fed batch operation. *Journal of Agricultural and Food Chemistry, 62*(20), 4643-4651.

Hussain, M. S., Al-Swailem, S., & Hala, A. (2009). Advanced nanocomposites for high temperature aero engine/turbine components.*International Journal of Nanomanufacturing, 4*(4), 248-256.

Huang, Z.-M., Zhang, Y. Z., Kotaki, M., & Ramakrishna, S. (2003). A review on polymer nanofibers by electrospinning and their applications in nanocomposites. *Composites Science and Technology, 63*(15), 2223-2253.

Inan, T. Y. (2017). Thermoplastic based nanoblends: Preparation and characterizations. In P. M. Visakh, G. Markovic & D. Pasquini (Eds.), *Recent developments in polymer macro, micro and nano blends*(1st ed., vol. 2, pp. 17-56). Cambridge: Woodhead Publishing.

Jassim, Z. E., & Rajab, N. A. (2018). Review on preparation, characterization, and pharmaceutical application of nanosuspension as an approach of solubility and dissolution enhancement. *Journal of Pharmceutical Research, 12*(2), 771-774.

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Janarthanan, G., Tran, H. N., Cha, E., Lee, C., Das, D., & Noh, I. (2020). 3D printable and injectable lactoferrin loaded carboxymethyl cellulose glyco- chitosan hydrogels for tissue engineering applications. *Materials Science and Engineering: C, 132*(10), 1118-1125.

Jang, S. H., Lee, K. W., Kim, J. R., Kim, J. H., Yoon, S. H., Cho, I. S., & Choi, J. H. (2016). The Combustion characteristics of residual fuel oil blended with fuel additives. *Journal of the Korean Society of Marine Environment & Safety, 22*(5), 554-563.

Karimzadeh, Z., Javanbakht, S., & Namazi, H. (2019). Carboxymethylcellulose/MOF-5/Graphene oxide bio-nanocomposite as antibacterial drug nanocarrier agent. *BioImpacts: BI, 9*(1), 5-10.

Khandoker, N., Hawkins, S., Ibrahim, R., Huynh, C., & Deng, F. (2010). Tensile strength of spinnable multiwall carbon nanotubes. *Procedia Engineering, 10*(2), 2572-2578.

Lan, W., He, L., & Liu, Y. (2018). Preparation and properties of sodium carboxymethyl cellulose/sodium alginate/chitosan composite film. *Coatings, 8*(8), 291-299.

Lee, H., & Yoo, B. (2020). Agglomerated xanthan gum powder used as a food thickener: Effect of sugar binders on physical, microstructural, and rheological properties. *Powder Technology, 362*(12), 301-306.

Liu, X., & Antonietti, M. (2014). Molten salt activation for synthesis of porous carbon nanostructures and carbon sheets. *Carbon, 69*(3), 460-466.

Lim, C. T. (2017). Nanofiber technology: Current status and emerging developments. *Progress in Polymer Science, 70*(7), 1-17.

Llewellyn, A. V., Matruglio, A., Brett, D. J., Jervis, R., & Shearing, P. R. (2020). Using *in situ* laboratory and synchrotron-based X-ray diffraction for lithium-ion batteries characterization: A review on recent developments. *Condensed Matter, 5*(4), 75-79.

Lozeman, J., Führer, P., Olthuis, W., & Odijk, M. (2020). Spectroelectrochemistry, the future of visualizing electrode processes by hyphenating electrochemistry with spectroscopic techniques. *The Analyst, 145*(7), 2482-2509.

Madkour, L. H. (2019). Introduction to nanotechnology (NT) and nanomaterials (NMs).*Nanoelectronic Materials*, *8*(2),1-47.

McCluskey, M. (2000).Local vibrational modes of impurities in semiconductors.*Journal of Applied Physics, 87*(8), 3593-3617.

Mirhosseini, H., Tan, C. P., Aghlara, A., Hamid, N. S., Yusof, S., & Chern, B. H. (2008). Influence of pectin and CMC on physical stability, turbidity loss rate, cloudiness and flavor release of orange beverage emulsion during storage. *Carbohydrate Polymers, 73*(1), 83-91.

Copyright to the author of some rights reserved This work is licensed under aCreative Commons Attribution-ShareAlike 4.0 International License.

Mohamed Shameer, P., & Mohamed Nishath, P. (2019). Exploration and enhancement on fuel stability of biodiesel: A step forward in the track of global commercialization. *In Advanced Biofuels*, *42*(2), 181-213.

Mohammed, A. and A. Abdullah (2018, November).*Scanning electron microscopy (SEM): A review.* Paper presented at the Proceedings of the 2018 International Conference on Hydraulics and Pneumatics, BaileGovora, Romania.

Nasrollahzadeh, M., Sajadi, S. M., Sajjadi, M., & Issaabadi, Z. (2019). An introduction to nanotechnology. In M. Nasrollahzadeh, S. M. Sajadi, M. Sajjadi, Z. Issaabadi & M. Atarod (Eds.),*Interface science and technology*, (3rd ed., Vol. 28, pp.1-27). Amsterdam: Elsevier.

Naderi, Z., & Azizian, J. (2018). Synthesis and characterization of carboxymethyl chitosan/Fe3O4 and MnFe2O4 nanocomposites hydrogels for loading and release of curcumin. *Journal of Photochemistry and Photobiology B: Biology, 185*(5), 206-214.

Nagarathnam, K. and K. Komvopoulos (1993).Microstructural characterization and *in situ* transmission electron microscopy analysis of laser-processed and thermally treated Fe-Cr-WC clad coatings.*Metallurgical and Materials TransactionsA, 24*(7), 1621-1629.

Ott, E., Spurlin, H. M., Grafflin, M. W., Bikales, N. M., & Segal, L. (1954). Cellulose and cellulose derivative. *Journal of Biological Chemistry 5*(4), 150-155.

Padron, S., Fuentes, A., Caruntu, D., & Lozano, K. (2013). Experimental study of nanofiber production through forcespinning. *Journal of Applied Physics, 113*(2), 024318-024325.

Pandey, J. K., Kumar, A. P., Misra, M., Mohanty, A. K., Drzal, L. T., & Palsingh, R. (2005). Recent advances in biodegradable nanocomposites.*Journal of Nanoscience and Nanotechnology, 5*(4), 497-526.

Pandya, S., Jani, S., Chavan, A., Singh, A., Bhatt, S., Patel, D., & Naik, K. (2013). Nanocomposites and its application review. *International Journal of Pharmaceutical Science and Research, 4*(1), 19-28.

Perkins, W. D. (1986). Fourier transform-infrared spectroscopy: Part l. Instrumentation. *Journal of Chemical Education, 63*(1), 1-5.

Prime, R. B., Bair, H. E., Vyazovkin, S., Gallagher, P. K., & Riga, A. (2009). Thermogravimetric analysis (TGA). *Thermal Analysis of Polymers: Fundamentals and Applications*, *88*(2), 241-317.

Rachtanapun, P., Jantrawut, P., Klunklin, W., Jantanasakulwong, K., Phimolsiripol, Y., Leksawasdi, N., & Ngo, T. M. P. (2021). Carboxymethyl bacterial cellulose from nata de coco: Effects of NaOH.*Polymers, 13*(3), 348-355.

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Rahman, M. S., Hasan, M., Nitai, A., Nam, S., Karmakar, A., Ahsan, M.,& Shiddiky, M. (2021). Recent developments of carboxymethyl cellulose. *Polymers, 13*(8), 1345-1350.

Rajeshkumar, S., Tharani, M., Rajeswari, V. D., Alharbi, N. S., Kadaikunnan, S., Khaled, J. M., Govindarajan, M. (2021). Synthesis of greener silver nanoparticle based chitosan nanocomposites and their potential antimicrobial activity against oral pathogens. *Green Processing and Synthesis, 10*(1), 658-665.

Ranjan, N., & Kumar, R. (2022). Nanoparticles: Properties and its 3D printing applications. *Materials Today: Proceedings, 48*(8), 1316-1319.

Ray, S. S., &Bousmina, M. (2005).Biodegradable polymers and their layered-silicate nanocomposites: In greening the 21st century materials world.*Progress in Materials Science, 50*(8), 962-1079.

Rhim, J.-W., an& NG, P. K. (2007). Natural biopolymer-based nanocomposite films for packaging applications.*Critical Reviews in Food Science and Nutrition, 47*(4), 411-433.

Sadasivuni, K. K., Ponnamma, D., Kim, J., & Thomas, S. (2015). Graphene besed polymer nanocomposites. In K. K. Sadasivuni, D. Ponnamma, J. Kim & S. Thomas (Eds.),*Graphene based polymer nanocomposites in electronics* (5th ed., Vol. 5, pp. 1-383). Switzerland: Springer.

Saputra, A. H., Qadhayna, L., & Pitaloka, A. B. (2014). Synthesis and characterization of carboxymethyl cellulose (CMC) from water hyacinth using ethanol isobutyl alcohol mixture as the solvents. *International Journal of Chemical Engineering and Applications, 5*(1), 36-42.

Sharma, C., Dhiman, R., Rokana, N., &Panwar, H. (2017).Nanotechnology: An untapped resource for food packaging.*Frontiers in Microbiology, 8*(2), 1735-1740.

Sherwood, p. (2001). Carbons and graphites: Surface properties of. *Encyclopedia of Materials: Science and Technology*, *25*(2), 985-995.

Shameli, K., Ahmad, M. B., Zargar, M., Yunus, W. M. Z. W., Ibrahim, N. A., Shabanzadeh, P., & Moghaddam, M. G. (2011). Synthesis and characterization of silver/montmorillonite/chitosan bio-nanocomposites by chemical reduction method and their antibacterial activity. *International Journal of Nanomedicine,6*(2), 271-275.

Sheikh, J., Bramhecha, I., & Teli, M. (2015). Recycling of terry towel (cellulosic) waste into carboxymethyl cellulose (CMC) for textile printing. *Fibers and Polymers, 16*(5), 1113-1118.

Shi, B. (2016). Transmission electron microscope. *Young Scientists Journal, 18*(2), 33-38.

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Shin, W. H., Jeong, H. M., Kim, B. G., Kang, J. K.,& Choi, J. W. (2012). Nitrogen doped multiwall carbon nanotubes for lithium storage with extremely high capacity. *Nano Letters, 12*(5), 2283-2288.

Silva, S., Almeida, A. J., & Vale, N. (2019). Combination of cell-penetrating peptides with nanoparticles for therapeutic application: A review. *Biomolecules, 9*(1), 22-26.

Singh, S., Guchhait, P., Bandyopadhyay, G., & Chaki, T. (2013). Development of polyimide nanosilica filled EPDM based light rocket motor insulator compound: Influence of polyimide nanosilica loading on thermal, ablation, and mechanical properties. *Composites Part A: Applied Science and Manufacturing, 44*(13), 8-15.

Sinha Ray, S. (2012). Polylactide-based bionanocomposites: A promising class of hybrid materials. *Accounts of Chemical Research, 45*(10), 1710-1720.

Sondi, I., & Salopek-Sondi, B. (2004). Silver nanoparticles as antimicrobial agent: A case study on E. coli as a model for gram-negative bacteria.*Journal of Colloid and Interface Science, 275*(1), 177-182.

Sorokin, A. V., Kuznetsov, V. A., & Lavlinskaya, M. S. (2021). Synthesis of graft copolymers of carboxymethyl cellulose and N, N-dimethylaminoethyl methacrylate and their study as Paclitaxel carriers. *Polymer Bulletin, 78*(6), 2975-2992.

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