A STUDY ON BIONANOCOMPOSITES

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Abstract - These days, the quick worldwide environmental change is creating a dangerous atmospheric deviation. Water contamination and destructive gas outflows are to a great extent brought about by the broad utilization of synthetic substances derived from oil and petroleum derivative and accordingly the consuming of plastic materials. The specialists from way across the world have referenced that the dumping of plastic waste and non-biodegradable materials is the essential issue of the contamination. To take care of this issue cellulose and different other biodegradable materials may be potential other options. This article contains the importance of Bio nanocomposites (BNC's), strategies for amalgamation of Bio nanocomposite, the ongoing turns of events and utilizations of naturally well-disposed nano-with miniaturized scale organized polymeric materials like chitin, starch, polycaprolactone and nanocellulose.

Key Words: *Global warming bio nanocomposites, Nanocellulose, nano- with micro-structured polymeric material.*

1. INTRODUCTION

In the recent few years, Nanocomposites mixed biopolymer creates a new grade of materials called Bio nanocomposites (BNCs). The nanostructure of a material is assumed as a critical job in the progression of properties and controlling the structure at the nano scale. Nano-sciences is a profoundly potential field, as it has imaginative applications in the fields of semiconductors, inorganic, and biotechnology [1]. Nanotechnology is comprehensively characterized as the creation; preparing, portrayal and use of material gadgets and framework with measurement inside the scope of 0.1-100 nm. Nanocomposites can be made with an improved physical, thermal and other interesting property [2].

II. PREPARATION OF BIONANOCOMPOSITE

Bio nanocomposite can be produced using various methods which are as follows,

1. Solution intercalation

In this procedure, the bio-polymer, model starch and protein is included into the dissolvable shaping a homogeneous blend. The inorganic nano fillers, for example, silicate platelets which are swollen in a dissolvable like water, chloroform or toluene. When the biopolymer and arrangement of swollen nanoparticles are blended, the polymer chains intercalate and dislodge the dissolvable in the middle of the layers of the silicate. Upon dissolvable evacuation, the intercalated structure remains, bringing about a creation of a layered silicate bio-nanocomposite [3,4]

2. Melt mixing

A polymer is heated at the grade-appropriate temperature till it achieves molten state and so its mixed with the nanoparticles to dispense them properly within the polymer matrix. The preparation is usually done using a extruder. This melt-mixing method can be applied only for thermoplastics. Proteins, like soy plant, wheat gluten, corn zein, caseinate, whey, and gelatin, match the necessity. PHAs is also one such the material that is being worked by the extrusion. Starch is an exception, but in its actually a form the polysaccharide is not a true thermoplastic material. It is converted into a thermoplastic-like state by mixing plasticizers at 90–180 °C. As the nanoscale particles, natural layered clay minerals are frequently used. The conditions of extrusion treatment make it possible to supply the great intercalation of macromolecules within the integralities of closely stacked silicate sheets and their exfoliation into individual nanoplatelets. it's convenient for the preparation of bio nanocomposite on lab to commercial scales.

3. Template synthesis

In this method, biomolecules, parts and whole cells, microorganisms function the template for inorganics which are generated from a precursor. The templating bio organics is in nanosized particle which is entrapped in mesoporous matrix. This method is very versatile. This can be a straightforward and simple procedure and applicable for large scale production. This method requires mostly water-soluble polymers and therefore the resulting product may have chances of contamination because of side product [4-6].

III. CONSTITUENTS OF BIONANOCOMPOSITES

1. Biomaterial

They are obtained from plants, animals and microorganisms and mostly contains cellulose, lignin and hemicellulose.

Nanocellulose has gained significant amount of attention among food packaging industry as a nano-reinforcement for polymer matrices, mainly which are biodegradable. Derived from the foremost galore polymeric resource in world and with inherent biodegradability, nanocellulose is an gripping nanofiller for the development of BNC's processed by traditional processing methods. because of the high number of hydroxyl groups on its surface, nanocellulose is easy to control, mainly to enhance its dispersion within the polymer matrix. A well-dispersed nanocellulose can enhance various properties of polymers, including thermal, mechanical, barrier, and surface wettability properties, as well as control of active compound release, etc.

a. **Chitosan:** it's a natural polysaccharide containing a large number of amino (-NH2) and hydroxyl (-OH) groups. Chitosan is a linear copolymer which is be synthesized from the deacetylation of chitin. it's a β (1-4) linked linear copolymer consists of 2-acetamido- 2-deoxy-D-glucopyranose and 2-amino-2-deoxy-D-glycopyranos. Its structure is extremely similar to cellulose [7]. it has many biological applications because of its unique chemical properties, electric charge, presence of reactive hydroxyl, and amino group. Chitosan has excellent physiochemical attribute like bio adhesive, biocompatible, and biodegradable. in order to extend the chitosan potential for biomedical applications, Chitosan derivative is produced by incorporating organic and inorganic polymers. Chitosan derivatives have increased tensile strength, swelling rate, water vapor permeability, and wettability of matrix. Synthesis of chitosan nanoparticles is one of the major focus of contemporary nanotechnology research because it has several inherent properties like bactericidal, fungicidal activity, and wound healing potential.
b. **Poly lactic acid (PLA)**: Poly Lactic Acid (PLA) is one of the most widely produced bioplastics. It is also known as Poly lactide. It is a linear thermoplastic polymer mainly derived from biodegradable materials such as corns or sugar beets, etc. It has various applications such as medical devices, food, packaging, textiles and 3D printing technology [8].
c. **Starch:** It has two components amylose and amylopectin. Mostly starch's main function is storing of energy in plants and microorganisms. Potato, Maize, Tapioca, Wheat are few of the natural sources of starch [8].
d. **Chitin:** Chitin is modified cellulose that has a high molecular weight and is synthesized from N-acetylglucosamine units. It is an effective binder in dyes and fabrics [8].
e. **Polyhydroxyalkanoates (PHA):** Polyhydroxyalkanoates (PHA) belongs to a family of naturally occurring hydrophobic, biocompatible, and biodegradable polyesters. It is available in a wide variety of forms and used for carbon or energy storage in microorganism in the form of light refracting granules inside the cell [8].

2. Nanoparticles [14]

They are in nano size (1 to 100 nm). Nanoparticle exist in spherical, tube and platelets.

a. **Layered silicates:** they are clay minerals and a part of a class of silicate minerals & phyllosilicate. Layered silicates is a combination of natural and synthetic clays such as mica, bentonite, laponite, magadiite and fluorohectorite.
b. **Nanotubes:** there are many types of nanotubes but most commonly used is carbon nanotubes. They are allotropes of carbon and belong to fullerene structural family. The diameter of nanotubes is in a nanoscale, but in few cases in millimetre or in centimetre. carbon nanotubes- reinforced composites can be used for developing Light-weight material.
c. **Spherical particles:** It is mostly in spherical shape. It can be obtained by sol-gel process. The properties are such as good thermal stability, mechanical properties (strength, elastic modules and dimensional stability) and permeability.

IV. Characterization of Bio nanocomposites

A number of tests can be carried out to check the characteristics of BNC's, few of them are,

a. X-Ray Diffraction (XRD)- study of formation of single phase, structural parameters.

b. Scanning Electron Microscopy (SEM)- study of the surface morphology of particle.

c. Energy Dispersive X-ray Spectroscopy (EDS)- chemical composition analysis.

d. Transmission electron microscopy (TEM)- to determine the particle size.

e. Fourier-transform infrared spectroscopy (FTIR)- study of stretching and bending vibrations.

f. Vibrating Sample Magnetometer (VSM)- study of magnetic properties of samples.

g. Dielectric studies- study of AC conductivity of the samples.

h. DC conductivity- study of activation energy of the samples.

i. UV visible spectroscopy- study of energy gap of the samples.

j. Thermal study-Thermal study of bio nanocomposite can be studied by differential scanning calorimetry. It can prove that whether the nanoparticles are homogenously entrapped within polymer or not.

V. Applications of Bio nanocomposites

1. The nanocomposite materials can be applicable as catalysts, gas-separation membranes, contact lenses and bioactive implant materials [9].

2. BNC's are used in fabrication of scaffolds, implants, diagnostics and biomedical devices and drug-delivery systems.

3. Ahemad et al (2017), focused on the application of Chitosan centered BNC's specifically in field of tissue engineering, drug and gene delivery, wound healing and bio imaging [7].

4. Stodolak et al (2009), study proved a possibility of nanocomposite fibers in medical applications. She successfully modified the calcium alginate fibers with the nanofillers which creates a new avenue in tissue regeneration [10].

5. Tamayo et al (2016), developed the copper polymer nanocomposites which is excellent and cost-effective way for preventing foodborne diseases and nosocomial infections [11].

6. Polymer nanocomposites used in gene delivery for purpose of anticancer drug delivery, DNA transfection, siRNA and DOX delivery, CPT drug and report [12].

7. Kumar et al (2010), prepared and characterized the bio-nanocomposite films based on soy protein isolate and montmorillonite using melt extrusion. These bio-nanocomposite films could be used for packaging of high moisture foods (fresh fruits and vegetables).

8. Cherian et al (2011), developed the cellulose nanocomposites with the help of nanofibers which is isolated by pineapple leaf fibers. The developed composites were utilized to fabricate various versatile medical implants. Pineapple leaf fibers derived nanocellulose embedded polyurethane has been utilized as an attractive and readily available range of materials for the fabrication of vascular Prostheses and used for to make heart valves and coronary stent in the cardiovascular system [13]. BNC's mostly applicable in development of cardiovascular stent [14].

9. It can be used in manufacturing of compostable bags which is need of the era [28].

10. Biopolymer-based nanocomposite can be of help in a treatment on Osteomyelitis, by the regeneration of tissue [15].

11. H.P.S. Abdul Khalil et al (2016), wrote about nano cellulosic fibers as new material for sustainable packaging: Process and applications

12. Andrés Felipe Ochica et al (2017), where the author writes about Cellulose acetate nanofibers that were obtained by electrospinning method, with an average diameter of 258 nm from the bagasse of sugar cane. By minimizing the injection rate, they obtained finer fibers without clusters and with better properties. Cellulose acetate from sugarcane bagasse is comparable with that from the Aldrich brand, according to the DSC and TGA.TGA presents loss between 325◦ C-390◦ C this is due to a phenomenon of fusion of cellulose derivative. On the basis of the characterization these nanofibers can be used as a material for biofilters.[18]

13. Alexander Ach (2006), writes "Cellulose acetate-based biodegradable plastic is a promising alternative to many of the known mass-produced plastic materials. Compared with other biodegradable materials, it is relatively resistant and, in the form of sheets, films, or shaped bodies, its properties are hardly different from those of "classical" plastics. With regards to waste disposal, appropriate logistic systems are still lacking for any kind of biodegradable material. "[17]

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