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Review on Green Polymer Nanocomposite and Their Applications

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ABSTRACT: The present paper study about the green polymer nanocomposites (GPNCs), through this paper we study of bio-reinforced composites in automotive, construction, packaging and medical applications due to increased concern for environmental sustainability. In the study of Green polymer nanocomposites we learned unique properties of combining the advantages of natural fillers and organic polymers. Plant fibers are found suitable to reinforce polymer. They are also biodegradable and are annually renewable compared to other fibrous materials. This paper reviews efforts, techniques of production, trends and prospects in the field of green polymer nanocomposites.

KEYWORDS: Green Polymers, Plant Fibers, Properties, Applications, Environmental friendly, Starch Based Resin 11C.

I. INTRODUCTION

Research efforts are geared to the development and application of environmentally friendly and sustainable bio-reinforced composites for use in automotive, construction, packaging and medical fields. It has been reported [1, 2]. That addition of nanoparticles to base polymers confers improved properties that make them usable in automotive, construction and medical areas. Properties which have been shown to improve substantially are mechanical properties (e.g., strength, elastic modulus and dimensional stability), thermo mechanical properties and permeability (e.g., gases, water and hydrocarbons). Polymer nanocomposites are new class of particle filled polymers for which at least one dimension of the dispersed particles is in the nanometres range. Nanocomposite materials consisting of polymeric matrix and nano-scale particles have offered a great opportunity in thermoplastic and rubber industry to make new products/applications with enhanced/unique properties. Although applications of polymeric nanocomposites grow significantly due to the potential capability of addressing current challenges faced in the polymer industry, the potential impact of polymeric nanocomposites on environment should be considered. Nanocomposite is a class of composites in which the dimensions of the reinforcing material are in the order of nanometers. Because of this nanometres size characteristic, nanocomposites possess superior properties than the conventional composites due to maximizing the interfacial adhesion.

In the past, major interest has been in the use of synthetic materials such as aliphatic polyesters, aliphatic-aromatic polyesters, polyvinyl alcohols, polyester amides, polystyrene, nanoclays, glass and carbon fibers and carbon nanotubes etc for the production of nanocomposites. The use of these materials, however, presents great challenges [3, 4, 5].

The use of polymer composites from renewable sources has advantages over synthetic sources, particularly as a solution to the environmental problems generated by plastic waste [6]. They offer alternatives to maintaining sustainable development of economic and ecologically attractive technology [7]. Green composites is today widely

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researched because of the need for innovations in the development of materials from biodegradable polymers, preservation of fossil based raw materials, complete biological degradability and reduction in the volume of carbon dioxide release into the atmosphere. Application of agricultural resources (wastes and products) for the production of green materials is some of the reasons why green composites have attracted tremendous research interests [7]. The use of these biocomposites is expected to improve manufacturing speed and recycling with enhanced environmental compatibility [6].

Polymer/clay nanocomposites based on traditional thermoplastics such as polypropylene (PP), polyethylene (PE), nylon and polyethylene terephthalate (PET) in packaging and structural applications will contribute to the biodegradability (within a defined manner) in addition to the improvement in barrier properties. However, Green nanocomposite derived from bio plastics such as polylactic acid (PLA) Polyhydroxyalkanoate (PHA), starch etc. and with nanomaterials such as layered silicates is an environmentally attractive substitute for conventional polymeric nanocomposite based on petroleum feedstock.

Paper is organized as follows. Section II describes automatic text detection using morphological operations, connected component analysis and set of selection or rejection criteria. The flow diagram represents the step of the algorithm. After detection of text, how text region is filled using an Inpainting technique that is given in Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

II. PROCESSING METHODS OF NANOCOMPOSITES

Many methods have been employed for the production of nanocomposites in an attempt to achieve optimum dispersion of fibers in the matrix.

Extrusion followed by injection molding has been used [8,9]. Although the effect of the method on the properties of the resulting composite has not been reported, it is believed that the process method leads to better exfoliation of fibers in the matrix. Melt extrusion is another method frequently been used [10,11].

Some of the widely used methods for manufacturing conventional composite parts are wet lay-up, pultrusion, resin transfer molding (RTM), vacuum assisted resin transfer molding (VARTM), autoclave processing, resin film infusion (RFI), prepreg method, filament winding, fiber placement technology, etc. [12]. Wet lay-up is a simple method compared to other composite manufacturing methods; it allows the resin to be applied only in the mold, but the mechanical properties of the product are poor due to voids and the final product is nonuniform. Pultrusion is a low cost continuous process with a high production rate. But near the die assembly, the prepreg or Review article: Polymer-matrix Nanocomposites: An Overview 1515materials accumulates and can create a jam. Voids can be also created if the dies run with too much opening for the fiber volume input. Moreover, a constant cross section is a limitation of this process [12].

The one step in-situ polymerization method involves the dispersion of nanofillers in monomer(s), followed by bulk or solution polymerization. The nanofillers are always modified by functional groups to increase the interaction between the polymers and the nanofillers, or to get a good dispersion in the polymer matrix. This method has been reported to have many advantages, such as ease of handling and better performance of the final products [13,14].

III. REVIEW OF GREEN POLYMER

Materials are said to be ‘green’ when they are biodegradable and renewable. The major attractions about green composites are that they are environmentally friendly, fully degradable and sustainable in every way. At the end of their service life they can be easily disposed of or composted without harming the environment. The challenge of green composite involves basically the challenge of obtaining ‘green’ polymers that are used as matrix for the production of the composites. Polymer is said to be green when it possesses environmentally favourable properties such as

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renewability and degradability. Biodegradation implies degradation of a polymer in natural environment that includes changes in the chemical structure, loss of mechanical and structural properties and changing into other compounds that are beneficial to the environment [11,15].

Green polymers, on the other hand, are those produced using green (or sustainable) chemistry, a term that appeared in the 1990s. According to the International Union of Pure and Applied Chemistry (IUPAC) definition, green chemistry relates to the "design of chemical products and processes that reduce or eliminate the use or generation of substances hazardous to humans, animals, plants, and the environment." Thus, green chemistry seeks to reduce and prevent pollution at its source. Natural polymers are usually green.

A vast number of biodegradable polymers (e.g. cellulose, chitin, starch, polyhydroxyalkanoates, polylactide, polycaprolactone, collagen and other polypeptides…) have been synthesized or are formed in natural environment during the growth cycles of 2 Biodegradable Polymers 15 organisms. Some micro organisms and enzymes capable of degrading such polymers have been identified [16,17]. A number of natural and other degradable polymers have been used in green composites and some of these are discussed below.

A. THEROPLASTIC STARCH BASED COMPOSITES:

Thermoplastic starch properties also appear to benefit from silica addition. Tang et al [21] have reported that inclusion of dry powder SiO2 particles in starch PVOH films increased tensile strength at break and improved water barrier properties. Xiong et al [22] have reported improved mechanical properties, transmittance, and water resistance of starch films containing nano-SiO2 particles.

Earlier researches of thermoplastic starch based composites focused on the use of plasticized starch as matrix for green nanocomposites. De Carvalho et al. [18] first reported the use of thermoplastic starch for the production of composites by melt intercalation in twin screw extruder. The composites were prepared with regular cornstarch plasticized with glycerine and reinforced with hydrated kaolin. The study recorded significant increase in the tensile strength from 5 to 7.5 MPa for the composite with 50 phr clay composition. The modulus of elasticity increased from 120 to 290 MPa while the tensile strain at break decreased from 30 to 14%. The maximum value for the modulus of elasticity observed and the tensile strength corresponded to the maximum quantity of clay that was incorporated in the matrix. Above which the authors noted that increase in the amount of filler increases the fragility of the composite.

Thermoplastic starches are beginning to show increased commercial use. There are many challenges still to be overcome in order to make commercially viable biodegradable and compostable starch polymers. Thermoplastic starch films generally need to have starch content greater than 70% to have biodegradable or compostable action [19]. The term composite refers to matrix polymers that contain dispersed conventional filler, such as glass, fibres, talc or clay particles. Polymers with fillers that are nano-sized in scale are named nano-composites. The properties of a composite depend on the volume fraction of the filler, its shape, size and interfacial adhesion [20].

Starch Based Resin 11C is a biodegradable and compostable resin based on a blend of thermoplastic starch (TPS). Starch based resin11C is a completely biodegradable polymer suitable for the manufacturing of film type products. It can be directly used in the film blowing process. It does not contain any non degradable polymer such as PE, PP, PS and PVC.

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Fig.1 Thermoplastic starch based resin 11C

B. POLY LACTIC ACID BASED COMPOSITES:-

Ogata et al. [23] in their study prepared nanocomposite using poly lactic acid (PLA). PLA/ organically modified clay (OMLS) blends were made by dissolving the polymer in hot chloroform in the presence of dimethyl distearyl ammonium modified MMT (2C18MMT). X-ray diffraction results of PLA/MMT show that the silicate layer forming the clay could not be intercalated in the PLA/MMT blends when prepared by the solvent-cast method. The clay existed in the form of tactoids with several stacked silicate monolayers.

The polylactic acid (PLA) has caught the attention of polymer scientist and proving to be a viable alternative biopolymer to petrochemical based plastics for many applications. PLA is produced from lactic acid, that is derived itself from the fermentation of corn or sugar beet and due to its biodegradation ability, PLA present the major advantage to enter in the natural cycle implying its return to the biomass.

Studies on the thermal, mechanical and morphological properties of PLA-based composites have been reported by Lee et al. [24]. Composites were prepared by melt compounding and injection molding. Thermal degradation, thermal transition, morphological, and mechanical properties of the composites were evaluated. Tensile modulus of the composite increased from 62.5 to 169.5% contrary to the earlier studies where no improvement was recorded. More recently, nanocomposite of PLA with a compatibilizer and cellulose fibrils have been developed by Qu, et al. [25]. The composites were obtained by solvent casting methods using N,N-Dimethylacetamide (DMAC) and characterized PLA reinforced with cellulose nanofibrils resulted in no improvement in tensile strength (30 MPa compared with PLA) and percent elongation (2.5% compared with pure PLA) of the composites. The authors attributed this to the poor interfacial bonding between cellulose nanofibrils and the PLA marix.

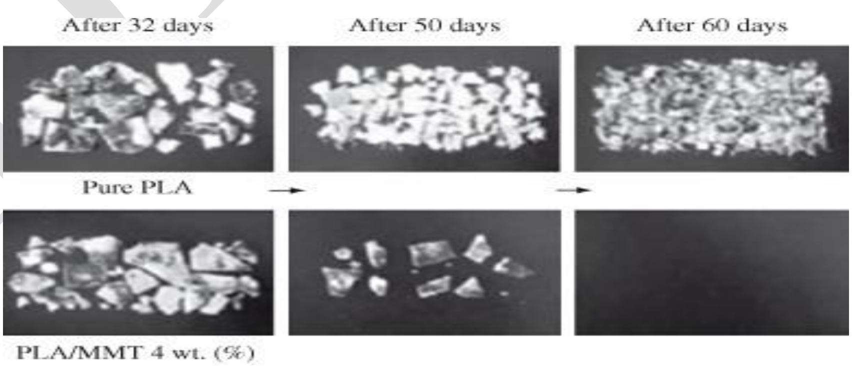

Fig.2 biodegradability studies for neat PLA/MMT 4 wt (%)

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C. Cellulose Based Composites:-

Cellulose from agricultural products has been identified as a source of biopolymer that can replace petroleum polymers. Green nanocomposites have been successfully produced from cellulose acetate (CA), triethyl citrate (TEC) plasticizer and organically modified clay via melt compounding [26]. All cellulose nanocomposites prepared by partially dissolution using ionic liquids were studied for tendon and ligament applications. Compares the micro structural morphology of undissolved nanofiber networks with those after dissolution. The undissolved network shows layer of nano fibers with homogeneous morphology. The partially dissolved composites showed core shell morphology with more dissolution on the surface layers.

Tensile strength and modulus of cellulosic plastic reinforced with 10 wt% organoclay improved by 75 and 180% respectively. Thermal stability of the cellulosic plastic also increased. Cellulose was obtained from cotton pulp via acid hydrolysis using a solution of Lithium chloride and N, N-dimethylacetamide. Nanoscaled polypyrrole was used as the second component of the nanocomposite. Nanocomposites were prepared by polymerization induced adsorption process.

D. Other Biopolymer Based Composites:-

Other biopolymers used in nanocomposites synthesized are Polyhydroxyl butyrate (PHB)—a natural occurring polyester produced by numerous bacteria in nature, Gelatin—a biopolymer obtained by thermal denaturation of collagen isolated from animal skin and bones with dilute acid and Chitosan—a natural polymer found in exoskeletons of crustaceans and insects and in the cell wall of fungi and micro organisms [27-30].

IV. APPLICATION OF GREEN POLYMER NANOCOMPOSITES

Nanocomposites have been used in several applications such as mirror housings on various vehicle types, door handles, door panels, trunk liners, instrument panels, parcel shelves, head rests, roofs, upholstery and engine covers and intake manifolds and timing belt covers. Other applications currently being considered include impellers and blades for vacuum cleaners, power tool housings, mower hoods and covers for portable electronic equipment such as mobile phones, pagers etc [1,6] Honeywell developed commercial clay–nylon-6 nanocomposite products for drink packaging applications [31]. Starch Based Resin 11C is a biodegradable and compostable resin based on a blend of thermoplastic starch (TPS). The basic applications of the starch based resin 11C is to making Compostable bags (Shopping bags/Check-out bags, Green bin liners) and Produce and meat liners (Overwrap Packaging, Mulch film, Breathable film).

V. CONCLUSION

So the finally the aim of our study was to gather the innovation and developments in technologies for accomplishing the green polymer nanocomposites. During the study, it is observed that the natural fiber reinforced composites using biodegradable polymer as matrix are considered as most environmentally friendly material. So the properties such as renewability and degradability, a series of interesting polymers have been realized through multiple research activities ranging from thermoplastic starch and its blends, PLA and its modifications, cellulose, gelatine, chitosan, etc. Natural fiber being preferred over synthetic fibers for environmental reasons has also been synthesized from agricultural sources such as kenaf, jute, hemp, flax, banana, bamboo, sisal and coconut coir, etc. There is thus a wide range of possible applications of nanocomposites. The objective of this study was to provide additional insight into the relationship between green polymer product innovation, firm performance, and competitive capability by examining the moderator effect of managerial environmental concern. It showed that green polymer nanocomposites product innovation is generally positively affects firm performance and competitive capability.

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