Revista Publicando, 5 No 12. (2). 2017, 681-688. ISSN 1390-9304

Composite in Fibber Production and Its Application in Nanotechnology

FahimeAlipoor[1,2*], Mehran Sadeghi[3] , Mikael Abolghasemi[1,2]

1*. Chemistry and Petrochemical Engineering Research Group, Bandar abbas branch, Institute of Standards and Industrial Research, Hormozgan, Iran

Alipour.fahime@gmail.com

2. Young Research and Elite Club, Bandar Abbas Branch, Islamic Azad University, Hormozgan, Iran

Mehran.sg91@gmail.com

3. Department of Mechanical Engineering, Faculty of Engineering, Mashhad Branch, Islamic Azad University, Khorasan Razavi, Iran

Mikael.a64@gmail.com

ABSTRACT

Nanostructure fibers composite are fibers that nanoscale fillers such as nanoparticles are used in their preparation. In fact, due to the unique intrinsic properties of nanomaterials including large surface area, porosity, stability, permeability, etc., special opportunities for the production of fibers composites with specific performance is provided. It is thus possible with the use of nanomaterials with unique properties of nanoscale dimensions, high volume surface area, etc., produce conventional fibers with better properties and more practicality.

keywords: Composite- Fibers- Nanotechnology

Received: 20-01-2018
Approved: 10-07-2018

Revista Publicando, 5 No 12. (2). 2017, 681-688. ISSN 1390-9304

1. INTRODUCTION

Fibers composite are a combination of two or more substances in order to achieve better fibers properties. To improve the properties of fibers various methods such as chemical modification, blending with other polymers or nanoparticles can be used. Usually by modifying the physical structure of the fibers by improving methods of spinning and stretching conditions, or with reinforcing fibers using a variety of filler materials with remarkable properties, fibers can be produced with the desired features. Fortunately, with the advent of nanotechnology in the twentieth century, it is possible to produce a variety of fibers composite with improved properties (1). Generally there are two approaches in the field of application of nanotechnology in the production of fibers composite which are shown in Figure.

2. FIBERS COMPOSITE BASED ON NANO PARTICLES

The material in various fields, including biotechnology, sensors, smart materials, filtration, etc. is used [2]. Used nano materials production of fibers composite can have organic origin (such as nano cellulose and carbon nano tubes), inorganic (silica, silver nano particles, titanium dioxide) or a combination of both [3]. However, the use of an organic or inorganic nanostructures or even a combination of both in the production of fibers, results in development ofmultipurpose properties in themand increases their application.

2-1 Different types of nano particle fibers composite

The most important nanostructures used in production of fibers nano composite includes:

2-1-1 fiber composite based on nano cellulose

Cellulose is one of the most abundant natural resources and renewable biofuels, which is widely available in various forms such as trees, plants, bacteria and crustaceans. This polymer is not onlycolourless, odourless and non-toxic but also has properties such as modulus and high specific strength, biocompatibility, relative thermal stability, hydrophilic, high absorption capacity and more. Nanocrystals and Nano-fibrils cellulose and nanostructures cellulose that are used to enhance a variety of synthetic fibers. In general nano-cellulose due to large surface area, high strength and high modulus, light weight, biodegradability, non-toxicity andrenewability as an amplifier is considered to be suitable in production of fibers composite (4)

2-1-2 Fibers composite based on carbon nanotubes (CNT)

Received: 20-01-2018
Approved: 10-07-2018

Revista Publicando, 5 No 12. (2). 2017, 681-688. ISSN 1390-9304

Fibers' mechanical performance is considered as the most important key factor in the application of these materials. Amongvarious types of nanomaterials, carbon nanotubes for its mechanical, electrical and thermal conductivity properties is used as a reinforcement material for the production of fibers composite. Also a high volume ratio of CNT, makes them an ideal option for reinforcing fibers. This material has an elastic modulus between GPa 270 to 950 and fortifications around GPa 11to 63. Thusby using carbon nanotubes can reinforce the tensile strength and modulus polymer of fibers. The use of CNT in polymer fibers have effects on the physical properties of the fibers which leads to improved tensile properties, reduced thermal deformation, improved chemical resistance, increased electrical and thermal conductivity, and so forth. The fibers are produced by using melt spinning, solution spinning and electrospinning [1]. Regarding the use of carbon nanotubes in the production of fibers composite, many studies have been done. For instance, Safai& et al in 2012 investigate the mechanical behaviour of fibers composite, polypropylene/carbon nano tubes. In this study, fibers composite produced by melt spinning and the results showed an improvement in the mechanical properties of produced fibers. Kearn&et al also reinforced polypropylene fibers with single-walled carbon nanotubes in a solvent mixing and melt-spinning method and reported 40% increase in tensile strength and 55% increase in modulus. In another study, Jose &et al studied structure and properties of polypropylene fibers containing 1.5 percent multi-walled carbon nanotubes and reported changes in the structure and crystallinity of the polymer. (5)

2-1-3 Fibers composite based on metal nanoparticles and metal oxide

As described, the use of nanomaterials in the production of fibers can result in fibers composite with different functions. Recently the use of metal nanoparticles because of their special properties such as optical, magnetic, electronic, catalytic and antimicrobial is considered in preparation of nanofibers composite [6]. For example, metals such as silver and metal oxides such as titanium dioxide nanoparticles (TiO2), zinc oxide (ZnO) Calcium oxide (CaO) and magnesium oxide (MgO) used in order to achieve simultaneous antimicrobial properties, self-cleaning, and UV-resistant fibers in fibers' preparation [7].

Silver nanoparticles due to catalytic properties, electrical conductivity and excellent antimicrobial properties are widely used in the preparation of fibers composite. For example, in a recent study the production of nanofibers composite made of polyvinyl Pyrvlydn,

Received: 20-01-2018
Approved: 10-07-2018

Revista Publicando, 5 No 12. (2). 2017, 681-688. ISSN 1390-9304

polyvinyl acetate and poly acrylonitrile-based on nano-silver is studied. Also in a study Hu & et al in 2012, reported the fiberscomposite, rubber / silver produced by electrospinning method result in production of fibers with %99.9 antibacterial properties [6]. In a study conducted in 2011 by the Telli& et al., nanoparticles of zinc oxide is used as a filler in production of nanoscale antimicrobial polyester fibers composite / nano zinc oxide.Sothe fibers composites are having the polyester fibers properties and added antimicrobial properties of zinc oxide[7]. The use of nanoparticles of titanium dioxide (TiO2) due to the photocatalytic properties has been highly regarded in numerous studies. For example, Kim &et al produced polydimethylsiloxane nanofiber composite / titanium oxide nanoparticles and observed that the resulting fibers composite have high tensile strength and modulus and also due to the presence of TiO2 have special photocatalytic properties. Also, the presence of nanoparticles of TiO2 in electrospun solution of poly acrylonitrile nanofibers in Lem& et al research has led to creation of anti-UV and photocatalytic properties of the fibers composite (2) .

2-1-4- Fiber composite based on clay nano particles(Nanoclay)

Nanoclay materials are unique and used as an additive to improve the properties of polymeric materials and preparation of fibers composite. The use of clay in small amounts reduces weight, increases strength and cause a significant reduction in the passage of gases in polymers. Due to the plate shape structure, nonoclays strengthened the typical polymer materials and improves their mechanical properties such as strength, modulus and dimensional stability. The polymers mixed with clay, compared to conventional polymer materials show better fire proof properties and show less deformation inexposing to extremely high temperatures or chemicals [8]. For example, in a study conducted in 2012 by the Telli& et al on fibers composite of polyester / polyethylene / spineclay result showed more amount of clay in solution, cause more heat resistance fibers and better flame-retardant properties [9]. In another study conducted in 2007 by Richard Horks& et al, nano clay is used as an amplifier in the production of fibers composite, polypropylene / nanoclay. Fibers produced by the presence of nano clay had a high modulus and also delay in flammability (10)

2-2- Production of nano particle-based fibers composite

Received: 20-01-2018
Approved: 10-07-2018

Revista Publicando, 5 No 12. (2). 2017, 681-688. ISSN 1390-9304

The most important challenge of nanoparticles in manufacturing processes for melt spinning fiber is the low accumulation and distribution of nanoparticles in the context of main polymer fibers and conventional extruders in melt-spinning process are not directly able to create this type of mixing. So the process of mixing nanoparticles with the polymer matrix to provide nanocomposite must be done in a single step. Dispersion in the molten state, dispersion in melting andin-situ polymerization are manufacturing methods for melt spinning nanocomposite particle (11)

• Dispersion in molten state (Melt dispersion)

This method known as the most common and easiest method for producing nano composite master batch. This method does not use solvents and its industrial capabilities is high (11)

• Dispersion in solution state (Solution dispersion)

This method requires the use of solvents and the production process will be more complicated than the previous method.

• In situ polymerization (In-situ Polymerization)

This method is more complex and requires more investment. Its production cost is high as well.

After preparing the nano composite master batch using one of abovementioned three methods, the blending produced master batch in the melt spinning process is done to produce multi-structure fibers.

The following video shows the design of a two / three-part melt spinning fiber composite. Thus, by mixing polymers and nanoparticles can produced high-performance fibers such as conductive fibers based on carbon nano tubes or fibers based on aromatic nanoparticles.

3. NANO FIBRES COMPOSITE

The easiest method in production of composite nanofibers are electrospinning and electrospray method which are shown in Figure 5 (2)

There are various processes for producing nano fibres composite using an electrostatic method which include:

• The use of two or more soluble raw material for electrospinning in order to achieve multi structural nanofibers such nanofiber composite core / shell or two-component nanofibers • electrospinning polymer solution containing dispersed inorganic nanoparticles such as

Received: 20-01-2018
Approved: 10-07-2018

Revista Publicando, 5 No 12. (2). 2017, 681-688. ISSN 1390-9304

carbon nanotubes • Surface modification of electrospinned nano fibres to convert to nano fibres composite (2)

One of the most important research in the field of nanofibers composite by electrospinning, nanofiber production of composite poly caprolactone / hydroxyapatite / gelatine is a fibers composite used in the restoration of bones in biomedical engineering. In this study, high porosity and high surface area ratio regarding to manufacturing nanofibers volume resulted in improved cell adhesion and on the other hand produced fibers composite are highly flexible. The combination of hydroxyapatite and poly caprolactoneand gelatine composite nano fibers produced from it, leading to the creation of biocompatibility, biodegradability, moisture resistance, mechanical properties, restoration of bones and ... at the same time in a product(12) . The following video shows composite nanofiber production of core / shell by electrospinning method. The product is made of poly caprolactone as a shell of poly vinylidene fluoride / iron oxide which forms the core. Thus, by using electrospinning, nanofibers composites with improved mechanical and physical properties, electrical properties and thermal resistance is achieved

4. APPLICATION OF FIBER COMPOSITE

Fibers composite having multiple properties resulting from the combination of fibers and nano materials are more suitable compared to conventional fibers in terms of mechanical properties, electrical, thermal and strength. These fibers can be applied in various industries such as textile, automotive, construction, aerospace, electronics, food packaging and medical industry. The use of fibers composite are briefly(2)

5. DISCUSSION & CONCLUSION

In this paper, the application of nanotechnology in production of fibers composite was investigated. Today, with the advent of nanotechnology producing nanostructure-based fibers composite with unique features and application in a variety of fields is possible. The use of appropriate technology in production of nanofibers composite and nanoparticles as a filler in the production of fibers composite are two main approaches in application of nanotechnology in the production of fibers composite that are discussed in this article.

REFERENCES

Received: 20-01-2018
Approved: 10-07-2018

-Almaadeeh, M., Kahraman, R., Khanam, N. and Madi,N., 2012. Date palm wood flour/glass fiberreinforced hybrid composites of recycled polypropylene: Mechanical and thermal properties.Journal of Materials and Design, 42: 289-294.

-Anurag, K., Xiao, F. and Amirkhanian, S., 2009.Laboratory investigation of indirect tensile strength using roofing polyester waste fiber in hot mixasphalt. Journal of Construction and Building Materials, 23: 2035-2040.

-Chang, W.P., Kim, K.J. and Gupta, R.K., 2009.Ultrasound assisted surface modification of wood particulates for improved wood plastic composites.

Journal of Composite Interfaces, 16: 687-709.

-Cui, Y.H. and Tao, j., 2009. Fabrication and mechanical properties of glass fiber- reinforced wood plastic hybrid composites. Journal of Applied

Polymer Science, 112: 1250-1257.

-Fiori, M.A., Paula, M.M.S., Angioletto, E., Santos,M.F., Riella, H.G. and Quadiri, M.G.N., 2008.Effect of the temperature in the antimicrobial action

of the bactericide wood polymer composite-BWPC.Journal of Materials Science Forum, 19: 591-593.

-Jiang, H., Kamdem, D.D., Bezubic, B. and Ruede, P.,2003. Mechanical properties of poly (vinyl chloride)wood flour glass fiber hybrid composites. Journal of Vinyl and Additive Technology, 9: 138-145.

-Lei, Y. and Wu, Q., 2010. Wood plastic composites based on microfibrillar blends of high density polyethylene/poly (ethylene terephthalate(. Journal

of Bioresource Technology, 101: 3665-3671.

-Lei, Y., Wu, Q. and Zhang, Q., 2009. Morphology and properties of microfibrillar composites based on recycled poly (ethylene terephthalate(and high density polyethylene. Journal of Composites: Part A,40: 904-912.

-Liu, H., Wu, Q. and Zhangm Q., 2009. Preparation and properties of banana fiber-reinforced composites based on high density polyethylene (HDPE(/ Nylon-6 blends. Journal of Bioresource Technology, 100:6088-6097.

-Miraftab, M. and Lickfold, A., 2008. Utilization of carpet waste in reinforcement of substandard soils.Journal of Industrial textiles, 38: 167-174.

Received: 20-01-2018
Approved: 10-07-2018

-Oromiehee, A. and Jafarzadeh, F., 2008. Plastic-Wood Composite. The Publication of Iranian Polymer Forum, Tehran, 97p.

-Razavi Nouri, M., Jafar Zadeh Dogouri, F., Oromiehie,A. and Ershad Langroudi, A., 2006. Mechanical properties and water absorption behavior of chopped rice husk filled polypropylene composites. Iranian Polymer Journal, 15: 757-766.

Semeralul, H.O. and Rizvi, G.M., 2009.Characterization of properties of wood plastic compocites (WPC(with glass fiber reinforcements.Journal of Reinforced Plastics and Composites, 2:22-25.

-Tajvidi,M.and Takemura,A.,2009.Effect of fiber content and type, compatibili- zer , and heating rate on thermogravimetric properties of natural fiber high density polyethylene composites. Journal of Polymer Composites, 30: 1226-1233.

-Valente, M., Sarasini, F., Marra, F., Tirillo, J. and Pulci, G., 2011. Hybrid recycled glass fiber/wood flour thermoplastic composites: Manufacturing and mechanical characterization. Journal of Composites:Part A, 42: 649-657.

Received: 20-01-2018
Approved: 10-07-2018