European Journal of Research Development and Sustainability (EJRDS)
Available Online at: https://www.scholarzest.com
Vol. 3 No. 8, August 2022
ISSN: 2660-5570

PREPARATION AND PROPERTIES OF NANOCOMPOSITE AND SOME OF ITS APPLICATION: A REVIEW

Ohood Hmaizah Sabr[1]
[1]Polymers and Petrochemical Engineering Industries Department, College of Materials Engineering, Babylon University, Al-Hilla, Iraq
Email: duha.ammar1988@gmail.com.

Article history:
Received 11th June 2022
Accepted: 11th July 2022
Published: 20th August 2022

Abstract:
Nanotechnology is now considered one of the most promising areas of technological development in the twenty-first century. In this article, a review on the preparation of the nanocomposite, its type and application because polymer nanocomposites have shown a rapid multidisciplinary research development whose results can expand the applications of polymers for the benefit of many different industries.

Keywords: Nanotechnology ,Nano composite, mechanical properties, applications

1.INTRODUCTION

Since the last century, nanotechnology is one of the most exciting fields for researchers, as a number of advances have been made in this field.[1]

Nanotechnology is a technology for studying and manipulating matter with dimensions ranging from (1 to 100) nm, as this technology allows new applications . The thickness of the sheet is about 100,000 nanometers. Nanotechnology, which includes engineering, science, and technology, includes measurement, imaging, modeling and manipulation of matter at this length scale.[2]

Polymeric nanocomposites have received a lot of attention in recent years. it a type of the hybrid material which component of inorganic filler and polymer matrix at least one dimension in the nanometer size domain (100 nm) [3] [4] [5]. Since there are a large number of crosslinking sites at the nanoparticle-matrix interface, nanoparticles embedded in a soft matrix can improve the electrical and mechanical properties . Improvements in material properties are obtained if the filler material has good dispersion in matrix [6]. Because of small size and high ratio of surface to volume, the nanoparticles have properties chemical and physical that distinguish them from bulk materials. They are gaining popularity due to their potential applications in a variety of fields such as electrics, optics , ceramics, magnetism and catalysis. [7].

The well best dispersion of nanoparticles within matrix is the main condition for achieving desired performance of nanocomposite. This is a difficult problem because nanoparticles have a strong tendency to agglomerate, which can be explained by the particle's small diameter (high surface energy) [8].

2. The Composites

The Composites materials are naturally or engineered materials that consists of a mixture of two or more different materials each with its own distinctive properties (chemical or physical properties), to create a new material in a specific final structure with higher properties than the original materials [9,10]. They are often designed to provide a wide range of features , some of these characterizations are as follow : strength, stiffness ,small coefficient of expansion, ease of producing ,resistance to fatigue and complex shapes.

3.Nanocomposites

Nanocomposites are composites materials that have multiple phases including continuous phase(matrix) and discontinuous phase(reinforced) with nanoscale morphology, the reinforce phase divided into nanoparticles have nanoscale in three dimension ,nanoplatelets have one dimension nanoscale and nanotubes have two dimension. Nanocomposites have emerged as beneficial alternatives to overcome the limitations of various engineering materials today [11]. Many new materials with novel characterization (such as insulating behavior, electrical conductivity, greater strength ,elasticity, greater reactivity-features , and different color)can be generated using synthetic approaches at the nanoscale ,and the properties of these new materials do not only depend on the original material ,but also on interfacial and morphological properties [12,13].

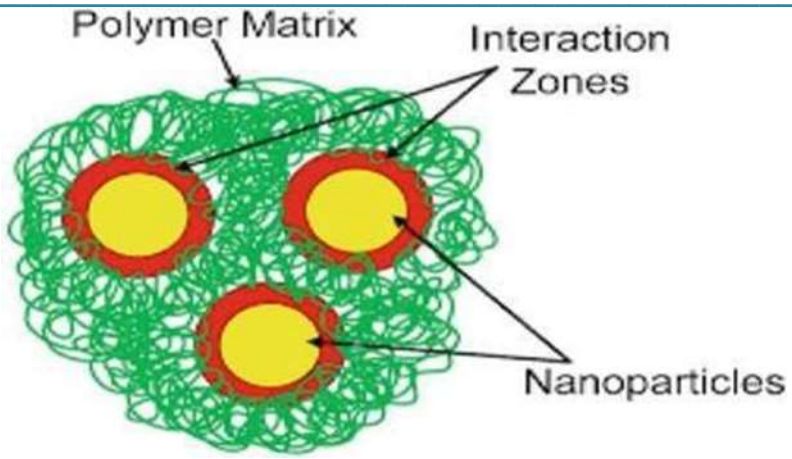

Figure 1. show the filler dispersed within the matrix in the nanocomposites. [14]

4. Classification of nanocomposites

The nanocomposite are classified according to the presence or absence of the polymer in composite. As shown in figure.2, the nanocomposites are classified into polymeric nanocomposites and non-polymeric nanocomposites (also known as inorganic nanocomposites)[15].

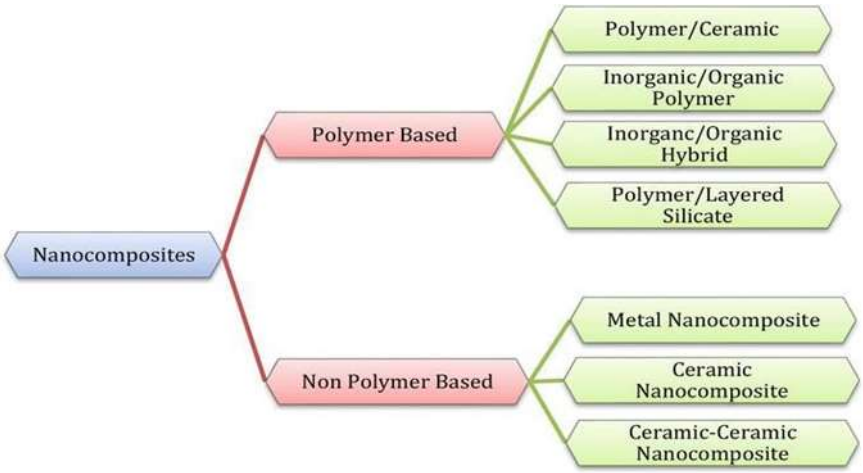

Figure 2. show Classification of nanocomposites.[15]

5.Preparation of nanocomposites

Nanocomposites have been prepared mainly by three methods:

5.1 In situ polymerization

These method is usually used for polymers that cannot be produced safely or economically using the solution methods due to the use of highly toxic solvents. These method promotes distribution and well dispersion of nanoparticles in polymer matrix [16, 17]. Also, some aspects of these method must be highlighted including the process cost, which may require some modifications to create the standard polymer. It is also necessary to be careful when choosing the right catalyst.

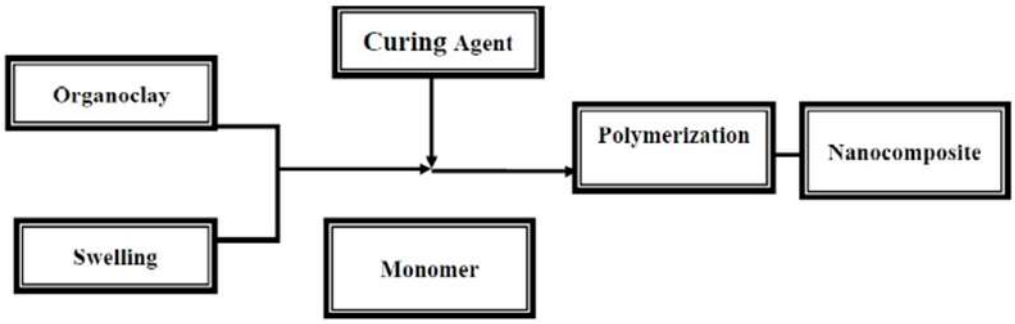

Figure 3. show diagram of in situ polymerization[18]

5.2 Solution method

When the solvent(such as acetone ,chloroform, water or alcohol) used is less toxic, this is an excellent method . Because of a good interaction between solvent and polymer, different amounts of nanoparticles can be dispersed using this method. This is the most straightforward method for producing high-quality nanocomposites. Because the solvent must be completely eliminated afterward, some caution must be exercised in its manipulation [19, 20, 21, 22]. The required apparatus is extremely simple shown in fig.4

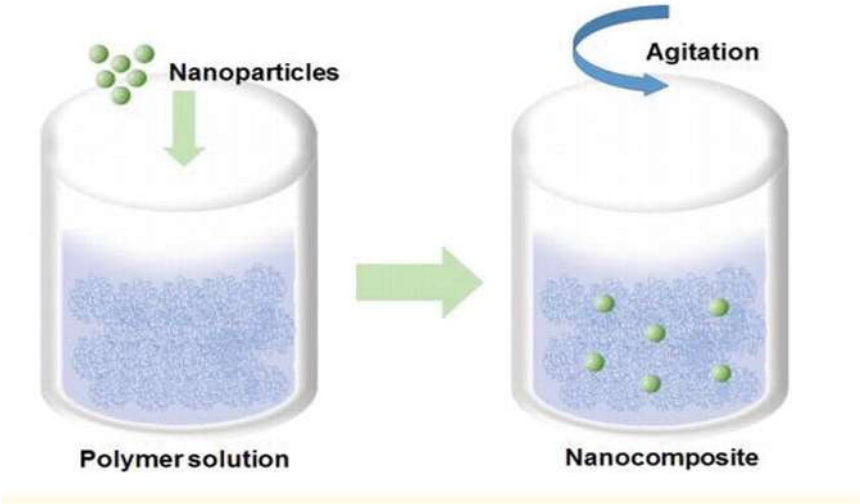

Figure.4 show the solution method of prepare nanocomposite[18]

5.3 The Melt extrusion

These method has a significant advantage over others methods because it does not require the solvent. However, the amount of nanoparticles to be dispersed is critical, because the nanoparticles agglomeration in this method more easily than other methods . The device is the same as that used to process polymer without the addition of nanoparticle. As a result, the researchers must pay attention to the temperatures used that the polymer does not degrade during extrusion, also the time required to properly disperse the nanoparticles . The degradation temperature and the melting temperature for the natural polymers and few biopolymers are very close [23, 24, 25]. Figure 6 depicts a typical extruder.

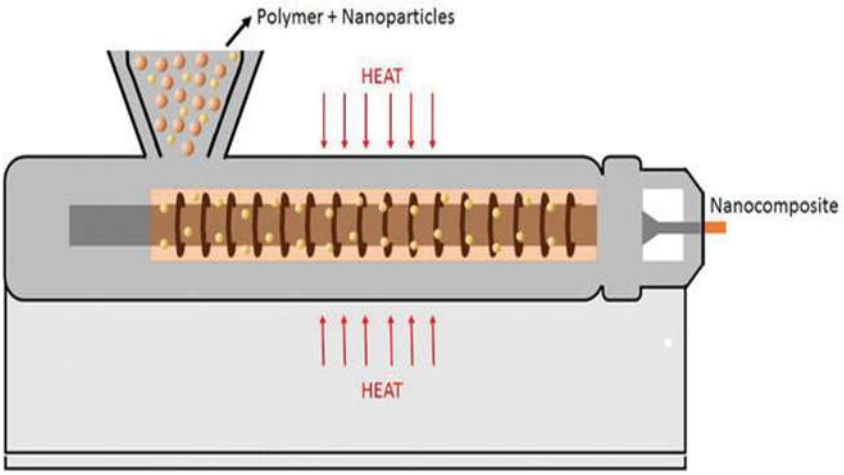

Figure 5.show typical extruder. [18]

6.Properties of nanocomposite

6.1Mechanical properties

Chan, et al. [26] preparation nanocomposite from polypropylene (PP) and calcium carbonate($CaCo_3$), the results show that addition nano-$CaCo_3$ lead to increase the modulus about (85%) and increased impact strength about (300%) of tensile test . R. Etefagha et.al [27] prepared the nanocomposite formed by addition metal oxide of zinc oxide (ZnO), titanium oxide(TiO2) ,copper oxide (CuO) to Polyvinyl Alcohol (PVA),where the result show excellent the mechanical properties of this film. Songee Beak, et.al[28] reported the tensile strength for the film from incorporated ZnO nanoparticle into Olive flounder bone gelatin increased about 6.62MPa. Sezgin Ersoy etal., [29],reported that the mechanical properties such as (tensile strength ,elastic modulus, yield strength ,elongation, hardness, and izod impact strength) decrease with disperse zinc oxide, calcium carbonate and magnesium hydroxide nanoparticles into HDPE matrix, due to the agglomeration of nanoparticle. Avalos-Belmonte's et.al.[30], prepared the Nanocomposite film from CNT and PP ,and show that the mechanical properties enhanced with addition of CNT .

Figure 6 show the effect of nano-CB, micro CB on the tensile strength of LDPE ,The tensile strength was increase at (2,4)wt.% of both nano, micro-CB while decrease at 8% CB, Conclude from figure the tensile strength improve with addition nano-CB more than micro-CB[31].Figure7 show increase the elastic modulus with increase carbon black nanoparticle, while the elastic modulus keep stable with increase micro-CB. The mechanical properties were enhancement with addition nanoparticles[31]. Table 1 show effect silica nanoparticle at (0,0.5,1,1.5)wt.% on tensile strength and elongation of the film that formed of 1PVA/1gelatin and 2pva/1gelatin , the result showed increase in TS and EAB% with increase nano-silica content.[32]

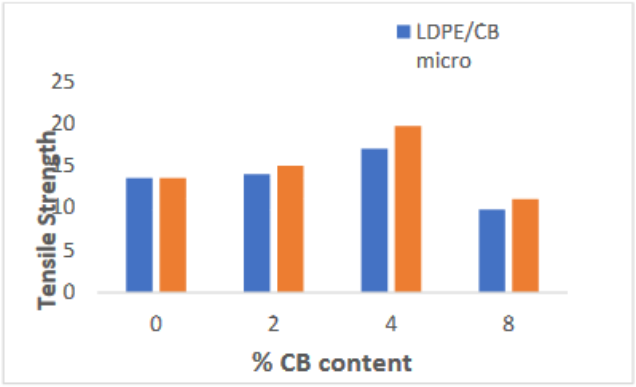

Figure 6 show the tensile strength of CB/LDPE [31]

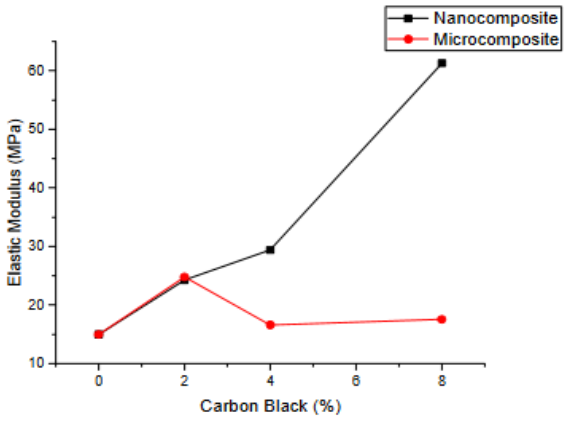

Figure 7 show modulus of elasticity of CB/LDPE[31]

TABLE 1:effect SiO_2 on tensile strength and elongation of PVA/gelatin film[32]

Films	Nano-SiO_2 (%)	TS (MPa)	EAB(%)
P1:G1	0	10.6 ± 0.36^{f}	83.6
	0.5	12.25 ± 0.47^{e}	89.2
	1	17.58 ± 0.15^{b}	116.6
	1.5	15.8 ± 0.62^{d}	145.8
P2:G1	0	13.2 ± 0.09^{e}	147.8
	0.5	15.33 ± 0.17^{d}	158.8
	1	18.05 ± 0.23^{a}	166.2
	1.5	16.1 ± 0.08^{cd}	183.5

6.2 Antibacterial properties

Radwan, T. and et.al,[33] reported that the antimicrobial test appeared effectively inhibit of the nanocomposites against E. coli and S. aureus, when addition ZnO nanoparticle and chitosan to Polylactic acid. Wu Haixia, et.al [34] reported prepare the nanocomposite film by solution blending method, these film formed from poly(vinyl alcohol)/sodium alginate/nano-TiO_2 .The antibacterial of the film increase with increase TiO_2 nanoparticle content. Elbarbary, A. M [35], reported effect Ag nanopartiical on antibacterial properties of the membrance from PVA/CS, Ag nanoparticle lead to improve the antibacterial of the nanocomposite film that formed from (PVA/CS/Ag). Table 2 show that the antibacterial of PVDF/MgO Nanocomposite film, the result show addition MgO nanoparticle at(3,5,7)% lead to improve antibacterial inhibition against S. aureus and E. coli [36].

Table 2:Zoon Inhibition Diameter Of PVDF/MgO Nanocomposite.[36]

	Zone inhibition diameter (mm)	
	S. aureus (Gram positive)	E.coli (Gram negative)
Pure PVDF	0	0
PVDF+3%n-MgO	18	14
PVDF+5%n-MgO	20	18
PVDF+7%n-MgO	27	22

6.Application of Nanocomposites

Different applications of polymer nanocomposites are shown in Figure 7 . Many number of polymer nanocomposites have been used in barrier applications, such as propylene, rubber , and styrene butadiene rubber [37, 38]. it is also used in surgical gloves and chemical protective because it has good solvent barrier properties to avoid contamination from medicines.

Figure 7. application of polymer nanocomposite

6.1 Food Packaging

The polymer-nanocomposites are also utilized in the food packaging, with specific examples including meat, dairy products, and processed cheese, as well as medical containers for transporting blood collection tubes, drinking water bottles, and baby pacifiers. The nanocomposites from clay and polymer are used in plastic bottles to improve mechanical ,barrier properties, and product life [39]. Nanocomposites are also used in the production of beer bottles to address issues such as instability of beer colloids , biological and non-biological aspects, taste changes caused by exposure to light ,and oxygen permeation.

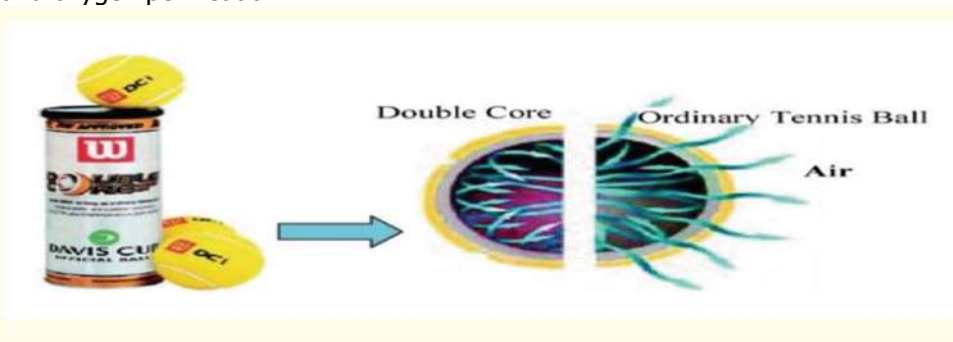

Figure 8. shows that the coating of polymer -clay covers the Wilson tennis ball

6.2 The Coatings

Coating is one of the most important surface modification properties . As a result, researchers are experimenting with a variety of methods and strategies in order to advance the properties of surface for various products. Nano-clay incorporated thermoset polymer nano-coatings exhibit properties corrosion resistance ,excellent chemical resistance, super hydrophobicity, and improved barrier properties [40]. The coating thickness is determined by process parameters : temperature, dipping time, surfactant type, and so on. The thermosetting polymer coatings with nano-clay and silver nanoparticles improvement the antibacterial properties and are used in medical sector.

6.3 The Bio nanocomposites

Bi-nanocomposites are natural nanocomposite, which are designed to meet the surrounding environmental conditions and the needs of life. The Natural materials differ in composition and structure, but the design of bio-nanocomposites necessitates considering biological molecules as synthetic building blocks, which is far removed from the context of their own natural function. They are made of inorganic solids and biopolymers with dimensions from (1-100) nm. They have a wide range of applications because of its multidimensional characterization such as (antimicrobial activity , biocompatibility, and biodegradability).

Significant reduction in the use of fossil fuels as a result of the increasing demand for biopolymers due to their being lightweight and environmentally friendly, traditional non-biodegradable petroleum-based plastics have been

easily replaced by bio-nanocomposites as they are a sustainable and long- lasting material for use in high-performance applications. they are useful for biomedical ,cosmetic and biotechnology applications Because they are biocompatible. Bio nanocomposite will be crucial sustainable materials in the future [41].

7.CONCLUSION

These article review preparation of nanocmposites ,properties and its application . The methods of prepare Nanocomposite are in-situ polymerization ,the melt extrusion and the solution method. Nanocomposite have excellent mechanical and antibacterial properties and they have applications such as food packaging, coating and bio-nanocomposite.

REFERENCES

[1] Shao Y, Xiao J, Wang W, Engelhard M, Chen X, Nie Z, et al. Sodium ion insertion in hollow carbon nanowires for battery applications. Nano Letters. 2013; 13:3909-3914 .

[2] Joseph H. Koo, "Polymer Nanocomposites : Processing, Characterization, and Applications" , Series Editor: Omar Manasreh, McGraw-Hill, New York, Chicago, San Francisco, Lisbon, London, Madrid, Mexico City Milan, New Delhi, San Juan, Seoul, Singapore, Sydney, Toronto, Manufactured in the United States of America; 2006.

[3] Werner E., van Zyl, Monserrat G., et.al "Hybrid Polyamide/Silica Nanocomposites: Synthesis and Mechanical Testing", Macromolecular Materials and Engineering, 287, 106-110, 2002.

[4] Sati N. Bhattacharya, Musa Rasim Kamal, Rahul K. Gupta "Polymer nanocomposite, theory and practice" Publishers 2008.

[5] Li W, Yang C ,Yang Z, Gu L, Yu Y. Nanoconfined antimony in sulfur and nitrogen co-doped three-dimensionally (3D) interconnected macroporous carbon for high performance sodium-ion batteries. Nano Energy. 2015; 18:pp12-19

[6] Ramirez I., Jayaram S., Cherney E. A., and Gauthier M., "Improving the dispersion onanofillers in silicone polymers by surface treatment", Proceedings of the ESA Annual Meeting on Electrostatics, West Lafayette, Indiana, USA, 2007.

[7] Maier J., Kaskhedikar NA "Lithium storage in carbon nanostructures." Advanced

[8] Thomas E. Twardowski" Introduction to Nanocomposite Materials: Properties, Processing, characterization "copyright by DES tech publications Inc. USA, 2007

[9] Shin WH, Jeong HM, Kim BG, Kang JK, Choi JW. Nitrogen-doped multiwall carbon nanotubes for lithium storage with extremely high capacity. Nano Letters. 2012; 12:2283-2288

[10] Liu X, Antonietti M. Molten salt activation for synthesis of porous carbon nanostructures and carbon sheets. Carbon. 2014; 69:460-466

[11] Wang J, Kaskel S. KOH activation of carbon-based materials for energy storage. Journal of Materials Chemistry. 2012; 22:3710-23725

[12] Wang S, Xiao C, Xing Y, Xu H, Zhang S. Carbon nanofibers/nanosheets hybrid derived from cornstalks as a sustainable anode for Li-ion batteries. Journal of Materials Chemistry A. 2015; 3:6742-6746

[13] Abdel Salam M, Mokhtar M, Basahel SN, Al Thabaiti SA, Obaid AY. Removal of chlorophenol from aqueous solution by multi-walled carbon nanotubes: Kinetic and thermodynamic studies. Journal of Alloys and Compounds. 2010; 500:87-92

[14] Ray SS, Bousmina M. Biodegradable polymers and their layered silicate nanocomposites: In greening the 21st century materials world. Progress in Materials Science. 2005; 50:962

[15] Khandoker N, Hawkins SC, Ibrahim R, Huynh CP, Deng F. Tensile strength of spinnable multiwall carbon nanotubes. Procedia Engineering. 2011; 10:2572-2578

[16] Guido Kickelbick, editor. Hybrid Materials: Synthesis, Characterization, and Applications. Federal Republic of German: John Wiley & Sons; 2007. 516 p.

[17] Mariana Sato de Souza de Bustamante Monteiro; Roberto Pinto Cucinelli Neto; Izabel Cristina Souza Santos; Emerson Oliveira da Silva; Maria Inês Bruno Tavares. Inorganic-organic hybrids based on poly (e-Caprolactone) and silica oxide and characterization by relaxometry applying low-field NMR. Materials Research. 2012;15(6):825-832. DOI: 10.1590/S1516-14392012005000121

[18] Muhammad Amin" METHODS FOR PREPARATION OF NANO-COMPOSITES FOR OUTDOOR INSULATION APPLICATIONS"Rev. Adv. Mater. Sci. 34 (2013) 173-184

[19] SILVA, Paulo Sergio Rangel Cruz da; TAVARES, Maria Inês Bruno. Solvent Effect on the Morphology of Lamellar Nanocomposites Based on HIPS. Materials Research. 2015;18(1):191-195. DOI: 10.1590/1516-1439.307314

[20] Monteiro, Mariana S. S. B.; Rodrigues, Claudia Lopes; Neto, Roberto P. C.; Tavares, Maria Inês Bruno. The Structure of Polycaprolactone-Clay Nanocomposites Investigated by 1H NMR Relaxometry. Journal of Nanoscience and Nanotechnology. 2012;12(9):7307-7313. DOI: 10.1166/jnn.2012.6431

[21] Soares, Igor Lopes; Chimanowsky, Jorge Pereira; Luetkmeyer, Leandro; Silva, Emerson Oliveira da; Souza, Diego de Holanda Saboya; Tavares, Maria Inês Bruno. Evaluation of the Influence of Modified TiO2 Particles on Polypropylene Composites. Journal of Nanoscience and Nanotechnology. 2015;15(8):5723-5732. DOI:

10.1166/jnn.2015.10041
[22] Antonio de Pádua C B Cunha, Maria Inês Bruno Tavares, Emerson Oliveira Silva, Soraia Zaioncz. The Effect of Montmorillonite Clay on the Crystallinity of Poly(vinyl alcohol) Nanocomposites Obtained by Solution Intercalation and In Situ Polymerization. Journal of Nanoscience and Nanotechnology. 2015;15(4):2814-2820. DOI: 10.1166/jnn.2015.9233
[23] Paulo S. R. C. da Silva, Maria I. B. Tavares. Intercalação por Solugão de Poliestireno de. 2013;23(5):644-648. DOI: 10.4322/polimeros.2013.047
[24] Ana Claudia S Valentim, Maria Inês Bruno Tavares, Emerson Oliveira Da Silva. The effect of the Nb2O5 dispersion on ethylene vinyl acetate to obtain ethylene vinyl acetate/Nb2O5 nanostructured materials. Journal of nanoscience and nanotechnology. 2013;13(6):4427-4432. DOI: 10.1166/jnn.2013.7162
[25] M.R. TavaresL.R. de MenezesD.F. do NascimentoD.H.S. SouzaF. ReynaudM.F.V. MarquesM.I.B. Tavares. Polymeric nanoparticles assembled with microfluidics for drug delivery across the blood-brain barrier. The European Physical Journal Special Topics. 2016;225(4):779-795. DOI: 10.1140/epjst/e2015-50266-2
[26] Chan Chi-Ming , Jingshen Wu, Jian-Xiong Li, Ying-Kit Cheung**" Polypropylene/calcium carbonate nanocomposites**" polymer, Volume 43,Issue 10,pages 2981-2992, 2002.
[27] R. Etefagha;c;e;_, S.M. Rozatia, E. Azhirb;c, N. Shahtahmasebib;c, A.S. Hosseinib;c;d and P. Madahib;c"Synthesis and antimicrobial properties of ZnO/PVA, CuO/PVA, and TiO2/PVA nanocompositesReceived 6 April 2016; received in revised form 28 August 2016; accepted 20 February 2017
[28] Songee Beak, Hyeri Kim, and Kyung Bin Song "Characterization of olive flounder bone gelatin-a nano-zinc oxide film and evaluation of its potential application in packages." Journal of Food Science 82 (11), 2643-2649, 2017 Summary
[29] Sezgin Ersoy, Münir Taşdemir, **" Zinc oxide (ZnO), magnesium hydroxide [Mg(OH)2] and calcium carbonate (CaCO3) filled HDPE polymer composites: Mechanical, thermal and morphological properties"** , Fen Bilimleri Dergisi, 24(4) (2012) 93-104,Marmara Üniversitesi, Turkey; 2012
[30] F.Avalos-Belmontes, L.F. Ramos-de Valle, E. Ramírez -Vargas , S.Sánchez-Valdes, J.Méndez-Nonel and R.Zitzumbo-Guzmán**, "Nucleating Effect of Carbon Nanoparticles and their Influence on the Thermal and Chemical Stability of Polypropylene"**, Hindawi Publishing Corporation , Journal of Nanomaterials, Volume 2012, Article ID 406214, 8 pages, Doi:10.1155/2012/406214, Mexico; 2012
[31] O.H. Sabr *, N.H. Al-Mutairi, A.Y. Layla "Characteristic of low-density polyethylene reinforcement with nano/micro particles of carbon black:a comparative study" ARCHIVES OF MATERIAL SCIENCE AND ENGINEERING,VOLUM 110,PP 49-58
[32] Mohaddeseh Kariminejad, Ehsan Sadeghi , Milad Rouhi ,Reza Mohammadi, Fatemeh Askari, Masoumeh Taghizadeh, Shirin Moradi"The effect of nano-SiO2 on the physicochemical and structural properties of gelatin-polyvinyl alcohol composite films " J Food Process Eng. 2018.
[33] Radwan, T. Rehayat, Suryani, S. Esme, Nurhaneva, S. Reskina "A mixture of poly-lactide acid and zinc oxide nanocomposites for application" IOP Conference Series: Materials Science and Engineering 830(4), 042018, 2020
[34] Haixia Wu." Preparation and characterization of ternary composite films of polyvinyl alcohol/sodium alginate/TiO2". Russian Journal of Applied Chemistry, 89(2), 287-292, 2016.
[35] Elbarbary A. M., & El-Sawy N. M. "Radiation synthesis and characterization of polyvinyl alcohol/chitosan/silver nanocomposite membranes: antimicrobial and blood compatibility studies". Polymer Bulletin, 74(1), 195-212, 2017.
[36] Asra Ali Hussein and Ohood Hmaizah Sabr "PREPARATION AND FACILITATION OF ANTIBACTERIAL ACTIVITY,HYDROPHILICITY OF PIEZO–PVDF/n-MgO FILM BY ELECTRO-SPINNING AND SPIN COATED FOR WOUND DRESSING: A COMPARATIVE STUDY" Journal of Mechanical Engineering Research & Developments (JMERD)42(4) (2019) 23-31
[37] Stankovich S, et al. Stable aqueous dispersions of graphitic nanoplatelets via the reduction of exfoliated graphite oxide in the presence of poly(sodium 4-styrenesulfonate). Journal of Materials Chemistry. 2006;16:155-158
[38] Qiuli Z, Zhenjiang J, Jun Z, Xicheng Z, Xinzhe L. Preparation of lanthanum oxide nanoparticles by chemical precipitation method. Materials Science Forum. 2012;724:233-236
[39] Basak Y, Kokuoz K, Serivalsatit BK, Olt G, McCormick E, John B. Er-doped Y2O3 nanoparticles: A comparison of different synthesis methods. Journal of the American Ceramic Society. 2009
[40] Mirosław Z, Kepinski L, Forget S, Chénais S. Preparation and Characterization of Lanthanum Oxide doped Barium Zirconate Titanate (BaZr0.1Ti0.9O3; BZT) Ferroelectric Glass Ceramics. Springer Series in Optical Sciences. p. 175. DOI: 10.1007/978-3-642-36705-2_2
[41] Vaia RA, Wagner HD. Framework for nanocomposites. Materials Today. 2004