iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** IV **Month of publication:** April 2018

DOI: http://doi.org/10.22214/ijraset.2018.4474

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue IV, April 2018- Available at www.ijraset.com

Polyimide Nanocomposites and Its Application

Priyanka Nirman, Rinki malik, Vinod kumar

Abstract: Polyimide is a polymer of imide monomers. Polyimide has properties like Thermal stability Good chemical resistance, Excellent mechanical properties, High tensile strength, Lightweight flexible, resistant to heat and chemicals. Polyimide is used in various application like EMI shielding, fuel cell, supercapicator, aerospace etc. Polyimide properties can be increased by adding filler like CNT and graphene. The syntheses of various polyimide nanocomposites including diamines and dianhydrides that have been used to make novel polyimides with unique properties, are reported in this review. Properties of polyimide like thermal properties, electrical conductivity, and mechanical properties by adding CNT and graphene is studied in this review.

I. INTRODUCTION

In this review Article, particular emphasis is given to the polyimide nanocomposite and its various application. Polyimides have been in mass production since 1955. With their high heat-resistance, polyimides enjoy diverse applications e.g. high temperature fuel cells, EMI shielding material and as supercapacitor material, and as separation membrane. Polyimide is also known as engineering plastic. In last years many work has been done by the scientists on polyimide. Mainly work was done on polyetherimide, polyamideimide, polyesterimide, etc. polyimide belongs to the class of high-temperature polymers with balanced chemical and mechanical properties in addition to superior film-forming properties. Mechanical properties ,electrical properties and thermal stability of polyimide can be improved by adding the filler. By adding the filler or forming of nanocomposites there is drastically change in the properties of polyimide can be noticed by many scientist in their research work .

Fillers like CNT, graphene, were used to increase the properties of polyimide. Mainly CNT and graphene is used as filler because of their low loading level [1]. CNTs (Carbon nanotubes) are composed of graphene sheet rolled up. CNTs is of two types SWNT and MWNT. CNTs can be considered as ultimate carbon fibers due to ultra high strength (10 to 100 GPa) and modulus (~1.0 TPa) values alongwith exceptional electrical (104-106 S/cm) and thermal properties (3000-6000W/mK) [2]. The higher intrinsic conductivity and aspect ratio of CNTs (100-5000) compared to carbon black allows the formation of conductive composites at low loading of CNTs due to low percolation thresholds (minimum loading level at which a continuous network of conducting particles is formed) resulting in achievement of better electrical conductivity and electromagnetic response at the same loading level.

Graphene is a nanoscale materials based on single/multi-layered 2-D graphene sheets have attracted much attention recently due to its unusual properties [3]. Though composite materials employing carbon-based materials are presently dominated by carbon nanotubes, the intrinsic bundling of carbon nanotubes, impurities from the catalysts and high costs have been hampering their application. It has been proposed that these problems could be resolved by incorporating single-layered graphene sheets into composite materials [4]. These novel graphene materials may offer another intriguing nanoscale filler material with low density for various composite applications.

II. SYNTHESIS OF POLYIMIDE NANOCOMPOSITES

A. Polyimide nanocomposite can be synthesis by polyamic acid precursor. which itself can be prepared by combining various type of dianhydrides and diamines. Then the nanocomposites are added and further thermal imidization for the preparation of polyimide nanocomposite. Lang Ma et al prepare polyimide graphene oxide nanocomposites by insitu polymerization in this a certain A certain amount of GO was dispersed in DMF and ODA was added, and then PMDA was added to the suspension in batches under N2 atmosphere and stirring for 24 h to get GO/PAA composites. The following thermal curing process was the same as the preparation of PI composites. PI/GO composite show the high tensil strength as compare to pure PI [5]. This reaction is shown in scheme 1

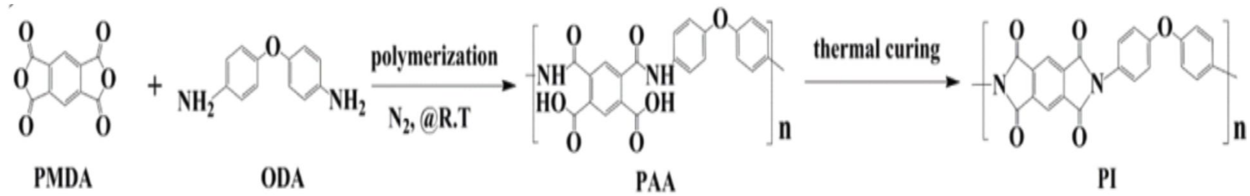

Fig 1. scheme 1

B. Hongli Yang, Zhi Yu,et al prepare composite of PI/RGO/MWCNT. Firstly, a certain amount of GO sheets and MWCNTs (the mass ratio was 1:1) were added to DMAc and then PAA solution was added . After this PAA/GO/MWCNTs/DMAc disperse system prepare and then after thermal imidization PI/Rgo/MWNTs nanocomposite obtained. this nanocomposite show high electrical conductivity ,and EMI shielding effectiveness will be enhance.

C. Xiao Chen,et al synthesis graphene fluoroxide/polyimide nanocomposite film. In this GFO-ODA was dispersed in NMP .To synthesize the PI-precursor (polyamic acid,PAA), ODA and GFO mixed and then PMDA was introduce After this GFO-ODA/PAA solution was obtained the given reaction shows in scheme 2. then thermal imidized the solution at different temperature range Upon thermal imidization, a PI composite film containing different GFO ODA loading iwas obtained . this composite show the low dielectric constant as compare to GO/PI nanocomposite .and 40% higher young modulu's than pure PI [6].

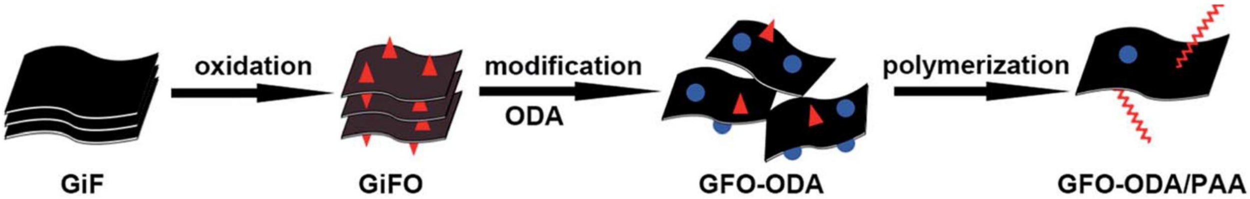

FIG 2. SCHEME 2

III. PROPERTIES OF POLYIMIDE NANOCOMPOSITES

Polyimide shows wide range of properties like electrical properties , mechanical properties , and thermal stability. Researchers work on these properties and observed that by addition of CNT and graphene on the polyimide properties of polyimide nanocomposites increases eg increase in electrical conductivity ,tensile strength , young modulu's, thermal stability etc.

A. Electrical conductivity

Yang Li, Xueliang Pei et al observed that the electrical conductivity of the polyimide was increase as the rgo content in nanocomposite is increases. the electrical conductivity for pristine PI foam is 3.8 × 10-16 S/m.but when 1wt. % rGO, is added this value increases sharply to 8.2 × 10-10 S/m, which show the high aspect ratio and electrical conductivity of rGO.49 The highest value of the PI/rGO foams reaches to 0.8 S/m when rGO loading is up to 16 wt. %.[7]. Whereas by adding GO loading of 1 wt % results in an electrical conductivity of 7.51×10^{-1} S cm^{-1}, which is 8 orders of magnitude higher than that of pure PI. The electrical conductivity of the nanocomposite film continued to increase to 6.2×10^{-5} S cm^{-1} at a GO content of 5 wt %.[8]

Wei Yuan, Jianfei Che et al observed that The electrical conductivity of neat PI is 3.5×10^{-16} S cm^{-1} .there was no increase in conductivity with the addition of 0.25 wt% MWNTs. As the MWNT loading increases from 0.25 wt% to 0.5 wt %, the conductivity Shows a sharp increase of ~8 orders of magnitude, from 6.8×10^{-16}S cm^{-1} to 8.3×10^{-8} S cm^{-1}, indicating the formation of a percolating network. The conductivity at 20 wt% MWNT loading reaches 13.3 S cm^{-1} and at 30 wt% MWNT loading, 38.8 S $cm\text{-}^{1}$ which is~17 orders of magnitude higher than that of pure PI[9].

When both CNT and graphene was used as filler in nanocomposite it observed that at the initial filler content was 0.43 vol%, the electrical conductivity of microcellular PI/RGO/MWCNTs nanocomposite increase to 5.69×10-6 S·m-1, With the filler content increasing, the electrical conductivity of microcellular PI/RGO/MWCNTs nanocomposite increased to 1.87 S·m-1 at initial filler content of 1.71 vol%. Compared with that of microcellular nanocomposite was merely 0.17 S·m-1, even at a higher filler content of 5.17 vol%.

B. Dielectric constant

when the GO content increases the value of dielectric constant decreases . The dielectric constant of the pure PI film is about 3.3. The dielectric constants of the PI composite at 5wt% GO loading was 2.0and a dielectric constant of around 2.0 was attained for a GO sheet concentration of 5 wt% in the precursor. which shows a much lower dielectric constant than that of the pure PI film[13]. but when GFO was added to the PI film composite the dielectric constant first decreases up to 2.23 but further increases by increasing the GFO content in composite[14]. The dielectric constant of the nanocomposites PI/MWNTs increases with increasing the content of MWNTs when the MWNTs content is 10 wt%, the is dielectric constant of the nanocomposites reaches 60 which is 17 times more than the pure polyimide .[10]

C. Mechanical Properties

Mechanical properties consist tensile strength and young modulu's .these properties increases as the filler loading in composite is increases. The tensile strength of porous PI is 109 MPa, lower than 118 MPa of pure PI. When the filler is GFO the maximum values of Young's modulus and tensile strength reach 4.43 GPa and 159 MPa, which are 57.7% and 34.7% higher than those of pure PI [11]. The tensile strength of microcellular PI was 18.1 MPa. When the filler loading increases the tensile strength of microcellular PI/RGO/MWCNTs nanocomposites decreases to 11.3 MPa at 8 wt% filler loading.but the Young's modulus of microcellular nanocomposites increases. Compared to that of microcellular PI, the Young's modulus of microcellular PI/RGO/MWCNTs nanocomposites was elevated from 540 MPa to 789 MPa at 8 wt% filler loading [12]. Ok-Kyung Park ,Jun-Yeon et al functionalise the graphene nanosheet with aminophenyl group. PIwith different loadings of APGNS shows increase in both tensile strength and young modulu's. The modulus of the APGNS/PI composites with 3 wt % of APGNS increased by 617% from 2.3 to 16.5 GPa as compared to that of pure PI. In addition, the tensile strength of the APGNS/PI composites was increased from 75 to 138 MPa, which is a roughly 83% increase compared to that of pure PI[18]. the polyimide/MWNTs nanocomposites have mechanical properties than the pure polyimide. the tensile strength of the nanocomposites increased at low content but decreased at high content of the MWNTs. The maximum value of tensile strength is 133 MPa At 5 wt% MWNTs loading is 40% higher than that of the pure polyimide. When the mass percentage of MWNTs is 9 wt%, the value is 108 MPa, also higher than the pure PI[10].

D. Thermal properties

Thermal stability is one of the important properties of PI-basedcomposites.thermal stability of PI/FGO is increases as the FGO loading increases at the 5% weight loss temperature increased by 17◦C than thatof the neat PI film.Tg of the composite also increases by adding different weight loading [13].the PI/GO composite also show increase in thermal stability as go loading is increases. At 3% of an initial weight loss at 220−310 °C, a major weight loss (32%) between 490 °C and 650 °C[14].the thermal stability of PI/MWNTS is decreases at different weight loss .the thermal stability of PI/MWNTs is lower than the pure PI. The Tg of composite films first increases with the GFO loading, and then decreases after the GFO loading reaches 0.60 wt%. A films have higher Tg than pure PI. Tg of GFO/pPI-2 is as high as 388 °C . The temperatures of 5% thermal weight loss (Td5%) of all GFO/pPI films are higher than 560°C[15]. The thermal stability of PI films can usually be improved by the addition of inorganic fillers. The temperature at 5 wt% weight loss (T5d) changes from 572 C for pure PI film to 582 C for 1.0 wt% GFO-ODA/PI.

IV. APPLICATION OF POLYIMIDE NANOCOMPOSITES

A. EMI shielding material

EMI is a electromagnetic interference caused by the electronic devices which is hazardous for the environment so to shield this signal coming from electronic device polyimide nanocomposites are used as ashielding material for the electronic devices polymers other than polyimide also used as shielding material but the shielding effectiveness (SE) of polyimide is higher than other polymer ,due to its high electrical conductivity, thermal stability and mechanical properties. Researcher investigated that when PI/Rgo composite foam is used the shielding effectiveness reaches to 17-21 dB in x-band at the loading 16wt.% Rgo and the thickness of the sample is 0.8mm. the EMI shielding SE of microcellular PI/RGO, PI/MWCNTs and PI/RGO/MWCNTs nanocomposites were 13.7-15.1, 13.0-14.3 and 16.6-18.2 dB .

B. Lliquid crystal alignment

One of the major applications of PIs in the photonics industry is as alignment films for liquid crystal displays (LCDs) to align LC molecules in a certain orientation with a specific pretilt angle hp, which is the angle between the LC director and the alignment films. The pretilt angle is very important and required for LC devices to obtain defect-free alignment and also to improve their electro-optical performance, such as driving voltage, response time, color performance and viewing angle. The proposed POSS(polyhedral oligomeric silsesquioxane)–PI nanocomposite films can be applied in LCDs for generating controllable pretilt angle from 0_ < hp < 90_ by modification of the surface energy of PIs through the addition of POSS.[16]

C. In filteration and separation

Electrospum PI nanofibre is used as filteration and seaperation mats/membrane and Li ion battery separator. It has been reported that PI nanofibre mats/membrane are excellent microfilteration media. Because of excellent mechanical properties and thermal stability of electrospun PI nanofiber mats/membranes is used as the separators for Li-ion batteries in electric vehicles .mechanical properties and thermal stability both are important for the battery safety.[17]

D. fuel cell

Polymer electrolyte fuel cells (PEFCs) as a new electric power source have the important applications for automobiles and residential heat and power supply among all kinds of fuel cells because of high efficiency and clean exhaust gas. sulfonated mesoporous silica nanoparticles (SMSNs)/sulfonated polyimide (SPI) nanocomposite proton exchange membranes were prepared.The mesoporous structure of SMSNs improved the water uptake of SPI membranes, and resulted in the higher proton conductivities.

V. CONCLUSION

In this review polyimide can be prepared by in-situ polymerization consisting two step reaction. In first step dianhydride and diamine reacted in presence of nitrogen medium and polyamic acid (PAA) which is precursor of polyimide formed. In second step thermal imidization of PAA can be done at various range of temperature and polyimide is prepared in PAA fillr like CNT and graphene is added and there is formation polyimide CNT/graphene nanocomposites. In this review we conclude that by addition of CNT electrical, mechanical property are increased as compared to graphene nanocomposite. but dielectric and thermal properties of graphene nanocomposites are more as compared to CNT nanocomposites. Polyimide nanocomposites because of their good properties can be used in various applications now a days and in future .

REFERENCES

[1] ANUPAMA JOSHI and SUWARNA DATAR journal of June 2015 physics 1099–1116.
[2] Zaheen Ullah Khan, Ayesha Kausar & Hidayat Ullah Polymer-Plastics Technology and Engineering 1525-6111 .
[3] Veena Choudhary1, S.K. Dhawan2 and Parveen Saini Theory and Development of New Materials, 2012 .
[4] Veena Choudhary1, S.K. Dhawan2 and Parveen Saini Theory and Development of New Materials, 2012
[5] Yang Li, Xueliang Pei, Bin Shen, Wentao Zhai,* Lihua Zhang, and Wenge Zheng RCS 2012 .
[6] Xiao Chen, Haohao Huang,* Xia Shu, Shumei Liu and Jianqing Zhao* RSC Adv., 2017, 7, 1956
[7] Yang Li, Xueliang Pei, Bin Shen, Wentao Zhai,* Lihua Zhang, and Wenge Zheng* RCS 2013
[8] Hun Wook Ha,§ Arup Choudhury,§ Tahseen Kamal, Dong-Hun Kim, and Soo YOUNG PARK ACS 2012
[9] A Novel Polyimide Dispersing Matrix for Highly Electrically Conductive Solution-Cast carbon Nanotube-Based Composite.ACS 2011
[10] Ok-Kyung Park,†,§ Jun-Yeon Hwang,† Munju Goh,† Joong Hee Lee,§ Bon-Cheol Ku,†,* and Nam-Ho You†,*Macromolecules 2013, 46, 3505−3511
[11] Zhigeng Chen a, Shumei Liu a,b, Shijing Yan a, Xia Shua, Yanchao Yuan a, Haohao, Jianqing Zhao Materials and Design 117 (2017) 150–156
[12] Hongli Yang, Zhi Yu, Peng Wu, Huawei Zou, Pengbo Liu applied surface science 2017
[13] Yong Qian⁎, Yanfei Lan, Jianping Xu, Fucheng Ye, Shizhen Dai
[14] Hun Wook Ha,§ Arup Choudhury,§ Tahseen Kamal, Dong-Hun Kim, and Soo Young Park*ACS Appl. Mater. Interfaces 2012
[15] Zhigeng Chen a, Shumei Liu a,b, Shijing Yan a, Xia Shua, Yanchao Yuan a, Haohao Huanga,⁎, Jianqing Zhao a,b,⁎ Zhigeng Chen a, Shumei Liu a,b, Shijing Yan a, Xia Shua, Yanchao Yuan a, Haohao Huanga,⁎, Jianqing Zhao a,b,⁎ Materials and Design 117 (2017) 150–156
[16] Han-Shiang Liu a, Shie-Chang Jeng b,⇑ Optical Materials 2013.
[17] Dan Liua, Lei Genga, Yuqin Fub, Xin Daia, Changli Lüa,⁎ Journal of Membrane Science 366 (2011) 251–257