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Mechanical and Thermal Analysis of SAN/Silver Nanoparticles/Graphene Nanocomposite

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Abstract—*Today the use of composite is increasing exponentially in several engineering areas because of their balanced properties with high strength to weight ratio being most important property. This research focuses on the development of an economically feasible composite material with enhanced mechanical and thermal properties. Styrene Acrylonitrile (SAN) being economical, transparent ,rigid, chemically and thermally stable material offers the solution with the help of Silver Nanoparticles (AgNP) and Graphene. The proposed nanocomposite is prepared by One step melt compounding of SAN, AgNP and Graphene in co-rotating twin screw extruder in different batches with different weight fractions of AgNP and Graphene followed by specimen preparation by compression moulding. Tensile test is performed to assess the mechanical properties while Thermogravimetric Analysis (TGA) is done to assess the thermal degradation temperature range. Scanning Electron Microscopy (SEM) is done to assess surface morphology of the nanocomposite. These findings will provide basis to design products with higher mechanical and thermal properties.*

Index terms*: Styrene Acrylonitrile(SAN), Graphene, Silver nanoparticles(AgNP), Thermogravimetric Analysis (TGA), Scanning Electron Microscopy (SEM)*

1. Introduction

The properties and applications of polymeric systems can be varied within large limits by modifying or copolymerization with other polymers, so that the performances of the resultant materials to meet the predetermined standards. Thus, in recent years, a remarkable effort has been directed to exploit the potential of various copolymers to blend and sometimes to potency the useful properties of each component at the expense of undesirable characteristics. The properties and applications of polymeric systems can be varied within large limits by their modifying or copolymerization with other polymers, so that the performances of the resultant materials can meet the predetermined standards. Thus, a remarkable effort has been directed to exploit the potential of various copolymers to blend and sometimes to potency the useful properties of each component at the expense of undesirable characteristics. Materials are the basis of evolution of human beings and along with the humans, materials also evolved. Today the most versatile material is polymer because the properties and applications of polymer materials can be varied to a very waste range since it can be easily be modified to meet the standards required.

One of the way of modifying the polymer properties is by addition of reinforcement material. These reinforcing materials are added into the matrix mostly to enhance the mechanical and thermal properties. But now with the discovery of nanoparticles these property enhancement has reached new heights. These materials because of their small sizes have very high specific surface area and thus their interaction with the matrix is better than then ever and thus they modify properties better than other conventional reinforcement materials. Graphene, a one atom thick layer of carbon atoms arranged in hexagonal lattice, it is incredibly strong material with excellent thermal and electrical conductivity. Silver nanoparticle is increasingly used in various fields like medical, food, healthcare and industrial applications because of its unique physical, chemical and biological properties.

2. Material and Method

2.1 Materials-

The proposed nano composite consists of:

1.Styrene Acrylonitrile(SAN) which is procured from INEOS Styrolution India Ltd., Vadodara, Gujrat.

2.Silver Nanoparticles(AgNP) is procured from Nano Research Lab., Jamshedpur, Jharkhand.

3. Graphene is procured from Nano Research Lab., Jamshedpur, Jharkhand.

2.2 Method

The proposed nanocomposite preparation started with preparation of different batches with different composition of matrix and reinforcement materials in different weight percentage(wt%)

Table 1. Batch composition in wt%

	SAN	Graphene	AgNP
Batch 1	100	0	0
Batch 2	98	1	1
Batch 3	96	2	2

The proposed nanocomposite is prepared by melt compounding of SAN, AgNP and graphene in a twin screw extruder. SAN/AgNP/Graphene is mixed manually in a glass jar and then transferred into the hopper of the twin screw extruder whose settings were as follows:

Table 2: Extruder temperature

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Temp. (^{O}C)	210	220	230	250	260

Extruder speed : 40 RPM

The extrudate that came out of twin screw extruder die is in the form of wire which is drawn out and cooled to room temperature in water bath and then converted into required sized pallets using palletizer. Afterwards, to make specimens these prepared pallets were pre-dried at $80^{o}C$ for 2 hours in the heating oven to evaporate any moisture content and then these dried palettes are transferred into the mould of the compression moulding machine whose temperature is set at $230^{o}C$ and pressure of 100 psi is applied for 4 minutes before cooling the mould. The output of the compression moulding is a sheet of 180x150 cm sheet which is cut to the required sized specimen using contour cutter.

3. Testing

3.1. Tensile Testing

Tensile test is performed on every sample using Universal Testing Machine (UTM) as per ASTM D638 standard to evaluate tensile strength of the nanocomposite i.e. to know how much uniaxial stress it can withstand before it fails.

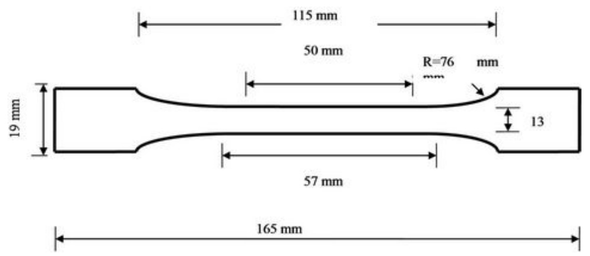

Fig.1: Tensile test specimen

Test speed - 50 mm/min

3.2 Thermo gravimetric Analysis

TGA is a thermal analysis which is used to examine the mass or weight change of a sample as a function of temperature (in scanning mode) and as a function of time (in). It is a technique which is used to primarily find the thermal stability of the material.

Testing conditions:

Minimum Temperature: $0^{O}C$
Maximum Temperature: $800^{O}C$
Rate: $20^{O}C/min$

3.3 Scanning Electron Microscopy

SEM is a type of instrument that produces image of the sample by scanning with the focused beam of electron. SEM is done to analyse the surface morphology of the specimen. For this test the fractured surface from the tensile test is used for scanning.

4. Result and Discussion

4.1 Tensile Test

Table 3. Tensile Strength

	Density (g/cm^3)	Tensile Strength (MPa)
Batch 1	1.04	68.2
Batch 2	1.1468	82.3
Batch 3	1.253	54.8

A good mechanical strength is an advantageous feature of any material to be used to produce any product. In this study it is clear that the nanomaterials were compatible with the base material SAN at low concentrations thus producing enhanced mechanical strength but as the percentage loading of Graphene and AgNP crossed 2 wt% the properties started to fall down as the voids of the base materials are filled completely and thus remaining excess nano material causes the material to fail early.

4.2 Thermo gravimetric Analysis

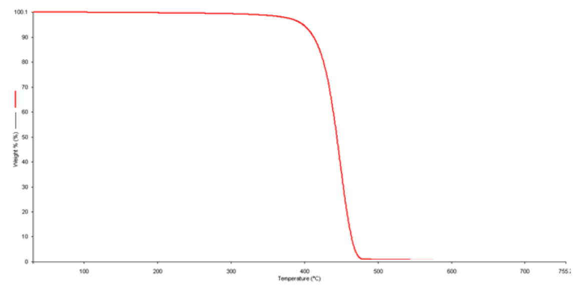

Figure 2. TGA of SAN

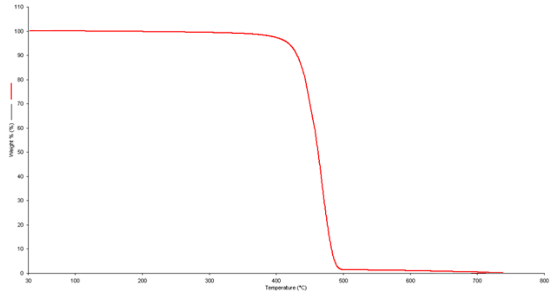

Figure 3. TGA of SAN+ 1% Graphene+ 1% AgNP

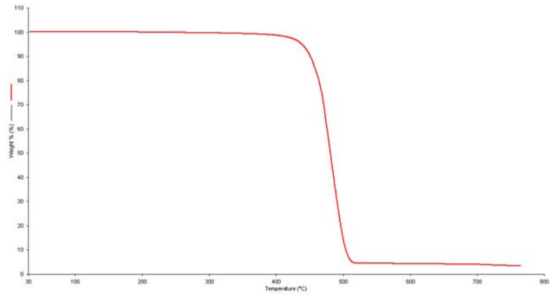

Figure 4. TGA+2% Graphene+2% AgNP

The TGA analysis of the samples reveals that the thermal stability of the nanocomposite increases with increase in the loading of the Graphene and AgNP. This is because of the reason that the Graphene and AgNP have very high thermal stability which causes increase in the thermal stability of the composite. The degradation of the SAN started from 400^{O}C upto About 480^{O}C but as the percentage of Graphene and AgNP increases, the degradation limit increased to about 510^{O}C.

4.3 Scanning Electron Microscopy

The SEM analysis of the sample containing SAN with 5 wt% of Graphene and 5wt% of AgNP is shown in figure 5, in the figure we can only see matrix which is SAN and not the Graphene and AgNP because the size of the Graphene and AgNP is in 1-5 nanometer range which are outside the resolving power of the SEM microscope that we used (JCM 6000 Plus). But we can infer one thing from the image that the surface is very smooth because the surface that we analysed is brittle fracture surface.

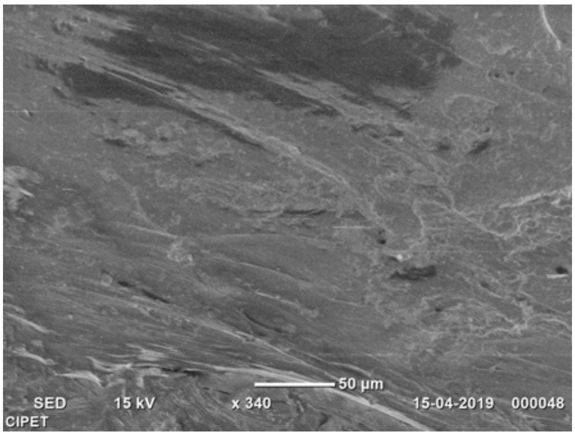

Figure 5. SEM image of SAN+2% Graphene+2%AgNP

5. Conclusion

The mechanical and thermal tests and the SEM characterization of the proposed nanocomposite revealed that the both mechanical and thermal stability of the material has increased substantially because of the synergetic effect of the Graphene and AgNP when added in SAN matrix. Because of its light weight, increased strength and better thermal properties and other important properties which it can offer is antibacterial property and EMI shielding because of AgNP and Graphene and thus this nanocomposite material can be used in electronics and healthcare industry.

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References

[1] W. Hu, C. Peng, W. Luo et al., “Graphene-based antibacterial paper,” ACS Nano, vol. 4, no. 7, pp. 4317–4323, 2010

[2] Xiao Huang, Xiaoying Qi, Freddy Boey and Hua Zhang, Graphene based composites, Chem. Soc. Rev., 2012, 41, 666–686.

[3] Barun Das, K. Eswar Prasad, U. Ramamurty and C.N.R. Rao, Nano-indentation studies on polymer matrix composites reinforced by few-layer Graphene, Nanotechnology, 2009, 20, 125705.

[4] Khalid Nawaz, Muhammad Ayub, Noaman Ul-Haq, M.B. Khan, Muhammad Bila, Khan Niazi, Arshad Hussain, The effect of large area graphene oxide (LAGO) nanosheets on the mechanical properties of polyvinyl alcohol. Journal of Polymer Engineering, 2016, 36(4), 399-405.

[5] Gahlot S., Kulshrestha V., Agarwal G. and Jha P.K., Synthesis and Characterization of PVA/GO Nanocomposite Films. Macromol. Symp., 2015, 357, 173–177.

[6] T. Ramanathan, A.A. Abdala, S. Stankovich, D.A. Dikin, M. Herrera-Alonso, R.D. Piner, D.H. Adamson, H.C. Schniepp, X. Chen, R.S. Ruoff, S.T. Nguyen, I.A. Aksay, R.K. Prud’Homme and L.C. Brinson. Functionalized graphene sheets for polymer nanocomposites. Nature Nanotechnology, 2008, 3(6), 327-331.

[7] Bogdanova, L.M., Kuzub, L.I., Dzhavadyan, E.A. et al. Polym. Sci. Ser. A (2014) 56: 304.

[8] Mudassar Abbas, Nida Naeem, Hina Iftikhar and Usman Latif (April 4th 2018). Synthesis, Characterization and Antimicrobial Properties of Silver Nanocomposites, Silver Nanoparticles - Fabrication, Characterization and Applications, Khan Maaz, IntechOpen, DOI: 10.5772/intechopen.74623.