



## IMPROVED ELECTRICAL PROPERTIES OF NEW TERPOLYMER BY COMPOSITE FORMATION

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### Abstract

Improvement in the electrical properties of a newly obtained terpolymer(AOTMNA) derived from aniline(A), ortho toluidine(OT) and m-nitroaniline(MNA) after its conversion into nano composite material by incorporation of graphene oxide (GO) in the polymer matrix have been reported in the present research paper. The composite under present investigation has shown significant improvement in its electrical properties as compared to terpolymer alone. AOTMNA terpolymer was obtained by condensation polymerisation of the starting materials and its structure has been proved by physicochemical and spectral evidences. GO was prepared from graphite using a modified Hummers method. GO was used as a nano-filler for the fabrication of AOTMNA-GO composite. The results prove that composite formation improves the electrical properties of the terpolymer to a great extent.

**Key words:** graphene oxide, terpolymer, composite, electrical properties, Hummers method.

### Introduction

Polyaniline is one of the most studied conducting polymers because of its high stability, enhanced conductivity and processability<sup>1</sup>. Terpolymers occupy the pivotal position in the field of polymer science. Their use in all spheres has been abundantly increased in recent years because of their novelty and versatility. The progress in this field has been extremely rapid, as they are generally useful in packaging, adhesives and coatings in electrical sensors, ion-exchangers, organometallic semiconductors, activators, catalyst and thermally stable materials<sup>2-7</sup>. Although carbon nano tubes (CNTs) are effective fillers to enhance the mechanical and electrical properties of polymers, they cannot be dispersed easily in a solvent or a polymer matrix due to the van der Waals forces<sup>8,9</sup>. Graphene is a two-dimensional carbonaceous material with sp<sup>2</sup>-bonded carbon atoms which has attracted much attention since its experimental discovery in 2004 due to both, its high aspect ratio and high surface area<sup>10-12</sup>. For composite applications, the significant van der Waals force of pure graphene such as CNTs presents an obstacle while attempting to disperse them in both organic and inorganic solvents<sup>13</sup>. In contrast, graphene oxide (GO) obtained by chemical oxidation of graphite, can meet this demand. It is well dispersed in organic solvents due to presence of functional groups on its basal planes and edges, such as epoxides, hydroxyls, ketones, diols and carbonyl groups<sup>14-19</sup>. GO has been chemically modified to improve degree of dispersion in a

solvent and a small amount of GO has been incorporated into a polymer matrix by a solution-casting method<sup>20-22</sup>. Application of terpolymer composite as an excellent adsorbent for removal of carcinogenic Cr (VI) from polluted water has been reported in the literature<sup>23</sup>. In the present investigation, composite containing a low content of GO was prepared to study the improvement in mechanical & electrical properties of newly synthesized terpolymer. AOTMNA-GO composite containing 5 % of GO was prepared via a conventional solution-casting method. The structure of the polymer is supported by Fourier transform-infrared spectroscopy.

### Experimental and Experimental Techniques

**Chemicals**  
 All the chemicals used were of Analytical reagent or chemically pure grade. Preparation of Terpolymer (AOTMNA), synthesis and purification of graphene oxide (GO) and composite fabrication has been done by methods which have already been published<sup>24</sup>.

### Characterization

The terpolymer and its composite have been characterised & the results obtained have already been published<sup>24</sup>. Electrical conductivity measurement of the terpolymer and its composite was done using digital multimeter (model DT 92080L.) An acceleration voltage of 15 kV was used to observe the morphology of the fractured surfaces of pure terpolymer and its composite.

### Results and Discussion

On the basis of physicochemical and spectral evidences<sup>24</sup> the most probable structure have

been suggested and given in Fig.1

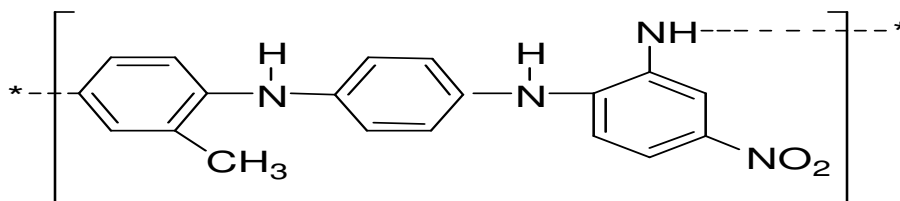


Fig.1. Structure of Terpolymer (AOTMNA)

**DC-Conductivity measurement**

The conductivity of polymers depend on number of parameters such as temperature, oxidation state, level of protonation, moisture content, and counter ion. The effect of temperature on electrical conductivity of

metallic conductors and semiconductors is quite different.

The results of electrical conductivity of AOTMNA-tercopolymer and its composite material at room temperature and at 150°C are listed in Table 1

**Table: 1 Electrical conductivity of AOTMNA tercopolymer and composites**

Properties	Conductivity (S/cm)	
	(30°C)	(150°C)
Tercopolymer (AOTMNA)	0.31	1.19
AOTMNA-GO (I)	27.3	53.0

The electrical conductivity of tercopolymer (AOTMNA) measured in the temperature range 30° C to 150° C. The electrical conductivity increases with temperature showing semiconducting behaviour and the conductivity at room temperature found to be 0.31 S cm<sup>-1</sup> while at 150° C has 1.19 S cm<sup>-1</sup>. A plot of log σ vs. 1/T would be linear in given temperature range with a slope of (-Ea/2.303K). Using slope the activation energy Ea was calculated. The activation energy of electrical conduction of AOTMNA tercopolymer was found to be 2.074kJ mole<sup>-1</sup>. The graph of log σ vs. 1/T of tercopolymer has shown in Fig.2. The experimental data revealed that electrical conductivity increases with rise in temperature have shown in Fig.3 Hence this

tercopolymer shows semiconducting behaviour in the temperature range 303 to 423 K.

The electrical conductivities of the AOTMNA tercopolymer/GO composites are increased dramatically in comparison with that of pure tercopolymer. Such enhancement of the conductivity of the composite might be attributed to extended H-bonding between the tercopolymer and graphene oxide allowing extended p-conjugation in the polymer chains. The polymerization on the surface and pores of GO sheets restricts the twisting of the polymer backbone away from planarity, which plays a major role in enhancing the conductivity. Also there may have π-π stacking between the GO sheets and polymer backbone. Therefore, graphene oxide plays an effective role in enhancement of conductivity.

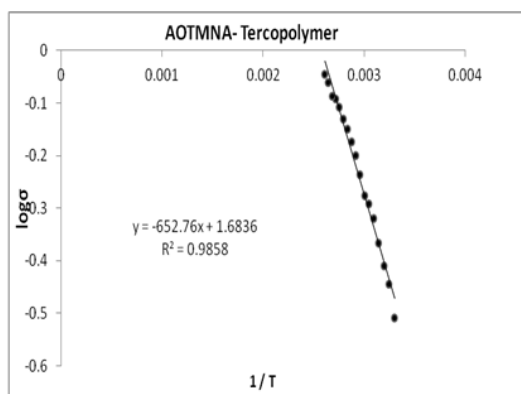


Fig.2 Plot of log σ Versus 1/T of AOTMNA-

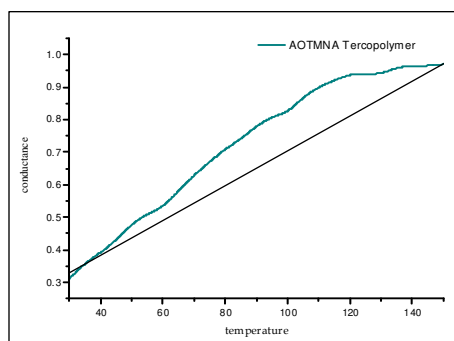


Fig.3 Effect of temperature on conductivity

**Terpolymer**

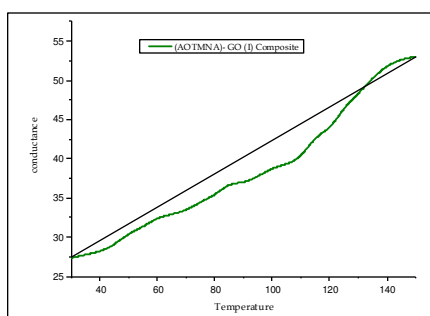
At high temperature, the mobility of the charge carrier increases with the increase in interchain and intrachain hopping. An increase in interchain and intrachain hopping results in high charge carrier mobility within the composite, which leads to an increase in conductivity at appropriate high temperature. The graph of  $\log \sigma$  vs.  $1/T$  of composite has

**of AOTMNA-Terpolymer**

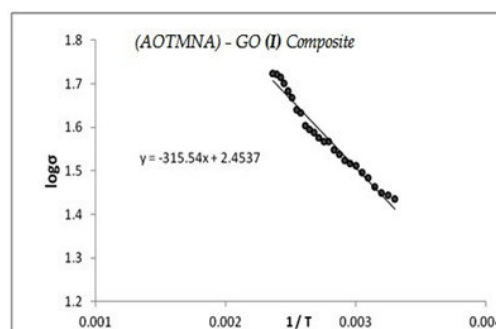
shown in Fig.4. The experimental data revealed that electrical conductivity increases with rise in temperature have shown in Fig.5 of Hence this composite shows semiconducting behaviour in the temperature range 303 to 423 K. The conductivity values of the concerned composite are higher than that of pure tercopolymer.

**Table: 2. Activation Energy of AOTMNA tercopolymer and composite**

Properties	'Ea' Activation Energy (kJ mole <sup>-1</sup> )
Terpolymer (AOTMNA)	2.074
AOTMNA-GO	1.00



**Fig.4 Effect of temperature on conductivity of (AOTMNA) - GO Composite.**



**Fig.5 Plot of  $\log \sigma$  Versus  $1/T$  of AOTMNA-GO Composite**

**Conclusions**

Following conclusions have been drawn on the basis of results obtained during the investigation

- Synthesis of AOTMNA terpolymer, fabrication of AOTMNA-GO composite is and their characterisation is successful.
- Most probable structure for AOTMNA terpolymer has been proposed on the basis of physicochemical and spectral evidences.
- AOTMNA-GO composite has superior properties than that of AOTMNA terpolymer.
- Improvement in the conducting behaviour is due to incorporation of GO during composite fabrication which might have created electrical percolation networks in the composites.
- Thus the composite fabrication is fruitful for improvement of superior electrical properties of terpolymers.

**Scope for future work**

The studies can be extended to evaluate the improvement in other properties (mechanical, morphological etc.) of the terpolymer under investigation by way of composite formation.

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