

**PREPARATION AND PROPERTIES
OF GRAPHITE NANOPATELETS
(GNPs) HYDRID POLYMER
NANOCOMPOSITES**

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**Preparation and Properties of Graphite
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ABSTRACT

This work tries to study the preparation, morphology and properties of graphite nanoplatelets (GNPs) hybrid polymer nanocomposites, and explore their potential applications in areas such as electromagnetic interference (EMI) shielding. The main results are as follows:

The GNPs were successfully prepared by a “chemical intercalation-hot expansion-ultrasonication” process: acid-intercalated expandable graphite (GICs) were heated at high temperature to obtained worm-like structure expanded graphite (EG), and then dispersed in *N,N*-dimethylformamide (DMF) solvent and treated in an ultrasonic bath to obtain stable and evenly dispersed exfoliated GNPs. The GNPs prepared possessed a thickness of less than 100 nm, which could be confirmed by SEM and TEM results. XRD results showed that the sharp (002) diffraction peak remained the same in the EG and GNPs compared with that of GICs, indicating that the heating and ultrasonic treatment had no effect on the carbon crystal layer spacing. Oxygen-containing groups were found on the GNPs from the FTIR results, which was beneficial to the interaction between the GNPs and polymers.

Two kinds of polymers were used to prepare GNPs filled polymer nanocomposites here, one was thermoplastic polyurethane (TPU), and the other was a thermosetting polymer, epoxy. A facile solution method was introduced to prepare GNPs/TPU nanocomposites: TPU/DMF solution was mixed with the GNPs/DMF suspension, and after ultrasonic treatment the GNPs/TPU/DMF mixture was added into a large ethanol-

bath to get GNPs/TPU nanocomposites aggregations. SEM images showed a well dispersion of GNPs in the TPU matrix, and XRD results implied that the TPU molecular chains could only enter the spaces between the graphite sheets. The addition of GNPs could significantly improve tensile and dynamic mechanical properties of the materials, resulting in the significantly improvements in the tensile modulus, the storage modulus (E') and glass transition temperature (T_g) of the nanocomposites. The cone calorimeter testing showed that the GNPs could act as intumescent flame retardant and improved the flame retardancy of the material. The electrical conductivity of the nanocomposites was greatly improved by GNPs, and the maximum value was 3.4×10^{-3} S/cm at the GNPs content of 6.8 vol%. With the increasing GNPs content, the nanocomposites showed a transition from insulator to semiconductor in both d.c and a.c conditions, and the percolation threshold (Φ_c) were found to be 2.1 and 2.2 vol%, respectively. There was a high positive temperature coefficient (PTC) effect followed by a sharp negative temperature coefficient (NTC) effect for the nanocomposites around Φ_c , due to the breakage and the reformation of the conducting networks. A nonlinear to linear transition in the I - V characteristics was observed when the nanocomposites underwent insulator-conductor transition, and the conduction mechanism was referred to tunneling-hopping model. The dielectric constant and dissipation factor of the nanocomposites increased dramatically around Φ_c and exhibited strong dependency on frequency, due to the Maxwell-Wagner-Sillars (MWS) polarization mechanism. The EMI shielding test showed that GNPs/TPU nanocomposites could be used as an EMI shielding material.

The GNPs/epoxy nanocomposites were successfully prepared through solidification process by the aid of ultrasonication. SEM images showed that GNPs dispersed uniformly in the epoxy matrix, and the XRD results showed that graphite crystal structure was not changed during the intercalation of the epoxy molecular chains. The thermal stability of the materials became worse, due to the existence of the residual solvent and unreacted small molecules. The a.c conductivity of the nanocomposites increased with the increase of frequency and GNPs content, and the dielectric constant increased with the GNPs content but decreased with frequency due to the polarization.

A facile method was applied to prepare GNPs/silver nanoparticles (SPs)/polymer nanocomposites, the SPs were *in situ* reduced successfully and anchored uniformly on the GNPs surface. The SEM and FEG-SEM confirmed the formation of the SPs and their evenly dispersion. XPS and XRD results further proved the reduction of SPs by this process. The GNPs/SPs/TPU and GNPs/SPs/epoxy nanocomposites were prepared *via* two different processes, and the SEM showed that the SPs were still anchored on the graphite surface. However the silver diffractions did not shown in XRD patterns of the two nanocomposites, due to the low concentration of the SPs in polymer matrix. The addition of the GNPs/SPs hybrids resulted in the greatly reduction of $T_{10\%}$ and deterioration in the thermal stability of the GNPs/SPs/epoxy nanocomposites due to the residual solvent. The GNPs/SPs/polymer nanocomposites are expected to have wide potential applications such as EMI shielding and so on.

OUTLINE

ABSTRACT	i
ACKNOWLEDGEMENTS.....	iv
OUTLINE	v
LIST OF FIGURES	ix
LIST OF TABLES	xii
CHAPTER 1 OVERVIEW OF THE GRAPHITE FILLED POLYMER NANOCOMPOSITES	1
1.1 Introduction of Graphite.....	1
1.2 Preparation of Graphite Nanoplatelets or Graphenes.....	4
1.3 Graphite/Polymer Nanocomposites	9
1.3.1 Preparation of GNPs/Polymer Nanocomposites	9
1.3.2 Properties of GNPs/Polymer Nanocomposites	12
1.3.2.1 <i>Electrical Properties</i>	12
1.3.2.2 <i>Dielectric Properties</i>	20
1.3.2.3 <i>Thermal Properties</i>	22
1.3.2.4 <i>Mechanical Properties</i>	24
1.3.2.5 <i>Other Properties</i>	25
1.4 Functional Graphite Nanoplatelets and Their Nanocomposites.....	27
CHAPTER 2 PREPARATION AND CHARACTERISTICS OF GRAPHITE NANOPLATELETS.....	31
2.1 Introduction.....	31
2.2 Experimental	32
2.2.1 Materials and Sample Preparation	32
2.2.2 Scanning Electron Microscope (SEM).....	32
2.2.3 Transmission Electron Microscopy (TEM).....	33
2.2.4 X-ray Diffraction (XRD).....	33
2.2.5 Fourier Transform Infrared Spectroscopy (FTIR).....	33
2.3 Results and Discussion.....	33

2.3.1 Morphology of Graphite Nanoplatelets	33
2.3.2 Structure of Graphite Nanoplatelets.....	37
2.3.3 FTIR Spectra of Graphite Nanoplatelets.....	38
2.4 Conclusions	39
CHAPTER 3 PREPARATION AND PROPERTIES OF GRAPHITE	
NANOPLATELETS/THERMOPLASTIC POLYURETHANE	
NANOCOMPOSITES	40
3.1 Introduction	40
3.2 Experimental	42
3.2.1 Materials and Sample Preparation	42
3.2.2 Scanning Electron Microscope (SEM).....	43
3.2.3 X-ray Diffractions (XRD).....	43
3.2.4 Tensile Test.....	43
3.2.5 Dynamic Mechanical Analysis (DMA).....	43
3.2.6 Thermogravimetric Analysis (TGA)	44
3.2.7 Combustion Testing	44
3.2.8 Electrical Properties	44
3.2.9 Dielectric Properties.....	45
3.2.10 Electromagnetic Interference Shielding (EMI shielding)	45
3.3 Results and Discussion.....	46
3.3.1 Morphology of the GNPs/TPU Nanocomposites.....	46
3.3.2 Structure of the GNPs/TPU Nanocomposites	47
3.3.3 Tensile Properties of the GNPs/TPU Nanocomposites	48
3.3.4 Dynamic Mechanical Properties of the GNPs/TPU Nanocomposites	50
3.3.5 TGA Results of the GNPs/TPU Nanocomposites	51
3.3.6 Combustion Testing of the GNPs/TPU Nanocomposites.....	55
3.3.7 Electrical Conductivity of the GNPs/TPU Nanocomposites.....	61
3.3.8 Temperature Dependence of Resistivity of the GNPs/TPU Nanocomposites.....	65
3.3.9 Current-Voltage Characteristics	66

3.3.10 Dielectric Properties of the GNPs/TPU Nanocomposites.....	71
3.3.11 EMI Shielding of the GNPs/TPU Nanocomposites	75
3.4 Conclusions	79
CHAPTER 4 PREPARATION AND PROPERTIES OF GRAPHITE NANOPLATELETS/EPOXY NANOCOMPOSITES	81
4.1 Introduction.....	81
4.2 Experimental	82
4.2.1 Materials and sample preparation	82
4.2.2 Scanning Electron Microscope (SEM).....	83
4.2.3 X-ray Diffractions (XRD).....	83
4.2.4 Thermogravimetric Analysis (TGA)	84
4.2.5 Electrical Properties	84
4.2.6 Dielectric Properties.....	84
4.3 Results and Discussion.....	84
4.3.1 Morphology of the GNPs/epoxy Nanocomposites.....	84
4.3.2 X-ray Diffractions of the GNPs/epoxy Nanocomposites	85
4.3.3 Thermal Stability of the GNPs/epoxy Nanocomposites.....	86
4.3.4 Electrical Conductivity of the GNPs/epoxy Nanocomposites	88
4.3.5 Dielectric Properties of the GNPs/epoxy Nanocomposites.....	89
4.4 Conclusions	90
CHAPTER 5 ANCHORING SILVER PARTICLES ON THE GRAPHITE.....	92
5.1 Introduction.....	92
5.2 Experimental	93
5.2.1 Materials and Sample Preparation	93
5.2.2 Scanning Electron Microscope (SEM).....	94
5.2.3 X-ray Diffractions (XRD).....	94
5.2.4 X-ray Photoelectron Spectroscopy (XPS).....	94
5.2.5 Thermogravimetric Analysis (TGA)	95
5.3 Results and Discussion.....	95

5.3.1 The Reduction of Silver Nanoparticles	95
5.3.2 Morphology of GNPs/SPs/polymer Nanocomposite	100
5.3.3 X-ray Diffractions of GNPs/SPs and GNPs/SPs/polymer Nanocomposites	101
5.3.4 Thermal Stability of the GNPs/SPs/epoxy Nanocomposites.....	102
5.4 Conclusions	105
CHAPTER 6 CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK..	106
6.1 Conclusions	106
6.2 Suggestions for Future Work.....	109
REFERENCES.....	112
PAPERS DURING THE PH.D STUDY	131

LIST OF FIGURES

Figure 1.1 Schematic diagrams of graphite structure.....	1
Figure 2.1 SEM images of graphite after receiving different treatments: (a) GICs; (b) EG at $\times 100$ magnification; (c) EG at $\times 1000$ magnification; and (d) GNPs.	34
Figure 2.2 (a) TEM images of GNPs after ultrasonic treatment and (b) the electron diffraction patterns in (a).....	35
Figure 2.3 Identification of monolayer graphene by electron diffraction patterns in TEM [51].....	36
Figure 2.4 X-ray diffraction patterns of GICs, EG and GNPs.	37
Figure 2.5 FTIR spectra of GICs, EG and GNPs.	38
Figure 3.1 Schematic diagram of EMI shielding testing setup.	45
Figure 3.2 SEM images of GNPs/TPU nanocomposites: (a) 2.7 vol%, $\times 300$ magnification; (b) 2.7 vol%, $\times 3000$ magnification; (c) 5.6 vol%, $\times 300$ magnification; (d) 5.6 vol%, $\times 1000$ magnification.....	46
Figure 3.3 XRD patterns of GICs, EG, GNPs and GNPs/TPU nanocomposites.	47
Figure 3.4 Tensile properties of the GNPs/TPU nanocomposites: (a) stress-strain curves; (b) effect of GNPs content on the tensile modulus.	49
Figure 3.5 DMA measurements of the GNPs/TPU nanocomposites: (a) storage modulus; and (b) $\tan \delta$ as a function of temperature.....	50
Figure 3.6 TGA results of the GNPs/TPU nanocomposites: (a) and (b) TG and DTG curves in nitrogen atmosphere; (c) and (d) TG and DTG curves in air atmosphere.	54
Figure 3.7 Cone calorimeter testing results of pure TPU and GNPs/TPU nanocomposites with different compositions: (a) HRR and (b) MLR curves.	56
Figure 3.8 Appearance of final chars of the GNPs/TPU nanocomposites (5.6 vol% GNPs) after combustion testing: (a) upper surface; (b) bottom surface.	58
Figure 3.9 SEM images of the GNPs/TPU nanocomposites after combustion testing: (a) and (b) GNPs content is 0.5 vol%; (c) to (e) GNPs content is 2.7 vol%.	60
Figure 3.10 Schematic diagram of the intumescent retardancy of GNPs.	61

Figure 3.11 Electrical conductivity of GNPs/TPU nanocomposites as a function of GNPs content and the inset plot is $\log \sigma$ versus $\log (\Phi - \Phi_c)$	61
Figure 3.12 Electrical conductivity of GNPs/TPU nanocomposites with different compositions in A.C condition, and the inset plot is $\log \sigma_{a.c}$ versus $\log (\Phi - \Phi_c)$. (Frequency is 100 Hz).....	63
Figure 3.13 (a) Electrical conductivity of GNPs/TPU nanocomposites as a function of frequency in A.C condition, and (b) linear fit of electrical conductivity at Φ_c	64
Figure 3.14 Temperature dependence of the resistivity of GNPs/TPU nanocomposites.....	65
Figure 3.15 I - V characteristics of GNPs/TPU nanocomposites with different GNPs content: (a) 2.2 vol%; (b) 3.3 vol%; (c) 4.4 vol%; (d) 5.6 vol%.....	68
Figure 3.16 The plots of $\log I$ versus $\log V$ and the linear fit of the data.....	69
Figure 3.17 The plot of exponent n of Eq. 3 versus GNPs content.....	69
Figure 3.18 Electrical conductivity values of the GNPs/TPU nanocomposites calculated from the I - V characteristic compared with the experimental values.....	70
Figure 3.19 Variation of dielectric constant of GNPs/TPU nanocomposites as a function of (a) GNPs content (Frequency is 100 Hz) and (b) frequency.....	72
Figure 3.20 Dissipation factor ($\tan \delta$) of GNPs/TPU nanocomposites as a function of (a) frequency and (b) GNPs content.	74
Figure 3.21 SE of pure TPU and GNPs/TPU nanocomposite (GNPs content is 5.6 vol%) as a function of frequency.	78
Figure 4.1 SEM images of GNPs/epoxy nanocomposites (GNPs content is 2 wt%).	85
Figure 4.2 XRD patterns of pure epoxy and GNPs/epoxy nanocomposites (GNPs content is 2 wt%).....	85
Figure 4.3 TGA analysis of the GNPs/epoxy nanocomposites: (a) weight loss curves and (b) derivative of the weight loss curves in nitrogen atmosphere.	87
Figure 4.4 Electrical conductivity of GNPs/epoxy nanocomposites as a function of (a) frequency and (b) GNPs content (the frequency is 100 Hz).	89
Figure 4.5 Dielectric constant of GNPs/epoxy nanocomposites as a function of (a) frequency and (b) GNPs content (the frequency is 100 Hz).	91

Figure 5.1 The micrographs of GNPs and GNPs/SPs hybrid: (a) SEM of GNPs; (b) SEM of GNPs/SPs hybrid; (c) EDX in (b); (d) FEG-SEM image of GNPs/SPs hybrid.	95
Figure 5.2 (a) broad scan and (b) Ag3d XPS spectra of GNPs and GNPs/SPs hybrid. ..	97
Figure 5.3 Standard XPS spectra of the element (a, b) Ag^0 and (c) AgO_x	99
Figure 5.4 XRD patterns of GNPs and GNPs/SPs hybrids.	99
Figure 5.5 SEM images of GNPs/SPs/TPU nanocomposites with different magnification (GNPs/SPs content is 10 wt%).....	100
Figure 5.6 SEM images of GNPs/SPs/epoxy nanocomposites with different magnification (GNPs/SPs content is 1 wt%).	101
Figure 5.7 XRD patterns of GNPs/SPs/polymer nanocomposites: (a) GNPs/SPs content is 10 wt%; (b) GNPs and GNPs/SPs content are 1 wt%, respectively.....	103
Figure 5.8 (a) TG and (b) DTG curves of the GNPs/epoxy and GNPs/SPs/epoxy nanocomposites in nitrogen atmosphere.	104

LIST OF TABLES

Table 1.1 Summary of the percolation threshold and maximum electrical conductivity of various GNPs/polymer nanocomposites (the data are the lowest one for each system reported).....	13
Table 3.1 Degradation temperatures of GNPs/TPU nanocomposites.....	55
Table 3.2 Combustion testing data of GNPs/TPU nanocomposites	57
Table 4.1 Degradation temperatures of GNPs/epoxy nanocomposites.....	88
Table 5.1 Degradation temperatures of epoxy, GNPs/epoxy and GNPs/SPs/epoxy nanocomposites.....	105