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Graphene-Based Polymer Nanocomposites

Models and Applications

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Preface

Polymer nanocomposites based on graphene and its derivatives are in the focus of numerous theoretical and experimental multidisciplinary studies, which describe novel mechanical, electrical, and thermal properties of the nanocomposites. There has been tremendous attention given to their promise as high-efficiency materials in a wide range of applications including thermal-interface materials, active electrodes for lithium-ion batteries and supercapacitors, membranes for fuel cells, gas separation and proton exchange, materials for electromagnetic shielding and flexible and stretchable electronics. In particular, with the increasing demand for high-elasticity materials used in tires, seals, and shock absorbers, it is plausible to add graphene fillers to matrices for reinforcement.

This book gives a comprehensive introduction to the physics of graphene-based polymer nanocomposites. In addition, particular emphasis is given in this book to the impact of the interfacial interactions on the mechanical and electrical behavior of these materials.

We have attempted to highlight key topics learned and developed by the authors over the past 20 years. We hope this treatment of a family of graphene-based polymer nanocomposites will provide materials scientists, graduate students, engineers, and material designers with a better understanding of this fascinating research and technology field.

Kyiv, Ukraine
January 2024

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Contents

Acronyms

ABS	Acrylonitrile butadiene styrene
AFM	Atomic force microscopy
ARGET	Activators regenerated by electron transfer
CB	Carbon black
CLD	Cross-linking degree
CMGs	Chemically modified graphenes
CNT	Carbon nanotube
CrGO	Chemically reduced GO
CVD	Chemical vapor deposition
DGEBA	Diglycidyl ether of bisphenol A
DMF	Dimethylformamide
DMG	Dry-milled graphene
FET	Field-effect transistor
FFT	Fast Fourier transform
fGNP	Functionalized GNP
fGO	Functionalized graphene oxide
FLG	Few-layer graphene; a 2D (sheet-like) material, either as a free-standing flake or substrate-bound coating, consisting of a small number (between 2 and about 5) of well-defined, countable, stacked graphene layers of extended lateral dimension
frGO	Functionalized rGO
fTRGO	Functionalized TRGO
GCE	Glassy carbon electrode
GNP	Graphene nanoplatelets, Graphite nanoplate, graphite nanosheet, graphite nanoflake; 2D graphite materials with ABA or ABCA stacking, and having a thickness and/or lateral dimension less than 100 nm
GNS	Graphene nanosheet

GO	Graphene oxide; the oxidized analogy of graphene, widely recognized as the only intermediate or precursor for obtaining graphenes on a large scale
GQD	Graphene quantum dot
HDPE	High-density polyethylene
HPC-Py	Pyrene-containing hydroxypropyl cellulose
IPLs	Interphase layers
iPP	Isotactic polypropylene
ITO	Indium-tin oxide
LB	Langmuir–Blodgett
LbL	Layer-by-Layer
LLDPE	Linear low-density polyethylene
MG	Methylene green
MLG	Multilayer graphene; same as FLG with greater layer numbers (typically up to 10)
MSA	Multiple scattering approach
MWCNT	Multi-walled carbon nanotube
NR	Natural rubber
N-TRGO	Nitrogen-TRGO
P3HT	Poly(3-hexylthiophene)
PA11	Polyamide 11
PA12	Polyamide 12
PA6	Polyamide 6
PAA	Poly(acrylic acid)
PAH	Polycyclic aromatic hydrocarbons
PANI	Polyaniline
PB	Polybutadiene
PBA	Poly(butyl acrylate)
PC	Polycarbonate
PCL	Polycaprolactone
PDDA	Poly(diallyldimethylammonium chloride)
PDMS	Poly(dimethylsiloxane)
PE	Polyethylene
PEG	Poly(ethyl glycol)
PEI	Polyethylenimine
PET	Polyethylene terephthalate
pG	Pristine graphene
PHPMA	Poly(N-(2-hydroxyphenyl)methacrylamide)
PI	Polyimide
PIL	Poly(ionic liquid)
PLA	Polylactic acid
PMMA	Poly(methyl methacrylate)
PNCs	Polymer nanocomposites
PNIPAM	Poly(N-isopropylacrylamide)
POSS	Polyhedral oligomeric silsesquioxane

PP	Polypropylene
$PPESO_3^-$	Poly(2,5-bis(3-sulfonatopropoxy)-1,4-ethynylphenylene-alt-1,4-ethynylphenylene)
PS	Polystyrene
PSS	Poly(styrenesulfonate)
PSSA-g-PPY	Poly(styrenesulfonic acid-g-pyrrole)
PTi	Polythiophene
PU	Polyurethane
PVA	Poly(vinyl acetate)
PVC	Poly(vinyl chloride)
QP_4VP-co-PCN	Cationic azo polyelectrolyte
RAFT	Reversible addition-fragmentation chain transfer
rGO	Reduced graphene oxide
RVE	Representative volume element
SAN	Styrene-acrylonitrile
SANS	Small-angle neutron scattering
SCMC	Sodium carboxymethyl cellulose
SDBS	Sodium dodecyl benzene sulfonate
SLS	Sodium lignosulfonate
SPANI	Sulfonated polyaniline
sPS	Syndiotactic polystyrene
TCF	Transparent conducting film
TGA	Thermogravimetric analysis
TMDSC	Temperature-modulated differential scanning calorimetry
TPU	Thermoplastic polyurethane
TRGO	Thermally reduced graphene oxide
UHMWPE	Ultra-high-molecular-weight polyethylene
UPS	Ultrasound phase spectroscopy