Green Polymers and Environmental Pollution Control

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Edited by

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LIST OF ABBREVIATIONS

1,4-CHD	1,4-cyclohexadiene
2fFCS	dual focus fluorescence correlation spectroscopy
AAD	aryl-alcohol dehydrogenases
AAO	arylalcohol oxidase
ABC	atomistic-based continuum
AcOH	glacial acetic acid
AFM	atomic force microscopy
AOPSC	acid treated oil palm shell charcoal
APS	ammonium peroxydisulfate
BA	Brønsted acid
BD	1,3-butadiene
BD	Brownian dynamics
BGL	β-glucosidases
BRF	brown-rot fungi
CBAM	chitosan blended alginate matrix
CBIC	Chamber of Construction Industry
CD	cyclodextrin
CHC	Cahn–Hilliard–Cook
CHD	1,4 or 1,3-cyclohexadiene
CHF	congestive heart failure
CHIT	chitosan
CMC	carboxymethyl chitin
CNTs	carbon nanotubes
CONAMA	National Council of Environment
CRV	carvedilol
CT	chain transfer
CTC	charge transfer complex
CVD	chemical vapor deposition
DA	degree of acetylation
DE	degree of esterification
DEX	dextran sulfate

DFT	dynamic density functional theory
DGEBA	diglycidyl ether of bisphenol A
DLS	dynamic light scattering
DMA	dynamic mechanical analysis
DMAEMA	dimethyl aminoethyl methacrylate
DPD	dissipative particle dynamics
DS	degree of substitution
DSC	differential scanning calorimetry
EA	electron acceptor
EB	emeraldine base
ECM	extracellular matrix
EMCMCR	ethylenediamine-modified crosslinked magnetic chitosan resin
ERM	effective reinforcing modulus
ESD	electrostatic discharge
ESEM	environmental scanning electron microscope
EWC	equilibrium water content
FCS	fluorescence correlation spectroscopy
FEM	finite element method
FITC	fluorescein isothiocyanate
FRP	fiber reinforced polymer
FT-NIR	Fourier transform near infrared
FTIR	Fourier-transform infrared spectroscopy
GO	graphene oxide
GSI	gigascale integration
H_2SO_4	sulfuric acid
HCl	hydrochloric acid
HE	heulandite
HEMA	hydroxyethyl methacrylate
HM	high methoxy
IB	isobutene
IBL	implantable bioartificial liver
IOP	iontophoresis
IP	isoprene
ISS	interfacial shear strength
ITO	indium tin oxide

IUPAC	International Union of Pure and Applied Chemistry
KMnO4	potassium permanganate
KPS	potassium peroxodisulfate
LA	Lewis acid
LB	lattice Boltzmann
LbL	layer-by-layer
LCST	lower critical solution temperature
LDPE	low density polyethylene
LJ	Lennard-Jones
LM	low methoxy
LMA	lauryl methacrylate
MAA	methacrylic acid
MAO	methylaluminoxane
MAP	modified atmosphere packaging
MAPE	maleic anhydride grafted polyethylene
MAPP	maleic anhydride grafted PP
MC	Monte Carlo
MD	molecular dynamics
MFI	melt flow index
MFR	melt mass flow rate
MH	multi-scale homogenization
MM	molecular mechanics
MMT	montmorillonite
MW	molecular weight
MWNTs	multi-wall carbon nanotubes
$NaNO_3$	sodium nitrate
NDD	nasal drug delivery
NFRPCs	natural fiber reinforced polymer composites
NG	nanogels
NMT	nano-magnetite
NR	natural rubber
O-CMCS	O-carboxymethyl chitosan
ODD	oral drug delivery
OPF	oil palm fiber
OSA	octenyl succinic anhydride
P(NiPAM-co-MAA)	poly(N-isopropylacrylamide-co-methacrylic acid)

PA-6	polyamide-6
PAA	poly(acrylic acid)
PAG	PANI/graphene particles
PAH	Poly(Allylamine Hydrochloride)
PANI	Polyaniline
pARG	poly L-arginine
pASP	poly L-aspartic acid
PCD	polycrystalline diamond tooling
PDACMAC	poly(diallyldimethylammonium chloride)
PDGFB	platelet-derived growth factor B
PE	polyelectrolytes
PE	polyethylene
PenG	penicillin G
PET	poly(ethylene terephthalate)
PF	phenol formaldehyde
PFLA	perfluoroarylated Lewis acid
PGA	poly l-glutamic acid
PGA	polyglycolide
PGLA	pectin/poly lactide-co-glycolide
PIB	polyisobutene
PLA	polylactic acid
PLL	poly L-lysine
PLLA	poly (L-lactic acid)
PMAA	polymethacrylate
PNCs	polymeric nanocomposites
PNiPAM	poly(N-isopropylacrylamide)
PP	polypropylene
PS	polystyrene
PVC	poly (vinyl chloride)
QR	quinone reductases
RCM	rate controlling membrane
RH	rice husk
rPE	recycled polyethylene
RVE	representative volume element
SA	sodium alginate
SANS	small angle neutron scattering

SCFC	sugarcane fiber cellulose
SDS	sodium dodecyl sulfate
SEM	scanning electron microscopy
SF	silk fibroin
SHP	sterically hindered pyridine
SI	swelling index
SSF	solid state fermentation
ST	styrene
SWNTs	single-wall nanotubes
TDDS	transdermal drug delivery system
TDGL	time-dependent Ginsburg–Landau theory
TEM	transmission electron microscopic
TEMED	tetramethylenediamin
TETA	triethylene tetramine
TGA	thermogravimetric analysis
TPP	sodium tripolyphosphate
UD	unidirectional fiber orientation
vdW	Van Der Waals
VE	vinyl ether
VESFA	vinyl ether soybean fatty acids
VGCFs	vapor-grown carbon fibers
VPT	volume phase transition
WCA	weakly coordinating anion
WPNC	wood polymer nanocomposite
WRF	white-rot fungi
XG	xanthan gum
XRD	X-ray diffraction

LIST OF SYMBOLS

B	benzenic-type rings
D_{001}	interlayer distance between clay layers
E	electric field strength
E	Young's modulus of the composite
E_f	Young's modulus of the filler
E_m	Young's modulus of the matrix
F^c_{ij}	conservative force of particle j acting on particle i, γ and σ are constants depending on the system
H(i) and H(j)	Hamiltonian associated with the original and new configuration, respectively
I	light intensity
K_B	Boltzmann constant
L	embedded length of the nanotube
n_0	refractive index of the sample
P	permeability coefficient (mL-mm/m^2/24 h/atm)
Pi	momentum of particle i
Q	quinonic-type rings
q	wave vector
t	film thickness under investigation (mm)
U^a	energies associated with truss elements that represent covalent bond stretching
U^b	energies associated with truss elements that represent bond-angle bending
U^c	energies associated with truss elements that represent van der Waals interactions
U_k	kinetic energy
U^r	energies associated with covalent bond stretching
U_v	Hookian potential energy
U^{vdw}	energies associated with van der Waals interactions
U^θ	energies associated with bond-angle bending
v_0	Poisson's ratio of the matrix
V_0	volume of dry scaffold
v_f	volume fractions of the fillers

v_m	volume fractions of the matrix
V_p	pore volume
W_0	weight of the dry scaffold
W_d	weight of dried film
W_{es}	weight of swollen films
W_{LDPE}	weight fraction of LDPE in the sample
x	pullout distance of the nanotube
X_c	degree of crystallinity

Greek Symbols

Γ	decay rate
	melting enthalpy of 100% crystalline polyethylene
Δp	partial pressure difference on two sides of the film (atm)
ΔU	change in the sum of the mixing energy and the chemical potential of the mixture
ε_0	permittivity of free space
ε_r	dielectric constant of the dispersion medium
$\zeta(t)$	Gaussian random noise term
η	dynamic viscosity of the dispersion medium
θ	half of the diffraction angle at the first peak
θ	the angle at which the detector is located with respect to the sample cell
λ	incident laser wavelength
λ	wavelength of the X-ray beam
λ_1	due to the electronic transition π to π^* band
λ_2	electronic transition of the polaronic band to π^* band in the benzenoid ring
λ_3	corresponds to the electronic transitions of the π band to the polaronic band
ρ	density of the scaffold
τ	delay time
υ	velocity of a dispersed particle
φ	porosity of the scaffold

PREFACE

Green polymers are those produced using green (or sustainable) chemistry, a term that appeared in the 1990s. According to the definition of the International Union of Pure and Applied Chemistry (IUPAC), green chemistry relates to the "design of chemical products and processes that reduce or eliminate the use or generation of substances hazardous to humans, animals, plants, and the environment." Thus, green chemistry seeks to reduce and prevent pollution at its source. Natural polymers are usually green. The polymer industry looks at alternatives to petrochemical sources to ensure a viable long-term future.

Green polymers are a crucial area of research and product development that continues to grow in its influence over industrial practices. Developments in these areas are driven by environmental concerns and interest in sustainability, desire to decrease our dependence on petroleum, and commercial opportunities to develop "green" products. Publications and patents in these fields are increasing as more academic, industrial, and government scientists become involved in research and commercial activities.

Green Polymers and Environmental Pollution Control examines the latest developments in producing conventional polymers from sustainable sources. The purpose of this book is to publish new work from a cutting-edge group of leading international researchers from academia, government, and industrial institutions.

Providing guidelines for implementing sustainable practices for traditional petroleum-based plastics, biobased plastics, and recycled plastics, green polymers and environmental pollution control explains what green polymers are, why green polymers are needed, which green polymers to use, and how manufacturing companies can integrate them into their manufacturing operations. The volume will be a vital resource for practitioners, scientists, researchers, and graduate students.

With the recent advancements in synthesis technologies and the finding of new functional monomers, research on green polymers has shown strong potential in generating better property polymers from renewable resources. This book, describing these advances in synthesis, processing, and technology of such polymers, not only provides the state-of-the-art information to researchers but also acts to stimulate research in this direction.

Green Polymers and Environmental Pollution Control offers an excellent source for researchers, upper-level graduate students, brand owners, environment and sustainability managers, business development and innovation professionals, chemical engineers, plastics manufacturers, agriculture specialists, biochemists, and suppliers to the industry to debate sustainable, economic solutions for polymer synthesis.

—Professor Moayad N. Khalaf

ABOUT THE EDITOR

Moayad N. Khalaf

Moayad N. Khalaf is a professor of polymer chemistry at the Department of Chemistry, College of Science, University of Basrah, Iraq. He received his BSc in chemistry science, MSc in physical-organic chemistry, and PhD in polymer chemistry from the University of Basrah in Iraq. Professor Khalaf has more than 27 years of professional experience in the petrochemical industry, earned while working with the company for Petrochemical Industries, Iraq. In 2005, he joined the Chemistry Department at the University of Basrah, where now he is lecturing on most polymer related subjects. Dr. Khalaf supervised more than 12 MSc and 4 PhD students. He has 19 Iraqi patents and more than 100 scientific papers published in peer-reviewed journals and conference proceedings. His research interests are:

- Modified polymer for corrosion inhibitor, demulsifier, additive for oil.
- Polymer additive (light stabilizer and antioxidant)
- Lubricant antioxidant
- Lubricant modifier
- Lubricant recycling
- Waste polymers recycling
- Lingnosulfonate for well drilling
- Mechanical properties of composite polymer
- Rheological properties of polymer and composite using nanofiller
- Water desalination
- Preparation of flocculent from waste polystyrene
- Using ground water as source for industrial water and agriculture
- Preparation of polymer for solar cell application
- Preparation of conductive polymer

He also works on modifying the chemical security and safety strategy at the Department of Chemistry of the University of Basrah through funds from CRDF Global. Dr. Khalaf also received funds totaling ($350.000US) so far from the Arab Science and Technology Foundation and the Iraqi Ministry of Higher Education and Scientific Research to support his research in the fields of polymer chemistry and water treatment.

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