
Polymer Synthesis: Theory and Practice

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Polymer Synthesis: Theory and Practice

Fundamentals, Methods, Experiments

Fifth Edition

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Preface to the Fifth Edition

The focus of the previous edition was on a broader description of the general methods and techniques for the synthesis, modifications and characterization of macromolecules. This was supplemented by selected and detailed experiments and by sufficient theoretical treatment so that no additional textbook be needed in order to understand the experiments. In addition to the preparative aspects, we had also tried to give the reader an impression of the relation of chemical structure and morphology of polymers to their properties. This concept is also maintained in this edition.

In recent years, the so-called functional polymers (which have special electrical, electronic, optical and biological properties), have attracted a lot of interest. We, therefore, felt, that a textbook should exist that would contain recipes which describe the synthesis of these materials. For this reason, we added a new chapter “Functional Polymers”.

Together with new experiments in Chaps. 3, 4 and 5, the book now contains more than 120 recipes that describe a wide range of macromolecules.

The completion of the 5th Edition was aided by the contribution of a number of scientists. Our special thanks are due to Dr. M. Tabatabai for her arduous task of checking, assembling and formatting the manuscript. We wish to express our sincerest appreciation to Prof. Dr. M. Buchmeiser for contribution chapter 3.3.3, Dr. B. Müller, Dr. J. Zhou and Ms. Dr. Z. Rezaie for production of chapter 2.3.4 and 6.1; Dr. J. Pionteck, Dr. P. Pötschke, and Dr. F. Böhme for contributing to and reading of the chapter 1 and 5. We also thank the Chemistry Editorial and Production Department of Springer-Verlag for an excellent cooperation.

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Relevant SI Units and Conversions

Relevant SI units and conversions

Name	SI unit		Multiples	Units outside ^a SI	
Length	Meter	m	km, cm, mm μm, nm	Ångstrom ^a	Å = 10 ⁻¹⁰ m
				Foot	ft = 30.48 cm
				Inch	in = 2.54 cm
				Micron	μ = 10 ⁻⁹ m
				Mil	mil = 2.54 10 ⁻⁵ m
Mass	Kilogram	kg	Mg, g, mg, μg	Statute mile	mile = 1609.3 m
				Ounce	oz = 28.349 g
				Pound (US, 16 oz)	lb = 453.592 g
				Ton (metric)	t = 1,000 kg
				Long ton (UK)	ton = 1.02 10 ³ kg
Time	Second	s	ks, ms, μs, ns	Short ton (US)	ton = 9.110 ² kg
				Minute ^a	min = 60 s
				Hour ^a	h = 3,600 s
Temperature	Kelvin	K		Day ^a	d = 86,400 s
				Degree Celsius ^a	0°C = 273.15 K
Density	kg/m ³	kg/m ³	mg/m ³ , kg/dm ³ , g/cm ³	Degree Fahrenheit	°F = 9/5 °C + 32
				t/m ³ , kg/l ^a	
Volume	Cubic meter	m ³	dm ³ , cm ³ , mm ³	liter ^a	l, L = 1 dm ³
Force	Newton	N	MN, kN, mN, μN	dyn kg force	dyn = 10 ⁻⁵ N

(continued)

Name	SI unit	Multiples		Units outside ^a SI	
					kgf (Kp)= 9.81 N
Pressure	Pascal	Pa	GPa, MPa, KPa, mPa, μ Pa	Bar	bar= 10^5 Pa
				Atmosphere	atm= $1.101 \cdot 10^5$ Pa
				mm Hg	torr= 133.3 Pa
				lbs/sq.in.	psi= 6.8910^3 Pa
Viscosity (dynamic)		Pa·s	mPa·s	Poise	P= 0.1 Pa s
				Centipoise	cP= 10^{-3} Pa s
Viscosity (kinematic)		m^2/s	mm^2/s	Stokes	St= 10^{-4} m^2/s
				Centistokes	cSt= 10^{-6} m^2/s
Electric charge	Coulomb	C=A·s			
Electric current	Ampere	A			
Electric potential	Volt	$V=J \cdot C^{-1}$	MV, kV, mV		
Energy, work, heat	Joule	J	TJ, GJ, MJ, kJ, mJ	Electron volt	eV= $1.60 \cdot 10^{-19}$ J
Power (radiant flux)	Watt	W (=V·A= J/s)	GW, MW, kW, mW		

^aAccepted for SI

List of General Abbreviations

[η]	Intrinsic viscosity, Staudinger index
AIBN	2,2'-azobis(isobutyronitrile)
Ar	Aryl
BDDA	Butandioldiacrylate
bp	Boiling point
BPO	Benzoyl peroxide
cat	Catalyst
CRU	Constitutional repeating unit
DMF	Dimethyl formamide
DMSO	Dimethyl sulfoxide
DP	Degree of polymerization
DSC	Differential scanning calorimetry
Et	Ethyl
g/l	Grams per liter
GPC	Gel permeation chromatography (alternatively: SEC)
h	Hour(s)
IR	Infrared
l	Liter(s)
LCST	Lower critical solution temperature
LED	Light emitting diode
Me	Methyl
min	Minute(s)
M_n	Number average molecular weight
mol	Mole(s)
mp	Melting point
MTB	Methyl- <i>tert</i> -butyl
MW	Molecular weight
M_w	Weight average molecular weight
NLO	Nonlinear optical
NMP	<i>N</i> -methylpyrrolidone
NMR	Nuclear magnetic resonance
OFET	Organic field-effect transistor
OLED	Organic light emitting diode

OPV	Organic photo voltage
OSC	Organic solar cell
OTFT	Organic thin-film transistor
Ph	Phenyl
POLED	Polymer based organic light emitting diode
ppm	Parts per million
s	Second(s)
SC	Solar cell
SEC	Size exclusion chromatography (alternatively: GPC)
SMP	Shape memory polymer
T_c	Crystallization temperature
T_d	Degradation temperature
T_g	Glass transition temperature
TGA	Thermogravimetric analysis
THF	Tetrahydrofuran
T_m	Melting temperature
UCST	Upper critical solution temperature
UV	Ultraviolet
η_{inh}	Inherent viscosity
η_{rel}	Relative viscosity
η_{sp}	Specific viscosity

Abbreviations for Technically Important Polymers

ABS	Acrylonitrile butadiene styrene copolymer blend
ACM, ANM	Acrylic ester rubber
APP	Atactic PP
ASA	Acrylonitrile styrene acrylic ester copolymer blend
BR	Polybutadiene rubbers (<i>cis</i> - or <i>trans</i> -1,4; 1,2)
CA	Cellulose acetate
CAB	Cellulose acetobutyrate
CAP	Cellulose acetopropionate
CF	Cresol–formaldehyde resin
CFC	Carbon fiber reinforced carbon
CFR	Carbon reinforced resin
CMC	Carboxymethylcellulose
CN	Cellulose nitrate
COC	Cycloolefin copolymers
CP	Cellulose propionate
CR	Chloroprene rubber
CSM	Chlorosulfonated polyethylene
CTA	Cellulose triacetate
EC	Ethyl cellulose
ECTFE	Ethylene chlorotrifluoroethylene copolymers
EEA	Ethylene ethyl acrylate copolymers
EP	Epoxide resin
EPDM	Ethylene propylene diene terpolymers
EPM	Ethylene propylene rubbers
EPS	Expandable polystyrene
ETFE	Ethylene tetrafluoroethylene copolymers
EVA, EVAC	Ethylene vinyl acetate copolymers
EVAL	Ethylene vinyl alcohol copolymers
FEP	Tetrafluoroethylene perfluoropropylene copolymers
FF	Furan resins
FRP	Glass fiber reinforced polymers
GR-I, IIR	Butyl rubber
HIPS	High impact polystyrene

HT-PDDT	Head-to-tail polydodecylthiophene
IPP	Isotactic PP
IR	Polyisoprene rubber (<i>cis</i> - or <i>trans</i> -1,4; -1,2; -3,4)
LCP	Liquid crystalline polymer
MBS	Methyl methacrylate butadiene styrene copolymer blend
MC	Methylcellulose
MF	Melamin–formaldehyde resin
MPF	Melamin-phenol-formaldehyde resin
MPPE	Poly(phenylene ether) polystyrene blend
NBR	Nitrile rubber
NC	Nitrocellulose
NR	Natural rubber
PA	Polyamides
PAEK	Poly(aryl ether ketone)
PAI	Poly(amide imide)
PAN	Polyacrylonitrile
PB	Polybutylene
PBI	Poly(benzimidazole)
PBT	Poly(butylene terephthalate)
PC	Polycarbonate
PCTFE	Poly(chlorotrifluoroethylene)
PE	Polyethylene
PEC	Chlorinated polyethylene
PEHD	High-density PE
PEI	Poly(ether imide)
PELD	Low-density PE
PELLD	Linear low density PE
PEMD	Medium-density PE
PEO, PEOX	Poly(ethylene oxide)
PES	Poly(ether sulfone)
PET	Poly(ethylene terephthalate)
PEVLD	Very low density PE
PF	Phenol–formaldehyde resin
PFA	cf. TFA
PFEP	Tetrafluoroethylene perfluoropropylene copolymers
PI	Polyimide
PIB	Poly(isobutylene)
PMI	Poly(methacrylimide)
PMMA	Poly(methyl methacrylate)
PMP, TPX	Poly(4-methylpent-1-ene)
PNiPAAM	Poly(<i>N</i> -isopropylacrylamide)
PO	Polyolefins
POM	Poly(oxymethylene), polyformaldehyde, polyacetal
PP	Polypropylene
PPC	Chlorinated PP

PPE, PPO	Poly(phenylene ether)
PPOX (PPO)	Poly(propylene oxide)
PPS	Poly(phenylene sulfide)
PPSU, PSU	Poly(phenylene sulfone)
PPV	Polyphenylvinyl
PS	Polystyrene
PTFE	Poly(tetrafluoroethylene)
PTP	Poly(terephthalate)
PUR	Polyurethane
PVA, PVAC	Poly(vinyl acetate)
PVAL	Poly(vinyl alcohol)
PVB	Poly(vinylbutyral)
PVC	Poly(vinyl chloride)
PVCC	Chlorinated PVC
PVDC	Poly(vinylidene chloride)
PVDF	Poly(vinylidene fluoride)
PVF	Poly(vinyl fluoride)
PVFM	Poly(vinylformal)
PVP	Poly(vinylpyrrolidone)
RF	Resorcin–formaldehyde resin
SAN	Styrene acrylonitrile copolymer
SBR	Styrene butadiene rubber
SBS	Styrene butadiene styrene triblock copolymers (ABA)
SI	Silicone plastics
SIR	Silicone rubbers
SPP	Syndiotactic PP
TFA	Tetrafluoroethylene perfluoropropyl vinyl ether copolymers
TPE	Thermoplastic elastomers
TPU	Thermoplastic polyurethanes
UF	Urea–formaldehyde resins
UP	Unsaturated polyester
VCE	Vinyl chloride ethylene copolymers

