

James Mark
Kia Ngai
William Graessley
Leo Mandelkern
Edward Samulski
Jack Koenig, and
George Wignall

Physical Properties of Polymers

Third Edition

CAMBRIDGE

Contents

<i>Notes on contributors</i>	<i>page x</i>
<i>Preface</i>	<i>xv</i>
Part I Physical states of polymers	1
1 The rubber elastic state, James E. Mark	3
1.1 Introduction	3
1.2 Theory	12
1.3 Some experimental details	19
1.4 Comparisons between theory and experiment	22
1.5 Some unusual networks	31
1.6 Networks at very high deformations	35
1.7 Other types of deformation	46
1.8 Gel collapse	49
1.9 Energy storage and hysteresis	50
1.10 Bioelastomers	52
1.11 Filled networks	54
1.12 New developments in processing	60
1.13 Societal aspects	60
1.14 Current problems and new directions	60
1.15 Numerical problems	62
1.16 Solutions to numerical problems	62
Acknowledgments	63
References	63
Further reading	70
2 The glass transition and the glassy state, Kia L. Ngai	72
2.1 Introduction	72
2.2 The phenomenology of the glass transition	75
2.3 Models of the glass transition	94

2.4	Dependences of T_g on various parameters	101
2.5	Structural relaxation in polymers above T_g	114
2.6	The impact on viscoelasticity	127
2.7	Conclusion	144
	Acknowledgments	146
	References	146
3	Viscoelasticity and flow in polymeric liquids, William W. Graessley	153
3.1	Introduction	153
3.2	Concepts and definitions	154
3.3	Linear viscoelasticity	159
3.4	Nonlinear viscoelasticity	170
3.5	Structure-property relationships	184
3.6	Summary	205
	References	206
4	The crystalline state, Leo Mandelkern	209
4.1	Introduction	209
4.2	The thermodynamics of crystallization-melting of homopolymers	212
4.3	Melting of copolymers	217
4.4	Crystallization kinetics	245
4.5	Structure and morphology	267
4.6	Properties	295
4.7	General conclusions	307
	References	308
	Further reading	315
5	The mesomorphic state, Edward T. Samulski	316
5.1	Introduction	316
5.2	General concepts	316
5.3	Monomer liquid crystals	333
5.4	Macromolecular mesomorphism	353
5.5	Theories of mesomorphism	364
	Acknowledgment	376
	References	376
Part II	Some characterization techniques	381
6	The application of molecular spectroscopy to characterization of polymers, Jack L. Koenig	383
6.1	Introduction	383
6.2	Vibrational techniques	384

6.3	Infrared spectroscopy	387
6.4	Raman spectroscopy	397
6.5	Nuclear-magnetic-resonance spectroscopy	406
6.6	Mass spectroscopy	419
	References	422
7	Small-angle-neutron-scattering characterization of polymers, George D. Wignall	424
7.1	Introduction	424
7.2	Elements of neutron-scattering theory	437
7.3	Contrast and deuterium labeling	444
7.4	SANS instrumentation	451
7.5	Practical considerations	457
7.6	Some applications of scattering techniques to polymers	468
7.7	Future directions	502
	Acknowledgments	504
	References	504
	<i>Index</i>	513