ELECTRICAL PROPERTIES OF POLYMERS CHEMICAL PRINCIPLES

by Chen C. Ku and Raimond Liepins

with 113 Figures and 47 Tables



Hanser Publishers, Munich - Vienna - New York

Distributed in the United States of America by Macmillan Publishing Company, New York and in Canada by Collier Macmillan Canada, Inc., Ontario

CONTENTS

CHAPTER 1	THE FOUR FUNDAMENTAL PARAMETERS OF ELECTRI- CAL PROPERTIES OF POLYMERS1.1 Introduction1.2 Electrical Properties of Polymers1.3 Chemical Aspects of Electrical Properties of Polymers1.4 Requirements for Polymers as Electrical Insulating Materials1.5 Use of Polymers as Materials with Special Electrical Properties1.6 References	1 3 7 10 12 16
CHAPTER 2	DIELECTRIC CONSTANT OF POLYMERS 2.1 Introduction 2.2 Historical Overview 2.3 Basic Relationships 2.4 Polarization of Polymers 2.5 Polarization and Dielectric Constant 2.6 Spontaneous Polarization or Ferroelectricity 2.7 Interfacial Polarization 2.8 Hyperelectronic Polarization – a Special Case of Interfacial Polarization 2.9 How to Keep Dielectric Constant Low 2.10 How to Keep Dielectric Constant High 2.11 Frequency Dependence of Dielectric Constant 2.12 Temperature Dependence of Dielectric Constant 2.13 Dielectric Constant as a Function of Frequency and Temperature 2.14 References	20 21 22 23 25 28 31 33 36 38 39 51 53 55 56
CHAPTER 3	 TANGENT OF DIELECTRIC LOSS ANGLE OF POLYMERS 3.1 Introduction	59 60 61 61 76 80 84 85 90 92 93 96 98
CHAPTER 4	DIELECTRIC BREAKDOWN OF POLYMERS 4.1 Introduction	102 105
PART I.	TREEING IN POLYMERS4.2 Historical Overview4.3 Basic Observations and Terms	106 107

SECTION A.	ELECTRICAL TREEING4.4 Initiation of Electrical Trees4.5 Growth of Electrical Trees4.6 Testing4.7 Inhibition of Electrical Treeing4.8 Polymer Structural Considerations4.9 Effects of Temperature, Voltage, and Mechanical Strain127
SECTION B.	WATER TREEING4.10 Introduction1284.11 Initiation of Water Trees1294.12 Growth of Water Trees1364.13 Testing1374.14 Inhibition of Water Treeing1384.15 Criteria for Tree-Resistant Insulation140
PART II.	DIELECTRIC BREAKDOWN IN POLYMERS4.16 Introduction1414.17 Historical Overview1414.18 Basic Observations1434.19 Theories of Dielectric Breakdown1444.20 Principal Mechanisms of Dielectric Breakdown1484.21 Polymer Structure and Dielectric Breakdown1544.22 Effect of Plasticization on Dielectric Breakdown1664.23 Effect of Fillers on Dielectric Breakdown1684.24 Effect of Molecular Weight on Dielectric Breakdown1714.25 Effect of Morphology on Dielectric Breakdown1734.26 Additives to Improve Dielectric Strength1764.27 How to Keep Dielectric Strength High1774.28 Electrical Aging1794.30 References188
CHAPTER 5	ELECTRICAL CONDUCTION IN POLYMERS2005.1Introduction204
PART I.	CONDUCTION PROCESSES IN INSULATING POLYMERS5.2Basic Concepts2055.3Experimental Technique and Data2435.4Conclusions255
PART II.	SYNTHETIC METALS5.5 Introduction2565.6 Basic Considerations2595.7 Charges in Polymers2615.8 Charge Transport in Doped Conjugated Polymers2675.9 Preparation of Conducting Polymers2725.10 Conducting Polymers with Special Properties2855.11 Superconducting Polymers2895.12 Molecular Electronics2985.13 Bioelectronics3025.14 Molecular Electronics Research Groups3055.15 References306

CHAPTER 6	ELECTRICAL PARAMETERS OF POLYMERS IN SUMMARY
	6.1 Introduction
	6.2 Correlations of the Four Key Electrical Parameters
	6.3 Dielectric Breakdown
	6.4 Effect of Molecular Weight, Morphology, and Plasticization on
	Conductivity in Insulating Polymers
	6.5 Materials with Selected Values
	6.6 References
APPENDICES	1. Dielectric Constants
	2. Dissipation Factor
	3. Dielectric Strength
	4. Arc Resistance
	5. Electrical Conductivity
	6. Water Vapor Permeability
	7. Water Absorption
AUTHOR INE	DEX
SUBJECT IND	DEX