



# **Oxidative Ageing of Polymers**

**Jacques Verdu**

**ISTE**

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## Table of Contents

<b>Acknowledgements</b> . . . . .	xi
<b>General Introduction</b> . . . . .	xiii
<b>Chapter 1. Methodological Aspects</b> . . . . .	1
1.1. Definitions . . . . .	1
1.2. Empirical and semi-empirical models . . . . .	4
1.2.1. The Arrhenius model . . . . .	4
1.2.2. The isodose model . . . . .	5
1.2.3. The overall kinetic model . . . . .	6
1.2.4. The correlation method . . . . .	6
1.2.5. Various mathematical “laws” . . . . .	7
1.2.6. Conclusion . . . . .	7
1.3. Towards a non-empirical method of lifetime prediction . . . . .	8
1.3.1. Principles . . . . .	8
1.3.2. The multiscale model . . . . .	8
1.3.3. A new philosophy of ageing . . . . .	10
1.4. Arguments against kinetic modeling . . . . .	11
1.4.1. Overcomplexity . . . . .	11
1.4.2. Heterogeneity . . . . .	12
1.4.3. Conclusion . . . . .	15
1.5. Principles of model elaboration . . . . .	15
<b>Chapter 2. Aspects Common to all Oxidation Processes</b> . . . . .	17
2.1. Oxidation: a radical chain mechanism . . . . .	17
2.1.1. Radical nature . . . . .	17
2.1.2. Chain reaction . . . . .	18
2.2. Propagation . . . . .	20

2.2.1. Propagation by addition to double bonds . . . . .	21
2.2.2. Propagation by hydrogen abstraction . . . . .	22
2.2.3. Propagation by $P^\circ$ radicals . . . . .	24
2.3. Termination. . . . .	25
2.3.1. The $P^\circ + P^\circ$ termination . . . . .	26
2.3.2. The $P^\circ + POO^\circ$ termination . . . . .	28
2.3.3. The $POO^\circ + POO^\circ$ termination. . . . .	29
2.4. Initiation. . . . .	30
2.4.1. Polymer decomposition . . . . .	30
2.4.2. Decomposition of oxidation products . . . . .	32
2.5. Thermodynamic aspects . . . . .	41
2.5.1. Initiation . . . . .	41
2.5.2. Propagation . . . . .	42
2.5.3. Termination . . . . .	43
<b>Chapter 3. Basic Kinetic Schemes . . . . .</b>	<b>45</b>
3.1. Simplifying hypotheses. . . . .	45
3.1.1. Hypothesis U: unicity of the reactive site. . . . .	45
3.1.2. Hypothesis E: oxygen excess . . . . .	47
3.1.3. Hypothesis A: constant initiation rate . . . . .	47
3.1.4. Hypothesis S: stationary state. . . . .	48
3.1.5. Hypothesis C: constant substrate concentration . . . . .	48
3.1.6. Hypothesis L: long kinetic chain. . . . .	49
3.1.7. Hypothesis T: relation between the termination rate constants . . . . .	49
3.1.8. Hypothesis H: homogeneity of reaction. . . . .	49
3.1.9. Hypothesis B: “closed loop” scheme . . . . .	49
3.2. The ASEC scheme. . . . .	50
3.2.1. Towards an AEC scheme . . . . .	53
3.3. The ASCTL scheme. . . . .	54
3.4. The BESC scheme. . . . .	57
3.4.1. Characteristics common to all BESC schemes. . . . .	58
3.4.2. Unimolecular decomposition of hydroperoxides . . . . .	61
3.4.3. Bimolecular decomposition of hydroperoxides . . . . .	63
3.5. The BASC scheme . . . . .	66
3.5.1. The unimolecular BASC model . . . . .	66
3.5.2. Another approach to the BASC schemes . . . . .	69
3.5.3. How are we to recognize the mechanisms?. . . . .	71
3.6. Other schemes . . . . .	74
3.6.1. Consumption of the substrate. . . . .	74
3.6.2. Unsaturated substrates . . . . .	76
3.6.3. Intramolecular propagation in polypropylene . . . . .	79
3.6.4. Co-oxidation. . . . .	83



3.7. General problems of kinetic analysis of polymer oxidation.	
The outlines of a new approach. . . . .	85
3.7.1. Near-universality of the kinetic behavior . . . . .	86
3.7.2. Rate constants . . . . .	88
3.7.3. A systematic approach . . . . .	89
<b>Chapter 4. Oxidation and Oxygen Diffusion . . . . .</b>	<b>93</b>
4.1. Properties of oxygen transport in polymers . . . . .	93
4.1.1. Solubility. . . . .	93
4.1.2. Diffusivity . . . . .	96
4.2. The reaction/diffusion equation . . . . .	101
4.2.1. Conventional approach . . . . .	101
4.2.2. Numerical resolution . . . . .	107
4.2.3. Thickness of the oxidized layer. Shape and evolution of the profile. . . . .	108
<b>Chapter 5. Stabilization . . . . .</b>	<b>111</b>
5.1. Principles of stabilization. . . . .	111
5.1.1. Action on $[O_2]$ . . . . .	112
5.1.2. Action on radiation . . . . .	113
5.1.3. Capture or destruction of radicals and hydroperoxides . . . . .	113
5.2. Action on hydroperoxide decomposition . . . . .	113
5.2.1. Hydroperoxide decomposers . . . . .	114
5.2.2. Metal deactivators . . . . .	116
5.3. Stabilization by capture of $P^\circ$ radicals . . . . .	117
5.3.1. Carbon black. . . . .	117
5.3.2. Nitroxide radicals. . . . .	118
5.4. Stabilization by capture of $POO^\circ$ radicals . . . . .	119
5.4.1. General . . . . .	119
5.4.2. $POO^\circ$ radical scavengers . . . . .	121
5.5. Synergistic mixtures HD + CBA . . . . .	125
5.6. Polyfunctional stabilizers. . . . .	126
5.7. Hindered amines. . . . .	127
5.7.1. Mechanistic aspects . . . . .	127
5.7.2. Kinetic aspects . . . . .	129
5.8. Other stabilizing mechanisms . . . . .	131
5.9. Physical aspects of stabilization by additives . . . . .	131
5.9.1. Solubility. . . . .	132
5.9.2. Volatility, evaporation . . . . .	135
5.9.3. Diffusivity . . . . .	138
5.9.4. Evaporation-diffusion . . . . .	141
5.9.5. Demixing and other phenomena . . . . .	142

<b>Chapter 6. Molecular Mobility and Reactivity</b> . . . . .	145
6.1. The issue . . . . .	145
6.2. The chemical way . . . . .	149
6.2.1. Example of application: oxidation of PE at low temperature . . . . .	151
6.3. The physical way . . . . .	154
6.4. Control by diffusion of macromolecular reactive species and heterogeneity . . . . .	158
6.5. The paradox of thermostability in glassy polymers . . . . .	161
<b>Chapter 7. Structural Changes Caused by Oxidation</b> . . . . .	163
7.1. On the molecular scale . . . . .	163
7.1.1. Absorbed oxygen, oxygenated groups. . . . .	163
7.1.2. Chemiluminescence . . . . .	164
7.1.3. Volatile oxidation products . . . . .	166
7.1.4. How are we to include the formation of the oxidation products in the kinetic model? . . . . .	169
7.2. On the macromolecular scale . . . . .	175
7.2.1. Scissions in linear polymers. . . . .	176
7.2.2. Scissions in three-dimensional polymers . . . . .	182
7.2.3. Simultaneous crosslinking and scissions . . . . .	187
7.3. On the morphological scale . . . . .	192
7.3.1. Amorphous polymers . . . . .	192
7.3.2. Immiscible mixtures of amorphous polymers . . . . .	193
7.3.3. Semi-crystalline polymers with a glassy amorphous matrix . . . . .	193
7.3.4. Semi-crystalline polymers with a rubbery amorphous phase . . . . .	194
<b>Chapter 8. Effects of Oxidation on Physical and Mechanical Properties</b> . . . . .	203
8.1. Introduction. . . . .	203
8.2. Weight changes . . . . .	204
8.2.1. Particular cases . . . . .	207
8.3. Changes in density and volume . . . . .	207
8.4. Optical properties . . . . .	210
8.4.1. Changes in the refractive index. . . . .	210
8.4.2. Coloration . . . . .	212
8.4.3. Surface state . . . . .	214
8.4.4. Quantifying the effects of oxidation on the optical properties. . . . .	215
8.5. Electrical properties . . . . .	215
8.5.1. Dielectrical spectrum. . . . .	215
8.5.2. Dielectric fracture. . . . .	217
8.6. Glass transition and melting . . . . .	218

8.6.1. Glass transition temperature . . . . .	218
8.6.2. Melting point . . . . .	222
8.7. Mechanical properties at low strains . . . . .	223
8.7.1. Reminders . . . . .	223
8.7.2. Elastomers, rubbery phases . . . . .	225
8.7.3. Glassy amorphous phases . . . . .	226
8.7.4. Semi-crystalline polymers. . . . .	229
8.8. Fracture properties in the case of homogeneous degradation. . . . .	230
8.8.1. Glassy and semi-crystalline amorphous linear polymers with a glassy amorphous phase undergoing degradation. . . . .	230
8.8.2. Semi-crystalline polymers with a rubbery amorphous phase undergoing degradation . . . . .	234
8.8.3. Elastomers undergoing degradation . . . . .	236
8.8.4. Thermoset materials undergoing degradation . . . . .	238
8.8.5. Effects of superficial oxidation on fracture behavior . . . . .	239
8.9. Fracture properties in the case of homogeneous crosslinking . . . . .	243
8.9.1. Glassy amorphous polymers . . . . .	243
8.9.2. Elastomers . . . . .	245
<b>Chapter 9. Couplings . . . . .</b>	<b>249</b>
9.1. Introduction. . . . .	249
9.2. “Spontaneous” cracking . . . . .	250
9.3. Coupling between cracking and oxidation. . . . .	252
9.4. Lifetime under static strain and oxidation . . . . .	254
9.4.1. Mechano-chemical initiation . . . . .	254
9.4.2. Effect of oxidation on the fracture kinetics. . . . .	257
9.5. Physical ageing and oxidation. . . . .	264
9.6. Oxidation during processing – degradation and recycling . . . . .	266
9.6.1. Thermoplastics . . . . .	266
9.6.2. Thermoset materials . . . . .	274
<b>Chapter 10. Oxidation Under Irradiation . . . . .</b>	<b>277</b>
10.1. Definitions. General aspects . . . . .	277
10.1.1. Characteristics of radiation . . . . .	277
10.1.2. Difference between photochemical and radiochemical initiation . . . . .	278
10.1.3. Quantities characterizing the radiation and interaction between the matter and the radiation . . . . .	279
10.1.4. Quantities characterizing the reaction . . . . .	282
10.2. Radiochemical initiation . . . . .	283
10.3. A peculiarity of radiochemical ageing. . . . .	288
10.3.1. Stabilization . . . . .	291

10.4. Photochemical initiation . . . . .	291
10.4.1. Initiation by photolysis of hydroperoxides . . . . .	292
10.4.2. “Acceleration factor”, linked to the intensity . . . . .	293
10.4.3. Initiation by thermal and photochemical decomposition of POOHs . . . . .	294
10.4.4. Initiation in an absorbent environment, thickness of the photo-oxidized layer . . . . .	295
10.4.5. Initiation by other processes . . . . .	296
10.4.6. Polychromatic light sources . . . . .	297
10.5. Photostabilization . . . . .	300
10.5.1. Stabilization by screen effect . . . . .	300
10.6. Ageing under natural sunlight . . . . .	308
10.6.1. Solar radiation at the earth’s surface . . . . .	308
10.6.2. Kinetics of polymer photo-ageing . . . . .	313
10.6.3. Conclusion on photochemical ageing under natural solar radiation . . . . .	319
 <b>Bibliography</b> . . . . .	 321
<b>Appendix</b> . . . . .	347
<b>Index</b> . . . . .	353

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## General Introduction

### **Why oxidation?**

The yellowing of a polyester-fiberglass hull, the crumbling of paint, the development of a purple coloration at the surface of a PVC extrudate for building are all manifestations of oxidative ageing of polymers. These are examples of changes in the visual aspect of the materials, which may have significant financial consequences but which do not, in themselves, pose a threat to the safe use of the system in question. The embrittlement of a carbon-polyimide part functioning at 200°C in an airplane engine, the hardening of a polybutadiene matrix rocket propeller, and the cracking of a polyethylene electrical cable sheath in a nuclear plant, are also manifestations of oxidative ageing of polymers, but here the resulting failures could have grave consequences on every level. Predicting failures is the main objective of ageing studies. What fails is a system, a structure (in the broader sense). In certain cases, this failure is related to an unforeseen change in the operating conditions (an accident, a fire, etc.). In others, it is related to an inadequate knowledge of the system's capacity to withstand the mechanical loads to which it is subjected (creep, fatigue, etc.). These failures may also result from two incompatible materials being brought into contact, or one material coming into contact with incompatible fluids. Here, we look only at the case of a system failure resulting from the change in the properties of one of its constituent materials, and that change resulting from that material interacting with oxygen. We shall focus on deterministic approaches to the problem, i.e. cases where the system failure can be associated more-or-less accurately with a critical structural state of the material, or at the very least with a critical value of a property of the material. Why limit ourselves to the study of oxidation? For the simple reason that if we lived in a neutral atmosphere, 99% of thermal or photochemical ageing problems would disappear, with the lifespan of polymers being many times higher than it is in the presence of oxygen. However, in many cases oxidation takes place alongside other types of ageing, and there may be significant interplay between these different phenomena. For example,