

Methods in Enzymology

Volume 319

*Singlet Oxygen, UV-A,
and Ozone*

EDITED BY

Lester Packer

UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

Helmut Sies

HENRICH-HEINE-UNIVERSITÄT
DÜSSELDORF, GERMANY

Editorial Advisory Board

Jean Cadet
Paolo Di Mascio
Chris Foote
Barry Halliwell
Jean Krutmann
William Pryor
Rex Tyrrell



ACADEMIC PRESS

San Diego London Boston New York Sydney Tokyo Toronto

Table of Contents

CONTRIBUTORS TO VOLUME 319	xi
PREFACE	xvii
VOLUMES IN SERIES	xix

Section I. Singlet Oxygen

A. Generation and Detection: Chemical Systems

1. Naphthalene Endoperoxides as Generators of Singlet Oxygen in Biological Media	CHRISTEL PIERLOT, JEAN-MARIE AUBRY, KARLIS BRIVIBA, HELMUT SIES, AND PAOLO DI MASCO	3
2. Photosensitized Production of Singlet Oxygen	IRENE E. KOICHEVAR AND ROBERT W. REDMOND	20
3. Singlet Oxygen from Irradiated Titanium Dioxide and Zinc Oxide	YORIHIRO YAMAMOTO, NORITAKA IMAI, RYUICHI MASHIMA, RYUSEI KONAKA, MASAYASU INOUE, AND WALTER C. DUNLAP	29
4. Time-Resolved Singlet Oxygen Detection	SANTI NONELL AND SILVIA E. BRASLAVSKY	37
5. Measurement of Photogenerated Singlet Oxygen in Aqueous Media	VÉRONIQUE NARDELLO AND JEAN-MARIE AUBRY	50

B. Generation and Detection: Biological Systems

6. Assay for Singlet-Oxygen Generation by Peroxidases Using 1270-nm Chemiluminescence	JEFFREY R. KANOFSKY	59
7. Formation of Electronically Excited States during the Oxidation of Arachidonic Acid by Prostaglandin Endoperoxide Synthase	ENRIQUE CADENAS AND HELMUT SIES	67
8. Singlet Oxygen Detection with Sterically Hindered Amine Derivatives in Plants under Light Stress	ÉVA HIDEG, ÍMRE VASS, TAMÁS KÁLAI, AND KÁLMÁN HIDEG	77

9. Cholesterol as a Singlet Oxygen Detector in Biological Systems	ALBERT W. GIROTTI AND WITOLD KORYTOWSKI	85
10. Singlet Oxygen Scavenging in Phospholipid Membranes	KENJI FUKUZAWA	101
11. Catalase Modification as a Marker for Singlet Oxygen	FERNANDO LLEDIAS AND WILHELM HANSBERG	110
C. Biological Effects: Role in Signaling		
12. Nuclear Factor- κ B Activation by Singlet Oxygen Produced during Photosensitization	JEAN-YVES MATROULE AND JACQUES PIETTE	119
13. Mitogen-Activated Protein Kinase Activation by Singlet Oxygen and Ultraviolet A	LARS-OLIVER KLOTZ, KARLIS BRIVIBA, AND HELMUT SIES	130
D. Toxic Effects		
14. Singlet Oxygen DNA Damage Products: Formation and Measurement	JEAN CADET, THIERRY DOUKI, JEAN-PIERRE POUGET, AND JEAN-LUC RAVANET	143
15. Ultraviolet A- and Singlet Oxygen-Induced Mutation Spectra	ANNE STARY AND ALAIN SARASIN	153
16. Damage to DNA by Long-Range Charge Transport	MEGAN E. NÚÑEZ, SCOTT R. RAJSKI, AND JACQUELINE K. BARTON	165
17. Cholesterol Photodynamic Oxidation by Ultraviolet Irradiation and Cholesterol Ozonization by Ozone Exposure	KYOICHI OSADA AND ALEX SEVANIAN	188
18. Bactericidal and Virucidal Activities of Singlet Oxygen Generated by Thermolysis of Naphthalene Endoperoxides	CORINNE PELLIEUX, ANNY DEWILDE, CHRISTEL PIERLOT, AND JEAN-MARIE AUBRY	197
19. Inactivation of Viruses in Human Plasma	Harald MOHR	207
20. 3-(4'-Methyl-1'-naphthyl)propionic Acid, 1',4'-Endoperoxide for Dioxygenation of Squalene and for Bacterial Killing	MINORU NAKANO, YASUHIRO KAMBAYASHI, AND HIDETAKA TATSUZAWA	216
E. Protection: Singlet Oxygen Quenchers		
21. Biological Singlet Oxygen Quenchers Assessed by Monomol Light Emission	KARLIS BRIVIBA AND HELMUT SIES	222

22. Synthetic Singlet Oxygen Quenchers	STEFAN BEUTNER, BRITTA BLOEDORN, THOMAS HOFFMANN, AND HANS-DIETER MARTIN	226
--	---	-----

Section II. Ultraviolet A

A. Dosimetry

23. Dosimetry of Ultraviolet A Radiation	BRIAN L. DIFFEY	245
--	-----------------	-----

B. Biological Responses: Signaling

24. Radiation-Induced Signal Transduction	AXEL KNEBEL, FRANK D. BÖHMER, AND PETER HERRLICH	255
25. Signaling Pathways Leading to Nuclear Factor- κ B Activation	NANXIN LI AND MICHAEL KARIN	273
26. Gene Regulation by Ultraviolet A Radiation and Singlet Oxygen	SUSANNE GRETHER-BECK AND JEAN KRUTMANN	280
27. Role for Singlet Oxygen in Biological Effects of Ultraviolet A Radiation	REX M. TYRRELL	290
28. Ultraviolet A-1 Irradiation as a Tool to Study the Pathogenesis of Atopic Dermatitis	JEAN KRUTMANN	296
29. Ultraviolet A Radiation-Induced Apoptosis	AKIMICHI MORITA AND JEAN KRUTMANN	302
30. Singlet Oxygen-Triggered Immediate Preprogrammed Apoptosis	DIANNE E. GODAR	309
31. Determination of DNA Damage, Peroxide Generation, Mitochondrial Membrane Potential, and Caspase-3 Activity during Ultraviolet A-Induced Apoptosis	SAEKO TADA-OIKAWA, SHINJI OIKAWA, AND SHOSUKE KAWANISHI	331
32. Mechanism of Photodynamic Therapy-Induced Cell Death	NIHAL AHMAD AND HASAN MUKHTAR	342

C. Biological Responses: Photocarcinogenesis, Photoaging, and Photoallergic Reactions

33. Photocarcinogenesis: UVA vs UVB	FRANK R. DE GRUIJL	359
34. Photoaging-Associated Large-Scale Deletions of Mitochondrial DNA	MARK BERNEBURG AND JEAN KRUTMANN	366

- | | | |
|--|--|-----|
| 35. Role of Activated Oxygen Species in Photodynamic Therapy | WESLEY M. SHARMAN,
CYNTHIA M. ALLEN, AND
JOHAN E. VAN LIER | 376 |
| 36. Gas Chromatography–Mass Spectrometry Analysis of DNA: Optimization of Protocols for Isolation and Analysis of DNA from Human Blood | ALMAS REHMAN,
ANDREW JENNER, AND
BARRY HALLIWELL | 401 |

D. Oxidative Damage Markers

- | | | |
|---|---|-----|
| 37. Sequence Specificity of Ultraviolet A-Induced DNA Damage in the Presence of Photosensitizer | KIMIKO ITO AND
SHOSUKE KAWANISHI | 417 |
| 38. Protein Oxidative Damage | EMLY SHACTER | 428 |
| 39. DNA Damage Induced by Ultraviolet and Visible Light and Its Wavelength Dependence | CHRISTOPHER KIELBASSA AND
BERND EPE | 436 |
| 40. Photoprotection of Skin against Ultraviolet A Damage | HANS SCHAEFER,
ALAIN CHARDON, AND
DOMINIQUE MOYAL | 445 |

E. Protection

- | | | |
|--|--|-----|
| 41. Topically Applied Antioxidants in Skin Protection | FRANZ STÄB,
RAINER WOLBER,
THOMAS BLATT,
REZA KEYHANI, AND
GERHARD SAUERMAN | 465 |
| 42. Erythropoietic Protoporphyrin: Treatment with Antioxidants and Potential Cure with Gene Therapy | MICHELINE M. MATHEWS-
ROTH | 479 |
| 43. Porphyrins: Photosensitivity and Phototherapy | MAUREEN B. POH-FITZPATRICK | 485 |
| 44. Carotenoids in Human Skin: Noninvasive Measurement and Identification of Dermal Carotenoids and Carotenol Esters | WILHELM STAHL,
ULRIKE HEINRICH,
HOLGER JUNGMANN,
HAGEN TRONNIER, AND
HELMUT SIES | 494 |

Section III. Ozone

- | | | |
|--|---|-----|
| 45. Reactive Absorption of Ozone: An Assay for Reaction Rates of Ozone with Sulfhydryl Compounds and with Other Biological Molecules | JEFFREY R. KANOFSKY AND
PAUL D. SIMA | 505 |
| 46. Assay for Singlet Oxygen Generation by Plant Leaves Exposed to Ozone | JEFFREY R. KANOFSKY AND
PAUL D. SIMA | 512 |
| 47. Ozone Effects on Plant Defense | CHRISTIAN LANGEBARTELS,
DIETER ERNST,
JAAKKO KANGASJÄRVI, AND
HEINRICH SANDERMANN, JR. | 520 |

48. High-Pressure Liquid Chromatography Analysis of Ozone-Induced Depletion of Hydrophilic and Lipophilic Antioxidants in Murine Skin	STEFAN U. WEBER, SUMANA JOTHI, AND JENS J. THIELE	536
49. Reactions of Vitamin E with Ozone	DANIEL C. LIEBLER	546
50. Induction of Nuclear Factor- κ B by Exposure to Ozone and Inhibition by Glucocorticoids	Kian Fan CHUNG AND Ian M. ADCKOCK	551
51. Detection of 4-Hydroxy-2-nonenol Adducts Following Lipid Peroxidation from Ozone Exposure	LUKE I. SZWEDA, PAMELA A. SZWEDA, AND ANDRIJ HOLIAN	562
52. Synthesis of Inflammatory Signal Transduction Species Formed during Ozonation and/or Peroxidation of Tissue Lipids	GIUSEPPE L. SQUADRITO, MARIA G. SALGO, FRANK R. FRONCZEK, AND WILLIAM A. PRYOR	570

Section IV. General Methods

53. Assay for Redox-Sensitive Transcription Factor	MADAN M. CHATURVEDI, ASOK MUKHOPADHYAY, AND BHARAT B. AGGARWAL	585
54. Fluorescent Fatty Acid to Monitor Reactive Oxygen in Single Cells	Eward H. W. PAP, G. P. C. DRUMMEN, J. A. POST, P. J. RIJKEN, AND K. W. A. WIRTZ	603
55. Noninvasive Techniques for Measuring Oxidation Products on the Surface of Human Skin	DANIEL MAES, TOM MOMMONE, MARYANN MCKEEVER, ED PELLE, CHRISTINA FTHENAKIS, LIEVE DECLERCO, PAOLO U. GIACOMONI, AND KEN MARENUS	612
AUTHOR INDEX		623
SUBJECT INDEX		661