# PROGRESS IN BIOMEDICAL OPTICS AND IMAGING

Vol. 8, No. 4

# Optical Methods for Tumor Treatment and Detection: Mechanisms and Techniques in Photodynamic Therapy XVI

**David Kessel** Editor

20–21 January 2007 San Jose, California, USA

Sponsored and Published by SPIE—The International Society for Optical Engineering

Volume 6427



The International Society for Optical Engineering

Proceedings of SPIE—The International Society for Optical Engineering, 9780819465405, v. 6427

SPIE is an international technical society dedicated to advancing engineering and scientific applications of optical, photonic, imaging, electronic, and optoelectronic technologies.

The papers included in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. The papers published in these proceedings reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from this book:

Author(s), "Title of Paper," in Optical Methods for Tumor Treatment and Detection: Mechanisms and Techniques in Photodynamic Therapy XVI, edited by David Kessel, Proceedings of SPIE Vol. 6427 (SPIE, Bellingham, WA, 2007) Article CID Number.

ISSN 1605-7422 ISBN 9780819465405

Published by **SPIE—The International Society for Optical Engineering** P.O. Box 10, Bellingham, Washington 98227-0010 USA Telephone 1 360/676-3290 (Pacific Time) · Fax 1 360/647-1445 http://www.spie.org

Copyright © 2007, The Society of Photo-Optical Instrumentation Engineers

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at http://www.copyright.com. Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 1605-7422/07/\$18.00.

Printed in the United States of America.

## Contents

- ix Conference Committee
- xi Introduction

#### SESSION 1 SIGNALING PATHWAYS

- 642702 **PDT: death pathways (Invited Paper)** [6427-01] D. Kessel, Wayne State Univ. (USA)
- 642703 Initial targets and cellular responses to PDT (Invited Paper) [6427-02]
   M. E. Rodriguez, K. Azizuddin, S. Chiu, G. Delos Santos, S. Joseph, L. Xue, N. L. Oleinick, Case Western Reserve Univ. (USA)
- 642705 Tumor cell hyperresistance to photodynamic killing arising from nitric oxide preconditioning [6427-04]
   M. Niziolek-Kierecka, W. Korytowski, Medical College of Wisconsin (USA) and Jagiellonian Univ. (Poland); A. W. Girotti, Medical College of Wisconsin (USA)

#### SESSION 2 LOCALIZATION

- 642706 **Optical molecular imaging in PDT (Invited Paper)** [6427-05] S. Mitra, J. W. Snyder, T. H. Foster, Univ. of Rochester (USA)
- 642707 Correlation between cell viability and cumulative singlet oxygen luminescence from protoporphyrin IX in varying subcellular localizations [6427-06]
   B. Li, Ontario Cancer Institute (Canada), Univ. of Toronto (Canada), and Fujian Normal Univ. (China); M. T. Jarvi, E. H. Moriyama, B. C. Wilson, Ontario Cancer Institute (Canada) and Univ. of Toronto (Canada)
- 642708 Macroscopic modeling of the singlet oxygen production during PDT [6427-07] T. C. Zhu, J. C. Finlay, X. Zhou, J. Li, Univ. of Pennsylvania (USA)

**Pagination:** Proceedings of SPIE follow an e-First publication model, with papers published first online and then in print and on CD-ROM. Papers are published as they are submitted and meet publication criteria. A unique, consistent, permanent citation identifier (CID) number is assigned to each article at the time of the first publication. Utilization of CIDs allows articles to be fully citable as soon they are published online, and connects the same identifier to all online, print, and electronic versions of the publication.

SPIE uses a six-digit CID article numbering system in which:

• The first four digits correspond to the SPIE volume number.

• The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc.

The CID number appears on each page of the manuscript. The complete citation is used on the first page, and an abbreviated version on subsequent pages.

#### SESSION 3 NEW SENSITIZERS

- 64270A Syntheses and cellular studies of water soluble porphyrin-peptide conjugates [6427-09] M. Sibrian-Vazquez, T. J. Jensen, R. P. Hammer, M. G. H. Vicente, Louisiana State Univ. (USA)
- 64270B Fractionation of the Hypericum perforatum L. extract: PMF, and PDT effects of the fractions against HL-60 leukemic cells [6427-10]
   M. Tsontou, Foundation for Research and Technology-Hellas (Greece); H. Dimitriou, Univ. of Crete (Greece); G. Filippidis, Foundation for Research and Technology-Hellas (Greece); I. Tsimaris, Hatzikosta General Hospital (Greece); M. Kalmanti, Univ. of Crete (Greece); D. Skalkos, Univ. of Ioannina (Greece)

#### SESSION 4 ALA

- 64270D Improved murine glioma detection following modified diet and photobleaching of skin PpIX fluorescence [6427-12]
   S. L. Gibbs, J. A. O'Hara, P. J. Hoopes, Dartmouth College (USA); B. W. Pogue, Dartmouth College (USA) and Wellman Ctr. for Photomedicine, Massachusetts General Hospital, Harvard Medical School (USA)
- 64270F Hyperbaric oxygen therapy augments the photodynamic action of methylene blue against bacteria in vitro [6427-14]
   S. K. Bisland, F. N. Dadani, C. Chien, B. C. Wilson, Univ. of Toronto, Ontario Cancer Institute, Univ. Health Network (Canada)
- 64270G Characterization of time-domain fluorescence properties of typical photosensitizers for photodynamic therapy [6427-15]
   J. Russell, McMaster Univ. (Canada); K. Diamond, Juravinski Cancer Ctr. (Canada);
   T. Collins, McMaster Univ. (Canada); M. Weston, McMaster Univ. (Canada) and Juravinski

T. Collins, McMaster Univ. (Canada); M. Weston, McMaster Univ. (Canada) and Juravinski Cancer Ctr. (Canada); J. Lovell, McMaster Univ. (Canada); J. Hayward, T. Farrell, M. S. Patterson, McMaster Univ. (Canada) and Juravinski Cancer Ctr. (Canada); Q. Fang, McMaster Univ. (Canada)

#### SESSION 5 CLINICAL PDT

(USA)

- 64270J Effect of implanted brachytherapy seeds on optical fluence distribution: preliminary ex vivo study [6427-18]
  F. W. Hetzel, Q. Chen, M. Ding, F. Newman, K. C. Dole, Z. Huang, Health Sciences Ctr. of Colorado Univ. (USA); D. Blanc, NEGMA-LERADS (France)
- 64270K A method to improve reconstruction of the distribution of hemoglobin, oxygenation, and MLu concentration in the human prostate before and after photodynamic therapy [6427-19]
   J. C. Finlay, T. C. Zhu, X. Zhou, A. Dimofte, S. B. Malkowicz, S. M. Hahn, Univ. of Pennsylvania

#### SESSION 6 DOSIMETRY

#### 64270M **Conformal light delivery using tailored cylindrical diffusers** [6427-21] A. Rendon, Univ. of Toronto (Canada) and Univ. Health Network (Canada); J. Okawa, Univ. of Toronto (Canada); R. Weersink, Univ. Health Network (Canada); J. C. Beck, Univ. of Toronto (Canada); L. Lilge, Univ. of Toronto (Canada) and Univ. Health Network (Canada)

- 64270N Modeling light fluence rate distribution in optically heterogeneous prostate photodynamic therapy using a kernel method [6427-22] J. Li, T. C. Zhu, Univ. of Pennsylvania (USA)
- 642700 Interstitial photodynamic therapy for primary prostate cancer incorporating real-time treatment dosimetry [6427-23]
   A. Johansson, J. Axelsson, Lund Univ. (Sweden); J. Swartling, T. Johansson, S. Pålsson, J. Stensson, SpectraCure AB (Sweden); M. Einarsdóttír, K. Svanberg, N. Bendsoe, Lund Univ. Hospital (Sweden); K. M. Kälkner, S. Nilsson, Karolinska Univ. Hospital (Sweden); S. Svanberg, S. Andersson-Engels, Lund Univ. (Sweden)

#### SESSION 7 VASCULAR RESPONSES

- 64270P In vivo on-line monitoring of molecular response to photodynamic therapy: molecular imaging of vascular endothelial growth factor (Invited Paper) [6427-24]
   S. K. Chang, I. Rizvi, N. Solban, T. Hasan, Wellman Ctr. for Photomedicine, Massachusetts General Hospital, Harvard Medical School (USA)
- 64270R Two-photon photodynamic therapy and its potential application to age related macular degeneration [6427-26]

A. Karotki, M. Khurana, S. K. Bisland, E. H. Moriyama, Ontario Cancer Institute, Univ. of Toronto (Canada); E. R. Simpson, Princess Margaret Hospital (Canada); M. C. W. Campbell, Univ. of Waterloo (Canada); H. Collins, H. L. Anderson, Univ. of Oxford (United Kingdom); D. T. Cramb, Univ. of Calgary (Canada); B. C. Wilson, Ontario Cancer Institute, Univ. of Toronto (Canada)

64270S Tumor vascular volume determines photosensitizer uptake in MATLyLu prostate tumor model [6427-27]

X. Zhou, Dartmouth College (USA); B. Chen, Dartmouth College (USA) and Dartmouth Medical School (USA); P. J. Hoopes, Dartmouth Medical School (USA); T. Hasan, Wellman Ctr. for Photomedicine, Massachusetts General Hospital, Harvard Medical School (USA); B. W. Pogue, Dartmouth College (USA) and Wellman Ctr. for Photomedicine, Massachusetts General Hospital, Harvard Medical School (USA)

#### SESSION 8 IMAGING

642701 Pharmacokinetic study of a systemically administered novel liposomal Temoporfin formulation in an animal tumor model [6427-29]

J. Svensson, A. Johansson, Lund Univ. (Sweden); N. Bendsoe, Lund Univ. Hospital (Sweden);

S. Gräfe, biolitec AG (Germany); T. Trebst, CeramOptec GmbH (Germany);

S. Andersson-Engels, Lund Univ. (Sweden); K. Svanberg, Lund Univ. Hospital (Sweden)

#### POSTER SESSION

# 64270W New near-infrared photosensitizers based on bacteriochlorin p derivatives: preliminary results of in vivo investigations [6427-32]

I. G. Meerovich, N.N. Blokhin Russian Cancer Research Ctr. (Russia); M. A. Grin, A. G. Tsyprovskiy, M.V. Lomonosov Moscow State Academy of Fine Chemical Technology (Russia); G. A. Meerovich, General Physics Institute (Russia); S. V. Barkanova, State Research Ctr. NIOPIK (Russia); L. M. Borisova, N. A. Oborotova, A. Yu. Baryshnikov, N.N. Blokhin Russian Cancer Research Ctr. (Russia); A. F. Mironov, M.V. Lomonosov Moscow State Academy of Fine Chemical Technology (Russia)

64270X Phenylthio-substituted phthalocyanines as new photosensitizers for photodynamic therapy [6427-33]

I. G. Meerovich, N.N. Blokhin Russian Cancer Research Ctr. (Russia); V. M. Derkacheva, State Research Ctr. NIOPIK (Russia); G. A. Meerovich, General Physics Institute (Russia); N. A. Oborotova, Z. S. Smirnova, A. P. Polozkova, I. Yu. Kubasova, N.N. Blokhin Russian Cancer Research Ctr. (Russia); E. A. Lukyanets, State Research Ctr. NIOPIK (Russia); A. Yu. Baryshnikov, N.N. Blokhin Russian Cancer Research Ctr. (Russia)

- 64270Y Blood porphyrin luminescence and tumor growth correlation [6427-34]
   L. C. Courrol, Unifesp-Campus Diadema (Brazil); F. Rodrigues de Oliveira Silva, M. H. Bellini,
   R. D. Mansano, EPUSP, LSI, USP (Brazil); N. Schor, N. D. Vieira, Jr., Ctr. de Lasers e Aplicações,
   IPEN/CNEN-SP (Brazil)
- 642710 Monte Carlo simulation of elastic-scattering spectroscopic measurement using the optical pharmacokinetic system (OPS): analysis of sensitivity to heterogeneous chromophore distribution [6427-36] S. C. Kanick, R. S. Parker, Univ. of Pittsburgh (USA)
- 642712 Fluence rate variability among light delivery devices for esophageal photodynamic therapy [6427-38] J. C. Finlay, G. G. Ginsberg, S. M. Hahn, Univ. of Pennsylvania (USA)
- 642713 Development of high-yielding photonic light delivery system for photodynamic therapy of esophageal carcinomas [6427-39]
   A. Premasiri, G. Happawana, Southern Methodist Univ. (USA); A. Rosen, Drexel Univ. (USA)
- Analysis of colon tumors in rats by near-infrared Raman spectroscopy [6427-40]
   J. Duarte, Univ. Federal de São Paulo (Brazil) and Univ. do Vale do Paraíba (Brazil); R. Hage, Univ. Federal de São Paulo (Brazil); L. Silveira, Jr., F. Silveira, M. T. T. Pacheco, E. Munin, Univ. do Vale do Paraíba (Brazil); H. Plapler, Univ. Federal de São Paulo (Brazil)
- 642715 The measurement of the phosphorescence and singlet oxygen fluorescence time-resolved waveforms of Photofrin(II) and Talaporfin sodium with pulsed excitation [6427-41] S. Hakomori, S. Ohmori, K. Masuda, K. Yamamoto, T. Arai, Keio Univ. (Japan)
- 642717 Infrared light utilized for photodynamic therapy by activation of rare earth phosphors for visible light generation [6427-43]
   J. E. Collins, T. V. Lakshman, J. E. Finlay, A. Kumar, H. Bell, B. T. Nguyen, V. Belov, J. Luo, J. S. Friedberg, Univ. of Pennsylvania (USA)

- 642719 In vitro study on methemoglobin formation in erythrocytes following hexyl-aminolevulinate induced photodynamic therapy [6427-45] E. L. P. Larsen, L. L. Randeberg, O. A. Gederaas, H. E. Krokan, D. R. Hjelme, L. O. Svaasand, Norwegian Univ. of Science and Technology (Norway)
- 64271A Enhancing PDT drug delivery by enzymatic cleavage of porphyrin phosphates [6427-46] B. Xu, G. Liang, L. Wang, Z. Yang, K. Chan, C. K. Chang, Hong Kong Univ. of Science and Technology (Hong Kong China)
- 64271B A versatile nanocrystal-based multi-sensory fiber-optic probe for dosimetry in PDT and thermal treatment [6427-47] T.-W. F. Chang, M. Boesen, R. Weersink, L. Charron, Princess Margaret Hospital (Canada); E. H. Sargent, Univ. of Toronto (Canada); L. Lilge, Princess Margaret Hospital (Canada)
- 64271C Photodynamic therapy (PDT) using intratumoral injection of the 5-aminolevulinic acid (5-ALA) for the treatment of eye cancer in cattle [6427-48] R. Hage, Univ. Federal de São Paulo (Brazil) and Univ. do Vale do Paraíba (Brazil); G. Mancilha, R. A. Zângaro, E. Munin, Univ. do Vale do Paraíba (Brazil); H. Plapler, Univ. Federal de São Paulo (Brazil)
- 64271F The apoptosis induced by HMME-based photodynamic therapy in rabbit vascular smooth muscle cells [6427-51]

H. Yin, X. Li, H. Lin, J. Liu, H. Yu, Sun Yat-Sen Univ. (China)

64271G The dual effects of polar methanolic extract of Hypericum perforatum L. in bladder cancer cells [6427-52]

U. O. Nseyo, Malcom Randall VA Medical Ctr. (USA) and Univ. of Florida College of Medicine (USA); O. U. Nseyo, K. T. Shiverick, T. Medrano, Univ. of Florida College of Medicine (USA); M. Mejia, Malcom Randall VA Medical Ctr. (USA); N. Stavropoulos, I. Tsimaris, Hatzikosta General Hospital (Greece); D. Skalkos, Univ. of Ioannina (Greece)

Author Index

## **Conference Committee**

Symposium Chairs

James G. Fujimoto, Massachusetts Institute of Technology (USA) R. Rox Anderson, Wellman Center for Photomedicine, Massachusetts General Hospital (USA), and Harvard School of Medicine (USA)

#### Program Track Chair

Reza Malek, Mayo Clinic (USA) Keith Black, Cedars-Sinai Medical Center (USA)

#### Conference Chair

David Kessel, Wayne State University (USA)

#### Program Committee

Thomas H. Foster, University of Rochester (USA)
Charles J. Gomer, Childrens Hospital Los Angeles (USA)
Tayyaba Hasan, Wellman Center for Photomedicine, Massachusetts General Hospital (USA), and Harvard Medical School (USA)
Nancy L. Oleinick, Case Western Reserve University (USA)
Brian W. Pogue, Dartmouth College (USA) and Wellman Center for Photomedicine, Massachusetts General Hospital (USA), and Harvard Medical School (USA)
Kevin M. Smith, Louisiana State University (USA)
Kenneth K. Wang, Mayo Clinic (USA)

#### Session Chairs

- Signaling Pathways
   David Kessel, Wayne State University (USA)
- 2 Localization Thomas H. Foster, University of Rochester (USA)
- 3 New Sensitizers Kevin M. Smith, Louisiana State University (USA)
- 4 ALA Charles J. Gomer, Childrens Hospital Los Angeles (USA)

- 5 Clinical PDT Kenneth K. Wang, Mayo Clinic (USA)
- 6 Dosimetry Brian W. Pogue, Dartmouth College (USA) Wellman Center for Photomedicine, Massachusetts General Hospital (USA), and Harvard Medical School (USA)
- Vascular Responses
   Tayyaba Hasan, Wellman Center for Photomedicine, Massachusetts General Hospital (USA), and Harvard Medical School (USA)
- 8 Imaging Soumya Mitra, University of Rochester (USA)

## Introduction

While conferences on photodynamic therapy had been organized as early as 1977, the first meeting sponsored by SPIE took place in Cambridge, MA. This was organized in 1987 by Doug Neckers (Bowling Green State University) and Tayyaba Hasan (Massachusetts General Hospital/Harvard). Thomas J. Dougherty began organizing annual conferences in 1989 as part of the SPIE BIOS program. These were held in Los Angeles until 1995, when the site was moved to San Jose. Dr. Dougherty continued to organize the PDT sessions until 2003, when I was asked to take the job.

SPIE also published a volume containing papers relating to the meeting of the International Photodynamic Association in 1994, and has provided a venue for several European conferences. In 1993, a compendium containing reprints of 89 key papers relating to PDT was published as part of the SPIE 'Milestone' Series, with the title, *Selected Papers on Photodynamic Therapy*. The Milestone Series now contains over 150 volumes dealing with various aspects of optics and related topics.

The annual inclusion of sessions relating to photodynamic effects provides an opportunity of basic researchers to meet with those involved in applications research. Since elements of dosimetry form an important part of PDT optimization, it is especially useful to bring together people working in bioengineering, optics, photophysics, and photochemistry. The two-day meeting in 2007 continues the format initially established by the earlier organizers.

David Kessel