

PROGRESS IN BIOMEDICAL OPTICS AND IMAGING

Vol. 12, No. 4

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

**David H. Kessel  
Tayyaba Hasan**  
*Editors*

**22–23 January 2011  
San Francisco, California, United States**

*Sponsored and Published by*  
SPIE

**Volume 7886**

Proceedings of SPIE, 1605-7422, v. 7886

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

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 XX*, edited by David H. Kessel, Tayyaba Hasan, Proceedings of SPIE Vol. 7886 (SPIE, Bellingham, WA, 2011) Article CID Number.

ISSN 1605-7422

ISBN 9780819484239

Published by

**SPIE**

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

SPIE.org

Copyright © 2011, 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 [copyright.com](http://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 1605-7422/11/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

**SPIE**   
Digital Library

[SPIDigitalLibrary.org](http://SPIDigitalLibrary.org)

---

**Paper Numbering:** 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. Numbers in the index correspond to the last two digits of the six-digit CID number.

# Contents

vii	<i>Conference Committee</i>
ix	<i>Introduction</i>

---

## SESSION 1 PRECLINICAL PDT I

---

- 7886 02 **Biological consequences of PDT: tying up the loose ends (Invited Paper)** [7886-01]  
D. Kessel, Wayne State Univ. School of Medicine (United States); M. Andrzejak, Univ. of Detroit Mercy (United States); M. Price, Wayne State Univ. (United States)

---

## SESSION 2 PRECLINICAL PDT II

---

- 7886 08 **Biologically relevant 3D tumor arrays: imaging-based methods for quantification of reproducible growth and analysis of treatment response** [7886-07]  
J. P. Celli, I. Rizvi, Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States); A. R. Blanden, Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States) and Binghamton Univ. (United States); A. O. Abu-Yousif, B. Q. Spring, T. Hasan, Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States)
- 7886 09 **Biologically relevant 3D tumor arrays: treatment response and the importance of stromal partners** [7886-08]  
I. Rizvi, J. P. Celli, Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States); F. Xu, Brigham and Women's Hospital (United States); C. L. Evans, A. O. Abu-Yousif, Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States); A. Muzikansky, Massachusetts General Hospital (United States); S. A. Elrington, Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States); B. W. Pogue, Dartmouth College (United States); D. M. Finkelstein, Massachusetts General Hospital (United States); U. Demirci, Brigham and Women's Hospital (United States); T. Hasan, Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States)
- 7886 0A **Determination of blood plasma fluorescence extinction coefficients for dyes used in three-compartment binding model** [7886-09]  
K. S. Samkoe, K. Sexton, K. Tichauer, S. C. Davis, J. A. O'Hara, Dartmouth College (United States); T. Hasan, Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States); B. W. Pogue, Dartmouth College (United States)
- 7886 0B **Combination of PI3K/Akt/mTOR inhibitors and PDT in endothelial and tumor cells** [7886-10]  
B. Fateye, B. Chen, Univ. of the Sciences in Philadelphia (United States)
- 7886 0C **Signaling from lysosomes to mitochondria sensitizes cancer cells to photodynamic treatment** [7886-11]  
H. Hung, G. Quiogue, J. J. Lemasters, A.-L. Nieminen, Medical Univ. of South Carolina (United States)

---

**SESSION 3 PRECLINICAL PDT III**

---

- 7886 0D **Folate receptor targeted Type 1 photosensitizer bioconjugates for tumor visualization and phototherapy** [7886-12]  
R. Rajagopalan, A. R. Poreddy, A. Karwa, B. Asmelash, N. E. Putnam, L. Chinen, M. Nichols, J. J. Shieh, R. B. Dorshow, Covidien Pharmaceuticals (United States)
- 7886 0F **A dynamic model for ALA-PDT of skin: analysis of the correlation of fluorescence and singlet oxygen luminescence to spatial distribution of singlet oxygen** [7886-14]  
B. Liu, T. J. Farrell, M. S. Patterson, McMaster Univ. (Canada) and Juravinski Cancer Ctr. (Canada)
- 7886 0G **Photosensitizer nanocarriers modeling for photodynamic therapy applied to dermatological diseases** [7886-15]  
I. Salas-García, F. Fanjul-Vélez, N. Ortega-Quijano, Univ. de Cantabria (Spain); M. López-Escobar, Marqués de Valdecilla Univ. Hospital (Spain); J. L. Arce-Diego, Univ. de Cantabria (Spain)

---

**SESSION 4 CLINICAL PDT I**

---

- 7886 0J **Photodynamic therapy of pancreatic cancer and elastic scattering spectroscopy of the duodenal mucosa for the detection of pancreaticobiliary malignancy (Invited Paper)** [7886-18]  
M. T. Huggett, Univ. College London (United Kingdom) and Univ. College Hospitals NHS Foundation Trust (United Kingdom); R. N. B. Baddeley, Univ. College London (United Kingdom); N. S. Sandanayake, Univ. College London (United Kingdom) and Univ. College Hospitals NHS Foundation Trust (United Kingdom); G. J. M. Webster, Univ. College London (United Kingdom); S. G. Bown, L. B. Lovat, Univ. College London (United Kingdom) and Univ. College Hospitals NHS Foundation Trust (United Kingdom); A. Gillams, Univ. College Hospitals NHS Foundation Trust (United Kingdom); B. W. Pogue, Dartmouth College (United States); T. Hasan, Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States); S. P. Pereira, Univ. College London (United Kingdom) and Univ. College Hospitals NHS Foundation Trust (United Kingdom)

---

**SESSION 5 CLINICAL PDT II**

---

- 7886 0K **5-Fluorouracil as an enhancer of aminolevulinic acid-based photodynamic therapy for skin cancer: New use for a venerable agent? (Invited Paper)** [7886-19]  
E. V. Maytin, S. Anand, C. Wilson, K. Iyer, The Cleveland Clinic (United States)
- 7886 0L **An IR navigation system for real-time treatment guidance of pleural PDT (Invited Paper)** [7886-20]  
T. C. Zhu, X. Liang, C. Chang, J. Sandell, J. C. Finlay, A. Dimofte, C. Rodriguez, K. Cengel, The Univ. of Pennsylvania Health System (United States); J. Friedberg, Penn Presbyterian Medical Ctr. (United States); E. Glatstein, S. M. Hahn, The Univ. of Pennsylvania Health System (United States)

- 7886 OM **Investigating the photosensitizer-potential of targeted gallium corrole using multimode optical imaging** [7886-21]  
J. Y. Hwang, J. Lubow, D. Chu, Cedars-Sinai Medical Ctr. (United States); Z. Gross, Beckman Research Institute, California Institute of Technology (United States) and Technion-Israel Institute of Technology (Israel); H. B. Gray, Beckman Research Institute, California Institute of Technology (United States); D. L. Farkas, Univ. of Southern California (United States) and Spectral Molecular Imaging, Inc. (United States); L. K. Medina-Kauwe, Cedars-Sinai Medical Ctr. (United States) and Univ. of Southern California (United States)

---

**SESSION 6 PDT MODELS**

---

- 7886 ON **Determining how uncertainties in optical properties affect light dose calculations for PDT** [7886-22]  
J. Sandell, J. C. Finlay, T. C. Zhu, The Univ. of Pennsylvania (United States)
- 7886 OO **Modeling of PDT kinetics in cell killing** [7886-23]  
I. Gkigkitzis, East Carolina Univ. (United States); C. Yang, Y. Feng, Tianjin Univ. (China); J. Q. Lu, X.-H. Hu, East Carolina Univ. (United States)
- 7886 OQ **Study of the relationship between light fluence and photodynamic therapy in a homogeneous tissue phantom** [7886-25]  
Y. Yao, J. Bai, Tsinghua Univ. (China)

---

**SESSION 7 ANIMAL STUDIES**

---

- 7886 OS **Assessment of biophysical tumor response to PDT in pancreatic cancer using localized reflectance spectroscopy** [7886-27]  
M. Isabelle, W. Klubben, T. He, A. M. Laughney, A. Glaser, V. Krishnaswamy, Dartmouth College (United States); P. J. Hoopes, Dartmouth College (United States) and Dartmouth Medical School (United States); T. Hasan, Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States); B. W. Pogue, Dartmouth College (United States), Dartmouth Medical School (United States), and Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States)
- 7886 OT **In vitro photodynamic therapy of MG-63 osteosarcoma cells mediated by aminolevulinic acid** [7886-29]  
V. M. Rossi, Pacific Univ. (United States), Oregon State Univ. (United States), and Oregon Health & Science Univ. (United States); B. M. White, M. J. Newton, Pacific Univ. (United States); S. L. Jacques, Oregon Health & Science Univ. (United States); P. J. Baugher, Pacific Univ. (United States)
- 7886 OU **Study of photosensitizers pharmacokinetics in mouse tumor model by transillumination fluorescence imaging in vivo** [7886-30]  
M. V. Shirmanova, Nizhny Novgorod State Univ. (Russian Federation) and Nizhny Novgorod State Medical Academy (Russian Federation); I. V. Balalaeva, Nizhny Novgorod State Univ. (Russian Federation); M. A. Sirotkina, Nizhny Novgorod State Univ. (Russian Federation) and Nizhny Novgorod State Medical Academy (Russian Federation); N. Yu. Lekanova, Nizhny Novgorod State Univ. (Russian Federation); I. V. Turchin, Institute of Applied Physics (Russian Federation); E. V. Zagainova, Nizhny Novgorod State Medical Academy (Russian Federation)

---

**POSTER SESSION**

---

- 7886 OW **EtNBS and EtNBS-COOH PDT efficacy in ovarian cancer cells** [7886-32]  
Y. J. Park, KAIST (Korea, Republic of); O. J. Klein, B. Bahayana, C. L. Evans, Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States)
- 7886 OX **Effect of fatty acids on the complexation of proteins with porphyrins** [7886-34]  
G. V. Gyulkhandanyan, Institute of Biochemistry (Armenia)
- 7886 OY **Preparation, characterization, and cellular studies of photosensitizer-loaded lipid nanoparticles for photodynamic therapy** [7886-35]  
F. P. Navarro, CEA LETI (France); D. Bechet, CRAN, CNRS, Nancy-Univ. (France); T. Delmas, CEA LETI (France); P. Couleaud, LRGP, CNRS, Nancy-Univ. (France); C. Frochot, LRGP, CNRS, Nancy-Univ. (France) and GdR, CNRS, PHOTOMED (France); M. Verhille, LRGP, CNRS, Nancy-Univ. (France); E. Kamarulzaman, LCPM, CNRS, Nancy-Univ. (France); R. Vanderesse, LCPM, CNRS, Nancy-Univ. (France) and GdR, CNRS, PHOTOMED (France); P. Boisseau, I. Texier, J. Gravier, F. Vinet, CEA LETI (France); M. Barberi-Heyob, CRAN, CNRS, Nancy-Univ. (France) and GdR, CNRS, PHOTOMED (France); A. C. Couffin, CEA LETI (France)
- 7886 10 **In vivo validation of high frequency ultrasound-guided fluorescence tomography system to improve delivery of photodynamic therapy** [7886-37]  
A. Paliwal, The Cleveland Clinic (United States); S. Torosean, J. Gruber, J. O'Hara, Dartmouth College (United States); T. Hasan, Wellman Ctr. for Photomedicine, Massachusetts General Hospital (United States); B. Pogue, Dartmouth College (United States); E. V. Maytin, The Cleveland Clinic (United States)
- 7886 14 **MS2 bacteriophage as a delivery vessel of porphyrins for photodynamic therapy** [7886-41]  
B. A. Cohen, A. E. Kaloyeros, M. Bergkvist, Univ. at Albany (United States)
- 7886 15 **Light distribution in turbid media: an approach based on matrices** [7886-42]  
L. T. Moriyama, Univ. de São Paulo (Brazil); E. C. C. C. Lins, Univ. Federal do ABC (Brazil); C. Kurachi, V. S. Bagnato, Univ. de São Paulo (Brazil)
- 7886 16 **Pheophorbide a mediated photodynamic therapy against human epidermoid carcinoma cells (A431)** [7886-43]  
Y.-C. Chen, W.-T. Li, Chung-Yuan Christian Univ. (Taiwan)
- 7886 17 **Mechanisms of tumor necrosis in photodynamic therapy with a chlorine photosensitizer: experimental studies** [7886-44]  
V. A. Privalov, Chelyabinsk State Medical Academy (Russian Federation); A. V. Lappa, Chelyabinsk State Univ. (Russian Federation); E. N. Bigbov, Chelyabinsk State Medical Academy (Russian Federation)
- 7886 19 **A study of light fluence rate distribution for PDT using MC simulation** [7886-47]  
J. L. Sandell, The Univ. of Pennsylvania (United States); T. C. Zhu, The Univ. of Pennsylvania Health System (United States); J. C. Finlay, The Univ. of Pennsylvania (United States)

*Author Index*

# Conference Committee

## *Symposium Chairs*

**James G. Fujimoto**, Massachusetts Institute of Technology (United States)

**R. Rox Anderson**, Wellman Center for Photomedicine, Massachusetts General Hospital, Harvard School of Medicine (United States)

## *Program Track Chair*

**Brian Jet-Fei Wong**, Beckman Laser Institute and Medical Clinic (United States)

## *Conference Chairs*

**David H. Kessel**, Wayne State University (United States)

**Tayyaba Hasan**, Wellman Center for Photomedicine, Massachusetts General Hospital (United States)

## *Session Chairs*

- 1 Preclinical PDT I  
**David H. Kessel**, Wayne State University (United States)  
**Tayyaba Hasan**, Wellman Center for Photomedicine, Massachusetts General Hospital (United States)
- 2 Preclinical PDT II  
**Conor L. Evans**, Massachusetts General Hospital (United States)
- 3 Preclinical PDT III  
**Jonathan P. Celli**, Wellman Center for Photomedicine, Massachusetts General Hospital (United States)
- 4 Clinical PDT I  
**Merrill A. Biel**, University of Minnesota, Twin Cities (United States)  
**Edward V. Maytin**, The Cleveland Clinic (United States)
- 5 Clinical PDT II  
**Kenneth K. Wang**, Mayo Clinic (United States)  
**Stephen P. Pereira**, University College London (United Kingdom)

- 6 PDT Models  
**Timothy C. Zhu**, The University of Pennsylvania Health System (United States)
- 7 Animal Studies  
**Martin Isabelle**, Dartmouth College (United States)



## Introduction

The 2011 conference on aspects of photodynamic therapy (PDT) was labeled as the 20<sup>th</sup> such meeting sponsored by SPIE. This all began with a 1987 gathering in Cambridge, Massachusetts, organized by Doug Neckers and Tayyaba Hasan. Tom Dougherty organized PDT sessions for SPIE in 1989 and 1991 at Los Angeles, but some of these apparently did not figure into the numbering system. As a result the session held in 1993 was listed as 'Optical methods for Tumor Treatment and Detection: Mechanisms and Techniques in Photodynamic Therapy II.' So it could be argued that the 2011 meeting was actually the 23<sup>rd</sup> such conference.

The origins of the field are well-known, beginning with the studies by Raab and von Tapiener in 1900. PDT was periodically re-invented, notably by Sam Schwartz and Robert Lipson in the 1960s, but the current era began with the pre-clinical and clinical work initiated by Tom Dougherty in the early 1970s. PDT has been shown capable of significant cancer control in a variety of settings, and it is widely used in many places. Clinical applications in the United States appeared to be slowed by the reluctance of pharmaceutical groups to support a procedure that does not promise substantial rewards. Use of PDT for treatment of macular degeneration was such an application, but that field has now moved in a different direction.

The annual SPIE conferences serve a useful purpose, bringing together workers in a variety of disciplines associated with PDT who can compare notes and report on recent progress. The opportunity to check out the exhibits of lasers, optical devices, and photonics technology, and to encounter those working in related fields are additional advantages. For 2012, we plan to incorporate a panel discussion that will include both leaders in the field and representatives from the NIH, with a view toward discussing mechanisms for support for PDT-related work not necessarily involving pharmaceutical companies.

**David H. Kessel  
Tayyaba Hasan**

