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Special issue on enhanced photodynamic therapy: Part II

Buhong Li*,‡ and Lothar Lilge†
*School of Science, Hainan University
Haikou 570228, P. R. China
†Department of Medical Biophysics
University of Toronto and Ontario Cancer Institute
Toronto M5G 2M9, Canada
‡bhli@hainanu.edu.cn

We welcome the readers to Part II of the special issue on Enhanced Photodynamic Therapy (PDT), an issue dedicated to highlighting the latest developments in both fundamental mechanisms and clinical applications for enhanced PDT. The first part of this special issue was published in July 2022 as Issue 4 of Volume 15, and five research articles were included.[1] It is really exciting that we have an enthusiastic response from our colleagues that continuously contributed eight articles to produce Part II. We believe these two special issues will provide a better understanding of enhanced PDT.

With the recent development of multifunctional nano-photosensitizer (PS) for enhanced PDT, Dong *et al.* addressed the recent advances in the use of cerium-based nanoparticles as novel PSs for cancer PDT, and the activation mechanisms for electron transfer to generate toxic singlet oxygen ($^1O_2$) are presented.[2] In addition, the different types of cerium-based nano-PSs used for PDT of cancer are summarized. To improve the tumor targeting ability, Dai's group designed an ultrasmall pH-responsive silicon phthalocyanine nanomicelle (PSN) for selective PDT of tumor.[3] The synthetized PSN has a high drug loading efficacy of 28% and exhibits morphological transitions, enhanced fluorescence, and enhanced $^1O_2$ production under acidic environment. It was shown that PSN was renal clearable and could rapidly accumulate and retain at tumor sites, achieving a tumor-inhibiting effect better than phthalocyanine micelle without pH response. In another study, a boron dipyrromethene (BODIPY)-based PS (ET-BDP-O) with aggregation-induced emission characteristics was developed by Liu's group, in which the two linear arms of BODIPY group were linked with triphenylamine to form an electron Donor-Acceptor-Donor (D-A-D) architecture, while the side chain was decorated with triethylene glycol group.[4] The self-assembled ET-BDP-O NPs have an excellent colloid stability with the size of 125 nm, and the strong fluorescence and reactive oxygen species (ROS) could be generated under light-emitting diode (LED) irradiation, which implies that ET-BDP-O NPs could be regarded as a promising PS candidate for fluorescence imaging-guided PDT. To enhance the treatment depth for PDT, Guo *et al.* developed the semiconductor polymer dots (Pdots) doped with Chlorin e6 (Ce6) and photochromic molecule 1,2-bis(2,4-dimethyl-5-phenyl-3-thiophene)-3,3,4,

5-hexauoro-1-cyclopentene (BTE) to construct a photoswitchable nanoplatform for PDT.[5] The absorption peaks of Ce6-BTE-doped Pdots are in the green region, and the tissue penetration depth could be potentially increased as compared to the most Pdots absorbed in the blue region. The Ce6-BTE-doped Pdots have the advantages of small size, excellent optical property, efficient ROS generation, and good photoswitchable ability, and the Ce6-BTE-doped Pdots could exert excellent photodynamic effect in ON state and reduce photosensitivity in OFF state.

Regarding the new light sources for PDT, a portable LED device consisting of a flexible circuit board with a liquid flow cooling module was developed by Hu's group.[6] The maximal irradiation area of the light source is up to 100 mm^2, and the irradiance could be varied was from 10–100 mW/cm^2. In addition, the irradiance coefficient variation for a treatment area of 81 mm^2 was less than 7%, which holds the specific application for PDT treatment of oral leukoplakia. Ortega-Zambrano *et al.* utilized visible light and UV-A radiation to excite four commercial PSs, including methylene blue, rose bengal, riboflavin and curcumin for photodynamic inactivation.[7] In order to compare photodynamic effects in an appropriate way, the same number of absorbed photons was performed for PDT. It was found that methylene blue leads to the major inactivation of *Escherichia coli.*

For monitoring dosimetric parameters for PDT, Gao's group successfully combined spatial frequency domain imaging (SFDI) with diffuse fluorescence tomography (DFT) to quantify the three-dimensional (3D) distribution of 5-aminolevulinic acid induced protoporphyrin IX (PpIX).[8] The SFDI maps both the distributions of tissue absorption and scattering properties at three wavelengths (405 nm, 520 nm, 630 nm), and provides the optical background for DFT and extracts the tissue oxygenation for assessing the therapeutic outcomes, while DFT dynamically monitors 3D distribution of PpIX concentration from the measured fluorescence for dosimetric optimization. It was demonstrated that the SFDI/DFT system is able to dynamically trace changes in the PpIX concentration and tissue oxygen during the treatment. To evaluate the $^1O_2$ luminescence-based PDT dosimetry, a set of highly sensitive optical fiber detection system was developed to detect the $^1O_2$ luminescence at 1270 nm during photosensitization.[9] The $^1O_2$ luminescence could be quantified in pig skin ex vivo. The $^1O_2$ lifetime was determined to $17.4 \pm 1.2\mu$s. The intensity of $^1O_2$ luminescence was increased with the TMPyP concentration, and the vasoconstriction of blood vessels is higher than 80% when the TMPyP dose was delivered as 25 mg/kg body weight for PDT.

As the guest editors of the two special issues of Journal of Innovative Optical Health Sciences devoted to enhanced PDT, we really appreciate the unique opportunity the Journal has provided for highlighting this important topic. Most importantly, we show our gratitude to all contributing authors for their valuable knowledge and experience.

References

1. B. Li, L. Lilge, "Introduction to the special issue on enhanced photodynamic therapy," *J. Innov. Opt. Health Sci.* **15**(4), 2202002 (2022).
2. H. Li, M. Wei, X. Lv, Y. Hu, J. Shao, X. Song, D. Yang, W. Wang, B. Li, X. Dong, "Cerium-based nanoparticles for cancer photodynamic therapy," *J. Innov. Opt. Health Sci.* **15**(6), 2230009 (2022).
3. Y. Zhou, W. Zeng, M. Wang, R. Li, X. Yue, Z. Dai, "Ultrasmall pH-responsive silicon phthalocyanine micelle for selective photodynamic therapy against tumor," *J. Innov. Opt. Health Sci.* **15**(6), 2250035 (2022).
4. Y. Zhang, G. Li, J. Li, M. Wu, X. Liu, J. Liu, "A novel BODIPY-based nano-photosensitizer with aggregation-induced emission for cancer photodynamic therapy," *J. Innov. Opt. Health Sci.* **15**(6), 2240009 (2022).
5. L. Guo, B. Xu, H. Chen, Y. Tang, "Photoswitchable semiconducting polymer dots with photosensitizer molecule and photochromic molecule loading for photodynamic cancer therapy," *J. Innov. Opt. Health Sci.* **15**(6), 2240007 (2022).
6. J. Xiong, X. Wang, X. Hu, Y. Han, Q. Li, "A Portable illumination device for photodynamic therapy of the oral cavity," *J. Innov. Opt. Health Sci.* **15**(6), 2240012 (2022).
7. D. Ortega-Zambrano, D. Fuentes-López, H. Mercado-Uribe, "Photoinactivation of Escherichia coli using five photosensitizers and the same number of photons," *J. Innov. Opt. Health Sci.* **15**(6), 2240010 (2022).
8. M. Dan, W. Song, M. Liu, Y. Zhang, F. Gao, "Three-dimensional quantification of protoporphyrin IX in photodynamic therapy using SFDI/DFT: A pilot

experimental validation," *J. Innov. Opt. Health Sci.* **15**(6), 2240008 (2022).
9. C. Zhang, H. Lin, Y. Hu, J. Sui, L. Lin, B. Li, "Monitoring of time-resolved singlet oxygen luminescence at 1270 nm by an optical fiber detection system," *J. Innov. Opt. Health Sci.* **15**(6), 2240011 (2022).