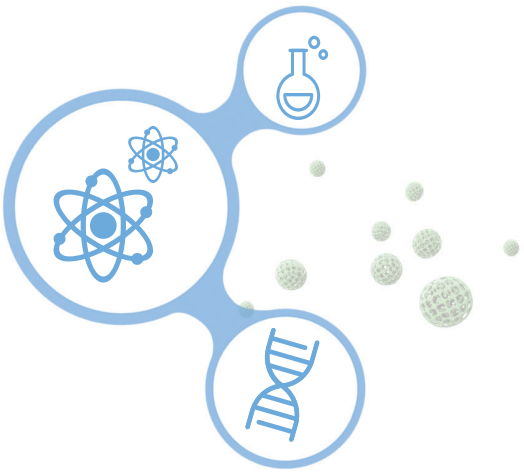
# The 16th Annual Congress of the Korean Photodynamic Association

## 2016년도 16회 대한광역학학회 정기 학술대회



일시 I 2016. 9. 3. Sat 11:00~

장소 I 대구가톨릭대학교 의과대학(루가관)
7층 세미나실

**Organizer**

• Korean Photodynamic Association

# 대한광역학학회

## KOREAN PHTODYNAMIC ASSOCIATION

# The 16th Annual Congress of the Korean Photodynamic Association

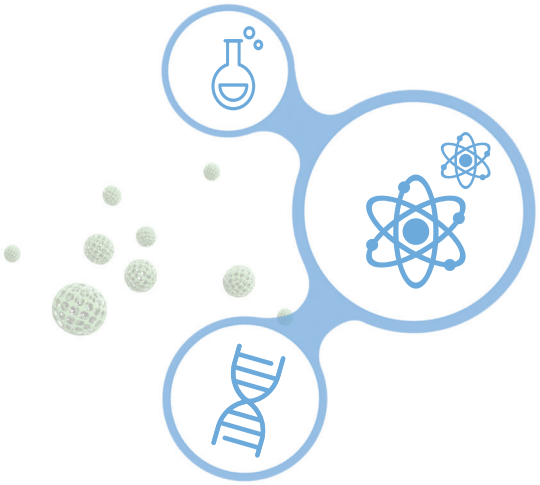
일 시 : **2016년 9월 3일(토요일)**
장 소 : 대구가톨릭대학교 의과대학(루가관) 7층 세미나실

| 시간 | 주제 | 연자 | |
|---|---|---|---|
| 11:00~12:00 | 학회 등록 | | |
| **12:00~13:00** | **점심 식사 (세미나실 7층)** | | |
| 13:00~13:10 | 인사말 | 회장 김종기<br>(대구가톨릭대) | |
| | **Session I.** | **좌장: 김종기** | |
| 13:20~13:40 | Sulforaphene enhances the efficacy of photodynamic therapy in anaplastic thyroid cancer through Ras/RAF/MEK/ERK pathway suppression | 안진철<br>(단국대학교) | 7 |
| 13:40~14:00 | Activatable Nano-theranostic Agents for Near-infrared Fluorescence Imaging and Photodynamic Therapy of Cancers | 최용두<br>(국립암센터) | 8 |
| 14:00~14:20 | Water-Soluble Ionic Liquid Type Photosensitizers for Photodynamic Therapy | 윤일<br>(인제대학교) | 15 |
| 14:20~14:40 | Multifunctional photosensitizing molecules or nanoparticles for enhanced photodynamic tumor therapy | 이은성<br>(가톨릭대학교) | 17 |
| 14:40~15:00 | 다각적 영상 평가법을 이용한 약물의 유효성 및 안전성 평가 | 김상균<br>(대구경북첨단의료복합단지) | 20 |
| 15:00~15:30 | **포스터 발표 및 다과** | | |

| | **Session II.** | **좌장: 최용두** | |
|---|---|---|---|
| 15:30~15:50 | 의료기기 적용을 위한 광단층영상 프로브 | 엄주범<br>(한국광기술원) | 31 |
| 15:50~16:10 | Targeted photodynamic therapy with colon cancer-specific peptide conjugated photosensitizer | 김주희<br>(가톨릭대학교 의과대학) | 32 |
| 16:10~16:30 | Nanoporphyrin-based spectrometric gas sensing | 최윤식<br>(대구가톨릭대학교) | 33 |
| 16:30~16:50 | Listening to Light and Seeing Through: In Vivo Multiscale Photoacoustic Imaging | 김철홍<br>(POSTECH) | 34 |
| 16:50~17:10 | Effect of chlorin e6-based photodynamic therapy with halogen light against *P. acnes*-induced inflammatory response | 이미영<br>(순천향대학교) | 53 |
| 17:10~17:30 | Enhanced production of ROS in carboplatine-assisted PDT | 전재근<br>(대구가톨릭대학교) | 55 |
| 17:30~17:50 | 정기총회 | | |
| 17:50~ | 만찬 | | |

# Session I.

좌장 : 김 종 기



# Sulforaphene enhances the efficacy of photodynamic therapy in anaplastic thyroid cancer through Ras/RAF/MEK/ERK pathway suppression

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Anaplastic thyroid cancer (ATC) is a rapidly growing thyroid cancer with poor prognosis due to aggressive proliferation and drug resistance. Alternative treatments like photodynamic therapy (PDT) is being implemented but the results are still not promising. Sulforaphene (SFE), a natural isothiocyanate has shown potential anticancer effect. The objective of this work is to establish an alternative method with combination of photofrin-PDT and SFE against human anaplastic thyroid cancer. Here, FRO cells were treated with low doses of photofrin and SFE for combination treatment and also expected to show minimal adverse effect to normal fibroblast cells. FRO cells were irradiated with 630 nm diode laser at a dose of 10.8 J/cm$^2$ for PDT treatment. Higher efficacy of the treatment was analysed by MTT assay, cell cycle study, ROS generation and MMP depolarization in flow cytometry. Western blot analysis of various proliferative proteins like MEK(1/2), ERK(1/2), EGFR, Ras, B-Raf etc. showed a noticeable decrease in expressions. Thus, combination treatment synergistically diminishes the proliferation of FRO cells by suppressing the Ras-Raf-MEK pathway proteins through ROS generation, MMP depolarization and cell cycle arrest. SFE showed minimum cytotoxicity against normal fibroblast cells thus confirming low side-effects. In conclusion, the combination of PDT and SFE can be a potential modality against human anaplastic thyroid cancer.

# Activatable Nano-theranostic Agents for Near-infrared Fluorescence Imaging and Photodynamic Therapy of Cancers

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Photodynamic therapy (PDT) using combinations of chemical photosensitizers, light, and molecular oxygen has long been used successfully to treat cancers and other nonmalignant conditions. Compared with conventional chemotherapy, photosensitizers become cytotoxic only in regions that receive the appropriate wavelength of light. However, problems with water-insolubility, limited tumor selectivity, and poor pharmacokinetics of PDT agents have been the main drawbacks to their clinical application. In particular, nonspecific activation of singlet oxygen generation in normal tissues causes prolonged skin photosensitivity, thereby limiting their utility as theranostic agents.

My laboratory has been developing various types of activatable and dual-targeted photosensitizing agents as smart theranostics for selective near-infrared fluorescence imaging and photodynamic therapy of cancers as well as inflammatory diseases. Here I am going to present activatable nanoparticle systems which have been recently developed in my lab. In their native state, photosensitizers in the nanoparticles were nonfluorescent and nonphototoxic, but it became highly fluorescent and phototoxic in cancer cells.

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Review Editor: Frontiers in Molecular Biosciences

Editorial Board: World Journal of Methodology

Guest Editor: BioMed Research International

Referee activity: ACS Nano, JACS, Chem Commun, Nanoscale, Chemical Science, Biomaterials, Small, Adv Func Mat, Angew Chem Int Ed

Korea moderator: “Cancer and Nanotechnology Asia-Pacific Network”

- Publication list

1. H Kim, HS Choi, S-K Kim, BI Lee, Y Choi.* Antigen-responsive molecular sensor enables real-time tumor-specific imaging. **Theranostics** Under revision.
2. J Kim, S-H Goh, Y Choi.* Redox-responsive theranostic agent for target-specific fluorescence imaging and photodynamic therapy of EGFR-overexpressing triple-negative breast cancers. **J. Mat. Chem. B**, Under revision.
3. J Kim, J Chae, JSoo Kim, -H Goh, Y Choi.* Photosensitizer-conjugated tryptophan-containing peptide ligands as new dual-targeted theranostics for cancers**. Int. J. Pharm.** Under revision.
4. S Mun, J Kim, DJ McClements, Y-R Kim, Y Choi.* Fluorescence imaging of spatial location and proteins during digestion of protein-stabilized oil-in-water emulsions: A simulated gastrointestinal tract study. **Food Chem**. Under revision.
5. JH Hyun, S-K Kim, KG Kim, HR Kim, HM Lee, S Park, SC Kim, Y Choi, DK Sohn. A novel endoscopic fluorescent band ligation method for tumor localization. **Surg. Endosc**. Online published (2016)
6. J Choi, H Kim, Y Choi,* Theranostic nanoparticles for enzyme-activatable fluorescence imaging and photodynamic/chemo dual therapy of triple-negative breast cancer. **Quant. Imaging Med. Surg**. 5(5):656-64 (2015)
7. S Kim, H Kim, Y Choi*, and Youngmi Kim*. A new strategy for fluorogenic esterase probes displaying low levels of non-specific hydrolysis. **Chemistry-A Eur. J.** 21(27):9645-9 (2015).
8. H Lee, W Hong, S Jeon, Y Choi, Y Cho. Electroactive polypyrrole nanowire arrays: Synergistic effect of cancer treatment by on-demand drug release and photothermal therapy. **Langmuir**, 31:4264-4269 (2015).
9. D Park, Y Cho, S-H Goh*, Y. Choi*. Hyaluronic acid-polypyrrole nanoparticles as pH-responsive theranostics. **Chem. Commun**., 50:15014-15017 (2014).
10. J Kim, CH. Tung, Y Choi*. Smart dual-functional warhead for folate receptor-specific activatable imaging and photodynamic therapy. **Chem. Commun**., 50:10600-10603 (2014).
11. H Lee, J Kim, H Kim, Y Kim, Y Choi*. A folate receptor-specific activatable probe for nearinfrared fluorescence imaging of ovarian cancer. **Chem. Commun**., 50:7507-7510 (2014).
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14. H Kim, Y Kim, I-H Kim, K Kim*, Y. Choi*. ROS-responsive activatable photosensitizing agent for imaging and photodynamic therapy of activated macrophages. **Theranostics** 4(1):1-11 (2014).

15. J Park, H Kim, Y. Choi*, Youngmi Kim*. A ratiometci fluorescent probe based on a BODIPY-DCDHF conjugate for the detection of hypochlorous acid in living cells. **Analyst** 138(12):3368-3371 (2013).
16. S-M Shon†, Y Choi†, J-Y Kim, D-K Lee, J-Y Park, D Schellingerhout, D-E Kim. Photodynamic therapy using a protease-mediated theranostic agent reduces cathepsin-B activity in mouse atheromas in vivo. **Arteriosclerosis, Thrombosis, and Vascular Biology** 33(6):1360-1365 (2013). † equally contributed author
17. Y-G Wang, H Kim, S Mun, D Kim, Y. Choi*. Indocyanine green-loaded perfluorocarbon nanoemulsions for bimodal 19F-magnetic resonance/nearinfrared fluorescence imaging and subsequent phototherapy. **Quant Imaging Med Surg.**, 3(3):132-140 (2013).
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# Water-Soluble Ionic Liquid Type Photosensitizers for Photodynamic Therapy

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Generally, most of the photosensitizers (PSs) are hydrophobic, which may afford disadvantages to make the PSs insoluble under physiological conditions and hinders to reach the accumulation in the tumor sites. For clinical application, it is need to prevent making aggregation of PS molecules in aqueous media. There are many efforts to make soluble the PSs in water by using various types, such as, cationic (pyridinium, ammonium), anionic (sulfate, phosphonate, carboxylate with sodium), saccharide, cyclodextrin, peptide, polyethylene glycol, polymeric micelles, polymers (starch, dextran, polyallylamine,[1] polyvinylpyrrolidone), and etc. Our group has developed water-soluble gold nanorod(GNR)-PS complex for controllable photodynamic therapy (PDT) effect.[1]

Ionic liquids (ILs) are useful materials based on good advantages, such as, negligible vapor pressure, high thermal stability, property improvement upon slight changes in the chemical architecture. IL type PS (IL-PS) may help PSs capable of increased solubility in aqueous system as well as support attachment of PSs on gold nanoparticles (GNPs) surface through stable electrostatic interactions between ILs and PSs.[2] In order to increase uptake of PSs into tumor cells, PSs should not highly water soluble (hydrophilic) to penetrate the tissue and cell membranes. Therefore it is very important to keep suitable hydrophobic/hydrophilic balance of PSs, for which use of GNPs has a great interest as an efficient carrier of IL-PS.

We developed various kind of ILs, such as morpholinium, cholinium, imidazolium, and ammonium type, of purpurin-18 (**IL1PSs**~**IL4PSs**) were used to prepare GNP complexes of **IL1-PS-GNPs**~**IL4-PS-GNPs** and their PDT effect was investigated.[3] The hydroxyl group of each IL-PS has important roles as a reducing agent to make Au(0) as well as a stabilizer through the electrically charged functional groups (i.e. carboxylate and amine groups) in forming the GNPs complexes without any additional reducing agents and surfactants. The GNPs complexes were characterized by a combination analysis of $^{1}$H-NMR and UV-Vis spectroscopies, TGA and TEM measurements. UV-Vis spectra show that long wavelength absorptions ($\lambda_{max}$ 715~762 nm) of the IL-PSs and IL-PS-GNPs. TGA spectra show the formation of the IL-PS-GNPs, result in directly measured amount of organic content of 37~48% and metallic Au of 52~63%. TEM images showed that the IL-PS-GNPs nanospheres have a size range of 20~80 nm.

All the IL-PS-GNPs showed better cell viability than that of the corresponding IL-PS, which result clearly reveal that the GNPs is an useful carrier for this IL-PS. PDT efficacy of the complexes

IL-PS-GNPs and the corresponding IL-PSs were investigated by MTT assay against A549 and Hela cell lines. The IL-PS-GNPs complexes showed higher cell viability compared to the corresponding free IL-PSs, respectively, due to higher cell penetration based on excellent delivery effect of the GNPs, and relative PDT activity difference among the complexes was depend on the property of the IL-PSs. The IL-PS-GNPs complexes could be delivered into cancer cell by endocytosis result in high penetration and intracellular localization, which was confirmed by confocal laser scanning microscopy (CLSM) images. This result may useful for design and synthesis of new water-soluble IL-PSs and PS-GNPs complexes for enhanced PDT effect.

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2. Lkhagvadulam B, Kim JH, Yoon I and Shim YK. *BioMed Res. Int.* **2013**, *2013*: 10 pages. Article ID 720579.
3. Yoon I and Shim YK. *In preparation*.

# Multifunctional photosensitizing molecules or nanoparticles for enhanced photodynamic tumor therapy

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Therapeutic benefit of photodynamic therapy (PDT) method using external light illumination source provides promising modality for the treatment of tumors, associated with ameliorated drug side effects for normal tissues. Fullerene ($C_{60}$) and chlorin e6 (Ce6) used in PDT, can readily transfers the exited energy to oxygen molecules, resulting in generating singlet oxygen in a high yield. The delivery of high doses of photosensitizing drugs to target cancer sites have shown highly increased efficiency in cancer therapy. Here, we introduce various examples of photosensitzing drugs modified using biopolymer-conjugation technologies for highly efficient photodynmaic tumor therapy. These system will be favorable to enhance tumor-specific accumulation of photosensitizing drugs and proivde effective treatments for tumors.

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ㅇSelected SCI journals (as a corresponding author)

1. Y-shaped ligand-driven gold nanoparticles for highly efficient tumoral uptake and photothermal ablation , ACS Nano. 12 (2014) 12858-12865

2. Facile synthesis of multilayered polysaccharidic vesicles, J. Control. Release 10 (2014) 83-90.

3. Hyaluronated fullerenes with photoluminescent and antitumoral activity, Chem. Commun. 49 (2013) 282-284.

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- 현재 126편의 SCI 논문 발표함(2003~2016)
- 산학 기술이전 3건.

**ㅇ 주요수상경력**

- Highly cited Researchers 2015 (by Thomson Reuters, USA): Category: Pharmacology & Toxicology, high 1% article-cited researcher.
- 한국약제학회 2015년 우수논문상 2015년
- 가톨릭대 교수연구업적부문 신진연구우수상 2013년
- GRRC 우수연구자 유공표창 (경기도 도지사) 2012년
- 지식창조대상(교육과학기술부, 장관상) 2011년
- Jorge Heller Outstanding Paper Award (CRS) 2009년

# 다각적 영상 평가법을 이용한 약물의 유효성 및 안전성 평가

실험동물센터 신약지원팀 김상균
대구경북첨단의료산업진흥재단, 대구광역시 동구 첨복로 80.

최근에 영상을 이용하여 약물동태학 뿐만 아니라 유효성/안전성 평가에 이용하는 사례가 많이 증가하고 있다. 특히 영상을 통한 약물의 유효성/안전성 평가는 활용성측면 뿐만 아니라 평가의 신뢰성 확보에 큰 역할을 하고 있다. 최근에는 평가에 있어 하나의 장비만을 이용하여 평가하는 대신에 multimodality장비를 이용하는 등 다각적 분석을 통하여 더욱 더 좋은 신뢰성 있는 평가법을 구축하고자 한다. 이와 같은 평가법 중에 1) 혈관관련 질병 연구에서 통합적 광학적 영상의 활용성  2) 독성평가에서 광학영상의 활용 3) 신약개발과정에서 광학영상의 활용한 약물동태학적 연구의 사례를 보여주고, 이를 통해 현재 대구경북첨단의료산업진흥재단 실험동물센터에서는 신약개발을 위해 영상을 어떻게 활용하고 있으며, 유효성 및 안전성 평가서비스는 어떻게 진행하는지를 소개한다.

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EDUCATION

***Ph.D.***, Department of Materials Science and Engineering, Gwangju Institute of Science and Technology; 2003 March 03 ~ 2007 August 27, Dissertation Title: Oral Formulation of Bile acid Acylated Low Weight Heparin. Supervisor: Professor Giyoong Tae, Ph.D.

***M.S.,*** Dept. of Life science & Biotechnology, Biochemistry, Korea University; 2000 sep 1 ~ 2002 Aug 24, Thesis Title: Oral And Parenteral Vaccination Against *Vibrio cholera* Using Lipid Nanocubicle And Liquid crystalline Cubic phase. Co-Supervisor: Professor Ha chin Sung, Ph.D. / Hesson Chung, Ph.D.

***B.S.***, Genetic Engineering Department, Microbioogy lab in Chonnam National University; 1994 March 02 – 2000 Aug 26. Supervisor: Chung gi-chul. Ph.D.

EXPERIENCE/

ACTIVITES

***Senior Scientist.,*** Gyeongbuk Institute for Bio industry

***Senior Post-Doc.***, Pharmacy, University of North Carolina at Chapel Hill, 2008 July 11 – 2011 July 26, Research Advisor: Professor Leaf Huang, Ph.D.

***Post-Doc.***, College of Pharmacy, Seoul National university; 2007 sep. 15 – 2008 June 15. Research Advisor: Professor Youngro Byun, Ph.D.

***Research Scientist***, Biomedical Research Center, Korea Institute of Science and Technology; 2000 Sep – 2002 Dec. Research Advisor: / Hesson Chung, Ph.D.

Professional Societies:

American Association of Pharmaceutical Scientists (AAPS), member

KSEA (Korean-American Scientist and engineers Association), member

Controlled Release Society (CRS), member

The Korean Society of Pharmaceutics (KSP), member

Research Project Implementations:

1. 보건복지부 첨단의료개발사업과제 " 의료제품의 영상기반 약물동태학, 유효성, 안전성평가 기반구축사업" PI 김상균 (2015.12~2017.9)
2. 보건복지부 첨단의료개발사업과제 "전임상 실험을 통해 망막색소상피세포(RPE)에서의 선택적망막치료 (SRT) 레이저시스템의 치료메커니즘 규명 및 효과성 검증" PI 김상균 (2013.9~2016.9)
3. 보건복지부 첨단의료개발사업과제 "bret시스템을 이용한 항암제 유효성 평가" PI 김상균 (2013.9~2015.9)
4. 지식경제부과제 "인플루엔자 등 백신원료 맞춤형 생산지원 사업" 경북바이오산업연구원 실무 김상균 (2010. 7~2013.4), 140억원
5. **The postdoctoral International Training Program** (research fellowship project no. E00066) from Korea Research Foundation (KRF). "study on catinonic lipid and dendritic cells". *School of pharmacy, University of North carolina*. (July 01, 2007 – June 30, 2008) - **Principal Investigator** Leaf Huang

Award

**1. 2010 T. Nagai Postdoctoral Research Achievement Award with 3000$**

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3. **Sang Kyoon Kim**, Michael B. Foote, Leaf Huang, The targeted intracellular delivery of cytochrome C protein to tumors using lipid-apolipoprotein nanoparticles, Biomaterials, 2012 Feb;33(15):3959-66. (IF=7.88)
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9. Jin Woo Park, Ok Cheol Jeon, **Sang Kyoon Kim**, Taslim

Ahmed Al-Hilal, Hyun Tae Moon, Choong Yong Kim and Youngro Byun, Anticoagulant efficacy of Solid Oral Formulations Containing a New Heparin Derivative, Molecular Pharmaceutics. , 2010 Mar, 7(3) 836-843 (IF=5.4)

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학술 등재지

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PATENTS

**Publication Patents**

1. Youngro Byun and **Sang Kyoon Kim**, "Drug formulation containing a solubilizer for enhancing solubility, absorption, and permeability", WO2007/011171, Jan25, 2007
2. Yu-Cheng Tseng, **Sang Kyoon Kim,** Michael Hackett, Sumio Chono, Leaf Huang, Shyr-dar Li. "Methods and Compositions for the delivery of Bioactive compounds", WO2009/141893 A2 (11/26/2009)

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2. Yu-Cheng Tseng, **Sang Kyoon Kim,** Michael Hackett, Sumio Chono, Leaf Huang, Shyr-dar Li. "Methods and Compositions for the delivery of Bioactive compounds", 61/054,338 (US) (05/01/2009)

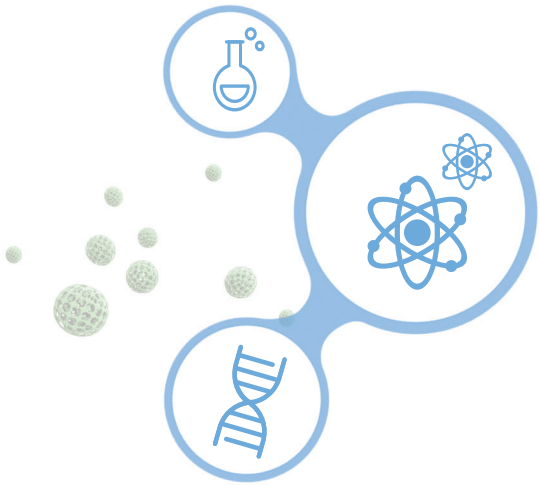
**PCT**

**Publication Patents**

1. Youngro Byun, **Sang Kyoon Kim**, "Drug formulation containing a solubilizer for enhancing solubility, absorption, and permeability", PCT/KR2006/002848, Jul19, 2006.
2. Yu-Cheng Tseng, **Sang Kyoon Kim,** Michael Hackett, Sumio Chono, Leaf Huang, Shyr-dar Li. "Methods and Compositions for the delivery of Bioactive compounds", PCT/US2009/042485

# Session I.

좌장 : 최 용 두



# 의료기기 적용을 위한 광단층영상 프로브

## Optical coherence tomography probe for medical equipment

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한국광기술원 광의료 연구센터

Abstract

OCT probe for dentistry and dermatology has been made with MEMs mirror, align holder and optical collimator. By simply aligning MEMS mirror directly connected and optical collimator, a compact optical probe could be implemented. With the optical probe, a swept source OCT system and spectral domain OCT system were implemented and used to demonstrate the feasibility as the dedicated probe for dentistry and dermatology.

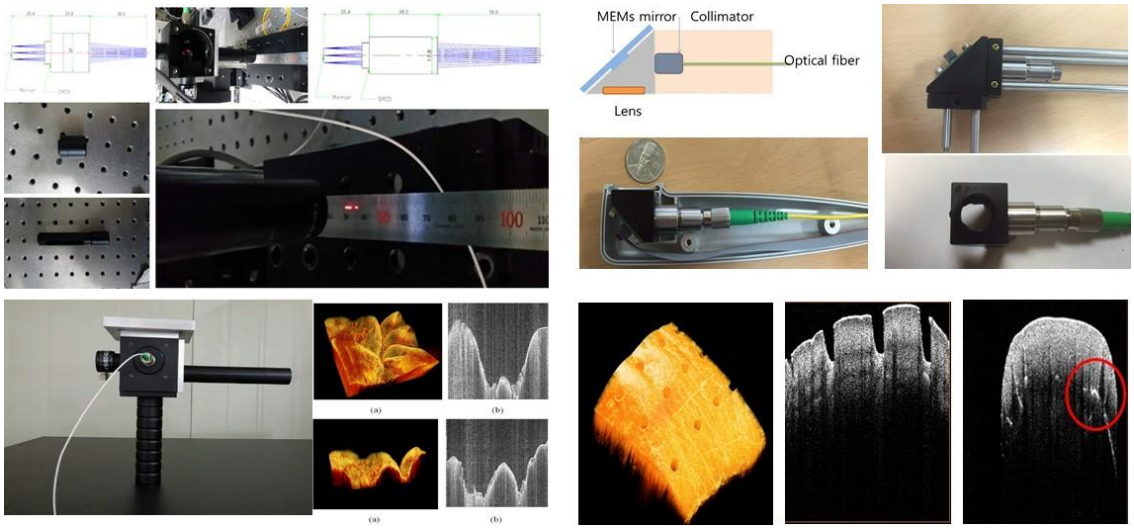


그림 1. 치아 영상획득을 위한 Galvo mirror 기반의 및 MEMs 기반의 광프로브

# Targeted photodynamic therapy with colon cancer-specific peptide conjugated photosensitizer

**Ju Hee Kim**[1], In-Wook Kim[1], Hyun-A Kim[1], Se-Mi Jung[1], Jae Myung Park[1,2], Tayyaba Hasan[3], Myung-Gyu Choi[1,2]

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[2]Division of Gastroenterology, Department of Internal Medicine, Seoul St. Mary's Hospital, The Catolic University o Korea, Seoul, Korea
[3]Wellman Center for Photomedicine, Department of Dermatology, Massachusetts General Hospital, Harvard School, Boston, USA

**Purpose:** Diagnostic methods for colon cancer with white light endoscopy have limits for detecting all pre-cancer lesions. Therefore, improved approaches for detecting pre-cancer lesion are needs. We aim to develop probe possible to detect and treat the small lesion at the same time.

**Methods:** To isolate the peptide specific to colon cancer, we screened phage display peptide libraries against human colon cancer cell lines. Analyzed peptide sequences were synthesized, and then conjugated with fluorescence or photosensitizer (Hematoprophyrin, HPP).

**Results:** Immunocytochemical staining using FITC or HPP-conjugated peptides showed high level of binding affinity to colon cancer cell lines. We also saw no binding the peptides to normal colon cell line. We confirmed that peptide conjugated HPP had enhanced photodynamic therapy (PDT) effect compared to none conjugated photosensitizer. We also checked binding affinity to colon lesion tissue using mouse colon cancer model. The data showed that HPP-conjugated peptide had more affinity than HPP in mouse colon lesion.

**Conclusions:** The results from this study suggest that targeted PDT using peptide probe may be a promising candidate drug in the development of a useful colon cancer diagnosis and treatment.

# Nanoporphyrin-based spectrometric gas sensing

최윤식[1], 이세희[2], 김종기[1]
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[2] 대구가톨릭대학교 안경광학과

목적: 환자의 호기가스로부터 폐암진단법을 개발하기 위해 기존의 단일 포프피린분자 대신 반응 단면적의 증강을 위해 나노메탈포르피린을 제작 폐암환자 호기가스에 대한 광학적 감응반응을 측정하였다.

방법: 용매 혼합기술로 제조한 Fe(II)-나노포르피린과 알려진 폐암 환자의 호기가스 중에서 Benzene, Dodecane, Pentane, Toluene을 선정하여 두 가지 다른 방법으로 반응시켰다.
다공성 Alginate Gel에 Fe(II)-나노포르피린을 embedding한 Fe(II)-나노포르피린 Gel과 용액상태의 Fe(II)-나노포르피린을 Dodecane, Pentane, Toluene을 반응시켜 감응감도를 비교하였다.

결과: UV-VIS 흡광도 Spectrum에서 Benzene을 제외한 Dodecane, Pentane, Toluene과의 반응에서 Soret band peak 및 Q-band가 현저히 감소하는 변화를 관찰할 수 있었다.
Fe(II)-나노포르피린용액이 Soaking되어 다공성 Alginate Gel에 고정되어 호기가스와 반응하는 것이 용액상태의 Fe(II)-나노포르피린 보다 반응감도가 증강되었으며 가시적 색깔 변화가 감지되었다. Pentane과 Toluene에 대한 반응감도가 가장 눈에 띄게 나타나 선별적 감지가 예상됨.

결론: Gel상에 나노포르피린을 고정시킬 때 반응이 가시적으로 색깔변화가 유도되어, 나노포르피린-가스 반응 증강을 도모한 나노메탈포르피린-젤 호기가스 센서 제작과 광학적 감응법이 가능함을 보였다.

# Listening to Light and Seeing Through: In Vivo Multiscale Photoacoustic Imaging

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## 1 ABSTRACT

High-resolution volumetric optical imaging modalities, such as confocal microscopy, two-photon microscopy, and optical coherence tomography, have become increasing important in biomedical imaging fields. However, due to strong light scattering, the penetration depths of these imaging modalities are limited to the optical transport mean free path (~1 mm) in biological tissues. Photoacoustic imaging, an emerging hybrid modality that can provide strong endogenous and exogenous optical absorption contrasts with high ultrasonic spatial resolution, has overcome the fundamental depth limitation while keeping the spatial resolution. The image resolution, as well as the maximum imaging depth, is scalable with ultrasonic frequency within the reach of diffuse photons. In biological tissues the imaging depth can be up to a few centimeters deep.

In this presentation, the following topics of photoacoustic imaging will be discussed; (1) multi-scale photoacoustic imaging systems (i.e., Photoacoustic Nanoscopy, Optical-Resolution Photoacoustic Microscopy, Fast 2-Axis MEMS based Optical-Resolution Photoacoustic Microscopy, Intravascular Photoacoustic/Ultrasound Catheter, Virtual Intraoperative Surgical Photoacoustic Microscopy, Acoustic-Resolution Photoacoustic Microscopy, Clinical Photoacoustic/Ultrasound Scanner), (2) morphological, functional, and molecular photoacoustic imaging, (3) potential clinical applications, and (4) contrast agents for photoacoustic imaging.

## 2 BRIEF BIOGRAPHY

Dr. Chulhong Kim studied for his Ph.D. degree and postdoctoral training at Washington University in St. Louis, St. Louis, Missouri under the supervision of Dr. Lihong V. Wang, Gene K. Beare Distinguished Professor (main advisor), Dr. Younan Xia, and Dr. Samuel Achilefu. He is currently an associate professor of Creative IT Engineering, Mechanical Engineering, Electrical Engineering, and Interdisciplinary Bioscience and Bioengineering at Pohang University of Science and Technology (***POSTECH, #1 in the world: The 100/50 Young University rankings for three consecutive years 2012-2014, #4 in the world: The world's best small universities 2016***) in Republic of Korea. Before he joined the department, he was an assistant professor of Biomedical Engineering at the University at Buffalo, the State University of New York from Aug 2010 to Jan 2013. He has published 80 peer-reviewed articles in journals including *Nature Nanotechnology, Nature Materials, Chemical Reviews, Nano Letters, Angewandt Chemie, Journal of American Chemical Society, ACSNano, Radiology, Biomaterials, Scientific Reports, Optics Letters, Applied Physics Letters, Journal of Biomedical Optics, etc*. His Google Scholar h-index and citations have reached 33 and over 4,400, respectively. He also co-authored five book chapters. He has currently served as an Editorial Board Member of Photoacoustics Journal and American Journal of Nuclear Medicine and Molecular Imaging, and a Guest Editor of Journal of Biomedical Optics, BioMed Research International, and IEEE Pulse Magazine. He has served as an Organizing Committee for the conference on "Photons plus Ultrasound: Imaging and Sensing" held annually under auspices of SPIE (Photonics West). He has served as a journal reviewer >60, including for *Nature Photonics, Nature Communication, Light Science & Applications, Nano Letters, ACS Nano, Scientific Reports, Optics Letters, Optics Express, Journal of Biomedical Optics, IEEE Transactions, and etc*. He has delivered a numerous invited presentations in technical conferences and seminars in universities. His research interests are the development of novel biomedical imaging techniques including photoacoustic tomography, ultrasound-modulated optical tomography, fluorescence imaging, ultrasound imaging, and laser speckle contrast imaging. Particularly, his lab developed photoacoustic gastro-intestinal tract imaging using organic agents, photoacoustic cystography, clinical photoacoustic/ultrasound imaging scanner, fast 2-axis water-proof MEMS based photoacoustic microscopy, virtual intraoperative photoacoustic surgical microscopy, raster scanning based photoacoustic whole body imaging of small animals, combined photoacoustic and optical coherence tomography using a single pulsed broadband laser source, acoustic-radiation force induced ultrasound-modulated optical tomography, etc.

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## SPECIALIZATIONS

**Biomedical optics and ultrasound imaging**

- Photoacoustic tomography
- Ultrasound-modulated optical tomography (also called Acousto-optical tomography)
- Optical coherence tomography
- Fluorescence imaging
- Ultrasound imaging
- Laser speckle contrast imaging
- Photon migration in biological tissues

## PEER-REVIEWED PUBLICATIONS

**Citation indices by Google scholar: Total citations, >4000; h-index, 30**

**Published Articles (78 papers) *Corresponding author. [§]Equal contribution.**

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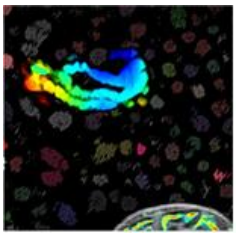

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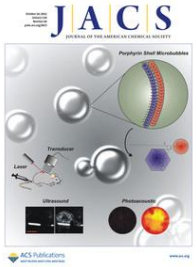


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**52.** **[W. Li[§], X. Cai[§], C. Kim[§]]**, G. Sun, Y. Zhang, R. Deng, M. Yang, J. Chen, S. Achilefu, L. Wang, and Y. Xia, "Gold Nanocages Covered with Thermally-responsive Polymers for Controlled Release by High-intensity Focused Ultrasound", ***Nanoscale***. Vol. 3, pp. 1724-1730 (2011). **IF: 5.9**

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57. **C. Kim**, “Photoacoustic transduction: from light to sound, High resolution optical imaging”, *Departmental seminar in Chemistry and Physics Department, Buffalo State College, the State University of New York, Buffalo, NY*, Nov 2010.

58. **C. Kim**, “Photoacoustic transduction: from light to sound, High resolution optical imaging”, *Departmental seminar in Electrical Engineering Department, University at Buffalo, the State University of New York, Buffalo, NY*, Oct 2010.

59. **C. Kim**, “*In vivo* morphological, functional, and molecular photoacoustic tomography, and its clinical application”, *Departmental seminar, University at Buffalo, the State University of New York, Buffalo, NY*, April 2010.

60. **C. Kim**, “*In vivo* photoacoustic tomography and its clinical application”, *Advanced Imaging Research Center seminar series, University of Texas Southwestern Medical Center, Dallas, TX*, February 2010.

61. **C. Kim**, “*In vivo* photoacoustic tomography and its clinical application, and ultrasound-modulated optical tomography”, *Departmental seminar, University of Texas at Arlington, Arlington, TX*, November 2009 and February 2010.

62. **C. Kim**, and L. V. Wang, “*In vivo* photoacoustic tomography and its clinical application”, *The 158$^{th}$ Acoustical Society of America, Conference on Ultrasound*, San Antonio, TX, Oct 2009.

63. **C. Kim**, “*In vivo* photoacoustic imaging and its clinical application”, *Departmental seminar, Korea Advanced Institute of Science and Technology,* Daejeon, Republic of Korea, June 2009.

64. **C. Kim**, “*In vivo* photoacoustic imaging and its clinical application”, *Departmental seminar, Yonsei University,* Wonju, Republic of Korea, June 2009.

65. **C. Kim**, “*In vivo* photoacoustic imaging and its clinical application”, *Departmental seminar, Kangwon National University,* Chuncheon, Republic of Korea, June 2009.

**66.** **C. Kim**, "*In vivo* photoacoustic imaging and its clinical application", *Departmental seminar, Chungnam National University,* Daejeon, Republic of Korea, June 2009.

**67.** **C. Kim**, "*In vivo* photoacoustic imaging and its clinical application", *Departmental seminar, Electronics and Telecommunications Research Institute,* Daejeon, Republic of Korea, June 2009.

**68.** **C. Kim**, "*In vivo* photoacoustic imaging and its clinical application", *Departmental seminar, Kyungpook National University,* Daegu, Republic of Korea, June 2009.

**69.** **C. Kim**, "*In vivo* photoacoustic imaging and its clinical application", *Departmental seminar, Pukyung National University,* Pusan, Republic of Korea, June 2009.

**70.** **C. Kim**, "*In vivo* photoacoustic imaging and its clinical application", *Biomedical Optics Workshop, Gwangju Institute of Science and Technology,* Gwangju, Republic of Korea, May 2009.

**71.** **C. Kim**, and L. V. Wang, "*In vivo* photoacoustic imaging and its clinical application", *The 4th Asian and Pacific Rim Symposium on Biophotonics, Conference on Biomedical Optics*, Jeju Island, Republic of Korea, May 2009.

## AWARDS AND HONORS

1. **Seno Medical Best Paper Award Finalist** (top 3%) to Seunghyun Lee (Chulhong Kim as senior author), Photons Plus Ultrasound Conference, Photonics West, SPIE, San Francisco, California. 2016.

   Seunghyun Lee, Owoong Kwon, Mansik Jeon, Jaejung Song, Minguk Jo, Sungjee Kim, Junwoo Son, Yunseok Kim and Chulhong Kim, "Super-resolution photoacoustic imaging of single gold nanoparticles"

2. 1st and 3rd Best Poster Awards in the Annual CiTE Research Affairs (Feb 2016).
3. 2nd Best Award in 2015 Fall Tech + Star Challenge, APGC Lab (Nov 2015).
4. Best Poster Award in the Annual Biophotonics Conference (Oct 2015).
5. Best Paper Award in the Optical Society of Korea Summer Meeting (Jul 2015).
6. Silver and Bronze Award in Light Images Contest on Optical Society of Korea Summer Meeting (Jul 2015).
7. First place, Best poster (1/150) in the 41st Northeast Bioengineering Conference (NEBEC) (Apr 2015).
8. Best Poster Award in the International Workshop on Bioengineering Innovations (Feb 2015).
9. Best Presentation Award in the POSTECH Presidential Business Model Fellowship Competition (Feb 2015).
10. Bronze Award from SAMSUNG Electro-Mechanics 1nside Edge Best Paper Competition (Oct 2014).
11. Best Oral Presentation Award in the 14th POSTECH-KYUTECH joint workshop (Aug 2014).
12. 2nd Best Creative Research Project Award from the NIPA Director in the Creative ICT Convergence Korea (Aug 2014).
13. Photonics West 2010 Travel Award (Jan. 2010)
14. Departmental Graduate Scholarship, Dept. of Biomedical Engineering, Texas A&M Univ. (Spring 2005 and Fall 2005)
15. Fellowship, Korean Science and Engineering Foundation, South Korea (Aug 2004-Aug 2006)
16. Departmental Scholarship (7 times), Dept. of Electrical and Computer Engineering, Kyungpook National Univ. (1997-2004)
17. Exchange Student Scholarship (tuition waiver), Univ. of Oklahoma, (Aug 2002-Dec2003)

18. Honors, Univ. of Oklahoma, (Spring 2003 and Fall 2003)

## PROFESSIONAL ACTIVITIES

**Editorial board**

1. American Journal of Nuclear Medicine and Molecular Imaging (AJNMMI, Mar. 2014 – present)
2. Photoacoustics (PACS, Feb. 2015 – present)
3. Clinics in Oncology (Apr. 2016 – present)

**Guest editor**

1. Journal of Biomedical Optics, a premier journal in biomedical optics (Sep 2014- present)
2. BioMed Research International (formerly titled Journal of Biomedicine and Biotechnology), Special Issue on Biomedical Imaging in Regenerative Engineering (June 2014)
3. IEEE Pulse, Special Issue on Photoacoustics (June/July 2015)

**Organizing and Program Chair**

1. The 14th POSTECH-KYUTECH Joint Workshop on Neuroinformatics, Kitakyshu, Japan (Aug 2014)
2. International Workshop on Bioengineering Innovations 2015: Imaging, Devices, Agents, and Applications, Pohang, Korea (Feb 2015)

**Program Committee**

1. Photon plus Ultrasound: Imaging and Sensing, Annual Conference of Photonics West, SPIE, San Francisco, USA (Feb 2016-)
2. The 4th International Conference on Photonics, Optics and Laser Technology, PHOTOPTICS 2016, Rome, Italy (Feb 2016)
3. OSA Biomedical Optics Conference and Exhibition (BIOMED), Optical Tomography and Spectroscopy 2016, Fort Lauderdale, FL, USA (Apr 2016)

**Conference session chair**

1. Novel Methods in Photoacoustic Tomography session in Biomedical Optics Congress Optical Society of America 2016, Fort Lauderdale, Florida, USA
2. Photoacoustic Imaging: Systems, Agents, and Applications Mini-symposium in IEEE Engineering in Medicine and Biology Society (EMBS) Annual Meeting 2015, Milan, Italy
3. Biomedical Optics in Nanomedicine Towards Clinical Translation session in The 9th IEEE International Conference on Nano/Molecular Medicine and Engineering 2015, Hawaii, USA
4. Photoacoustic Imaging and its Applications Mini-symposium in International Conference on Health Informatics 2013, Vilamoura, Portugal
5. Plasmonic and Biophotonics Sensing (III) session in the 4th Asian Pacific Rim Symposium on Biophotonics 2009, Jeju island, Republic of Korea

**Non-executive Director**

**1.** Corporation 가심: Nov 2015 ~ Oct 2017

**Reviewer (>60)** for *Nature Photonics, Nature Communication, Light Science & Applications, Nano Letters, Nanomedicine, Nanoscales, ACS Nano, Lab on a chip, Scientific Reports, Journal of Neuroscience Methods, Phil. Trans. Royal Soc A, Small, IEEE journals, Biomedical Optics Express, Optics Letters, Optics Express, Medical Physics, Applied Optics, Photoacoustics, Applied Physics Letters, Biomedical Engineering Letters, Theranostics, and Journal of Biomedical Optics*

**Selected top 10 reviewers by Journal of Biomedical Optics, who reviewed the highest number of manuscripts over the past five years.**

**Member** of the *Society of Photo-Optical Instrumentation Engineers (SPIE), Optical Society of America (OSA), Institute of Electrical and Electronics Engineers (IEEE), and Korean-American Scientists and Engineers Association (KSEA)*

**Student member** of the *Biomedical Engineering Society (BMES)*

## MENTORING

### RESEARCH FACULTY, RESEARCH ASSOCIATES, POSTDOCS, AND STAFF

**COMPLETED**

1. 03/2011–02/2015, Masik Jeon, Ph.D. from Kyungpook National Univ. S. Korea. Placement: Assistant Professor of School of IT Engineering, Kyungpook National Univ. S. Korea
2. 06/2014–01/2015, Chakyung Woo, M.S. from Kyungpook National Univ. S. Korea.
3. 08/2013–01/2016, Changho Lee, Ph.D. from Kyungpook National Univ. S. Korea. Placement: Postdoctoral Research Associate, Electrical Engineering, Johns Hopkins University. USA

**CURRENT**

1. 08/2014–present, Hyunjung Kim, M.S. from Daegu Catholic Univ. S. Korea.
2. 11/2014–present, Unsang Jung, Ph.D. from Kyungpook National Univ. S. Korea.
3. 02/2015–present, Sungjo Park, Ph.D. from Kyungpook National Univ. S. Korea.
4. 03/2015–present, Sehui Kim, M.S. from Kyungpook National Univ. S. Korea.
5. 08/2015–present, Jinyoung Kim, Ph.D. from POSTECH. S. Korea
6. 03/2016–present, Sunyoung Yu, Ph.D. from GIST. S. Korea

### DOCTORAL STUDENTS

**COMPLETED**

1. 08/2013–08/2015, Jinyoung Kim, Mechanical Eng. POSTECH

**CURRENT**

1. 02/2013–present, Jeesu Kim, Electrical Eng. POSTECH.
2. 02/2013–present, Changhoon Choi, Creative IT Eng. POSTECH.
3. 06/2014–present, Donghyun Lee, Creative IT Eng. POSTECH.
4. 07/2014–present, Seunghyun Lee1, Creative IT Eng. POSTECH.
5. 08/2014–present, Kyungjin Park, iBio. POSTECH.
6. 08/2014–present, Seungwan Jeon, Creative IT Eng. POSTECH.
7. 03/2015–present, Sunghui Cho, iBio. POSTECH.
8. 03/2015–present, Sara Park, Creative IT Eng. POSTECH.
9. 03/2015–present, Jaewoo Kim, Creative IT Eng. POSTECH.
10. 09/2015–present, Seunghyun Lee2, Creative IT Eng. POSTECH.
11. 09/2015–present, Byullee Park, Creative IT Eng. POSTECH.
12. 09/2015–present, Wonseok Choi, Electrical Eng. POSTECH.
13. 09/2015–present, Eunyoung Park, Electrical Eng. POSTECH.
14. 02/2016–present, Hoyong Lee, Creative IT Eng. POSTECH.
15. 02/2016–present, Jinwoo Baik, Creative IT Eng. POSTECH.
16. 02/2016–present, Joongho Ahn, Creative IT Eng. POSTECH.
17. 02/2016–present, Dayoun Kang, iBio. POSTECH.

### MASTER'S STUDENTS

**COMPLETED**

1. 01/2011–05/2012, Sriranjani Ramasubramanian, Electrical Eng. SUNY Buffalo.

**CURRENT**
1. 03/2015–present, Yuhwan Jeong, Electrical Eng. POSTECH.

## VISITORS AND OTHER TRAINEES

**COMPLETED**
1. 08/2010–02/2013, Yang Li, Biomedical Eng. SUNY Buffalo.
2. 08/2010–12/2010, Deepak Kumar, Mechanical Eng. SUNY Buffalo.
3. 05/2011–08/2011, Stephanie Rosenbaum, Biomedical Eng. SUNY Buffalo.
4. 07/2011–08/2011, Avery Becker, Williamsville north high school.
5. 08/2011–12/2011, Abhiram S Rao, Biomedical Eng. SUNY Buffalo.
6. 08/2011–02/2013, Kristy Lindner, Biomedical Eng. SUNY Buffalo.
7. 07/2011–08/2011, Changho Lee, Electrical Eng. Kyungpook National Univ.
8. 07/2011–08/2011, Sangyup Han, Electrical Eng. Kyungpook National Univ.
9. 07/2011–08/2011, Sungjo Park, Electrical Eng. Kyungpook National Univ.
10. 07/2011–08/2011, Jasung Ku, Biomedical Eng. Pukyung National Univ.
11. 07/2012–08/2012, James Billingham, Williamsville north high school.

**CURRENT**
None.

## COMMITTEES OF DOCTORAL STUDENTS

1. 08/2013, Changho Lee, Electrical Eng. Kyungpook National Univ.
2. 02/2014, Je Yup, Mechanical Eng. POSTECH.
3. 06/2014, Min-Young Lee, Material Sci. and Eng. POSTECH.
4. 02/2015, Sungjo Park, Electrical Eng. Kyungpook National Univ.
5. 02/2016, Hee Jung Kim, Biomedical Eng. Seoul National Univ.

## COMMITTEES OF MASTER'S STUDENTS

None.

# Effect of chlorin e6-based photodynamic therapy with halogen light against *P. acnes*-induced inflammatory response

Mi-Young Lee

Department of Medical Biotechnology, Soonchunhyang University, Asan, Chungnam, Korea

The therapeutic potential of chlorin e6-based photodynamic therapy (PDT) using halogen light against *P. acnes*–triggered inflammation was examined in this study. A second generation photosensitizer of chlorin e6 (Ce6) was synthesized from *Spirulina* chlorophyll, and the antibacterial, anti-inflammatory, and collagen biosynthesis-promoting activity in the presence of halogen light were evaluated. Chlorin e6-based PDT showed superior antibacterial activity against various microbes including *P. acnes.* The anti-inflammatory effect of Ce6-mediated PDT was also measured *in vitro* in *P. acnes*-stimulated HaCaT cells and *in vivo* in *P. acnes*-injected mice. Moreover, Ce6-based PDT with halogen light up-regulated collagen biosynthesis, but down-regulated MMPs expression in *P. acnes*-infected HaCaT cells. Our results suggest for the first time the feasibility of Ce6-based PDT as a superior treatment against skin disorder by pathogenic infection.

This study was supported by a grant of the Korean Health Technology R&D Project, Ministry of Health & Welfare, Republic of Korea. (Grant No. HN12C0059).

**성명:** 이미영

**소속:** 순천향대학교 의료생명공학과 교수

**학력 및 경력:**

연세대학교 생화학과 (학사)

연세대학교 생화학과 (석사)

연세대학교 생화학과 (박사)

Wisconsin –Madison 대학교 (방문연구원)

Univ. of Michigan (방문교수)

# Enhanced production of ROS in carboplatine-assisted PDT

전재근, 최윤식, 김종기
대구가톨릭대학교 의과대학 생체의료공학과

(초록)

목적 : 최근 low-dose carboplatine 병용 광 역학치료(CCPDT)의 효능증강 현상이 임상적으로 관찰되어 분자적 기작을 규명하기 위해 백금이 포함된 Carboplatin과 광민감제-photofrin를 사용하여 단일 광 역학치료 대비 활성산소류 증감 비교 연구를 수행 하였다.

방법 : 자궁경부암세포주에 광민감제를 농도(20μM)로 투여하고 3시간 동안 배양한 다음 Carboplatin(1mM)과 ROS 측정 probe-Hydrocyanine(10μM)와 함께 3시간 동안 동일 조건에서 배양 후 PDT laser 50mW로 2.5, 5J 조사하였다 형광측정장비(plate reader)를 이용하여 Excitation : 635nm, Emisstion : 670nm에서 대조군과 실험군에서 ROS형광을 검출 비교 분석하였다.

결과 : Carboplatin투여 PDT 시험군에서 단일 광역학치료 대비 약 29.6% 정도 높게 측정되었으며, 조사선량에 따라 ROS 측정 값이 대조군에 비해 약 38.5%만큼 높게 측정되었다. 이 결과 대조군대비 CP+PDT 시험군이 활성산소 증가율에 따른 ROS 측정값이 높아 자궁경부암세포 사멸이 증강될 수 있음이 관찰되었다.

# Photosensitizer-conjugated EGFR (epidermal growth factor receptor) targeting peptides for activatable fluorescence imaging and photodynamic therapy of EGFR-overexpressing cancers

Jisu Kim and Yongdoo Choi*

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Photodynamic therapy (PDT) has been successfully used to treat cancers and other malignant conditions in clinics. Even though targeted PDT agents have been developed to enhance target selectivity in imaging and therapy, the fundamental disadvantage of "always on" type of targeted PDT agents is that they emit fluorescence signals regardless of their proximity or interaction with target cells, and unwanted phototoxicity in normal tissues is still possible. Therefore, development of targeted PDT agents with activatable optical properties is highly challenging.

Here, we showed that small-sized activatable PDT agents could be developed by conjugating PDT agents Chlorin e4 (Ce4) with EGFR-targeting peptide *via* disulfide linkers (i.e. L-EGFR). EGFR overexpression is frequently found in a variety of human cancers, and considered as an important target for receptor-mediated delivery system of drugs. We hypothesized that L-EGFR conjugates are nonfluorescent and nonphototoxic in its native state, but becomes highly fluorescent and phototoxic after internalizion into EGFR-positive cancer cells *via* receptor-mediated endocytosis and subsequent cleavage of the disulfide bonds by intracelluar reducing agents. As expected, both fluorescence and singlet oxygen generation (SOG) of L-EGFR were turned off. When L-EGFR were treated with 5 mM reducing agent, fluorescence and SOG were almost recovered to the level of free Ce4.

Next, the utility of L-EGFR in activatable near-infrared (NIR) fluorescence imaging of EGFR-postive cancer cells was tested. As expected, NIR fluorescence of L-EGFR was quenched in the extracellular region but becomes highly fluorescent inside EGFR-overexpressing cells with time. And target-cell-specific PDT of the L-EGFR was evaluated. Good PDT effect was obtained in EGFR-overexpressing cells depending on their EGFR-expression levels. From the *in vivo* studies, tumor sites of L-EGFR-treated mice showed greater fluorescence intensities than buffer- and free photosensitizer- treated mice. This activatable agent with dual target-specificity showed potential utility in NIR fluorescence imaging with a high tumor-to-background ratio and photodynamic therapy of target cells.

# Indocyanine Green-Loaded Hollow Mesoporous Silica Nanoparticles as a Novel Theranostic Agent

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## Extended Abstract

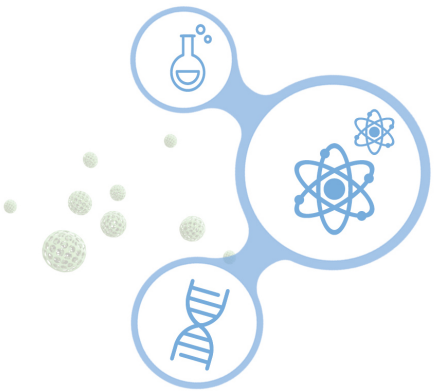
Indocyanine green (ICG) is a FDA-approved near-infrared (NIR) fluorophore that is widely used in *in vivo* NIR fluorescence imaging and potentially photodynamic therapy (PDT) of cancers [1]. However, as a simple molecular PDT agent, it has the potential problem of high background fluorescence when circulating in the blood stream, which can result in a low target-to-background ratio (TBR) in *in vivo* imaging. In addition, non-specific uptake by normal cells and tissues of ICG further reduced TBR. Due to these reasons, its applications for fluorescence imaging as well as PDT of cancers have been limited.

Here we developed ICG-loaded hollow mesoporous silica nanoparticles (HMSNP) for selective NIR fluorescence imaging and phototherapy of cancers. We hypothesized that NIR fluorescence and phototoxicity are self-quenched in the extracellular regions but becomes highly fluorescent and phototoxic inside cancer cells, thereby enabling selective fluorescence imaging and therapy of cancers. The size of the prepared nanoparticles was about 160 nm in diameter, and ICG was loaded onto HMSNP at 12 w/w%. Comparison of the UV-Vis absorption spectra of ICG-loaded HMSNP and free ICG in aqueous solution confirmed aggregation of the loaded ICGs inside the nanoparticles. As expected, both NIR fluorescence and singlet oxygen generation of ICG-loaded HMSNP were significantly inhibited in comparison with free ICG. In the *in vitro* cell study, strong fluorescence was observed in the cancer cells treated with ICG-loaded HMSNP indicating activation of its fluorescence inside cancer cells. Upon light irradiation, ICG-loaded HMSNP showed significantly higher cytotoxicity than that of free ICG molecules. These features make HMSNP a promising "off-on" platform for utilizing ICG in theranostics.

## References

[1] Y.-G. Wang et al., "Indocyanine green-loaded perfluorocarbon nanoemulsions for bimodal $^{19}$F-magnetic resonance/nearinfrared fluorescence imaging and subsequent phototherapy," *Quant. Imaging Med. Surg.*, vol. 3, no. 3, pp. 132-140, 2013.

# MEMO



# MEMO