林岛诺贝尔奖获得者大会申请书

主题	物理学		
林岛会议时间	2019.6.30-7.5		
学术访问时间	具体时间另行通知		
举办地点	德国林岛和德国学术参访城市		
申请人姓名		性别	
出生日期		出生地	
学校/单位			
联系方式： 地址/邮编 联系电话 E-Mail			
研究领域			
外语水平			
预计毕业时间			

1. 个人陈述（采用宋体字五号，单倍行距）

a. 研究领域：请简单描述你的论文题目、研究计划、正在进行的工作和目前取得的结果。

b. 决定攻读博士以及选择现在的研究方向的影响因素。

c. 国际交流经验：你是否在国际交流中介绍过你的研究工作。比如是否和来自国外的研究学者一起工作过？是否在国际会议中作过学术报告或者是否拜访过国外实验室？

d. 你的职业发展规划是什么？

申明

我们用签名确认，我们推荐我校该生申请今年林岛项目。

申请者签名

研究生培养机构签名/公章

附件：

1、 由本单位导师或学术委员会提供的推荐信（须研究生院或学术委员会盖章）；

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4、 已发表文章首页（含摘要页）；

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国家纳米科学中心

推荐信

本人很高兴推荐刘晶同学申请参加本次诺贝尔奖获得者大会。

刘晶的博士研究课题主要集中在多模态成像指导的无机纳米材料抗肿瘤作用。在完成课题期间，刘晶同学关注前沿科学问题，展现出了优秀的实验技能和独立思考能力，已经在 Adv. Mater., ACS Nano, Biomaterials, Small 等国际学术期刊发表论文 13 篇。多次参加国内及国际会议并做口头报告获奖。除此之外，刘晶同学乐于助人，具有团队合作精神，积极组织参加多项活动，担任各项学生会职务，具有良好的组织和沟通能力。

该生综合能力突出，对科研有浓厚兴趣，具有科研的素质与能力，有相当好的科研潜质，故推荐参会，望审核通过。

推荐人：赵宇亮

2016年10月8日

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2008.09 - 2012.07 学士 陕西师范大学 生物学基地班（保送读研）

获奖情况：

2008 优秀学生党员

2008 **陕西师范大学“三好学生”**

2008 陕西师范大学“校运会优秀负责人”

2008 理科部首届心飞扬曲艺大赛“最佳音色奖”

2009 **陕西师范大学“二等优秀奖学金”**

2009 **陕西师范大学“三好学生”**

2009 陕西师范大学摄影大赛优秀奖

2009 陕西师范大学“优秀团干部”

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2012 **中国科学院大学生奖学金**

2012 **中国科学院大学“三好学生”**

2013 **中国科学院大学“三好学生”**

2013 纳米好声音季军

2013、2014 **国家纳米科学中心二等主任奖学金**

2014 **中国科学院大学“三好学生”**

2014 **国际博士生学术论坛 “十佳墙报奖”**

2015 **国家纳米科学中心“主任特等奖学金”**

2015**Chinese Nanomedicine 国际会“Best Poster Award”**

2015 **环太平洋国际化学年会 “Oral Presentation Award”**

2016 **“国家奖学金”**

科研经历：

2012-至今 中国科学院大学 国家纳米科学中心 纳米生物效应与安全性重点实验室

多模态成像指导的无机金属纳米材料抗肿瘤作用：

主要针对目前肿瘤治疗失败可能存在的问题（药物低效，副作用大，限制用药剂量；不能及时发现和治疗；治疗过程不能实时监测），从化疗和热疗两个方面尝试解决。

（1）设计合成高效低毒新型配位聚合物 Fe_3O_4@Salphen-In^{III}，可被肿瘤细胞大量摄取，是正常细胞摄取量三倍以上。在细胞内酸性环境下由无活性的前药水解后重新形成具有抗肿瘤活性的 Fe-Salphen 络合物，选择性杀伤肿瘤细胞，从而达到高效低毒的目的。这个过程伴随着溶酶体 pH 的改变以及溶酶体膜结构完整性的破坏，并且是通过线粒体介导的细胞凋亡途径来实现的。

（2）设计合成多种功能化模块结合的 Fe_3O_4@Carbon@Gd^{III}-Cy/PEG-FA 纳米复合物。其中氧化铁和钆可用作核磁成像，近红外染料 Cy 可用作荧光成像，同时由于其近红外吸收可以做光声成像。从而达到多模态成像的目的。

（3）鉴于纳米复合材料复杂的合成过程，我们设计合成了 Bi_2S_3 纳米棒，从而用一种简单的纳米材料来代替多种功能化模块结合的复杂过程，但同时可以达到多模态成像指导的肿瘤热疗作用。选择 Bi 用作 CT 成像是由于，CT 成像是临床上一种非常有用的检测方式，不仅高分辨，没有组织深度限制，同时可以进行 3D 重构，这非常有利于疾病的诊断。Bi 由于较高的 X 射线吸收，因此比目前临床使用的 CT 造影剂碘比醇具有更强的 CT 成像优势。我们利用 Bi_2S_3 纳米棒清楚地看到了小鼠几处重要的血管以及肿瘤部位的血管，同时光声成像也显示了其在肿瘤部位一个先富集再代谢的过程。体内体外的光热治疗实验也显示，Bi_2S_3 纳米棒本身几乎没有毒性，但在激光照射下可以高效杀伤肿瘤细胞。从而达到了高效低毒，多模

态成像指导的肿瘤热疗作用。

(4) 至此，我们面临的问题即大多数无机材料面临的问题：无机纳米药物易在体内脏器积累，带来长期毒性和免疫反应的风险。因此我们设计合成了 Cu_3BiS_3 纳米点。铜的掺杂使吸收移至近红外二区，更有利于光热治疗。重要的是，在不影响其 CT 和光声成像性质的前提下，Cu_3BiS_3 纳米点由于其较小的尺寸以及在细胞内酸性环境下易降解的性质，可以在 24h 内通过尿液及粪便排出体外。从而解决了脏器积累的问题。

(5) 有趣的是，我们发现，激光不仅可以进行光热治疗，同时还可以促进纳米药物从肿瘤边缘向内部渗透。这也解决了纳米药物由于肿瘤内部高压而很难在肿瘤部位滞留和渗透的问题。我们首次用多种成像方式（CT，核磁，光声和 X 射线荧光）定性及定量地证明了 $Au@SiO_2(Gd)@Dox@HA$ 在肿瘤部位的渗透。

参加学术会议：

2012 年第六届纳米毒理学国际大会	北京	注册参会
2013 年中国毒理学会	广州	墙报展示
2013 年中国国际纳米大会	北京	注册参会
2013 年全国高能加速器战略研讨会暨用户年会	上海	墙报展示
2014 年第 29 届中国化学年会	北京	注册参会
2015 年纳米药物及纳米生物技术国际学术大会	杭州	墙报展示
2015 年环太平洋国际化学年会	夏威夷	口头报告
2016 年中国医学表观遗传学大会	北京	注册参会

项目经历：

2009-2010 陕西师范大学理科部外联部部长、生物基地班团支书 主要负责活动外联赞助

2010-2011 陕西师范大学生命科学学院学生会副主席 主要负责学院各项活动的组织策划等

2011 四川若尔盖湿地、包座自然保护区和九寨沟国家级自然保护区全国生物学野外实习

2011 秦岭生物学野外实习

2011 清华大学、中科大暑期夏令营 参观清华、中科大各个实验室及学校各项拓展活动

2012-2013 日本光子工厂（KEK-PF/AR）、上海光源

负责本课题组同步辐射相关的国际、国内研究课题，多次赴日本、上海交流、实验

2012-2013 材料学院 1206 文艺委员 组织策划学院及中心迎新晚会，表演节目并担任主持

2012-2013 中国科学院大学材料与光电技术学院学生会主席 学院各项活动的组织策划

2012-2013 国科大组织部、文艺部 组织策划并主持“舌战群雄”辩论大赛、“歌行科院”第四届校园歌手大赛、中国科学院中关村园区主席联席会

2012-2013 中国科学院大学学生会主席助理 组织策划系列活动并参与学生会日常事务

2012-2013 国科大“跨学科课程兼修计划”，取得"项目管理与工程经济"国家 D 级证书

2011、2015 西安世界园艺博览会志愿者 中国科学院第十一届公众科学日科普志愿者

2013-至今 国家纳米科学中心研究生部助理 协助研究生部老师协调处理中心工作

基本技能：

- 毒理学分析、细胞生物学、分子生物学、动物实验、成像技术、同步辐射相关技术
- 激光共聚焦显微镜（CLSM）、X 射线 CT、核磁成像（MRI）、光声成像（MSOT）、X 射线荧光(XRF)、 X 射线吸收(XAFS)、软 X 射线成像(STXM)、电感耦合等离子体质谱等
- 英语水平 CET-6　　计算机水平　二级　　熟练使用 office 等办公软件
- 钢琴、竖笛、驾驶执照

兴趣爱好：

音乐、游泳、油画、旅行

已发表文章列表：

1. Jing Wang, **Jing Liu (共同一作)**, Ying Liu, Liming Wang, Mingjing Cao, Yinglu Ji, Xiaochun Wu, Yingying Xu, Bing Bai, Qing Miao, Chunying Chen, and Yuliang Zhao*. Gd-Hybridized Plasmonic Au-Nanocomposites Enhanced Tumor-Interior Drug Permeability in Multimodal Imaging-Guided Therapy. ***Adv. Mater.,*** 2016, DOI: 10.1002/adma.201603114. **(封底文章)** **影响因子:18.96**
2. **Jing Liu**, Pengyang Wang, Xiao Zhang, Liming Wang*, Dongliang Wang, Zhanjun Gu, Jinglong Tang, Mengyu Guo, Mingjing Cao, Huige Zhou, Ying Liu*, and Chunying Chen*. Rapid Degradation and High Renal Clearance of Cu_3BiS_3 Nanodots for Efficient Cancer Diagnosis and Photothermal Therapy in Vivo. ***ACS Nano,*** 2016, 10, 4587-4598. **影响因子:13.33**
3. **Jing Liu**, Xiaopeng Zheng (co-first author), Liang Yan, Liangjun Zhou, Gan Tian, Wenyan Yin, Liming Wang, Ying Liu, Zhongbo Hu, Zhanjun Gu*, Chunying Chen*, and Yuliang Zhao*. Bismuth Sulfide Nanorods as a Precision Nanomedicine for in Vivo Multimodal Imaging-Guided Photothermal Therapy of Tumor. ***ACS Nano,*** 2015, 9, 696-707. **(highly cited paper) 影响因子:13.33**
4. Qiao An, **Jing Liu (共同一作),** Meng Yu, Jiaxun Wan, Dian Li, Changchun Wang, Chunying Chen*, and Jia Guo*. Multifunctional Magnetic Gd^{3+}-Based Coordination Polymer Nanoparticles: Combination of Magnetic Resonance and Multispectral Optoacoustic Detections for Tumor-Targeted Imaging in vivo. ***Small,*** 2015, 11, 5675-5686. **影响因子:8.315**
5. Shuai Xu, **Jing Liu (共同一作)**, Dian Li, Liming Wang, Jia Guo*, Changchun Wang, Chunying Chen*. Fe-salphen complexes from intracellular pH-triggered degradation of Fe_3O_4@Salphen-In^{III} CPPs for selectively killing cancer cells. ***Biomaterials,*** 2014, 35, 1676-1685. **影响因子:8.387**

申请专利:

1. 陈春英，**刘晶**，王静。一种金钆复合纳米材料、制备方法及其用途，201511031874.4，2015-12-31.
2. 陈春英，**刘晶**，谷占军，张潇。一种 Cu_3BiS_3 纳米药物及其制备方法和应用，201610173299.X，2016-03-24.

本人身份证扫描件（正反面）

影响因子:18.96

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COMMUNICATION

Gd-Hybridized Plasmonic Au-Nanocomposites Enhanced Tumor-Interior Drug Permeability in Multimodal Imaging-Guided Therapy

*Jing Wang, Jing Liu, Ying Liu, Liming Wang, Mingjing Cao, Yinglu Ji, Xiaochun Wu, Yingying Xu, Bing Bai, Qing Miao, Chunying Chen, and Yuliang Zhao**

Nanotechnology-based tumor imaging has rapidly developed in recent years, in particular, the multimodal imaging-guided chemotherapy.[1] However, anticancer drugs are often insufficient to cause tumor regression and eradication due to the lack of specificity towards the tumor lesion, limited transportation across the vascular barrier (physiological barrier), and poor penetration through the dense extracellular matrix (pathological barrier), which also leads to the severe toxic effects of anticancer drugs on healthy tissues.[2] The application of nanotechnology for drug delivery offers potential solutions for current challenges in cancer therapy.[3] To enhance the accumulation in the tumor, large numbers of nanomedicines have been designed and applied by virtue of their tunable physicochemical properties, including their size, shape, surface charge, hydrophilicity, and targeting moiety.[4] However, the in vivo performances of many tailor-designed nanomedicines are not as good as initially envisioned because of the shielding by protein corona, and tumor heterogeneity between different patients and different tumor models.[4,5]

Recently, some stimuli-responsive nanomedicines combined with external stimuli such as light, ultrasound, and magnetic field have proven to be effective in tumor-specific delivery.[6] Locally applied external stimuli can flexibly and efficiently enhance site-specific accumulation because the area, timing, and intensity of the stimuli can be easily and precisely manipulated. We have previously developed a thermo-responsive polymer-encapsulated gold nanorod (AuNR) for near-infrared (NIR) laser-induced targeted cancer therapy.[6a] NIR laser irradiation at the tumor site significantly improved their accumulation in the tumor (gold element content 7.6 times higher than the unirradiated group), providing a prerequisite for efficient cancer treatment. Recently, Ferrari and co-workers reported an interesting work. They pre-delivered AuNRs from blood vessels to the tumor via the enhanced permeability and retention (EPR) effect, and subsequently injected a macromolecule or liposome into mice. Then they irradiated the tumor to generate a mild thermal to enhance the trans-vascular transport of the macromolecule and liposome in a two-step manner.[7]

Multifunctional nanomedicines with combined diagnostic and therapeutic functions have evolved as a new paradigm in cancer therapy.[8] An ideal theranostic platform should provide optimized therapeutic efficacy together with a reliable assessment of the details of tumor characteristics. As the single-modality imaging technique offers inadequate diagnostic information, the development of multimodal imaging techniques has drawn significant attention.[9] Owing to their remarkable physicochemical properties, some inorganic nanoparticles, especially gold nanoparticles, have drawn considerable attention for multimodal imaging-guided therapy.[10] Gold nanoparticles hold great potential in X-ray computed tomography (CT) since elemental gold provides almost three times greater X-ray attenuation per unit weight than that of commercial iodine.[11] Some gold nanoparticles such as AuNR with high NIR absorption and photothermal conversion ability can serve as photoacoustic (PA) imaging probes for real-time guidance to monitor therapeutic response.[12] In addition, the ease of the surface functionalization makes the gold nanoparticle an attractive platform for the development of multimodal imaging contrast agents. Kircher et al. employed gadolinium (Gd) and Raman molecular functionalized gold nanoparticles for triple-modality imaging, which accurately delineated the margins of brain tumors in living mice both pre- and intra-operatively.[9] Zeng et al. fabricated a magnetic resonance imaging (MRI)/CT dual-modal imaging probe by functionalization of the outer surface of AuNR with Gd-based macromolecular complexes.[13] The simultaneous use of CT and MRI takes full advantage of each imaging technique with both excellent bone detail information and clear soft tissue structure. However, the existing methods for the modification of gold nanoparticles with Gd species suffer from shortcomings such as low Gd loading capacity, easy leakage of Gd ions to cause undesired toxicity, and the difficulties of further drug loading or surface functionalization.[9,13–15]

Here, we designed a Gd-hybridized plasmonic Au-nanocomposite which is based on mesoporous silica-coated AuNR with loading citrate-Gd complexes for tracing. Anticancer drug Doxorubicin (Dox) was loaded onto the nanocomposite to examine the therapeutic outcome. Upon NIR laser irradiation, localized

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ARTICLE

Rapid Degradation and High Renal Clearance of Cu_3BiS_3 Nanodots for Efficient Cancer Diagnosis and Photothermal Therapy *in Vivo*

Jing Liu,[†] Pengyang Wang,[†,‡] Xiao Zhang,[†] Liming Wang,[*,†] Dongliang Wang,[†] Zhanjun Gu,[†] Jinglong Tang,[†] Mengyu Guo,[†] Mingjing Cao,[†] Huige Zhou,[†] Ying Liu,[*,†] and Chunying Chen[*,†]

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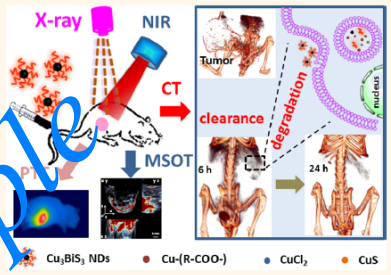
Supporting Information

ABSTRACT: A key challenge for the use of inorganic nanomedicines in clinical applications is their long-term accumulation in internal organs, which raises the common concern of the risk of adverse effects and inflammatory responses. It is thus necessary to rationally design inorganic nanomaterials with proper accumulation and clearance mechanism *in vivo*. Herein, we prepared ultrasmall Cu_3BiS_3 nanodots (NDs) as a single-phased ternary bimetal sulfide for photothermal cancer therapy guided by multispectral optoacoustic tomography (MSOT) and X-ray computed tomography (CT) due to bismuth's excellent X-ray attenuation coefficient. We then monitored and investigated their absorption, distribution, metabolism, and excretion. We also used CT imaging to demonstrate that Cu_3BiS_3 NDs can be quickly removed through renal clearance, which may be related to their small size, rapid chemical transformation, and degradation in an acidic lysosomal environment as characterized by synchrotron radiation-based X-ray absorption near-edge structure spectroscopy. These results reveal that Cu_3BiS_3 NDs act as a safe but powerful "theranostic" nanoplatform for MSOT/CT imaging-guided tumor ablation with excellent metabolism and rapid clearance that will improve safety for clinical applications in the future.



KEYWORDS: *Cu_3BiS_3 nanodots, multispectral optoacoustic tomography, X-ray computed tomography, photothermal therapy, clearance, degradation, chemical transformation*

Nanotechnology is a rapidly expanding field, and many nanoparticles are being tested as candidates for multifunctional, molecular, and physically targeted contrast agents for clinical diagnosis and therapy.[1−3] Materials at the nanometer scale have very different physical and biochemical properties that make nanomaterials attractive in diagnostics and therapy.[4] This approach, referred to as "theranostics", holds great promise for cancer diagnosis and therapy, and theranostic nanomedicine is an important direction in which nanotechnology is progressing at this time.[1,5,6] Even more attractive is combining different modalities (targeting, imaging, and therapy) in one particle to make multifunctional platforms that can both detect and treat tumors.[7,8] Such complex nanosystems are the basis of intelligent detection−killing platforms. Recently, many such nanoparticles have been applied in active fields of research such as drug delivery,[2,9] cancer diagnostics,[10−12] and therapeutics.[13−15] However, a most worrisome problem has been safety. Most nanoparticles can accumulate in the vital organs, leading to acute toxicity, a long-term inflammatory response, or even fibrosis and cancer. Therefore, a general but elusive goal to strive for is to ensure the safety of multifunctional theranostic contrast agents.

In addition to safety, these agents must be effective. For effective phototherapy, nanoparticle platforms must absorb in an appropriate therapeutic window of laser irradiation. As the tissue is mostly transparent to near-infrared (NIR) (700−1400 nm) light, especially the second NIR window (1000−1400 nm), NIR absorption by the contrast agent results in deeper penetration and eliminates the absorption of laser light by the

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Bismuth Sulfide Nanorods as a Precision Nanomedicine for *in Vivo* Multimodal Imaging-Guided Photothermal Therapy of Tumor

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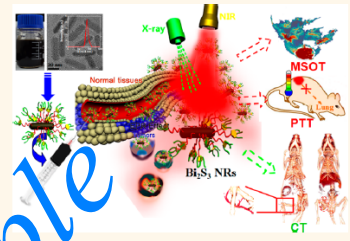
ABSTRACT Here, we present a precision cancer nanomedicine based on Bi_2S_3 nanorods (NRs) designed specifically for multispectral optoacoustic tomography (MSOT)/X-ray computed tomography (CT)-guided photothermal therapy (PTT). The as-prepared Bi_2S_3 NRs possess ideal photothermal effect and contrast enhancement in MSOT/CT bimodal imaging. These features make them simultaneously act as "satellite" and "precision targeted weapon" for the visual guide to destruction of tumors *in vivo*, realizing effective tumor destruction and metastasis inhibition after intravenous injection. In addition, toxicity screening confirms that Bi_2S_3 NRs have well biocompatibility. This triple-modality-nanoparticle approach enables simultaneously precise cancer therapy and therapeutic monitoring.



KEYWORDS: Bi_2S_3 nanorods · thin bandgap semiconductor · multispectral optoacoustic tomography · X-ray computed tomography · photothermal therapy

Nanomedicines offer unprecedented opportunities to reach the objectives such as promoting the precision treatment of cancer and mitigating undesired side effects.[1,2] Over the past decade, precision nanomedicines have been extensively explored to fabricate theranostics that integrate multiple imaging approaches and therapeutic modalities.[3−13] Among these investigations, imaging-guided photothermal therapy (PTT) has drawn considerable attention. PTT employs an efficient light harvesting agent for the localized conversion of the tissue-transparent near-infrared (NIR, λ = 700−1100 nm) light into heat to ablate cancer cells.[14−20] Multimodality imaging provides PTT with real-time guidance to diagnose disease, guide procedures, monitor therapeutic response, and treat disease with greater specificity and sensitivity.[21−32] By distinguishing from the assorted imaging approaches, X-ray computed tomography (CT) is a mainstay of clinical diagnostic modality with the advantages of high resolution, no depth limitation, and allowing for three-dimensional (3D) reconstruction.[33−35] However, pharmacokinetic limitations of clinically available CT contrast agents (small iodinated molecules), including short circulation half-lives and nonspecific distribution, are the main causes of CT failure for tumor target imaging and angiography.[36,37] Moreover, various intrinsic limitations of CT imaging particularly with respect to poor soft tissue contrast, low throughput capacity, limited accessibility, and ionizing radiation also represent as notable hurdles that prevent the application of CT for clinical diagnosis.[38] Thus, combining CT with another imaging technique that can fully take the advantages of each while avoiding the drawbacks of both is more preferable for the precision diagnosis since no single modality is perfect and sufficient to obtain all the necessary information.[39] From this point, multispectral optoacoustic tomography (MSOT)

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Coordination Polymers

Multifunctional Magnetic Gd^{3+}-Based Coordination Polymer Nanoparticles: Combination of Magnetic Resonance and Multispectral Optoacoustic Detections for Tumor-Targeted Imaging in vivo

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To overcome traditional barriers in optical imaging and microscopy, optoacoustic-imaging has been changed to combine the accuracy of spectroscopy with the depth resolution of ultrasound, achieving a novel modality with powerful in vivo imaging. However, magnetic resonance imaging provides better spatial and anatomical resolution. Thus, a single hybrid nanoprobe that allows for simultaneous multimodal imaging is significant not only for cutting edge research in imaging science, but also for accurate clinical diagnosis. A core-shell-structured coordination polymer composite microsphere has been designed for in vivo multimodality imaging. It consists of a Fe_3O_4 nanocluster core, a carbon sandwiched layer, and a carbocyanine-Gd^{III} (Cy-Gd^{III}) coordination polymer outer shell (Fe_3O_4@C@Cy-Gd^{III}). Folic acid-conjugated poly(ethylene glycol) chains are embedded within the coordination polymer shell to achieve extended circulation and targeted delivery of probe particles in vivo. Control of Fe_3O_4 core grain sizes results in optimal r_2 relaxivity (224.5×10^{-3} M^{-1} s^{-1}) for T_2-weighted magnetic resonance imaging. Cy-Gd^{III} coordination polymers are also regulated to obtain a maximum 25.1% of Cy ligands and 5.2% of Gd^{III} ions for near-infrared fluorescence and T_1-weighted magnetic resonance imaging, respectively. The results demonstrate their impressive abilities for targeted, multimodal, and reliable imaging.

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1. Introduction

As an emerging hybrid optical and ultrasound diagnostic modality, multispectral optoacoustic tomography (MSOT) has attracted increasing attention over recent years. This technology shows potential for noninvasive imaging modality tissue illumination with light pulses at multiple wavelengths, and detects acoustic waves arising from thermoelastic expansion in the environment of absorbing molecules. Detected acoustic signals can be transferred to the optical absorption distribution in tissue, with spatial resolution, deep penetration, and high soft tissue contrast. Compared with traditional optical imaging that is typically limited by photon scattering and results in image blurring, MSOT overcomes various long-standing limitations, and can acquire a high spatial resolution, optical contrast and real-time imaging in deep tissue

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Fe–salphen complexes from intracellular pH-triggered degradation of Fe_3O_4@Salphen-In^{III} CPPs for selectively killing cancer cells

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ABSTRACT

We propose a modular synthetic strategy to constitute metallosalphen prodrugs in the form of coordination polymer nanoparticles, comprising magnetite nanocrystal colloidal cluster as core and salphen-In^{III} coordination polymer as shell. These composite nanoparticles are not only equipped with intense photoluminescence, sensitive magnetic responsiveness and pH-dependent degradability, but also serve as prodrugs to accomplish intercellular conversion from non-toxic nanoparticles (Fe_3O_4@Salphen-In^{III}) to pharmacologically active complexes (Fe-salphen), allowing to specifically inhibit the proliferation of A549 cancer cells via caspase activation.

1. Introduction

Medical inorganic chemistry is a thriving area of research [1–7], which was initially fueled by the serendipitous discovery of the cisplatin anti-proliferative activity [8].Tremendous efforts have been dedicated to exploring a variety of metal complexes in pharmaceutical use [1–11]. From the point of view of synthesis, metal complexes offer a versatile platform for design of anticancer agents due to the distinct characteristic of central metal ions, such as multiple coordination numbers, accessible redox states, flexible ligand substitutions, and diverse geometries. Of these members, cisplatin is one of the leading metal-based chemotherapeutics, being pronouncedly potent against a wide spectrum of cancer cell lines while used alone or in combination with other drugs [12]. Significant toxicity side effects and drug resistances, however, have limited its clinical applications [13,14]. There is a need, thereby, for new metallodrugs that are aimed at the lower side effects as well as specificity and efficacy in cancer therapies. Linppard et al. prepared a polymeric nanoparticle to encapsulate the water-soluble Pt(IV) prodrug by double emulsion for the purpose of reduced toxic side effect and controlled release [15]. Metallo-salen/salphen complexes are widely used as catalysts in selective oxidation, organic epoxidation, CO_2 fixation, and so on [16]. More intriguingly, their notable apoptotic and antitumor activities have been specifically investigated in the primary studies, which elucidated that functions of central metal ions (e.g. Mn^{III}, Fe^{II}, and Fe^{III}) and substituents of salen/salphen ligands were both responsible for tumor-selective apoptosis and cytotoxicity toward cisplatin-resistant cancer cells [17–21]. Albeit with the achievements of metallo-salen/salphen complexes, there still exist some major drawbacks, i.e., large dose of administration, poor water solubility, short circulating time and low bioavailability, all of which would elicit pharmacological deficiencies and deleterious effects [22]. To circumvent these issues, rationally designed drug delivery systems rather than new metal complexes should be greatly developed with the aim of enhancing the performance profile of current metallodrugs. Meanwhile, "safe" delivery of metal complexes to their targets also poses one crucial challenge in cancer chemotherapy, owing to their strong coordination interaction with specific biomolecules [23].

Since Mirkin et al. pioneered the study in synthesis of coordination polymer particles (CPPs), CPPs arouse mounting interests in a wide range of fields [24,25]; they promise great potentials for gas

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