分会场九：微纳米马达与微纳米智能机器人

主　席：官建国（武汉理工大学）、贺强（哈尔滨工业大学）

特邀报告 1：Nanotheranostic Opportunities and Challenges

张学记，教授，现任深圳大学副校长，美国医学与生物工程院院士、英国皇家化学学会会士、俄罗斯工程院外籍院士,国家重大研究项目和国家重点研发专项首席科学家，任中组部人才评审巡察小组组长，国防科工局、教育部、科技部评委，中国国家自然科学基金委评委、化学部咨询委员会委员，及任中国生物检测监测产业技术创新战略联盟理事长、北京科技大学生物工程与传感技术北京市重点实验室主任和北京科技大学生物工程与传感技术研究中心主任。曾任世界精密仪器公司高级研究员、首席科学家、高级副总裁和解放军 301 医院临床生化科副主任及特聘教授。在 Chem. Rev.、Nature Comm.、J. Am. Chem. Soc.、Adv. Mater.、ACS Nano 等国际刊物上发表论文 400 多篇；专利 80 多项，分别在 Elsevier、Springer 出版专著 8 部。开发 30 余项产业化技术，在全球 100 多个国家得到广泛应用。现任《American Journal of Biomedical Sciences》主编，《Frontiers in Bioscience》副主编等 21 个国际期刊编委。获 2018 年度高等学校科学研究优秀成果自然科学二等奖和 2018 年度中国分析测试协会科学技术奖（CAIA 奖）一等奖，首都劳动奖章和全国创新争先奖等奖项。

报告摘要：

近年来，纳米材料应用于肿瘤诊疗领域逐渐成为肿瘤研究的热点。纳米材料因其小尺寸效应、表面效应、体积效应和量子效应，在肿瘤诊疗中具有独特的优势。一方面由于高通透-滞留效应，纳米材料能够在肿瘤部位大量聚集从而提高肿瘤的治疗效果，降低毒副作用。另一方面，纳米材料由于其本征的声、电、光、磁、热等理化性质，能够通过功能化实现靶向运输、肿瘤诊断，对简化治疗步骤，优化治疗方案，提高诊疗效率具有重要的意义。因此，将功能化的纳米材料用于肿瘤的诊断治疗受到越来越广泛的关注。

特邀报告 2：仿生粘附界面材料

王树涛，研究员，博士生导师，中科院仿生材料与界面科学重点实验室副主任。主要从事仿生多尺度粘附可控界面材料的研究，提出了分子识别与结构匹配的界面协同识别理念并合成了系列可控粘附界面材料，如抗粘附界面材料、高效粘附、生物特异识别粘附界面和器件以及疾病早期诊断等方面研究。曾获 2013 年中国化学会青年化学奖，2014 年国家基金委杰出青年基金，2014 年国家"万人计划"青年拔尖人才，2016 年科技部领军人才，2016 年教育部长江学者特聘教授，2017 年第三期国家"万人计划"科技创新领军人才，2017 年中国科学院青年科学家奖等。发表 SCI 论文 190 余篇，其中包括 Sci. Adv.，Angew. Chem.，Adv. Mater.，JACS，Chem. Rev.，Chem. Soc. Rev.，Acc. Chem. Res.，Nat. Rev. Mater.，引用 13000 余次，H 因子 59。

报告摘要：

生物界面粘附是界面化学研究中的前沿热点之一，揭示生命的奥秘、对发展新型功能界面材料和技术有着重要指导意义。向自然学习，我们研究了几种生物界面上的特殊粘附现象，并受此启发发展了系列仿生粘附可控界面。1）揭示了鸟类羽毛耐撕裂的性能是源于羽毛上的钩-槽-钩机械级联互锁结构，颠覆了传统认为的简单钩-槽互锁结构；发展了仿蜻蜓干态粘附材料，解决了传统仿苍耳尼龙粘扣已坏、噪音大等问题；发展了仿肾小管内壁的抗矿物粘附界面材料；2）提出结构匹配和分子识别的协同仿免疫界面识别理念，利用化学刻蚀、气相沉积、电化学沉积、模板复形、电纺等技术构筑了系列仿免疫 CTC 捕获芯片；提出界面乳液聚合方法，构筑了系列形状可控（从 Janus 到多孔）与表面化学可控的仿免疫磁珠微球；3）揭示了伤口血痂的微观结构，构筑了系列仿血痂伤口辅料，有效的促进了伤口的愈合。

特邀报告 3：胶体马达群体运动的物理化学机制

贺强，哈尔滨工业大学，2003 年 6 月于中科院化学所获物理化学博士学位。2003 年 7 月起先后任中科院化学所助理研究员、副研究员。2006 年 5 月获德国洪堡基金会资助在德国马普胶体与界面研究所从事博士后研究。2010 年 04 月至今在哈尔滨工业大学微纳米技术研究中心工作。2011 年入选教育部新世纪优秀人才。2012 年入选黑龙江省龙江学者特聘教授。

报告摘要：

自然界中诸如细菌群落生长、昆虫集体合作、鱼类集群趋避等群体行为随处可见，而如何实现人工合成胶体马达的群集与离散受到人们的广泛关注，这是因为胶体马达的集体协作可以完成超越个体能力的复杂任务。通过向自然界学习，我们构筑了一种光催化诱导的花生状胶体马达，可在碰撞中沿径向一维组装成胶体马达带。这些胶体马达带在梯度光场下向着光斑中心移动，表现出正的趋光性（类似"飞蛾扑火"）。它们是通过流体场的相互作用来"感觉"彼此，揭示在一定条件下胶体马达个体层面上的碰撞足以形成有序的动态组装体并实现集体定向运动。同时这些胶体马达的群体行为存在巨数值涨落的典型非平衡体系特征。这种可利用光来人为控制自驱动胶体马达的聚集过程，并实现数百万之众向一个方向运动的研究结果可作为自驱动马达之间集体行为的模型来模拟自然界中生物的群体行为、设计新的活性材料及成群协同运动的纳米机器。

近期代表性研究论文：

[1] H. Xie, M.M. Sun, X.J. Fan, Z.H. Lin, L.X. Dong, Q. He, Science Robotics 2019, 4, eaav8006.

[2] M.J. Xuan, J.S. Shao, C.Y. Gao, W. Wang, L.R. Dai, Q. He, Angew. Chem. Int. Ed. 2018, 57, 12463.

[3] Y.J. Wu, T.Y. Si, C.Y. Gao, M.C. Yang, Q. He, J. Am. Chem. Soc. 2018, 140, 11902.

[4] Z.H. Lin, T.Y. Si, Z.G. Wu, C.Y. Gao, X.K. Lin, Q. He, Angew. Chem. Int. Ed. 2017, 56, 13517.

特邀报告 4：Progress in thermochromic materials

Y. Long, School of Materials Science and Engineering, Nanyang Technological University. Dr. Long studied at Cambridge University, United Kingdom and currently hold senior lecturer position in School of Materials Science in Nanyang Technological University, Singapore. Her research area is to develop different nanostructured functional thin films. She has successfully implemented two technology transfer from lab to industry including the leading hard disk company Seagate in her early career. Her more recent work is developing functional smart coatings. She has published widely in high impactful journals such as Joule, Advanced Functional Materials, ACS Nano, Journal of Materials Chemistry A and Small, etc. and her work has been widely reported in different media and has won TechConnect Innovation Award, Washington in 2015.

报告摘要：

Thermochromic material responds to solar spectrum differently at the stimulus of heat which makes it attractive in the energy saving smart windows application. The most studied inorganic VO2 has the intrinsic problems of low luminous transmission (Tlum) and low solar modulation (ΔTsol the transmission difference between high and low temperatures).1,2 Numerous efforts such as employing dopings, 1,3 nanoparticle-based composites,1,4 and nano-porous structuring 1,5 have been widely studied. Our group have developed five new approaches to tackle this veritable challenge, namely, biomimetic nanostructuring including photonic structure6 and moth eye7 gridded structures8,9 tunable plasmonic structures10,11,12 organic and hybrid structures.13,14 In addition, new active controls has also been applied to thermochromic material to generate a new electro-thermochromics or mechanical-thermochromic materials.15,16,17,18

References

1. Cui, Y.Y; Ke, Y.J.; Liu, C. ;Wang, N. ; Chen, Z. ; Zhang, L.M. ; Zhou, Y.; Wang S.C.; Gao, Y.F ; Y. Long*, (2018) Joule, https://doi.org/10.1016/j.joule.2018.06.018

2. Wang, S.F., M. S. Liu, L. B. Kong, Y. Long, X. C. Jiang and A. B. Yu (2016). Progress in Materials Science 81: 1–54

3. Wang, N., S. Liu, X. T. Zeng, S. Magdassi and Y. Long* (2015). Journal of Materials Chemistry C 3(26): 6771-6777.

4. Li M., S. Magadssi, Yf Gao, and Y. Long*. (2017) Small 10.1002/smll.201701147

5. Cao, X., N. Wang, J. Y. Law, S. C. J. Loo, S. Magdassi and Y. Long* (2014). Langmuir 30(6): 1710-1715.

6. Qian, X. K., N. Wang, Y. F. Li, J. H. Zhang, Z. C. Xu and Y. Long* (2014). Langmuir 30(35), 10766-10771.

7. Ke, Y. J., I. Balin, N. Wang, Q. Lu, A. T. I. Yoong, T. J. White, S. Magdassi, I. Abdulhalim and Y. Long* (2016). ACS Materials and Interface, DOI: 10.1021/acsami.6b12175

8. Liu C., S. Magdassi, D. Mandler, and Y. Y. Long* (2016). Nanoscale, DOI: 10.1039/C6NR06614C (back cover)

9. Lu, Q., C. Liu, N. Wang, S. Magdassi, D. Mandler and Y. Long* (2016). Journal of Materials Chemistry C, DOI: 10.1039/C6TC02694J (back cover)

10. Ke, Y. J, Wen X.L., Zhao D. Y, Che R. C, Xiong Q. H., and Y. Long* (2017). ACS Nano, DOI: 10.1021/acsnano.7b02232.

11. Wang, S.C., Owusu K.A., Mai, L Ke, Y., Zhou, Y., Hu, P, Magdassi, S., Y. Long* (2017) Applied Energy 211, 200-217.

12. KY. Ke, S. Wang, G. Liu, M. Li, T.J. White, Y. Long*, Small 14 (39), 1802025 (inside cover)

13. Zhou, Y., Y. F. Cai, X. Hu; Y. Long* (2014).Journal of Materials Chemistry A 3(3), 1121–1126

14. Zhou, Y., Y. F. Cai, X. Hu; Y. Long* (2015). Journal of Materials Chemistry A 3(3), 1121–1126.

15. Zhou, Y., M. Layani, F. Y. C. Boey, I. Sokolov, S. Magdassi, and Y. Long* (2016). Advanced Materials Technologies, DOI: 10.1002/admt.201600069

16. Zhou, Y., M. Layani, S. Magdassi, and Y. Long* 2018. Advanced Functional Materials 28, 1705365.

17. KY. Ke, C. Zhou, Y. Zhou, S. Wang, S. H. Chan, Y. Long*, Invited review Advanced Functional Materials (2018) DOI: 10.1002/adfm.201800113.

18. Ke, Y. J.; Yin, Y,; Zhang, Q.T.; Tan, Y.T.; Hu, P.; Wang, S.C.; Tang, Y.C.; Zhou, Y.; Wen, X.L.; Wu, S.F.; Yin, J.; Peng, J.Q.; Xiong, Q. H.; Zhao, D. Y.; Y. Long*, Joule, 10.1016/j.joule.2018.12.024

特邀报告 5：Magnetic Swimming Microrobots for Biomedicine

Li Zhang, is currently an Associate Professor in the Department of Mechanical and Automation Engineering at The Chinese University of Hong Kong (CUHK). He received the Ph.D. degree from the University of Basel, Basel, Switzerland, in 2007. And then, he joined the Institute of Robotics and Intelligent Systems, Swiss Federal Institute of Technology (ETH) Zurich, Switzerland as a postdoctoral fellow until 2009, and as a senior scientist from 2009 to 2012. He joined CUHK as an Assistant Professor in 2012.

His main research interests include micro-/nanorobots and their biomedical applications. He won the Hong Kong Research Grants Committee (RGC) Early Career Award in 2013, and CUHK Young Researcher Award 2017. Dr. Zhang is a senior member of IEEE, who has won several awards from IEEE international conferences. Since 2004 he has authored and co-authored over 160 papers, including Science Robotics, Nature Communications, Science Advances, as the corresponding author.

报告摘要：

People have envisioned tiny machines and robots that can explore the human body, find and treat diseases since Richard Feynman’s famous speech, “There's plenty of room at the bottom,” in which the idea of a “swallowable surgeon” was proposed in the 1950s. Even though we are at a state of infancy to achieve this vision, recent intense progress on nanotechnology, MEMS/NEMS technology and micro-/nanorobotics has accelerated the pace toward the goal. A number of research efforts have been recently published regarding the development of tiny swimming machines/robots from the basic principles and fabrication methods to practical applications.

I will present the recent research progress in my lab on using swimming microrobots for early diagnosis and targeted delivery, from the design, magnetic actuation, to perspective of using these small agents for biomedical applications in vitro and in vivo.

特邀报告 6：多维度光操作纳米机器人的设计，制备和挑战

唐晋尧，博士，香港大学化学系，副教授。2003 年本科毕业于中国科技大学，2008 年在美国哥伦比亚大学获得博士学位。随后，在美国加州大学伯克利分校从事 4 年博士后研究，师从杨培东院士。2012 年加入香港大学化学系任助理教授，2018 年获终身教职，担任副教授至今。唐晋尧博士主要从事基于低维纳米材料的纳米光驱动纳米马达，热电传热和热电材料与太阳能材料研究。唐博士在纳米材料的加工制备、工艺开发以及应用开发具有丰富的经验，相关成果发表在 Science、 Nature Nano.、 Nano Letter、Angew.Chem.EdInt、 J.Am.Chem.Soc.等国际一流期刊上，并获得香港杰出青年学者奖，香港大学优秀青年学者等奖项。

报告摘要：

Recently, with the interest of building nanoscale machinery for biomedical application and low-cost nanofabrication, verities of self-propelled synthetic micro/nanoparticles are developed to mimic the functions of motile algae/bacteria. These active particles could harvest energy from the environment and generate the thrust to propel itself through the solution which bears great importance of both fundamental soft matter physics and practical applications such as targeted drug delivery and noninvasive surgery.

Light based operation has been proved as the most versatile tools for micromanipulation, which has been well developed in optical tweezer system. However, the optical tweezers are based on the momentum transfer process from incident photon, which intrinsically need high photo flux due to the low photon mass. In typical optical tweezer experiment MW/cm2 light intensity is needed, while only mW/cm2 is needed for the newly developed light-powered photoelectrochemical propelled microswimmer system. In this system, the light is utilized as the power source as well as the control signal to navigate the semiconductor-based microswimmer. With novel nanostructure design, the artificial microswimmer demonstrated superb controllability as well as programmability.

特邀报告 7：Phototaxis Motion Behavior of Self-propelled Water Droplet Microrobot in Oil Solvent

李隆球，哈尔滨工业大学，机器人技术与系统国家重点实验室教授、博士生导师。国家“万人计划”青年拔尖人才，教育部“青年长江学者”，国家优青年。主要从事微纳机器人技术、微纳器件与系统、超材料与增材制造技术等领域的研究。主持或参与国家级课题 30 多项。获省技术发明一等奖 1 项、省科技进步二等奖 2 项、美国机械工程学会“最佳论文奖”2 项、载人航天学术大会“优秀论文奖”、中国新锐科技人物“卓越影响”奖等。发表 SCI 论文 50 多篇，获授权国家发明专利 40 多项。担任 Research、ASME Transaction Journal of Tribology 等国际权威期刊编委、Associate Editor。美国机械工程学会微纳系统分会、接触力学分会执行委员，中国微米纳米技术学会青年工作委员会委员、微纳执行器与微系统学会理事/秘书长，中国机械工程学会机器人分会委员，中国机械工程学会微纳制造分会委员。

报告摘要：

Controllable self-propelled water droplet microrobot shows great potential applications as carries, sensors and actuators in biological medicine and oil exploration areas. In this paper, a light-driven self-propelled water droplet microrobot is proposed and its phototaxis motion behavior in oil phase solvent is studied. Under the blue laser irradiation, the water droplet microrobot doped with Fe2O3 nanoparticles approaches the direction of light source which is triggered by light induced ion concentration gradient flow. Numerical simulations are performed to investigate the water-oil interface behavior and its motion mechanism. It is found that these light-driven self-propelled water droplet microrobots present schooling behaviors and aggregate at the center of light source.

特邀报告 8：Dynamic Nanomachines for Clean Air, Water and Energy

Alexander A. Solovev, received his Ph.D. from the Institute for Integrative Nanosciences, Leibniz Institute for Solid State and Materials Research, Germany. During past 15 years, he was working in major research institutes worldwide, including the Max Planck Institute, Leibniz Institute, Technical University of Munich, Princeton University and Columbia University. He was a postdoc with Geoffrey Ozin at University of Toronto and David Weitz at Harvard University. Currently, Dr. Solovev holds a full professorship at the department of Materials Science, Fudan University, Shanghai, P. R. China. His group is renowned for innovative and transformative fundamental scientific, technological advances and original contributions to fields of inorganic nanomembranes capable of producing novel quantum, chemical, electrical, optical and mechanical properties in unprecedented ways. His awards include: Emerging Leader from the IopScience Publishing, a “1000 Talent” Award from government of P.R. China, “Dawn program” Award from Shanghai City, Humboldt Feoder Lynen, Max Planck, University of Toronto fellowships, DSM Science and Technology Award from Switzerland, the DAAD Prize and he hold the Guinness Word Record for “the Smallest man-made Jet Engine”. Interests of his research lab include new properties of 3D nanomaterials, nano/-micromachines, theranostics, clean water, clean air and clean energy.

报告摘要：

Miniaturization in the machine design leads to multiple improvements of machine performance including negligible inertia, higher surface to volume ratio, higher strength to weight ratio, volumetric energy density, efficiency, faster relative motion and ultra-precise movements. We made a breakthrough development by making a new generation of catalytic nano/-micromotors consisted of inorganic nanomembranes. This result is a major step forward to a practical powering of tomorrow's micro- and nanomachines and it represent the entry in the Guinness Book of World Records for “the smallest man-made motors.” Today, nano-/micromachines are fascinating new devices, which can transform local chemical energy and/or energy of external field (e.g. light, ultrasound, temperature, magnetic field, electric field) into autonomous movement, pumping of fluids and potentially revolutionary ways to convert energy, perform diagnostics and delivery of biomedical cargo. My presentation will discuss concepts, achievements, challenges and perspectives facing dynamic nanomachines, their technological relevancy and important breakthroughs.

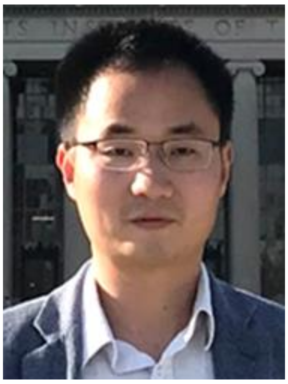
特邀报告 9：FABRICATION AND BIOMEDICAL APPLICATIONS OF MICRO/NANO-MOTORS

马星，博士，哈工大（深圳）材料科学与工程学院教授，主要从事生物智能材料与生物医用微纳米机器的合成及其生物医学等领域的应用研究。已发表 SCI 收录论文 70 余篇（包括 1 篇 Chem. Rev.、3 篇 JACS、3 篇 ACS Nano、1 篇 Angew Chem. Int. Ed.、1 篇 Adv. Funct. Mater.、1 篇 Nano Lett.），论文总引 4000 余次，个人 H 因子为 36。担任 JMST 期刊编辑（JCR 一区）及 Angew Chem. Int. Ed.、ACS Nano 等国际顶级期刊审稿人。2014 年获德国洪堡博士后基金，2016 年获德国马普智能所杰出青年科学家奖（Günter Petzow Prize），2016 年入选国家第十二批青年千人计划。

报告摘要：

Self-propelled micro/nano-motors (MNM) are active matters that can convert energy from their surroundings into kinetic force to propel themselves. MNM have been proven as powerful tools that can accomplish a variety of on-demand tasks at small scales, leading to revolutionary solutions to traditional strategies. MNM for biomedical purpose such active drug delivery system should be biocompatible in terms of fabrication materials, as well as fuel providing the energy to power their self-propulsion. Meanwhile, integration of multiple functions into a single motor is highly demanded. Novel nanomaterials such as mesoporous silica have been proved wide applications in virtue of unique structure and specific functions at small scale. Hereby, by integration between novel nanomaterials, we successfully fabricated a series of MNM capable of self-propulsion by consuming non-toxic fuel or by fuel free propulsion, and realizing multiple functionalities. We also achieved reversible velocity control on the motors by manipulating the enzymatic activity with inhibitors/re-activation molecules. Magnetic guidance was utilized to control the motors' movement direction, towards target locations. In addition to magnetic and enzymatic control, we also utilized external field such as light to propel and control the motion of the MNM by photocatalytic reactions. By combining with surface enhanced Raman spectroscopy, we realized active and intelligent biochemical sensing with self-propelled motors as well, giving new solution to the intelligent Raman analysis.

特邀报告 10：Colloidal Electronic Cells Based on 2D Materials



刘平伟，浙江大学"百人计划"特聘研究员。2014 年博士毕业于浙江大学，2014-2018 年在美国 MIT 化工系从事博士后研究。研究领域涉及聚合物材料、二维材料、纳米复合材料、纳米催化及微纳机器人等方面。近年在 Science、Nature Materials、Nature Nanotechnology 等期刊上发表论文 20 余篇，获中国、国际发明专利授权各 1 件，在层状和卷涡状二维材料/聚合物纳米复合材料、基于二维材料的智能微粒器件和微纳机器人等方向取得了创新成果，相关成果被 MIT News、Angew. Chem. Int. Ed.、Nano Today、Mater. Today 等权威媒体和期刊报道和评述。

报告摘要：

Graphene and other 2D materials possess desirable mechanical and functional properties for incorporation into or onto novel colloidal particles, potentially granting them unique electronic and optical functions. A here-to-fore unexplored property of 2D electronic materials such as graphene, hexagonal boron nitride and MoS2 is the ability to build electronic circuits, transistors, memory and sensors onto or into colloidal particles. Such particles can access local hydrodynamics in fluids to impart mobility and can otherwise enter spaces inaccessible to larger electronic systems. In this talk, I will present our recent work on the fabrication and application 2D materials-based colloidal electronic cells from two aspects: (1)We developed an "autoperforation" technology providing a means of spontaneous assembly for colloidal microparticles comprised of 2D molecular surfaces at scale. Such particles demonstrate remarkable chemical, mechanical and thermal stability. They can function as aerosolizable electronic tattoo capable of storing and transferring digital information, and recoverable microprobes for sensing and recording chemical information in water and soil. (2) We further demonstrated the design and fabrication of fully autonomous state machines built onto a SU-8 particle powered by a p-n heterojunction of MoS2 and WSe2 operating as a photodiode. These colloidal state machines enable new functions, such as the detection and storage of information after aerosolization and hydrodynamic propulsion to targets over 0.6 m away. The systems are texted in a variety of constrained conduit environments and are also shown to enable large area surface detection of triethylamine, ammonia and aerosolized soot in otherwise inaccessible locations. Such two different types of synthetic electronic cells, enabled by 2D nanoelectronics, may find widespread application as probes in confined environments such as the human digestive tract, oil and gas conduits, chemical and biosynthetic reactors, and as autonomous environmental sensors.

特邀报告 11：微纳米马达在血液疾病治疗中的应用研究

毛春，南京师范大学化学与材料科学学院，副院长，教授。目前主要进行血液接触类生物医用材料及器械的制备及应用、微纳米科学与技术、生物传感技术等研究。在 Nature Communications、Angewandte Chemie International Edition、ACS Applied Materials & Interfaces、Macromolecules 等 SCI 期刊上发表论文近八十多篇；获得授权发明专利三项；获得 2009 年度教育部高等学校科学研究优秀成果奖（自然科学）一等奖一项；主持和参与国家自然科学基金项目和省部级科研项目多项，以及千万元产学研项目两项，横向课题两项。

报告摘要：

血液因其对生命的重要性而成为关乎人类健康的重要研究对象，但由于其组分及代谢状况复杂，目前血液相关疾病的治疗仍旧存在缺陷甚至不可逾越的障碍。利用纳米技术进行血液相关疾病的治疗成为重点和前沿。我们课题组长期致力于血液接触类生物医用材料的设计、研制、生物相容性及诊疗效果评价，针对血液相关疾病在治疗过程中存在的技术瓶颈开展了如下工作：针对当前血液重金属离子（如血铅）中毒治疗存在的难点，即现有血铅去除剂的研究大多止步于血浆铅离子的去除，我们通过深入分析铅离子在血液中的存在状态，设计可安全高效去除血液（尤其是红细胞内）铅离子的纳米马达型血铅去除剂，并通过体外生物相容性评价、铅离子去除效果和动物实验证实了该纳米马达型血铅去除剂能够高效、安全地去除血铅，为治疗血铅中毒探索新的解决思路。

同时，我们还将纳米马达技术引入血管修复和肿瘤治疗中，从仿生理念出发，利用人体自身化学反应（一氧化氮合成酶催化 L-精氨酸与活性氧产生一氧化氮（NO）和 L-瓜氨酸）为原理，设计并制备出以 NO 为驱动源的新型纳米马达，并利用其运动过程中释放的 NO 促进内皮细胞生长或杀死肿瘤细胞，以实现血管修复或肿瘤治疗的目的。
用先进的技术和创新的思维去对待传统血液疾病治疗中的困境，是纳米技术推动现代生物医学快速发展的主要原因，我们将为此继续努力探索。

特邀报告 12：Collective Behaviors of Micromotors

牟方志，男，副研究员，博士生导师，武汉理工大学青年拔尖人才（第二层次）。2012 年 6 月毕业于武汉理工大学材料复合新技术国家重点实验室，并获得博士学位。2010-2011 年其间获国家留学基金委的资助赴美国 Washington University in St.Louis 联合培养学习。2012.7 起先后任武汉理工大学材料复合新技术国家重点实验室助理研究员、副研究员。2016 年入选武汉理工大学 15551 人才工程青年拔尖人才（第二层次）。主要从事微纳米马达和仿生微纳米机器人集群的研究，重点关注微纳米马达的驱动原理、相互作用、集群行为等基本科学问题，致力于智能微纳米马达和微纳米机器人及其集群的设计、构建和应用。现已在 Chemical Society Reviews、 Advanced Materials、 Accounts of Chemical Research、ACS Nano、Angewandte Chemie International Edition、Advanced Functional Materials、Small、Nanoscale、ACS Applied Materials & Interfaces 等国际权威学术期刊上发表研究论文 40 余篇。

报告摘要：

Lives ranging from microorganisms, insects, birds, fishes to mammals can interact with one another and exhibit complex collective behaviors.1 Even though individuals have simple behaviors or functions, flocks assembled from many individuals usually exhibit complex population-level behaviors and functions.2 Researches have revealed that, besides the repulsion and alignment rules, the most crucial rule that group members must follow is the attraction rule (global or local attraction) to achieve flocking motions.3 Drawing inspiration from collective behaviors in nature, creating artificial flocks of micro/nanomotors4-8 with navigable collective motions may offer new opportunities to develop reconfigurable robots or programmable matter for cooperative grasping, collective cargo transportation, and microfactories, etc., but it is of great challenge nowadays.9-11

In this presentation, at first, we are to demonstrate the gathering of individual micromootors by setting the attraction rules through external stimuli, including near infrared light, AC electric field and magnetic field, and their light-navigated flocking behaviors by utilizing their phototactic motions. The population-level behaviors, such as flock density, shape, polarity and velocity, can be modulated dynamically by adjusting parameters of external stimuli, and the corresponding mechanisms are uncovered by elucidating the local interactions between the flocking members. Due to the versatility of external stimuli, the strategy developed in this

work has a broad applicability, and can realize the gathering and phototactic flocking of various micromotors or active-passive particle system with different geometrical and material features. Secondly, we will highlight the spontaneous gathering behaviors of isotropic micromotors and their phototactic flocking behaviors in response to the self-secreted chemical signals. The electrolyte and nonelctrolyte diffusiophoresis respectively governs the spontaneous gathering and phototactic flocking of individual micromotors. Thanks to its phototactic flocking behaviors and adaptive pattern transformation, the micromotor flock not only can move along programmed paths, but also bypass local obstacles under light navigation. The results we are about present may have far-reaching implications for the development of intelligent biomimetic micro/nanomotors and their applications in micro/nanomachinery, cargo manipulation, biomedicine and chemical sensing.