上海交通大學
SHANGHAI JIAO TONG UNIVERSITY

Workshop on Dielectric and Energy Materials

Hosted by

School of Chemistry and Chemical Engineering, SJTU

Shanghai Key Lab of Electrical Insulation & Thermal Ageing

January 13~15, 2017 Shanghai, China

The Workshop Chairs

Dr. Xingyi Huang
Shanghai Key Laboratory of Electrical Insulation and Thermal Ageing
Research Center of Dielectrics and Electrical Insulation
Shanghai Jiao Tong University
Shanghai, China 200240

Dr. Xuesong Jiang
Department of Polymer Science and Engineering
Shanghai Key Laboratory of Electrical Insulation and Thermal Ageing
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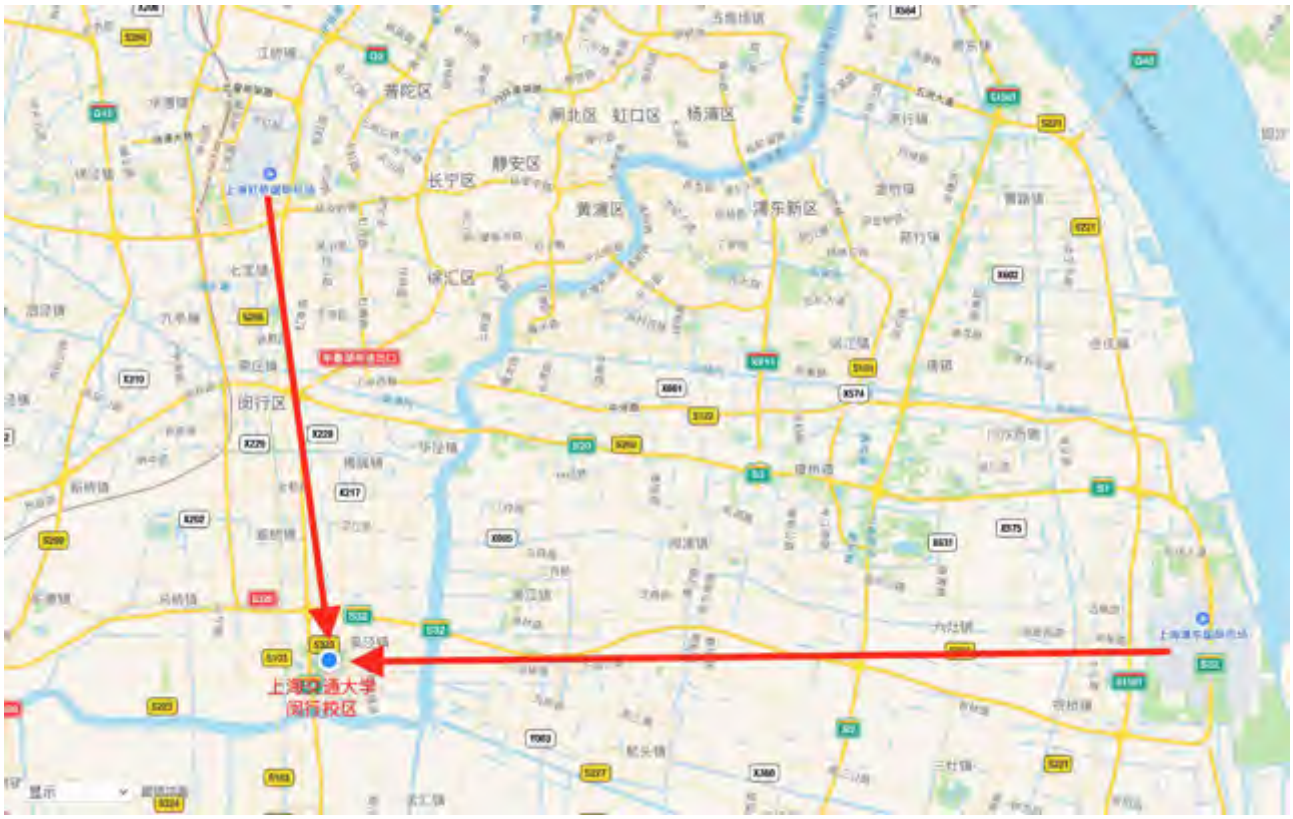
The Workshop Advisory Committee

Professor Pingkai Jiang, Shanghai Jiao Tong University
Professor Yongfeng Zhou, Shanghai Jiao Tong University
Professor Wei Yu, Shanghai Jiao Tong University
Professor Qinghua Lu, Shanghai Jiao Tong University
Professor Xinyuan Zhu, Shanghai Jiao Tong University

The Workshop Venue

Room 528, Lecture Hall, Building A
School of Chemistry and Chemical Engineering
Shanghai Jiao Tong University
No. 800 Dongchuan Road, Minhang District, Shanghai 200240, China

Directions to Minhang Campus, SJTU



Invited Speakers

(Alphabetically ordered by last name)

Quan Chen	**Changchun Institute of Applied Chemistry, Chinese Academy of Sciences**
Xingyi Huang	**Shanghai Jiao Tong University**
Xuesong Jiang	**Shanghai Jiao Tong University**
Qi Li	**Pennsylvania State University/Tsinghua University**
Lei Li	**Shanghai Jiao Tong University**
Tao Li	**Shanghai Jiao Tong University**
Qundong Shen	**Nanjing University**
Meiran Xie	**East China Normal University**
Shuhui Yu	**Shenzhen Institutes of Advanced Technology, Chinese Academy of Science**
Wangzhang Yuan	**Shanghai Jiao Tong University**
Cheng Yang	**Graduate School at Shenzhen, Tsinghua University**
Chunyi Zhi	**City University of Hong Kong**
Zhicheng Zhang	**Xi'an Jiaotong University**
Hongliang Zhong	**Shanghai Jiao Tong University**

Workshop Program

January 14, 2017, Saturday

Room 528, Lecture Hall, Building A, School of Chem. & Chem. Eng., SJTU

Opening Ceremony	**Chair: Dr. Xingyi Huang**
08:30-08:50	Prof. Xinyuan Zhu, Shanghai Jiao Tong University **Welcome Speech**
Invited Lectures	**Chair: Prof. Pingkai Jiang**
08:50-09:15	Prof. Chunyi Zhi, City University of Hong Kong **Functional Flexible & Wearable Energy Storage Devices**
09:15-09:40	Prof. Tao Li, Shanghai Jiao Tong University **Self-Assembled Monolayers of Photochromic Dihydroazulenes for Solid-State Switchable Junctions**
09:40-10:05	Prof. Qundong Shen, Nanjing University **Ferroelectric Polymer Flexible Electronic Devices**
10:05-10:20	**Coffee Break**
Invited Lectures	**Chair: Prof. Wei Yu**
10:20-10:45	Prof. Cheng Yang, Tsinghua University **Metallic Nanostructures for Current Collecting & Wiring.**
10:45-11:10	Prof. Hongliang Zhong, Shanghai Jiao Tong University **Effect of Molecular Skeleton on Material Properties in Organic Electronics**
11:10-11:35	Prof. Quan Chen, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences **Activation Energy of Associative Polymers**
11:35-12:00	Prof. Xuesong Jiang, Shanghai Jiao Tong University **Reversible Diels-Alder Reaction Controlling Wrinkle Pattern: From Dynamic Chemistry to Dynamic Pattern**
12:00-14:00	**Lunch**

Invited Lectures	Chair: Prof. Qinghua Lu
14:00-14:25	Prof. Zhicheng Zhang, Xi'an Jiaotong University **Synthesis of PVDF Based Ferroelectric Polymers with Excellent Electroactive Performances**
14:25-14:50	Prof. Lei Li, Shanghai Jiao Tong University **A Polymer Lithium-Oxygen Battery**
14:50-15:15	Prof. Shuhui Yu, Shenzhen Institutes of Advanced Technology, Chinese Academy of Science **Development of High-K Materials, and the Gap Between Research and Applications**
15:15-15:30	**Coffee Break**
Invited Lectures	**Chair: Prof. Xuesong Jiang**
15:30-15:55	Prof. Qi Li, Pennsylvania State University/Tsinghua University **Polymer Nanocomposite-Based Dielectric Materials for Capacitive Energy Storage at Elevated Temperature**
15:55-16:20	Prof. Wangzhang Yuan, Shanghai Jiao Tong University **Organic Luminogens: from Fluorescent to Phosphorescent, from Traditional to Nonconventional**
16:20-16:45	Prof. Meiran Xie, East China Normal University **Nanostructured Metathesis Polymers and Enhanced Dielectric Properties**
16:45-17:10	Prof. Xingyi Huang, Shanghai Jiao Tong University **Thermally Conductive but Electrically Insulating Polymer Nanocomposites**
18:00-20:00	**Dinner**

Functional Flexible & Wearable Energy Storage Devices

Chunyi Zhi
Department of Physics & Materials science, City University of Hong Kong

Wearable electronic textiles that store capacitive energy are a next frontier in personalized electronics. My talk focus on our recent progresses on development of flexible/wearable energy storage devices, including supercapacitor, aqueous battery and metal air battery.

Starting with a couple of unique electrode materials, such as a conducting polymer with superb cycling stability, we have developed quite a couple of novel functional flexible/wearable supercapacitor devices. For example, we demonstrate supercapacitors with vinyl hybrid silica nanoparticles (VSNPs-PAA) as the electrolyte are self-healed, achieving an excellent healing efficiency of ~100% even after 20 cycles of breaking/healing. By a designed facile electrode fabrication procedure, they are stretched up to 600% strain with performance enhanced. In addition, we have also developed magnetic force facilitated self-healable yarn supercapacitor, shape memory supercapacitor and supercapacitor-sensor ultimately integrated systems etc.

In addition to supercapacitors, we have also developed highly safe aqueous electrolyte based batteries and flexible zinc-air fuel cells, which may greatly enhance practical applications of flexible energy storage devices.

Refences:

1. Zhu and Zhi et al. A highly durable, transferable and substrate-versatile high performance all-polymer micro-supercapacitor with plug-and-play function, Adv. Mater. Accepted.
2. Xue and Zhi et al. Photoluminescent Ti_3C_2 MXene Quantum Dots for Multicolor Cellular Imaging, Adv. Mater. Accepted.
3. Huang and Zhi et al. Smart Energy Storage Devices. Adv. Mater. DOI: 10.1002/adma.201601928.
4. Zhu and Zhi et al. Highly flexible, freestanding supercapacitor electrode with enhanced performance obtained by hybridizing polypyrrole chains with MXene. Advanced Energy Materials 2016, 6,1600969.
5. Huang and Zhi et al. A self-healable and highly stretchable supercapacitor based on a dual crosslinked polyelectrolyte. Nature Communications 2015, 6.

Dr. Chunyi Zhi（支春义） got his PhD degree in physics from institute of physics, Chinese Academy of sciences. After that, he started to work as a postdoctoral researcher in National Institute for Materials Science (NIMS) in Japan, followed by a research fellow in International Center for Young Scientists in NIMS and a permanent position in NIMS as a senior researcher. He is currently an assistant professor in Department of Physics & Materials science, City University of Hong Kong. Zhi's research is currently focused on flexible/wearable energy storage devices and sensors etc. He has published more than 170 papers with a citation of >7800 and h-index of 48.

Self-Assembled Monolayers of Photochromic Dihydroazulenes for Solid-State Switchable Junctions

Tao Li[1]*
[1]School of Chemistry and Chemical Engineering, Shanghai Jiao Tong University, Shanghai, CHINA

Molecular electronics seeks to understand charge transport properties of single molecules and their ensembles. Ultimately it will pave the way for logic circuits made of molecular building blocks. To date, various test beds for contacting and probing molecular components have been reported[1], among which molecular junctions based on self-assembled monolayers (SAMs) can be constructed and operated in a more reproducible manner, more amenable to mass production and integration[2,3].

In this sense, we designed a series of photochromic molecules and studied their properties in the form of SAMs. By using transparent graphene top-contact, we realized solid-state photo-gated devices based on monolayered photochromic molecules[4]. Specifically, we mounted the photochromic cores with different types of anchoring groups at different positions to study their influence on charge transport pathways and switching behaviors. For example, we mounted a less studied photoswitching couple dihydroazulene/vinylheptafulvene (DHA/VHF) on the derivatives of triazatriangulenium (TATA) ion. The TATA platform lies flat on the substrate with the central DHA/VHF orienting perpendicular to the surface. Substituents at the nitrogen atoms control the size of the platform and thus define the intermolecular distances. Well-ordered SAMs of DHA-TATA molecules can be formed on Au substrates and we incorporated them into solid-state micropore junctions. Electrical measurements with an *in situ* photo-gate revealed distinct device performances for TATA SAMs and meta-thiol SAMs. Almost instant response to UV radiation was observed for monolayered DHA-TATA molecules because the intermolecular interactions (e.g., steric hindrances or excitonic coupling) were to a large extent avoided. DFT-NEGF calculations were in agreement with the experimental results. We believe this study will offer deeper insights into molecular engineering for SAM devices and more significantly, take a solid step in helping molecular electronics to become a robust technology in the future.

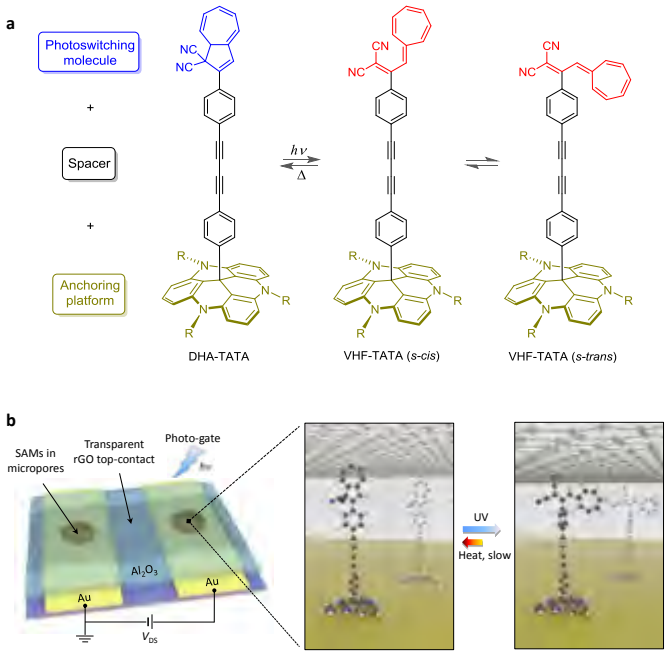


Figure 1. a) DHA/VHF photoswitch attached to TATA platform with a spacer group that decouples the electronic interaction between the switching group and bottom electrodes. b) Schematic illustration of a molecular double junction with SAMs of DHA/VHF derivatives as active components and a transparent rGO top-contact offering access for in-situ photo irradiation.

References

[1] T. Li, W. Hu and D. Zhu, *Adv. Mater.*, 22 (2010), pp. 286-300.
[2] T. Li, J. Hauptmann and Z. Wei, et al. *Adv. Mater.*, 24 (2012), pp. 1333-1339.
[3] W. Zong, H. Dong and T. Li et al., *Nat. Commun.*, 6 (2015), no. 7478.
[4] T. Li, M. Jevric and J. Hauptmann, et al. *Adv. Mater.*,25 (2013), pp. 4164-4170.

Tao Li (李涛) is an Associate Professor in School of Chemistry and Chemical Engineering, Shanghai Jiao Tong University. He received his Ph.D. from Institute of Chemistry, Chinese Academy of Sciences in 2010. Then he joined University of Copenhagen as a postdoc fellow. In 2013, he was appointed as an Assistant Professor in Department of Chemistry, University of Copenhagen. He returned to China and joined Shanghai Jiao Tong University as an Associate Professor in 2015. His research mainly focuses on molecular electronics, especially on the fabrication of solid-state molecular scale devices.

Ferroelectric Polymer Flexible Electronic Devices

*Xin Chen, Xu Han, Xin Tang, Pei-Jian Feng, Qun-Dong Shen**

Department of Polymer Science & Engineering, School of Chemistry & Chemical Engineering, Nanjing University, Nanjing 210023, China.

Polyvinylidene fluoride (PVDF) and its copolymer have been widely used in organic electronics for information storage and electric energy utility, due to their outstanding performance of piezoelectricity, pyroelectricity, and ferroelectricity. These semi-crystalline polymers have versatile chain conformations and crystalline phases, which provides enough space for regulation of their condensed states by incorporation of structure defects or extrinsic interface, and more directly, change of the polarization states during external energy input. We will discuss several flexible electronic devices of PVDF-based copolymers. Nonvolatile memory is realized using mechanical force, which can lead to highly localized polarization switching in the polymer thin film and consequent high-density data storage. The copolymers are also attractive for electric energy generator or pressure transducer. Combination with polymer semiconductor, the flexible sensors fabricated from PVDF copolymers are extremely sensitive to tiny force or thermal energy, thus are applicable to recognize physiological signals, such as pulse wave and body temperature. They are suitable for portable electronics by attaching on the wrist, and thereby monitoring dynamic pulse signals under physical exercise or taking medicine for heart disease. Such mobile healthcare devices can provide abundant and real-time information about our healthy condition. We will also discuss artificial retina with nerve cell-readable electric signals generated through polarization change of the ferroelectric polymers by light stimuli.

Qun-Dong Shen（沈群东） received his B. Sc. in polymer materials and Ph. D. degree in polymer physics and chemistry from Nanjing University. He is presently a professor at the Department of Polymer Science and Engineering, School of Chemistry and Chemical Engineering, Nanjing University. He has been active in the design and synthesis of functional polymers. His current research focuses on ferroelectric polymers for information storage and energy utilization, as well as conjugated polymers for biomedical applications.

Metallic Nanostructures for Current Collecting & Wiring

Cheng Yang
Tsinghua University

Advanced current collecting and wiring materials play important roles in the blooming miniaturized energy storage devices and high density flexible circuits. This seminar reviews Prof. Cheng Yang group's recent technological advances about silver and nickel based nanostructures, including their preparations, device fabrications, and performance characteristic evaluations.

Prof. Cheng Yang（杨诚）obtained his bachelor degree in Nanjing University and PhD degree in the Hong Kong University of Science and Technology (HKUST). He had been working in HKUST and Georgia Institute of Technology as post-doc and visiting faculty before joining Graduate School at Shenzhen, Tsinghua University in 2011. His research interest covers novel nanostructures fabrications and their applications in electronic components. As corresponding author, he has published high impact journal papers including *Nature Communications, Advanced Materials, Energy & Environmental Science, ACS Nano, Advanced Functional Materials*, and *Nano Energy* etc. He is currently a technical board member of *IEEE International Conference of Electronic Packaging Technology* and one of the associate board members of *Scientific Reports*.

Effect of Molecular Skeleton on Material Properties in Organic Electronics

Hongliang Zhong
School of Chemistry and Chemical Engineering, Shanghai Jiao Tong University

Abstract: Organic materials have attracted enormous interests due to their potential applications in printable electronics. It is highly desirable to study the instinct structure-property relationship of organic materials so that the principle of molecular design could be built up to develop high performance materials. Herein, we study various organic materials including small molecules and polymers with different molecular skeleton which could be tuned by heteroatoms, sidechains and regioregularity, eventually revealing the approaches how chemical structure affects the material properties and device performance in organic electronics.

Hongliang Zhong（钟洪亮） received his Bachelor degree in Chemistry at Wuhan University in China. He then moved to Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences to study conjugated materials under the supervision of Prof. Qiang Fang and obtained his Ph.D degree in 2010. After the postdoctoral training at Imperial College London (UK) and University of Washington (USA), he started his independent career at Shanghai Jiao Tong University in June 2016 funded by "1000 Young Talents" Program. His study focuses on organic functional materials in particular the design, synthesis and characterization of small molecules and polymers for the applications of organic electronics as well as the fundamental understanding of the structure-property relationship in optoelectronic materials.

Activation Energy of Associative Polymers

*Zhijie Zhang, Chang Liu, Quan Chen**
State Key Laboratory of Polymer Physics and Chemistry, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, Changchun 130022, China

Associative polymers contain stickers that can associate with each other. The lifetime of stickers within the association can be written as $\tau_s = \tau_0 \exp(E_a/kT)$, where τ_0 is characteristic time of a Kuhn segment and E_a is the activation energy for dissociation. In literature, there are usually two types of approaches to determine E_a: The first approach is based on a delay of terminal relaxation time of the physical gel formed from the association with respect to τ_0; The second approach is based on the temperature dependences of terminal relaxation time, viscosity, or linear viscoelastic shift factor. Nevertheless, inconsistency is frequently seen for E_a determined from these two types of approaches. In this study, we will explain sources of the inconsistency and provide an experimental solution.

Quan Chen（陈全） received his Ph.D. degree in the Graduate School of Engineering, Kyoto University, Japan in 2011. After a postdoctoral fellowship at the Pennsylvania State University, he has been at the current position as a Professor at the Changchun Institute of Applied Chemistry, Chinese Academy of Sciences since 2015. He was awarded with the JSPS scholarship in 2009 and the "Thousand Youth Plan" national fund in 2015. He is now a committee member of the Chinese Society of Rheology. His current research interests include structure-property relationship of polymer blends, copolymers, nanocomposites, and ion-containing polymers.

Reversible Diels-Alder Reaction Controlling Wrinkle Pattern: From Dynamic Chemistry to Dynamic Pattern

*Honghao Hou, Xuesong Jiang**
School of Chemistry & Chemical Engineering, Shanghai 200240, People's Republic of China

Surface patterns with periodic or random microarchitectures have become increasingly important for a broad range of applications because micro/nano-scale patterned topographies with spatial periodicity or aperiodicity endow materials with unique acoustic, electronic, optical, mechanical, and biological properties. We present a facile and effective strategy for the fabrication of a reversible wrinkle pattern with a morphology that can be dynamically erased and tuned *in-situ* by simply controlling the dynamic Diels-Alder (D-A) chemical reaction (**Figure 1**). The D-A reaction between furan and maleimide was chosen due to its high reversibility and easy operability. For temperature ranging from room temperature to approximately 100 °C, the cross-linked network with high modulus can be formed thorough the D-A reaction between furan and maleimide. Meanwhile, the cross-linked D-A adducts can undergo a reverse reaction which is known as a retro D−A reaction, typically at the higher temperatures above 120 °C to produce the raw materials. The key point for this strategy is that the modulus of the top layer can be tuned by the dynamic D-A reaction cross-linking. The reversible nature of the D-A click chemistry enables the dynamic change of the pattern morphology from the smooth state to the wrinkle pattern, allowing for accurate control of the adhesion, wettability and optical properties of the resulting surface. This one-step and robust approach for the fabrication of complex tunable wrinkle patterns provides the possibility that surface properties can be controlled on demand.

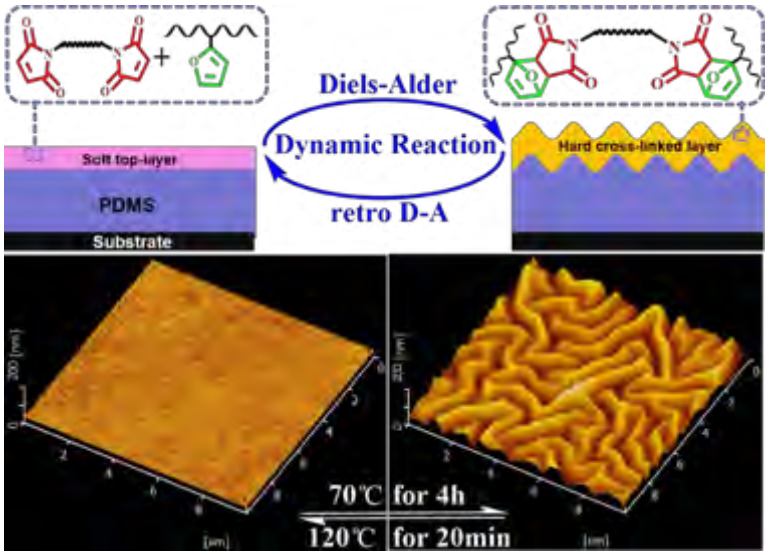


Figure 1. The strategy for the reversible wrinkle pattern based on the reversible Diels-Alder reaction

Prof. Xuesong Jiang（姜学松） was born in 1977 in China, and earned his Bachelor degree from East China University of Science and Technology (ECUST) in 1999 and Ph.D. Degree from Shanghai Jiao Tong University (SJTU) in 2005, respectively. From 2009 to 2010, he worked as Postdoctoral in Georg-August-Universitat Gottingen, supported by the Alexander von Humboldt fellowship. Now, he is a professor in polymer department of Shanghai Jiao Tong University (SJTU). He got some awards such as Hitachi-Chemical Outstanding Researcher of Oversea, and Excellent Young Scientist Foundation of NSFC. His research is focused on the responsive polymers, photo-curable polymers and their applications.

Selected Publications:

1. Reversible Diels-Alder reaction to control wrinkle patterns: from the dynamic chemistry to dynamic pattern,
   H. Hao, J. Yin, X. S. Jiang*, **Adv. Mater.,** 2016, 28, 9126-9132
2. Versatile Functionalization of the Micro-patterned Hydrogel of Hyperbranched Poly(ether amine) Based on “Thiol-yne” Chemistry
   Yanling Xu, Hongjie Xu, Xuesong Jiang*, Jie Yin, **Adv. Funct. Mater**., 2014, 24, 1679–1686
3. Supramolecular Networks of Hyperbranched Poly(ether amine) (hPEA) Nanogel/Chitosan (CS) for the Selective Adsorption and Separation of Guest Molecules
   Jin Li, Zhilong Su, Hongjie Xu, Xiaodong Ma, Jie Yin, Xuesong Jiang*, **Macromolecules,** 2015, 48, 2022–2029

Synthesis of PVDF Based Ferroelectric Polymers with Excellent Electroactive Performances

Xiao WANG[a, b], *Shaobo TAN*[a,b], *Zhicheng Zhang**[a,b]
[a]Department of Applied Chemistry, School of Science, Xi'an Jiaotong University, Xi'an, P. R. China.
[b]MOE Key Laboratory for Nonequilibrium Synthesis and Modulation of Condensed Matter, Xi'an, P. R. China, 710049.

Abstract. Poly(vinylidene fluoride) (PVDF) based relaxor ferroelectric polymers show great potential application in transducers, sensors and artificial muscles for their excellent electrostrictive properties. In state-of-the-art relaxors, terpolymers of VDF and TrFE with the third monomer including chlorotrifluoroethylene (CTFE) and chlorofluoroethylene (CFE) with optimized composition show the best properties including the largest strain of 6% and the maximum polarization of 10μC/cm^2 under 400MV/m field. However, a high driven electric field over 50 MV/m (Ec) is required to achieve the polarization of ferroelectric domains thus the high electrostrictive properties. To reduce the driving electric field, for the first time, a series of relaxor ferroelectric polymer films have been fabricated from uniaxial stretching crosslinked amorphous PVDF films. The amorphous PVDF bearing no TrFE units, named as P(VDF-DB), was synthesized facilely from a full dehydrochlorination of P(VDF-CTFE) copolymer with 20 mol% CTFE. The optimized P(VDF-DB) film with an extension ration of 500% exhibits the best relaxor ferroelectric behaviors including a dielectric constant of 70 at 100Hz, a Curie temperature at 20-40 ^{o}C, a maximum polarization of 12.3μC/cm^2 at 375 MV/m and a remnant polarization of 3.5μC/cm^2. Most noticeably, a lowest Ec of 18 MV/m and a highest strain of 14%@300MV/m are observed, which are much better than current terpolymer relaxors.

Keywords: PVDF; relaxor ferroelectric.

Prof. & Dr. Zhicheng Zhang（张志成） was born in April, 1977 and got his bachelor's and master degrees at Xi'an Jiaotong University majored in Polymer Materials and Engineering from 1995 to 1999, and 1999 to 2002, respectively. From 2002 to 2005, he received his PhD in the Institute of Chemistry, Chinese Academy of Sciences. After that, he went to work in the Department of Materials Science of the Pennsylvania State University as postdoc in Prof. T. C. Mike Chung's group. In 2008, he came back to work in Xi'an Jiaotong University as full professor in School of Science. During past decades, he has published over 60 SCI cited papers which have been cited about 1100 times. His personal H-index is 20. In 2010, he was selected as the New Century Excellent Talents in University. His present research interests are the functionalization of fluoropolymers, developing novel functionalization method for the fluoropolymers, design and synthesis of novel electro-active polymer materials. During past decade, his group has obtained over 10 financial programs from NSFC, MOE, and the other institutes and industry with over 4 million RMB.

A Polymer Lithium-Oxygen Battery

Lei Li
Shanghai Key Laboratory of Electrical Insulation and Thermal Aging, School of Chemistry & Chemical Engineering, Shanghai Jiaotong University, Shanghai 200240, China

Abstract: Non-aqueous lithium-O_2 (Li-O_2) batteries are expected to be widely applied as energy storage systems for hybrid electric vehicles, plug-in hybrid electric vehicles and electric vehicles due to their higher specific energy density compared with the conventional lithium-ion batteries (LIBs). Despite many research efforts have been devoted on Li-O_2 batteries, some major challenges still limit the practical application of Li-O_2 batteries including the low stability of the conventional liquid electrolytes against superoxide radical (O_2-), the poor cycling stability and the low rate capability. Indeed, efficient operation of Li-O_2 batteries requires a stable electrolyte media. Compared with the conventional liquid electrolytes, there are some advantages to develop solid polymer electrolytes for Li-O_2 batteries. The solid polymer electrolytes will not only solve the problems of the liquid electrolytes including electrolyte drying out and flooding of air-electrode, but also prevent lithium dendrite formation, and block water and oxygen crossover towards anode, which will improve cycle life of Li-O_2 batteries. Herein, we prepared new polymer electrolytes based on lithiated perfluorinated sulfonic acid ionomer (PFSA-Li) for high energy Li-O_2 battery, and test the electrochemical stability of these polymer electrolytes in Li-O2 battery with ATR-FTIR and solid state 19F nuclear magnetic resonance spectroscopy (19F NMR) spectroscopy. This new polymer Li-O_2 battery shows good cycling stability, and can be operated stable for 290 cycles under a fixed capacity of 500 mAh g^{-1}carbon.

This research was supported by National Key Basic Research Program of China (No. 2014CB932303), National Natural Science Foundation of China (21573145), Natural Science Foundation of Shanghai (14ZR1422100).

Dr. Lei Li（李磊） obtained his Ph.D. in Chemical Engineering from Tianjin University in 2003. Then he worked in Shanghai Institute of Applied Physics, Chinese Academy of Sciences (2003-2004), Karl-Winnacker-Institut der DECHEMA e.V., Frankfurt am Main, Germany (2004-2006). His research interests are rechargeable batteries (lithium-ion batteries, sodium-ion batteries and metal-air batteries) and fuel cells. In particular, he focuses his researches on electrolyte and separator for batteries, and proton exchange membrane for fuel cells. More than 70 papers have been published in peer-reviewed journals, including Energy & Environmental Science, Chemical Communication and Journal of Material Chemistry etc. He is Associate Editor of RSC Advances, editorial board member of Chinese Chemical Letters and Journal of Research in Nanotechnology.

Development of High-K Materials, and the Gap Between Research and Applications

Shuhui Yu
Center for Advanced Material, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, Shenzhen 518055, China

Abstract: In our previous and ongoing research work, various inorganic particles and structures have been designed and synthesized including $BaTiO_3$-supporting Nano Ag (BT-Ag), BT-Cu, and 3D-BT network which are used as fillers for polymer matrix to obtain high dielectric constant (high-k), low loss and enhanced energy density. Dielectric constant over 100 with low loss less than 0.1 can be achieved by modulating the microstructure of particles, filler content and processing art. However, for the commercial polymer based thin film capacitors, the filler is still $BaTiO_3$ and the dielectric constant is less than 30. It is imperative to bridge the research and industrial applications.

Shuhui Yu（于淑会） is currently a Research Professor at Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences (SIAT). She received her Ph.D degree from National University of Singapore in 2006 followed by one year and a half research in Hong Kong Polytechnic University. And then she joined SIAT in 2007. Her research interests include design and synthesis of nanoparticles with specific structure for applications in energy storage composites and devices. She has published over 100 articles and more than 50 of them are SCI indexed, including in Energy Environ. Sci., Chem. Mater., Appl.Phys.Lett. and ACS Appl.Mater&Interfaces etc. She also has more than 30 patents filed in China, USA and as PCT. Over the past several years, she and her group have developed thin film capacitors for industrial applications.

Polymer Nanocomposite-Based Dielectric Materials for Capacitive Energy Storage at Elevated Temperature

Qi Li

Department of Electrical Engineering, Tsinghua University, Beijing 100084, China

Dielectric capacitors, in which dielectric materials form the core component, are electrostatic charge storage devices commonly present in electronics and electrical power systems. The demand for high-temperature dielectric materials for dielectric capacitors has been driven by the rise of many high power applications such as electric automobiles and pulsed power systems where the power electronics are exposed to elevated temperature conditions. Polymer dielectrics enjoy inherent advantages of scalability, light weight, flexibility and the ability to be shaped into intricate configurations in addition to the higher breakdown strength and greater reliability compared to their inorganic counterpart. However, polymer dielectrics have low operating temperatures and much inferior energy and power densities at high temperatures. On the other hand, switching to inorganic dielectric materials would compromise the intriguing properties exclusively present in polymer dielectrics that are in demand for advanced electronics and power systems. Here we point out critical issues in the design of high-temperature dielectric polymers that have been unfortunately overlooked or remained unsolved by using the current approaches, and present a completely new class of high-temperature dielectric materials based-on polymer nanocomposites. We demonstrate that these dielectric materials significantly outperform all the state-of-the-art high-temperature dielectric polymers and is even comparable to that of some ceramic dielectrics at elevated temperature oriented toward applications such as electric vehicles and pulsed power technologies.

Qi Li（李琦） received his Ph.D. degree in materials science at Wuhan University of Technology in 2013. He was awarded the National Scholarship for Graduate Students and Changfei Scholarship as a Ph.D. candidate. He received the Excellent Ph.D. Dissertation Award of Hubei Province in 2014. From March of 2013 to November of 2016, he was a postdoctoral fellow at the Department of Materials Science and Engineering of the Pennsylvania State University, and he was the recipient of the MRS Postdoctoral Award in 2016. Qi Li started his appointment as an Associate Professor with Department of Electrical Engineering at Tsinghua University in December 2016. He has published more than 40 SCI-indexed papers in high-impact journals such as Nature, PNAS, Nature Communications and Advanced Materials. As a first-author or corresponding author, he has published more than 20 SCI-indexed papers, among which 11 papers are published in journals with impact factors higher than 9. Three patent applications have been submitted based on his research outcome. He is the MRS member and IEEE member. He is the reviewer of more than 10 international journals such as Advanced Materials, Polymer Chemistry and Journal of Physical Chemistry.

Organic Luminogens: from Fluorescent to Phosphorescent, from Traditional to Nonconventional

Wang Zhang Yuan
School of Chemistry & Chemical Engineering, Shanghai 200240, People's Republic of China

Abstract Efficient organic solid-state luminogens have attracted increasing attention due to their extensive applications in organic light-emitting diodes (OLEDs), organic lasers, bioimaging, chemo- and bio-sensors, etc. Herein, we reported our recent progress on the fabrication of high efficiency luminogens with aggregation-induced emission (AIE) characteristics.[1] Besides fluorophores, we also discovered the phenomenon of crystallization-induced phosphoprescence (CIP) of pure organic luminogens, thus providing a simple but effectual way toward efficient room temperature phosphorescence (RTP) at ambient conditions.[2] Apart from above conventional luminogens with remarkable conjugation, we also observed intriguing emission from those without classic chromophores, such as common rice, starch, cellulose, dextran,[3] and polyacrylonitrile (PAN).[4] We proposed clustering-triggered emission (CTE) mechanism, namely clustering of nonconventional chromophores and subsequent electron cloud overlap that results in extended electron delocalization and conformation rigidification, to rationalize the origin of the emission.[3,4] Moreover, based on the CTE mechanism, we can rationally design new nonconventional luminogens.[5] It is believed that such CTE mechanism is instructive for further exploration of unorthodox luminogens.

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Nanostructured Metathesis Polymers and Enhanced Dielectric Properties

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Abstract: Metathesis polymerization is a powerful tool for the synthesis of functional polymers with stereoregular chain microstructure, which can be used to improve the dielectric properties of polymers. Polar bis(trifluoromethyl)biphenyl-functionalized polynorbornenes, *endo*-**PTNP**, *exo*-**PTNP** and, *endo*-**PTNDI**, were synthesized via ring-opening metathesis polymerization (ROMP). The *endo*-**PTNP** is supposed to have practically *trans* double bonds and adopt isotactic *syn* conformation, whereas the *exo*-**PTNP** and *endo*-**PTNDI** have mixed *trans*/*cis* double bonds and atactic microstructure, and they have different dielectric constants of 20, 9, and 7, respectively, which is attributed to the dipolar polarization and the stereoregular chain microstructure. A new type of insulating-conductive block copolymers, **PFNP**-*b*-**PFHD** and **PTNP**-*b*-**PFHD**, were synthesized by a tandem ROMP-metathesis cyclopolymerization (MCP) procedure, and they have the self-assembly ability to form a stable core-shell micelle, hollow sphere nanostructure, or even a superhelical nanotube morphology, in which the current leakage may be effectively inhibited because of the conductive **PFHD** core being enwrapped by the insulating **PFNP** or **PTNP** shell. Therefore, a combination of the high permanent dipole of **PFNP** or **PTNP**, the electronic polarization of conjugated **PFHD**, and the favorable nano-interfacial polarization between the conductive **PFHD** core and the insulating **PFNP** or **PTNP** shell was expected to endow the novel materials of **PFNP**-*b*-**PFHD** or **PTNP**-*b*-**PFHD** with high dielectric permittivity of 17-29, low dielectric dissipation of 0.01-0.04, and relatively high stored energy density of 1.01-2.0 J cm^{-3} and the released energy density of 0.89-1.7 J cm^{-3} at the breakdown field of 200-270 MV m^{-1}, due to the multiple polarizations and stereoregular chain microstructure contributions. The ionic poly(bisnorbornene)- and conjugated polyacetylene-based ladderphanes, **PFNP**-*b*-**PNB**-*b*-**PFNP**, **PTNP**-*b*-**PNBIF**-*b*-**PTNP**, and **PTNP**-*b*-**PAF**-*b*-**PTNP**, were also synthesized by ROMP and tandem MCP-ROMP, which have the tree ring-like or core-shell nanostructure. They displayed high dielectric constant of 17-29, low dielectric loss of 0.01-0.04, and high stored energy density of 2.69-2.95 J cm^{-3} and released energy density of 2.38-2.78 J cm^{-3} at the breakdown field of 245 MV m^{-1}, as well as the high charge-discharge efficiency of 84-93%. This strategy presented a practical way to effectively improve the dielectric properties by combining the dipolar, ionic, electronic, and nano-interfacial polarizations, as well as the stereoregular chain microstructure contribution to achieve advanced dielectric polymers.

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Thermally conductive but electrically insulating Polymer Nanocomposites

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Rapid increase of power density of electric equipment and electronic devices brings forward the need for thermally conductive but electrically insulating materials. Polymer materials have been widely used as dielectrics and electrical insulation in power equipment and electric devices because of their easy processing and low cost. However, most of polymer materials have low thermal conductivity (i.e., lower than 0.3 W/mK), which makes the thermal management of high-power-density equipment and devices become a large challenge. The search for high thermal conductivity materials has inspired multiple studies of polymer composites. However, the simultaneous enhancement of thermal conductivity and insulating properties of polymer composites remains a difficult materials engineering challenge.

In this presentation, I will report our recent progress on the development thermally conductive but electrically insulating polymer nanocomposites by using boron nitride nanofiller, including nanosheets, nanotubes and nanospheres. It has been concluded that tailoring nanocomposite microstructure and engineering nanofiller surface are keys to achieving composites materials with desirable thermal and dielectric properties.

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