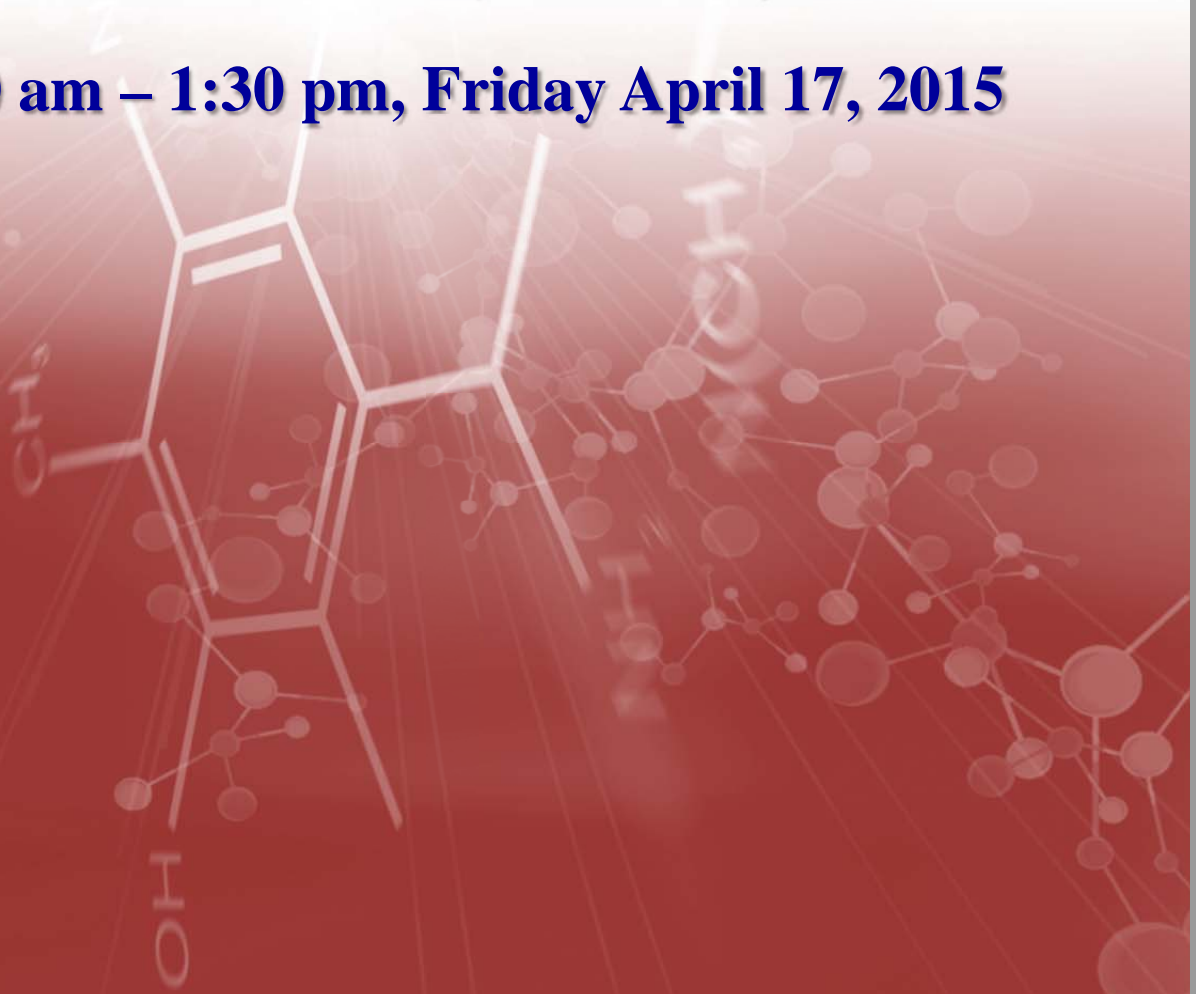


2015 Departmental Research Day

Department
of
Chemical & Biomedical Engineering
FAMU-FSU College of Engineering

Challenger Learning Center
200 S. Duval Street, Tallahassee, FL

8:00 am – 1:30 pm, Friday April 17, 2015



Schedule of Events

07:30	Poster and Presentation Setup – Multipurpose Room
08:00	Keynote – Dr. Carol K. Hall, NC State – Planetarium
09:00	Break – Multipurpose Room
09:10	Oral Graduate Student Presentations - Planetarium
10:40	Break – Multipurpose Room
11:00	Graduate Student Poster Session – Multipurpose Room
12:30	Lunch and Poster Session – Multipurpose Room
13:30	Adjournment & Cleanup

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Welcome!

On behalf of the Department of Chemical & Biomedical Engineering at the FAMU-FSU College of Engineering, I wish to extend to you our sincerest welcome to the Annual Departmental Research Day. This showcase provides our graduate students, undergraduates and postdoctoral fellows with the opportunity to display and discuss their research over the last year in an informal setting with fellow students and faculty. We are proud of the work performed by our students and trainees, and this event gives them the opportunity to defend their research and inform the local community about their progress and the advancements generated within the department. These kinds of exchanges are critical to the education and maturation of our students but also educate the faculty and local scientific community about the resources and techniques under development in Chemical & Biomedical Engineering.

This year, we are very happy to have a keynote address provided by Dr. Carol K. Hall, Camille Dreyfus Distinguished University Professor of Chemical and Biomolecular Engineering at North Carolina State University. A fellow of the NAE, AIChE and APS, Dr. Hall's research is driven by a fascination with molecules of interesting architectures and energetics, and by a desire to understand how these molecular features combine to yield complex mesoscopic or macroscopic features. Her primary tools in this effort are statistical thermodynamics and computer simulation. She will be discussing her modeling of the self assembly of soft materials, with a focus on proteins whose aggregation is implicated in Alzheimer's and other neurodegenerative diseases.

We look forward to a fascinating discussion with Dr. Hall and fruitful day of conversations and networking among students, fellows and faculty.

With Regards,



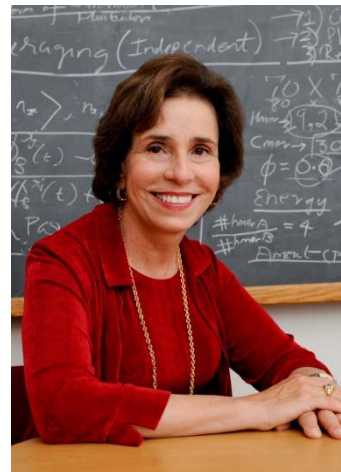
Samuel C. Grant, PhD

CBE Graduate Coordinator

Keynote Address

Dr. Carol K. Hall, Ph.D.

Camille Dreyfus Distinguished University Professor
Department of Chemical & Biomolecular Engineering
North Carolina State University



Education

Ph.D., Physics, State University of New York at Stony Brook
B.A., Physics, Cornell University

A Computational Study of the Thermodynamic and Kinetic Origins of Alzheimer's and Related Diseases

The pathological hallmark of more than twenty neurodegenerative diseases, like Alzheimer's, Parkinson's and the prion diseases, is the presence within the brain of plaques containing ordered protein aggregates called fibrils. It is not yet known why these structures form in some individuals and not in others, or whether the plaques are toxic or Nature's way of sequestering toxic species. Dr. Hall will describe current thinking on the scientific underpinnings for this phenomenon, and her computational efforts to contribute to our knowledge of how and why proteins assemble into fibrils.

Short Biography: Professor Carol K. Hall is the Camille Dreyfus Distinguished University Professor of Chemical and Biomolecular Engineering at North Carolina State University. She joined the Chemical Engineering Department at Princeton University in 1977 as one of the first women to be appointed to a chemical engineering faculty in the U.S. In 1985, she joined the Chemical Engineering Department at North Carolina State University. Hall's research focuses on applying statistical thermodynamics and molecular-level computer simulation to topics of chemical, biological or engineering interest involving macromolecules or complex fluids. Current research topics include protein folding/aggregation, multipolar colloids, amino-acid-based polymers, dispersants for oil spills, liposomal drug delivery devices, nanoparticle toxicology, DNA-hybridization and nucleic-acid-based nanostructures. She is the author of over 220 publications, is a Fellow of the American Institute of Chemical Engineers and of the American Physical Society and was elected to the National Academy of Engineering in 2005.

List of Graduate Student Oral Presentations

Presentation Time

- 9:10-9:40** **Junfei Xia**, *Asymmetric Biodegradable Microdevices for Cell-Borne Drug Delivery*
- 9:40-10:10** **Venroy Watson**, *Quest for Grid Energy Storage: Case for the Performance of Iron Ion/Hydrogen Redox Flow Battery Mixed Electrolytes*
- 10:10-10:40** **Chenkun Zhou**, *Phosphorescent Molecular Butterflies with Tunable Photoinduced Structural Change and Dual Emission*

List of Graduate Student Poster Presentations

Poster

1. **Xuejian Chen**, *Effect of Crystallinity on Melt Memory of Random Ethylene Copolymers*
2. **Oyidia Elendu**, *Production of Chemicals from Glycerol using CuNiMoP Electrocatalyst*
3. **Zhibin Wang**, *Facile Functionalization and Assembly of Live Cells with Microcontact Printed Polymeric Biomaterials*
4. **Yuanwei Yan**, *Acellular Matrices Derived from Pluripotent Stem Cells Modulated Tissue Development*
5. **Hamed Janani**, *Mechanical Properties and Stress-Induced Polymorphic Transition in Blends of iPP and Isotactic Propylene-1-Hexene Copolymers*
6. **Xiaoshi Zhang**, *FTIR Spectroscopic Analysis of the Crystallization of Precision Halogen Substituted Polyethylenes*
7. **James Akraasi**, *Feasibility Study for the Use of Glycerol as a Substitute for Hydrogen in the Iron-Ion/Hydrogen Redox Flow Cell*
8. **Ghoncheh Amouzandeh**, *MREPT at 21.1 T*
9. **Lianyang Dong**, *A Comparative Study of Two Narrow Gap Semiconductors FeGa₃ and FeSb₂*
10. **Yijun Liu**, *Pentose Phosphate Pathway-Mediated Metabolic Reconfiguration Improves Human Mesenchymal Stem Cell Stemness in Three Dimensional (3D) Aggregates*
11. **Ben Hudson**, *Fluorenyl-9-methoxycarbonyl-diphenylalanine Self-Assembly*
12. **Ang-Chen Tsai**, *Expansion of Human Mesenchymal Stem Cells in Fibrous Bed Bioreactor*
13. **Yuan Gao**, *Aggregation Mechanism of Fibroblast Growth Factor-1 (FGF-1)*
14. **Abdol Aziz Ould Ismail**, *Magnetic Resonance Electrical Impedance Tomography*
15. **Guang Yang**, *A Convenient Phase Transfer Protocol to Functionalize Gold Nanoparticles with Short Alkylamine Ligands*
16. **Huihui Wang**, *The Influence of Input Voltage on H₂O₂ Production in Plasma Formed Along a Gas-Liquid Interface*
17. **Sifei Zhou**, *COMSOL Two-phase Flow Level Set Method*
18. **Xuegang Yuan**, *Expansion and Thermal Release of Human Mesenchymal Stem Cells from Micro-Carriers*
19. **Onyekachi Oparaji**, *Measuring Water Diffusion in Block Copolymer Membranes with Fourier Transform Infrared-Attenuated Total Reflectance (FTIR-ATR) Spectroscopy*
20. **Yu Shu**, *Application of Thermal Inter-diffusion Processing in PHJ Structure Perovskite Solar Cells*
21. **Nastaren Abad**, *Tracking Stem Cells in Irradiated Traumatic Brain Injury Models Using ¹H MRI at 11.75 T*
22. **Hailing Liu**, *Lignin-induced Self-healing Polymer*
23. **Alexander Rausch**, *Studying Voltage Stability of Polymer Electrolyte on Planar Metal Electrodes*
24. **Divya Bahadur**, *Gel Formation in Binary Mixtures of Nanocolloids with Short Range Attraction*
25. **Julie Bejoy**, *Biological Relevance of YAP Regulation by Wnt Signaling During Neural Differentiation of Human Induced Pluripotent Stem Cells*
26. **Liqing Song**, *PCL-PDMS-PCL Copolymer-based Microspheres Mediated Cardiovascular Differentiation from Embryonic Stem Cells*

Graduate Student Oral Presentation 1

Asymmetric Biodegradable Microdevices for Cell-Borne Drug Delivery

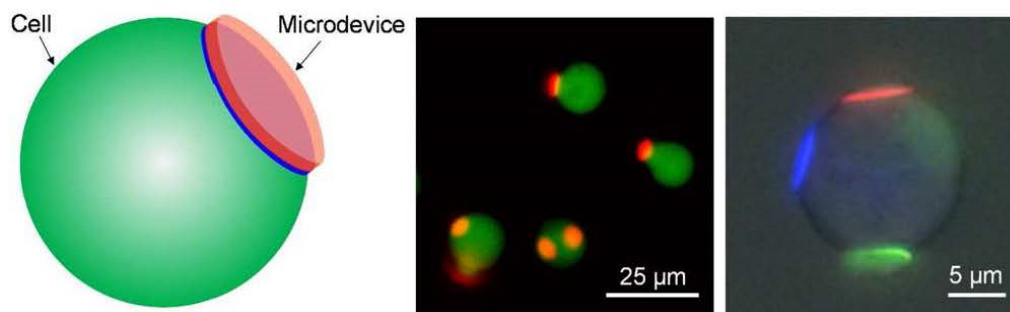
Junfei Xia [†], Zhibin Wang [†], Danting Huang [†], Yuanwei Yan [†], Yan Li [†], and Jingjiao Guan ^{**†}

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[‡] Integrative NanoScience Institute, Florida State University, Tallahassee, Florida 32306-4370, United States

Abstract

Use of live cells as carriers for drug-laden particulate structures possesses unique advantages for drug delivery. In this work, we report on the development of a novel type of particulate structures called microdevices for cell-borne drug delivery. The microdevices were fabricated by soft lithography with a disklike shape. Each microdevice was composed of a layer of biodegradable thermoplastic such as poly(lactic-*co*-glycolic acid). One face of the thermoplastic layer was covalently grafted with a cell-adhesive polyelectrolyte such as poly-L-lysine. This asymmetric structure allowed the microdevices to bind to live cells through bulk mixing without causing cell aggregation. Moreover, the cell-microdevice complexes were largely stable, and the viability and proliferation ability of the cells were not affected by the microdevices over a week. In addition, sustained release of a mock drug from the microdevices was demonstrated. This type of microdevice promises to be clinically useful for sustained intravascular drug delivery.



Graduate Student Oral Presentation 2

Quest for Grid Energy Storage: Case for the Performance of Iron-Ion/Hydrogen Redox Flow Battery Mixed Electrolytes

Venroy Watson¹, Derrick Nguyen², Edward E. Effiong³, Egwu E. Kalu¹

¹Department of Chemical & Biomedical Engineer Florida A&M University, Tallahassee, FL*
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²Department of Environmental Engineering University of Oklahoma, Norman, OK 73019

³Department of Chemical Engineering, Federal University of Technology, Owerri, Nigeria

Abstract

The progression of the Iron-ion/Hydrogen redox flow battery (RFB) system as a cost effective energy system has been impeded by the poor performance of electrolyte. We report here results of an improvement of the RFB electrolyte performance using a mixed electrolyte of iron sulfate and iron chloride and also ammonium iron sulfate and iron chloride. Present results show that the addition of Cl⁻ increases performance of sulfate electrolyte. Similarly, the performance of the ammonium iron sulfate electrolyte was increased. Charging potential was reduced by about 50% for a mixed electrolytes of iron sulfate 50%(V/V) and iron chloride 50%(V/V) suggesting that a sulfate/chloride electrolyte system can lead to an improved charging/discharging of the Fe-ion/H₂ RFB. Electrolyte performance criteria defined as “electron transfer efficiency” was introduced and using this criterion it was observed that a reverse addition of iron sulfate to iron chloride showed a decrease in the mixed electrolyte’s electron transfer efficiency equivalent to a decrease in electrolyte performance. Based on the results, a 100% pure 0.8 M FeCl₂ corrosive electrolyte system can be replaced by less corrosive mixture of 46 mol % Cl⁻ in 0.8 M FeSO₄ to achieve the same performance of an all chloride electrolyte system.

* Corresponding authors: ekalu@eng.fsu.edu (EEK) and venroy1.watson@fam.u.edu (VW)

Graduate Student Oral Presentation 3

Phosphorescent Molecular Butterflies with Tunable Photoinduced Structural Change and Dual Emission

Chenkun Zhou¹, Yu Tian², Zhao Yuan^{1,3}, Mingu Han¹, Jamie Wang³, Lei Zhu³, Maliheh Shaban Tameh⁴, Chen Huang^{2,4}, and Biwu Ma^{1,2,3}

¹ Department of Chemical and Biomedical Engineering, ² Materials Science Program, ³ Department of Chemistry and Biochemistry, ⁴ Department of Scientific Computing

Abstract

Molecular excited states with extra energy produced by the interactions between light and molecules are the foundation for solar energy conversion and storage, photosensitization, photocatalysis, and molecular machines. Detailed studies of the molecular excited state properties, including structure, energetics, and decay pathways, allow us to gain fundamental understandings on many chemical and biological processes, and to develop new functional materials and devices. As one of major excited state dynamic processes of molecular systems, photoinduced structural change (PSC) has recently become a research frontier due to the advent of ultrafast time-resolved absorption and emission spectroscopies, and X-ray spectroscopy. However, precise control of PSC is very challenging, due to the lack of guidelines for designing excited-state potential energy surface (PES).

In this talk, I will present a series of rationally designed butterfly-like phosphorescent platinum binuclear complexes¹ that undergo controlled PSC via Pt-Pt distance shortening and exhibit tunable dual emission of greenish-blue and red. We demonstrate that the PSC can be described as a classic chemical reaction like process between the two energy minima on the first triplet excited-state PES with the energy barrier being manipulated by molecular engineering in accordance with the Bell-Evans-Polanyi principle. Our results show a simple means to engineer dual emission of photoactive molecular systems by effectively manipulating PES to control PSC.

Reference

- 1 Han, M., Tian, Y., Yuan, Z., Zhu, L. & Ma, B. A Phosphorescent Molecular “Butterfly” that undergoes a Photoinduced Structural Change allowing Temperature Sensing and White Emission. *Angewandte Chemie International Edition* **53**, 10908-10912 (2014).

Graduate Student Poster Presentation 1

Effect of Crystallinity on Melt Memory of Random Ethylene Copolymers

Xuejian Chen, Al Mamun, Rufina G. Alamo

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Abstract

A strong memory effect of crystallization has been observed in melts of random ethylene copolymers even above the equilibrium melting temperature. Melt memory is correlated with self-seeds that increase the crystallization rate of ethylene copolymers. The seeds are associated with molten ethylene sequences from the initial crystals that remain in close proximity and are unable to diffuse quickly to the randomized melt state. Fast diffusion is restricted by topological chain constraints (loops, knots, and other entanglements) that build in the intercrystalline region during crystallization. The molten nature of the self-seeds is supported by a linear variation of T_2^H with T_{melt} in a range from 180°C to 100°C, covering both the homogeneous and heterogeneous melt regions of a random ethylene copolymer with 2.2 mol% ethyl branches. The effect of topological constraints on melt memory, or on number of remaining seeds in the melt, was analyzed studying copolymers with different levels of crystallinity. There is a threshold level of crystallinity below which copolymers do not display strong melt memory. A faster development of the initial crystallinity may trap more efficiently knots and loops around the crystallites leading to a lower crystallinity threshold than for slow or isothermally crystallized copolymers. Increasing 1-hexene content from 0.5 to 3.5 mol%, the crystallinity threshold decreases from 40 to 4%, while decreasing branch length from hexyl to ethyl, the threshold crystallinity decreases from 19% to 6% in agreement with stronger melt memory in copolymers with increasing comonomer content and with shorter branches.

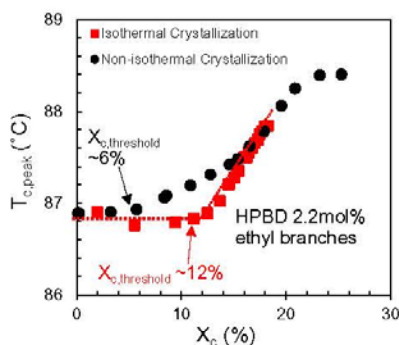


Fig 1. CRYSTALLINITY EFFECT BY DIFFERENT MODES OF CRYSTALLIZATION

References

1. B. O. Reid, M. Vadlamudi, A. Mamun, H. Janani, H. Gao, W. Hu, R. G. Alamo, Strong Memory Effect of Crystallization above the Equilibrium Melting Point of Random Copolymers. *Macromolecules* **2013**, *46*, 6485.
2. A. Mamun, X. Chen, R. G. Alamo, Interplay between a Strong Memory Effect of Crystallization and Liquid-Liquid Phase Separation in Melts of Broadly Distributed Ethylene-1-Alkene Copolymers. *Macromolecules* **2014**, *47*, 7958.
3. X. Chen, A. Mamun, R. G. Alamo, Effect of Level of Crystallinity on Melt Memory above the Equilibrium Melting Temperature in a Random Ethylene 1-Butene Copolymer. *Macromolecular Chemistry and Physics* **2014**, accepted.

Graduate Student Poster Presentation 2

Production of Chemicals from Glycerol using CuNiMoP Electrocatalyst

Oyidia Elendu, Yaw Yeboah and Egwu Eric Kalu

Department of Chemical & Biomedical Engineering, FAMU-FSU College of Engineering

Quaternary supported Cu-Ni-Mo-P electro-catalyst has been synthesized by electroless deposition, as anode-side catalysts for use in alkaline direct glycerol fuel cell capable of co-generation of electricity and fine chemicals. Both formaldehyde and sodium hypophosphite were used as the reducing agents in the electroless deposition process. Characterization of the prepared catalysts show the effects of changing $\text{Cu}^{2+}/\text{Ni}^{2+}$ ratio in the electroless bath on the elemental composition of deposited materials. Preliminary results showing the activity of the electrocatalyst towards glycerol oxidation under alkaline conditions are presented.

Graduate Student Poster Presentation 3

Facile Functionalization and Assembly of Live Cells with Microcontact Printed Polymeric Biomaterials

Zhibin Wang^a, Junfei Xia^a, Yuanwei Yan^a, Ang-Chen Tsai^a, Yan Li^a, Teng Ma^a,
Jingjiao Guan^{a,*}

^aDepartment of Chemical and Biomedical Engineering,
Florida State University
2525 Pottsdamer Street, Tallahassee, Florida 32310-2870 USA

Abstract

Functionalization and assembly of live cells with microfabricated polymeric biomaterials have attracted considerable interests in recent years, but the conventional methods suffer from high cost, high complexity, long processing time or inadequate capability. This present study reports on the development of a novel method for functionalizing and assembling live cells by integrating microcontact printing of polymeric biomaterials with a temperature-sensitive sacrificial layer prepared by spin coating. This method has been used not only to functionalize live cells with microscopic polyelectrolyte and thermoplastic structures of various sizes and shapes, but also to assemble the cells into macroscopic stripes and sheets (Figure 1). The method is applicable to multiple types of cells including human leukemic cells, mouse embryonic stem cells, and human mesenchymal stem cells in the forms of single cells and cell aggregates. In addition, the microcontact printed structures can be prepared using biodegradable and biocompatible polyelectrolytes and thermoplastic. The unique combination of low cost, ease of use and high versatility renders this method potentially useful for diverse biomedical applications including drug delivery, cell tracking and tissue engineering.^[1]

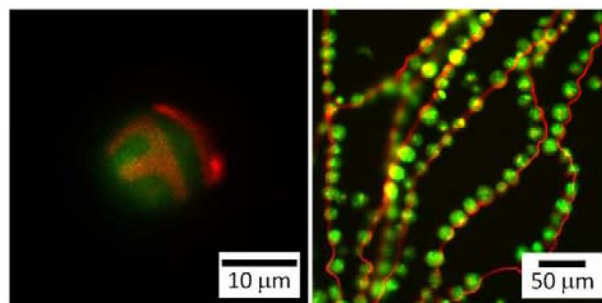


Figure 1. A released cell bound by an “F”-shaped particle and released cells-stripe complexes.

References

- [1] Z. Wang, J. Xia, Y. Yan, A. Tsai, Y. Li, T. Ma and J. Guan*. Facile Functionalization and Assembly of Live Cells with Microcontact Printed Polymeric Biomaterials. *Acta Biomaterialia*, 2015, 11: 80-87.

Graduate Student Poster Presentation 4

Acellular Matrices Derived from Pluripotent Stem Cells Modulated Tissue Development

Yuanwei Yan, Yan Li

Department of Chemical and Biomedical Engineering,
FAMU-FSU College of Engineering, Florida State University, Tallahassee, Florida, USA

Abstract:

Extracellular matrices (ECMs) derived from pluripotent stem cells (PSCs) can regulate neural lineage commitment from PSCs and are used in neural transplantation and neurological disorder treatments. Therefore, the characterization of PSC-derived ECMs is critical for constructing *in vitro* cellular models and for applications in *in vivo* transplantation studies. In this study, three-dimensional (3-D) ECMs secreted from undifferentiated embryonic stem cell (ESC) aggregates (AGG), spontaneously differentiated embryoid bodies (EB), and ESC-derived neural progenitor cell (NPC) aggregates were decellularized. Their capacities to affect the reseeded mouse ESC and human induced pluripotent stem cell (hiPSC) proliferation and neural differentiation were investigated. Proteomic analysis indicated the shared and distinct proteins in ECMs, reflecting different niche properties associated with the cells. High expression of Oct-4 and Nanog was observed for the cells grown on ECMs derived from AGG while the NPC-derived ECMs showed higher expression of β -tubulin III. The cellular response to the ECMs from EB group was more similar to those of AGG group. The role of Wnt/ β -catenin signaling in the cell-matrix interactions was also studied. The expression of various forms of β -catenin was reduced in the cells grown on the ECMs from NPC, comparing with the AGG and EB groups. This study demonstrated that PSC-derived ECMs have distinct biochemical/biological properties and can influence stem cell proliferation and differentiation by providing a spectrum of stem cell niche microenvironments during tissue development.

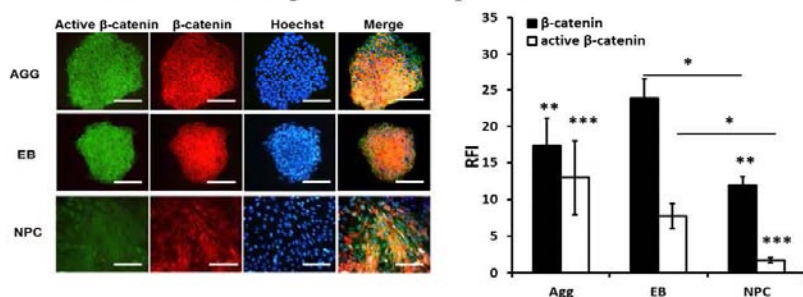


Figure 1. A: The expression of β -catenin and active β -catenin in human iPSK3 cells grown on different types of ECMs (AGG, EB, and NPC). Scale bar: 100 μ m. B: The relative fluorescence intensity of β -catenin and active β -catenin in human iPSK3 cells.

Graduate Student Poster Presentation 5

Mechanical Properties and Stress-Induced Polymorphic Transition in Blends of iPP and Isotactic Propylene-1-Hexene Copolymers

Hamed Janani, Rufina G. Alamo¹

¹FAMU-FSU College of Engineering, Department of Chemical and Biomedical Engineering
2525 Pottsdamer St. Tallahassee, FL 32310

Abstract

The polymorphic transition and mechanical properties of blends of highly crystalline iPP with thermoplastic elastomers of isotactic propylene-1-hexene (PH) copolymer with 11 and 21 mol% of 1-hexene (PH11 and PH21) are studied. Adding 25 wt% copolymer to iPP significantly enhances the elongation at break from ~4% to ~300% for iPP/PH11 and to 250% for iPP/PH21, accompanied by a clear strain hardening in the blends while the tensile strength remains the as high as rigid iPP, i.e. ~35 MPa. The elastic modulus decreases from ~2120 MPa in iPP to ~1440 MPa in iPP/PH21 and to ~371 MPa in iPP/PH11. The ductility of the blends increases as the content of PH11 and PH21 increases. Lower modulus and higher elongation of blend iPP/PH11 compared to iPP/PH21 shows that the toughness and ductile behavior is higher for iPP/PH11 blend. This is due to co-crystallization of PH11 and iPP. Consequently crystals in the blends of iPP/PH11 are more defective and less stable. The significant strain hardening in the blends is correlated with the alignment of crystals as well as polymorphic transition. During deformation, monoclinic crystals transform to mesophase while more trigonal crystals form.

Graduate Student Poster Presentation 6

FTIR Spectroscopic Analysis of the Crystallization of Precision Halogen Substituted Polyethylenes

Xiaoshi Zhang, Laura Santonja-Blasco, Rufina G. Alamo

FAMU-FSU College of Engineering
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2525 Pottsdamer St, Tallahassee, FL 32310

Abstract

Polyethylenes with halogen substitution at a precise distance along the methylene backbone are unique models to study the effect of nano-structured chain-defects on folding and crystallization of polymers. Prior work has shown that packing of the chlorine units in the crystallites of precise polyethylenes with chlorine were found to undergo a transition within several degrees of undercooling.¹ On crystallization from the melt below the transition temperature the chains pack in an all-trans planar conformation (Form I) with layered crystalline chlorines that present some longitudinal disorder. The crystals formed at higher temperatures pack in a non-planar herringbone-like structure (Form II) with a TGGT...TG'G'T backbone conformation around the substitution, while conserving the trans packing of the methylene sequence.^{1,2} The analysis of the FTIR spectra for the rocking-twisting progression in a broad range of crystallization temperatures is extended here to a series of precise polyethylenes with Br and F. The unique polymorphic transition is also found in the system with bromine. However, the polymorphic transition is not found in the system with Fluorine, indicating the van der Waal radius of halogen atoms play the main role of polymorphic transition. The kinetic information of crystallization of all samples is analyzed as a function of increasing temperature. Special self-poisoning crystallization phenomenon is found in the system with bromine.

Reference

1. P. Kaner, C. Ruiz-Orta, E. Boz, K. B. Wagener, M. Tasaki, K. Tashiro and R. G. Alamo. *Macromolecules*, 2014, 47 (1), pp 236–245
2. M. Tasaki, H. Yamamoto, M. Hanesaka, K. Tashiro, E. Boz, K. B. Wagener, C. Ruiz-Orta and R. G. Alamo, *Macromolecules*. 2014.

Graduate Student Poster Presentation 7

Feasibility Study for the Use of Glycerol as a Substitute for Hydrogen in the Iron-Ion/Hydrogen Redox Flow Cell

James Akrasi

FAMU-FSU College of Engineering

Department of Chemical and Biomedical Engineering, Tallahassee, Florida. 32310

Abstract

The electrochemical oxidation of glycerol has been studied and known to be a source of several chemicals of premium industrial value and has also been utilized in the concept of direct glycerol fuel cells to produce electrical energy additionally. In the current study however, this concept is extended to cover both electrochemical oxidation and reduction of glycerol as a substitute for the hydrogen ion in redox flow battery with a $\text{Fe}^{2+}/\text{Fe}^{3+}$ couple as cathode. A conceptual Iron-ion/Glycerol redox flow battery is proposed and its thermodynamic feasibility during discharge is evaluated for the cases of partial and complete oxidation of glycerol to mesoxalic acid, tartronic acid, glyceraldehyde and carbon dioxide, respectively. The reduction of glycerol to propane-1,2-diol in both acidic and alkaline media during charging is also computed. Benson's group additivity method was used to estimate the Gibbs free energy change of products and intermediates of aqueous organic species and hence calculation of electric potentials (E^0) of the associated half-reactions. The theoretical data obtained were compared to the data obtained through cyclic voltammetry technique in both acidic and alkaline media. The scope and feasibility of a working iron-ion/glycerol flow battery will be discussed.

Graduate Student Poster Presentation 8

MREPT at 21.1 T

Ghoncheh Amouzandeh^{1,2}, Jens T. Rosenberg^{1,3} & Samuel C. Grant^{1,3}

¹The National High Magnetic Field Laboratory, ²Physics and ³Chemical and Biomedical Engineering, The Florida State University, Tallahassee, FL, United States

Abstract

Biological tissues present an anisotropic conductivity distribution determined by the electrical properties of numerous interfaces and domains. Visualization of frequency-dependent conductivity and permittivity distribution in the range from DC to hundreds of MHz may expand our ability to provide diagnostic information about the physiological and pathological state of tissues and organs. Magnetic Resonance Electrical Property Tomography (MREPT) is a recently developed method for reconstructing images showing the complex permittivity distribution in target tissues. As such, MREPT can provide both a map of permittivity μ , which relates to energy storage in the medium, and a map of conductivity \tilde{A} , which relates to the energy loss. Unlike related techniques such as electrical impedance tomography (EIT), MREPT makes use of a standard MRI system with no additional hardware or the need to inject current into the tissue under examination. Instead, the MREPT approach employs post-processing of the magnetic field map of the applied RF pulse, making MREPT quantitative by yielding absolute values of \tilde{A} and μ . Phantom and human experiments have proven the feasibility of MREPT, with ongoing clinical studies demonstrating encouraging results.

In this presentation, the physical and mathematical principles of MREPT, novel data collection methods and reconstruction algorithms, and experimental techniques for phantom and *in vivo* rat acquisitions will be extended to operations at 21.1 T, corresponding to an operational frequency of 900 MHz, the highest field currently available for MRI studies.

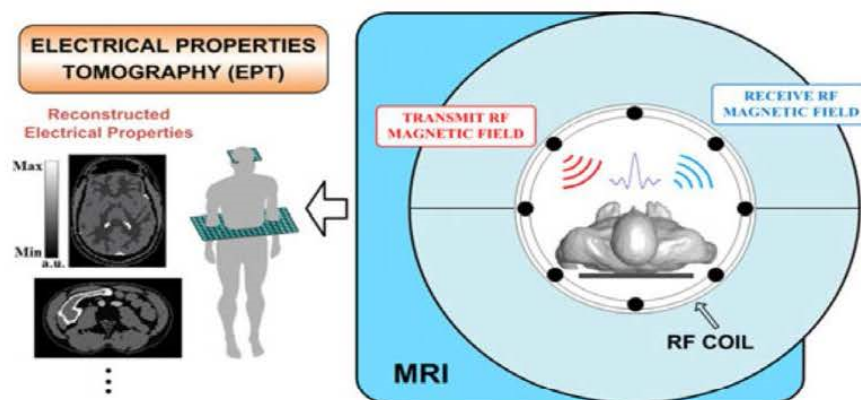


Fig 1. Clinical Diagram of electrical properties tomography (EPT) experiment [Zhang X. et al. IEEE Trans Biomed Eng, 7, 2014]

Graduate Student Poster Presentation 9

A Comparative Study of Two Narrow Gap Semiconductors FeGa₃ and FeSb₂

Lianyang Dong

Chemical & Biomedical Engineering, FAMU-FSU College of Engineering, Florida State University

Introduction

Fe-based semiconductors FeSb₂ and FeGa₃ have attracted great attention in recent years due to their interesting physical properties. Both of them have fairly small band gap opened up by the hybridization of the transition metal d orbitals with the main group metal p orbitals, however, the intrinsic energy gap of FeGa₃ found above room temperature is one order of magnitude larger than intrinsic energy gap of FeSb₂.^{1,2} In 2007, Bentien et al. reported a colossal Seebeck coefficient of -45000 mV/K at 10K in single crystal FeSb₂.³ Interestingly, Seebeck coefficient of a similar order of magnitude (in the order of -16000 μ V/K) was also found in FeGa₃ single crystalline samples most recently.⁴ These two narrow-gap semiconductors have such high Seebeck coefficient, which leads to a record-large thermoelectric power factor, that make them potential candidates for thermoelectric application.

Results and discussion

FeSb₂ and FeGa₃ were prepared by self-flux method from mixtures of the pure elements. The structures were refined from single-crystal X-ray data, showing FeSb₂ compound crystallizing in orthorhombic space group *Pnmm* (#58) with *Z*=2 and lattice constants *a*=5.8328 Å, *b*=6.5376 Å and *c*=3.1973 Å, and FeGa₃ compound crystallizing in tetragonal space group *P4₂/mnm* (#136) with *Z*=4 and lattice constants *a*=6.2615 Å and *c*=6.5562 Å.

The resistivity of FeSb₂ decreases with increasing temperature which is clearly semiconducting, and a large decrease in resistivity of more than six orders of magnitude was observed in the temperature range from 0 to 150 K. The resistivity of FeGa₃ decreases with increasing temperature which is also clearly semiconducting, and a large decrease in resistivity of more than seven orders of magnitude was observed in the small temperature range from 0 to 60 K.

The FeGa₃ is diamagnetic with susceptibility $\chi \sim 2 \times 10^{-5}$ emu/mol, weakly temperature dependent between 150-350 K, with some upturn below 150K which is the development of a Curie tail that originates from tiny amount of impurities in the system. Magnetic susceptibility of FeSb₂ increases with an increase in temperature from a low temperature of 25K and passes through a region of diamagnetic to paramagnetic crossover and becomes paramagnetic at high temperatures. The crossover temperatures are around 125K. Minimum susceptibility values were found at approximately 50K. At *T*<25K, the development of a Curie tail can be associated with saturation from impurity states dominating the magnetic contribution in the sample once all intrinsic states are “frozen” out.

In general, n-type behavior with electrons as majority carriers is observed over the whole temperature range for Seebeck measurements on FeGa₃, the onset of increasing of Seebeck coefficient consistent with the resistivity decreasing. Seebeck measurements on FeSb₂ crystals showed behavior consistent with the activated behavior also evidenced by resistivity data, with the increase in thermopower below 25K, and peaking around 10K. Interestingly, a crossover of negative value to positive value was observed at about 6K which might indicate an n-type to p-type transition.

References

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Graduate Student Poster Presentation 10

Pentose Phosphate Pathway-Mediated Metabolic Reconfiguration Improves Human Mesenchymal Stem Cell Stemness in Three Dimensional (3D) Aggregates

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Human mesenchymal stem cells (hMSCs) are primary cell source in cell therapy for a wide range of diseases. However, immediately after isolation and upon culture expansion, MSCs acquire and accumulate genetic and phenotypic changes in culture and that many proliferating cells progressively enlarge, exit the cell cycle, and become senescent. Emerging studies have shown that in vitro self-assembled 3D MSCs have intriguing biological properties, including enhanced multi-lineage differentiation potential and more primitive stem cell phenotype¹. It has been shown that undifferentiated MSCs have higher dependence on glycolysis for energy supply and undergo metabolic reconfiguration during differentiation². The role for bioenergetics in MSCs phenotype reprogramming during 3D aggregation is however remains uncertain. Moreover, as 3D culture of MSC been proposed as preconditioning strategy to enhance MSCs function, understanding the adaptive changes of MSCs metabolism during self-assembly has important implication in optimizing aggregate properties and function activation. The objective of present study is to investigate energy metabolism in regulating MSCs phenotype changes in 3D aggregates of human mesenchymal stem cells with aim to develop approachable strategy for MSCs expansion with enhanced stem cell phenotype.

hMSC aggregates were formed by seeding cells into ultra-low adherent surface plates. To assess the role of bioenergetics in MSCs phenotype enhancement under aggregation, metabolic modulators, including glycolysis inhibitor (2-DG), pentose phosphate pathway (PPP) inhibitor were used, and their metabolic and cellular impacts on hMSCs in aggregates and adhesive conditions were discussed.

The results showed that hMSCs in self-assembled 3D culture undergo phenotypic changes associated with improved "stemness" compared with hMSCs grown in adherent culture, indicated by up-regulation of three representative stem cell genes, including Nanog, Oct4, and Sox2. With improved stemness, hMSCs in aggregates are also found to be more glycolysis for energy metabolism, with more glycolytic ATP generation, and increased expressions of several glycolytic enzymes, including HK2, PKM2, and LDHA (Fig.1). hMSCs aggregates are also under high oxidative stress with low ATP production, decreased mitochondrial membrane potential (MMP), and increased ROS generation (Fig.2). Consequently, the metabolic redox sensor, PPP, was also found to be elevated in cell aggregates, indicated by increased expressions of two PPP enzymes, G6PD, 6PGD (Fig.3). The metabolic reconfiguration is thought to be a result of oxidant stress, since the expressions of several stress-mediated transcriptional factors are found to be up regulated, including UCP2, Akt2, HIF-1 \pm , NFKB. In deed, the inhibition of redox sensor PPP by DHEA (200uM) abolished the stem cell gene enhancement found in hMSCs aggregates (Fig.4).

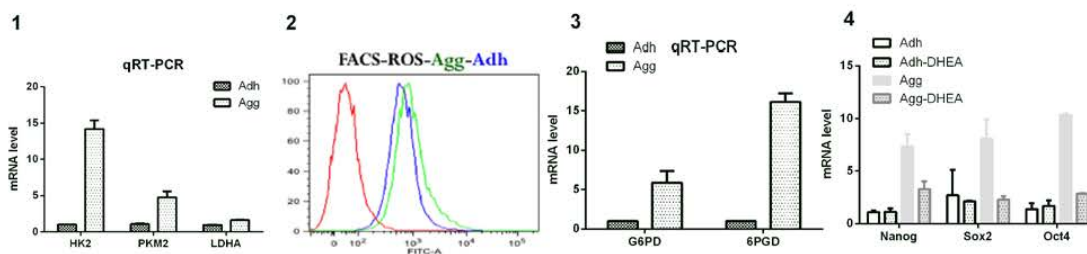


Figure 1. qRT-PCR measurement of glycolytic enzymes in hMSCs aggregates and adherent counterpart. 2. Flow cytometry measurement of ROS level. 3. qRT-PCR measurement of ppp enzymes. 4. qRT-PCR measurement of stem cell genes after PPP inhibitor DHEA treatment.

The results of present study demonstrate that energy metabolic transition plays an important role in hMSC stemness improvement under 3D culture. The metabolic transition could be further mediated by oxidative stress. Understanding the metabolism transition associated with hMSCs phenotypic changes has important implication for adapting 3D aggregation culture into as a non-genetic preconditioning method to potentiate hMSC properties for cell therapy.

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Graduate Student Poster Presentation 11

Fluorenyl-9-methoxycarbonyl-diphenylalanine Self-Assembly

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Abstract

Fluorenyl-9-methoxycarbonyl-diphenylalanine (FMOCFF) is one of the smallest known peptide-based molecules that undergoes nanofiber self-assembly. The diphenylalanine (FF) motif has been the focus of much study in recent years due to its presence in the amino acid sequence of A^β-42, the self-assembling peptide known to cause Alzheimer's disease¹. When dissolved in an organic solvent, such as DMSO, and exposed to water, FMOCFF in solution will form a hydrogel^{2,3}. The final microscale structure of the FMOCFF molecules is a nanofiber matrix^{2,3}. The nanofibers will regrow (self-heal) if broken by mechanical stress (e.g. being pushed through a syringe)⁴. The ability of nanofibers to self-heal, as well as other gel properties, is dependent on the solvent used in making the gel and on treatment of the gel after self-assembly⁴. The unique properties of this molecule and its relative simplicity make it an ideal system for studying basic principles of peptide self-assembly. Canonical protein analysis techniques (e.g., circular dichroism and Fourier transform infrared spectroscopy) have been used to examine FMOCFF and show evidence for an anti-parallel β -sheet structure⁵. Though there is some doubt as to how results from these experiments may be interpreted because of the presence of the FMOC group⁶. We will present solid state nuclear magnetic resonance (NMR) data that support the presence of anti-parallel β -sheet structure in FMOCFF nanofibers. Moving forward, we will use solid state NMR to probe the structure of FMOCFF gelled in environments of varying degrees of hydrophobicity. It is our hypothesis that the change in environment will lead to changes in molecular structure, giving insight into the nature of FMOCFF self-assembly.

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Graduate Student Poster Presentation 12

Expansion of Human Mesenchymal Stem Cells in Fibrous Bed Bioreactor

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Abstract

Expansion of human mesenchymal stem cells (hMSCs) in bioreactor while preserving their innate properties is important in translation of hMSC-based therapy to clinical applications. The present study investigates the feasibility of hMSC expansion in a 2.5 L CelliGen[®] 310 Bioreactor packed with Fibracel[®] disks. After 9 days of expansion, a 9.2-fold increase in cell number with the population doubling (PD) time of 2.8 days (67.2 hours) was achieved and that the specific glucose consumption and lactate production are measured to be 12.48 pmol/cell/day and 20.95 pmol/cell/day, respectively. hMSCs harvested from the bioreactor maintained their properties based on the analysis of phenotypic surface markers, colony forming unit-fibroblasts (CFU-F) number, and multilineage differentiation ability. The results demonstrate the feasibility and the potential of the fibrous bed bioreactor for large scale hMSC expansion.

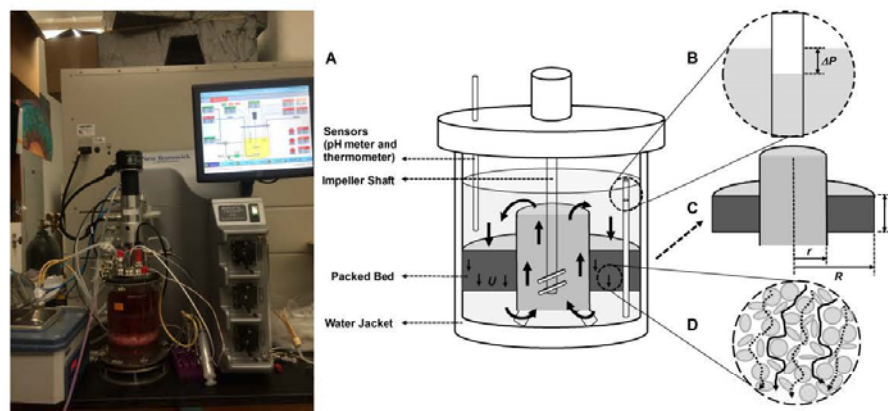


Figure 1. The setup and configuration of a 2.5 L CelliGen[®] 310 Bioreactor

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Graduate Student Poster Presentation 13

Aggregation Mechanism of Fibroblast Growth Factor-1 (FGF-1)

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Abstract

Fibroblast growth factor-1 (FGF-1) is an efficient angiogenic factor which has potential to be a pro-angiogenic biopharmaceutical drug for treatment of ischemic diseases (e.g., coronary heart disease^[1]). However, the significant obstacle in pharmaceutical

application is the intrinsically low thermodynamic stability of FGF-1^[2], which makes it highly aggregation-prone in heating, physical agitation, and abrupt changes in solution conditions (e.g., pH, ionic strength). Thus, to understand the mechanism of FGF-1 aggregation may be helpful for finding new methods to stabilize the protein during long term storage and administration.

In this study, we first analyzed the unfolding process of FGF-1 in different concentrations of guanidine hydrochloride (GuHCl) and extrapolate some important value of the two-state thermal unfolding process, such as G_{mf} and T_m . Then, without GuHCl, we found the apparent melting temperature varies according to the protein concentration and the scan-rate in differential scanning calorimetry (DSC). These results clearly exclude a simple two-state irreversible unfolding transition (N → D) and necessitating, at a minimum, an irreversible three-state model. Finally, to identify the ordered region in the FGF-1 aggregated state, solid-state NMR analysis was taken on aggregated, uniformly labeled ¹³C FGF-1 samples. The spectra of two-dimensional finite pulse radio frequency driven recoupling (fpRFDR) and CHHC do suggest a well-structured region with anti-parallel ²-sheet structure.

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Graduate Student Poster Presentation 14

Magnetic Resonance Electrical Impedance Tomography (MREIT)

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Abstract

Image reconstructions of conductivity pathways across an electrical conducting object is particularly advantageous in living subjects for its non-invasive approach and unique contrast. Future use of conductivity distribution information could be powerful in terms of diagnosing and monitoring wide range abnormalities. Magnetic Resonance Electrical Impedance Tomography (MREIT)^{1,4} is a relatively new technique that combines Magnetic Resonance Imaging (MRI) and Electrical Impedance tomography (EIT) to transform the ill-posed nature of the EIT problem to a well-posed one. The key idea in EIT is to inject a small current (on the order of 10mA) through electrodes that are attached to the surface of an electrical conducting object, and then measure the phase and amplitude of the corresponding induced voltage on these electrodes. These measurements are used to reconstruct the internal conductivity distribution. MREIT uses the magnetic flux density data obtained from the MRI scanner (in term of the phase change due to the perturbation of the main field) along with surface voltage data (as in EIT technique). The conductivity pathways are obtained from solving the Neumann boundary value problem using either J-based MREIT (obtaining the current density from the Ohm's law)¹ or Bz-based MREIT algorithms^{2,4} with a known initial conductivity value or a non-zero surface voltage data as the boundary condition. The primary goal of this project is to reconstruct the conductivity pathways across the abdominal ganglion in *Aplysia californica* to determine the connection between the internal conductivity distribution and the connectivity of the involved neurons.

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Graduate Student Poster Presentation 15

A Convenient Phase Transfer Protocol to Functionalize Gold Nanoparticles with Short Alkylamine Ligands

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Abstract

Aqueous citrate-stabilized gold nanoparticles (Au NPs) cannot be directly transferred from water to an immiscible organic solution using short alkyl ligands. However, Au NPs can be transferred from water to a water-organic interface if chemical and mechanical inputs are used to modify the interfacial energy and interfacial area. Ligand exchange can then take place at this interface. After separating the particles from the liquids, they can be transferred to a different organic phase.

Hexane, alkylamine, and acetone were added to aqueous citrate-stabilized Au NPs to form a film at the system interfaces. After removing the liquid phases, Au NPs were readily redispersed into tetrahydrofuran (THF). The preservation of the size and shape of the transferred Au NPs was evaluated by transmission electron microscopy (TEM) and small-angle X-ray scattering (SAXS).

Au NPs are readily segregated from water with the aid of short alkylamine ligands and form a thin film on water/organic solvent interface and water/glass interface, rendering them easy to separate from the liquid phases and possible to redisperse into another organic solvent. After the phase transfer process, Au NPs were functionalized with short amine ligands. In addition, the shape and size of Au NPs were preserved. The short amine-protected Au NPs in THF can stay stable for up to 27 day or longer.

Graduate Student Poster Presentation 16

The Influence of Input Voltage on H₂O₂ Production in Plasma Formed Along a Gas-Liquid Interface

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Keywords: Gas – liquid plasma; H₂O₂ efficiency; emission spectroscopy

Abstract

Plasma discharges with liquid water are of significant interest for applications in chemical synthesis as well as for the degradation of pollutants in water. In the case of pure water the formation of hydrogen peroxide and hydroxyl radicals is important. The high energy electrons from the plasma dissociate water molecules into hydroxyl radicals and atomic hydrogen. The plasma channel forms along the liquid – gas interface and H₂, H₂O₂ and other species are generated by radical recombination near this interface. Several parameters such as input energy, liquid conductivity, and reactor geometry contribute to the water treatment efficiency and hydrogen peroxide production rate. Therefore, in order to improve the efficiency of this plasma technique, the optimal operation conditions should be found.

In this work, the influence of input voltage was investigated by changing the value of the input voltage while keeping the other parameters fixed. The energy yield and production rate of hydrogen peroxide were determined under different input voltages. We utilized a tubular reactor with two hollow metal tube electrodes which also function as the inlet spray nozzle and the reactor outlet. The gas temperature and electron density were measured by optical emission spectroscopy, and UV – Vis spectroscopy was used to measure the concentration of hydrogen peroxide. Although the production rate of H₂O₂ increased as the input voltage increased; the H₂O₂ efficiency did not change significantly with the increase of input voltage. Since changing the input voltage changed the input power, these results imply that the amount of H₂O₂ formed is affected by input power. The gas temperature also increases slightly with the input power, however it doesn't change much when the mean discharge power is above 0.35 kW.

Graduate Student Poster Presentation 17

COMSOL Two-phase Flow Level Set Method

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Abstract

Gas-liquid two phase flow is important for many chemical reactors and in the present work we deal with gas-liquid flow that occurs in a non-thermal plasma reactor for the production of hydrogen peroxide. However, it is not easy to determine the details of fluid behavior and the interface formed in the complex gas-liquid flow. In the present work we utilize COMSOL Multiphysics to model the fluid flow.

In this work, the Laminar Two-phase flow level set method was used to model gas and liquid two phase flow in a small plasma reactor. The reactor size in the model corresponds to the experimental work and is assumed cylindrical with a diameter of 3 mm and length of 4 mm. The reinitialized, conservative level set method is used to describe and convect the fluid interface and this approach provides a way to model the fluid interface with a finite thickness. This approach can allow the computation of the interface movement and deformation on fixed grids. The velocities of the two fluids and the time ranges are the most important factors in this simulation. We perform simulations of different velocities and time ranges. In combination with these simulations studies, high speed photography of air-water flow in the small plasma reactor is conducted.

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Graduate Student Poster Presentation 18

Expansion and Thermal Release of Human Mesenchymal Stem Cells from Micro-Carriers

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Abstract

Mesenchymal stem cells (MSCs) harvested from bone marrow has the ability to differentiate into bone, cartilage and adipose tissue, together with the trophic property and anti-inflammatory that will enhance the tissue repair and regeneration process. Common 2D culture provides only small cell yield with the limitations of space and supply. To perform large-scale cell culture, 3D culture using micro-carriers in bioreactor as cell-growing platform is widely studied. Another aspect for large-scale culture of cells is to harvest cells efficiently while maintain their functions. Introducing chemicals and enzyme for detachment, such as trypsin or dispase, may influence the cellular properties of stem cells. Surface modification with polymers provides the potentials for non-enzymatic cell harvest.²

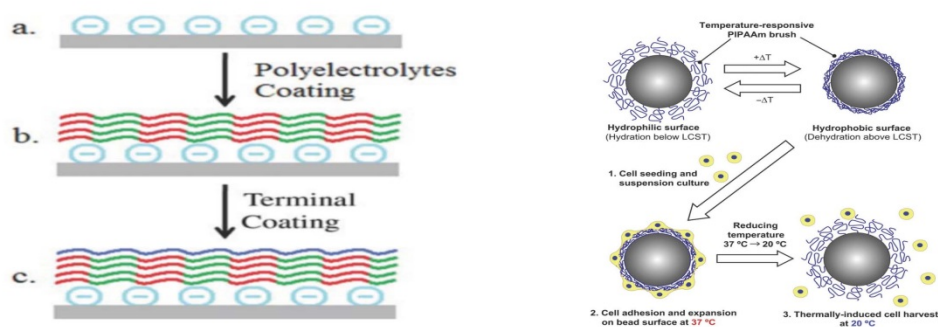


Figure 1. Copolymer multi layers formed on the micro-carrier by ion bonds¹ and diagram of the mechanism of cell thermo-release².

In this work, both surface modification and scale up culture were studied using thermal response copolymers (PAH-co-PNIPAM and PSS-co-PNIPAM) and different micro-carriers. The toxicity, cell growth and detachment were tested on 2D glass slides and micro-carriers.

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Graduate Student Poster Presentation 19

Measuring Water Diffusion in Block Copolymer Membranes with Fourier Transform Infrared–Attenuated Total Reflectance (FTIR-ATR) Spectroscopy

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Abstract

Poly(styrene-*block*-ethylene oxide) (PS-*b*-PEO) membranes are of interest for lithium-air batteries, carbon dioxide separation, and water purification. Water purification requires high water flux through purification membranes, whereas low water flux is needed for lithium-air battery stability. The presence of water can significantly affect the permeation of carbon dioxide during gas separation. Therefore, accurate measurement of both water sorption and diffusion in PS-*b*-PEO membranes is important. Our research focuses on using FTIR-ATR spectroscopy to measure water diffusion in PS-*b*-PEO and poly(ethylene oxide) homopolymer membranes at different water activities. Equilibrium water uptake in the membranes was also measured using gravimetric sorption experiments. The time-resolved intensity of infrared absorbances associated with water vibrations were used to determine the normalized water concentration in each membrane as a function of time. These transient concentration measurements were used to determine water diffusion in the PS-*b*-PEO and PEO membranes. These results will be discussed in terms of Fickian and non-Fickian behavior of water transport in the membranes at the various relative humidities. In addition to providing fundamental insight into water transport in PS-*b*-PEO membranes, these studies could lead to better performing separation membranes or solid electrolytes for lithium-air batteries.

Graduate Student Poster Presentation 20

Application of Thermal Inter-diffusion Processing in PHJ Structure Perovskite Solar Cells

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Abstract

Organolead trihalide perovskite materials have been successfully used as light absorbers in efficient photovoltaic cells¹ with a rapid improvement of cell efficiencies from less than 4% in 2009 to a certified 20.1% in 2014². There are many process methods to fabricate the perovskite thin film, such as single solution process, two-step solution process, vapor deposition. And as one among them thermal inter-diffusion process has shown its advantages on film morphology and device efficiency³. Now our group are focused on application of this method to build solar cell devices in such structure: Al/PCBM/CH₃NH₃PbI₃/PEDOT:PSS/ITO/glass. I have been optimizing the thicknesses of each layer and process conditions, etc. The figure 1 is a brief introduction of this process method and figure 2 is a sample result of my devices.



Fig 1. Thermal Inter-diffusion method

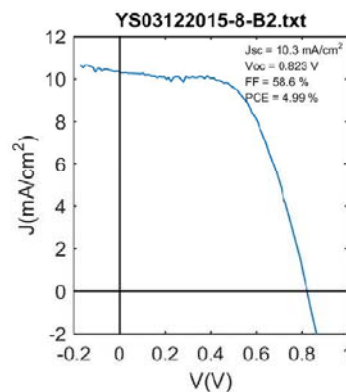


Fig 2. J-V curve sample

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Graduate Student Poster Presentation 21

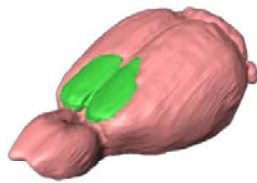
Tracking Stem Cells in Irradiated Traumatic Brain Injury Models using ^1H MRI at 11.75 T

Nastaren Abad^{1,2}, Abdol Aziz Ould Ismail^{1,2}, Ali Darkazali³, Cathy Levenson³, Samuel C. Grant^{1,2}

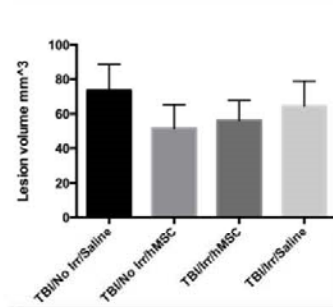
¹The National High Magnetic Field Laboratory, The Florida State University, Tallahassee, FL ²Chemical and Biomedical Engineering, The Florida State University, Tallahassee, FL ³Department of Biomedical Sciences and Program in Neuroscience, Florida State University College of Medicine, Tallahassee, FL, USA

Abstract

Traumatic brain injury (TBI) is associated with an expansive set of symptoms and disabilities. In the U.S, 1.5 million TBI incidences are reported annually and about 2% of the American population lives with impairments associated with TBI¹. This study explores stem cell mediated therapies and effects on neurogenesis in TBI as detected by high field magnetic resonance imaging (MRI). To provide a clean backdrop for the analysis of stem cell therapies, irradiation has been shown to deplete multi-potent neural stem cells. Therefore, this study employs irradiation² to eliminate endogenous cell populations and test functional recovery of TBI site following stem cell therapy. High resolution, *ex vivo* rat brain imaging at 11.75 T is being conducted to generate ^1H images of the region of interest. Currently, MRI experiments are being performed using 3D FLASH sequences with field of views (FOV) of 2.8 x 2.5 x 2.5 mm and 100-micron spatial resolution and diffusion tensor imaging (DTI) sequences of 2.5 x 2.5-mm FOV and 100-micron resolution. The goal of this effort is to detect changes in brain structure and connectivity due to the TBI and track progression of the injected stem cells.



3D rendering of a TBI site (green)



Volumetric analysis at the TBI with and without the presence of endogenous or exogenous stem cells

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Graduate Student Poster Presentation 22

Lignin-induced Self-healing Polymer

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Self-healing polymer is an increasingly popular topic as its special function to make material useful. Because most of modern polymeric materials are designed for single purpose disposable items, polymers with a self-healing function can lengthen the lifespan of polymers and expand their corresponding applications significantly. An important driving force of secure self-healing property is formation of covalent bonds and/or non-covalent bonds at materials' damaged area. Diels-Alder reaction is the mostly used covalent bond, and non-covalent bond has formats as hydrogen bonding, π - π stacking and metal complex. The materials' healing process can be facilitated by external stimulation such as heat, light, electricity, and pressure.

In the present research, we have developed a lignin-based self-healing polymers. The lignin is a biopolymer that is driven from a plant. Because of its abundancy, cheap price, biodegradability, and physical/chemical stability, the lignin can be a very useful base material of self-healing polymers. In particular, lignin has abundant hydroxyl groups that can be used for various chemical modifications.

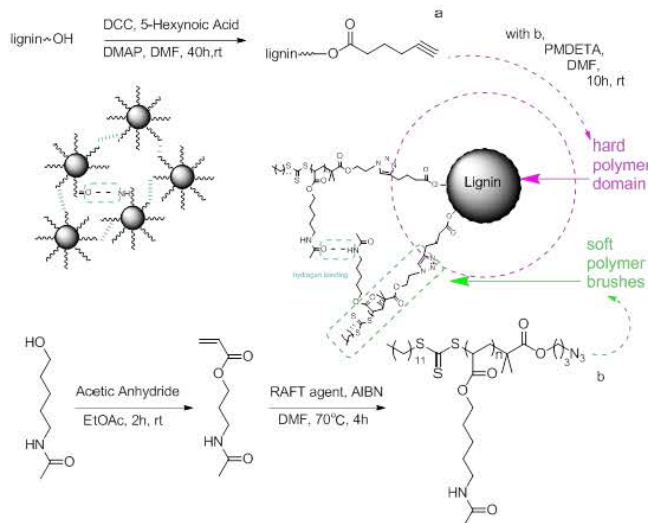


Figure 1. Synthesis of lignin core – polymer arm self-healing materials. The final lignin-based polymers' mechanical and self-healing properties can be controlled by length/density of acetyl amino group containing polymers. Finally, the prepared lignin-based polymers were tested by tensile/compression tester to confirm polymer's self-healing/mechanical properties.

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Graduate Student Poster Presentation 23

Studying Voltage Stability of Polymer Electrolyte on Planar Metal Electrodes

Alexander Rausch, Daniel Hallinan Jr.

Chemical & Biomedical Engineering, FAMU-FSU College of Engineering

Abstract

Lithium batteries offer high energy density, high capacity, and long cycle life. However, these batteries use dangerous organic solvents in the electrolytes that can lead to malfunction, fires, and explosions. Polymer electrolytes are being used to replace these dangerous organic solvents as safer alternatives. In order for polymer electrolytes to become commercially feasible, they must be stable at high voltages. This project aims to determine the voltage stability of solid polymer electrolyte with different metal current collectors for use in solid-state lithium batteries. In particular, it focuses on poly(ethylene oxide) (PEO) doped with lithium bis-trifluoromethanesulfonimide salt (LiTFSI) as the electrolyte at a molar ratio of 0.085 mol(Li⁺)/mol(EO). Copper, aluminum, and gold are used as the various working electrodes, and lithium is used as the counter electrode. Impedance spectroscopy is used to verify that the half-cells are well assembled by comparing the conductivity to literature values. Voltammetry is used to characterize the voltage stability of the electrolyte in the different half-cell assemblies. The results of these experiments will help determine battery materials that allow for better voltage stability in solid state batteries.

Graduate Student Poster Presentation 24

Gel Formation in Binary Mixtures of Nanocolloids with Short Range Attraction

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Abstract

Colloidal suspensions transform between fluid and disordered solid states as parameters such as the colloid volume fraction and the strength and nature of the colloidal interactions are varied. Seemingly subtle changes in the characteristics of the colloids can markedly alter the mechanical rigidity and flow behavior of these soft composite materials. This sensitivity creates both a scientific challenge and an opportunity for designing suspensions for specific applications. Employing a combination of x-ray photon correlation spectroscopy (XPCS), rheometry, and molecular-dynamics simulations, we investigate the phase behavior and microstructural dynamics of binary mixtures of nanocolloids with a size ratio near two that are driven through a gel transition by the introduction of an intrinsic short-range attraction. The fluid-gel boundary of the mixtures does not follow an ideal mixing law, but rather the gel state is stable at significantly weaker interparticle attraction in the mixtures than in the corresponding monodisperse suspensions. In contrast with depletion-driven gelation at larger size ratio, gel formation in the mixtures coincides with dynamic arrest of the smaller colloids while the larger colloids remain mobile. This arrest results from microphase separation that is triggered by the attraction and that drives the smaller particles to form dense regions. These observations thus indicate a potential new avenue for tailoring the gel-forming properties of colloidal suspensions through judicious combination of interparticle interaction and size distribution.

Graduate Student Poster Presentation 25

Biological Relevance of YAP Regulation by Wnt Signaling During Neural Differentiation of Human Induced Pluripotent Stem Cells

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Abstract:

Human induced pluripotent stem cells (hiPSCs) have the special ability to self-assemble into microtissues or mini-organ like structures (e.g., mini-brains). Wnt signaling has been recently shown to impact regional patterning and positional identity of hiPSC-derived neural progenitors. One function of Wnt signaling is to regulate YAP expression (nuclear or cytoplasmic), the pivotal regulator of cell proliferation and differentiation during organ growth and tissue regeneration. However, the crosstalk between Wnt and YAP expression during neural differentiation of hiPSCs has not been well investigated. The objective of this study is to reveal the capability of Wnt signaling in the regulation of YAP expression to modulate 3-D neural microtissue formation from hiPSCs. In the preliminary study, human iPSK3 cells were induced toward neural lineages in the absence or the presence of dual SMAD inhibitors LDN193189 and SB431542 through embryoid body (EB) formation. Wnt signaling was activated using CHIR99021, which was found to induce nuclear localization of YAP. In addition, CHIR99021 treatment upregulated the expression of HOXB4, the marker for hindbrain/spinal cord, while in the absence of Wnt activation, the cells maintained rostral forebrain neural identity (expression of TBR1, PAX6 etc.). Stiffening the EBs using microparticles did not affect neural marker expression, but the cells seemed to be more responsive to Wnt activation. This study will advance our understanding on the biological processes regulated by Wnt signaling and YAP activity during neural tissue patterning. The research outcome has the significance in neurological disease modeling, drug screening, and neural tissue regeneration.

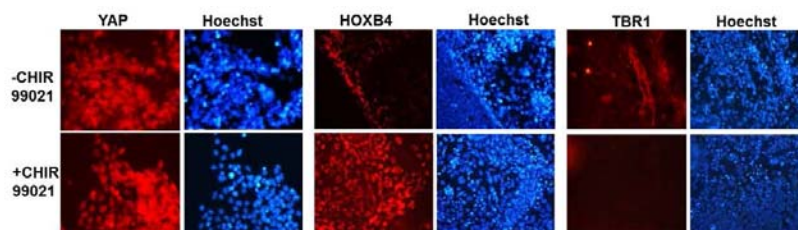


Figure 1. Expression of YAP, HOXB4, and TBR1 in the absence or the presence of Wnt activator CHIR99021 in neural progenitor cells derived from human iPSK3 cells.

Graduate Student Poster Presentation 26

PCL-PDMS-PCL Copolymer-based Microspheres Mediated Cardiovascular Differentiation from Embryonic Stem Cells

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Abstract:

Poly-ε-caprolactone (PCL) based copolymers have received much attention as drug or growth factor delivery carriers and tissue engineering scaffolds due to their biocompatibility, biodegradability, and tunable biophysical properties. However, the influence of biophysical properties of PCL-based co-polymers on stem cell lineage commitment is not well understood. In this study, polydimethylsiloxane (PDMS) was used as soft segments of varying length to tailor the biophysical properties of PCL-based co-polymers. While low elastic modulus (<10 kPa) of the tri-block copolymer PCL-PDMS-PCL affected cardiovascular differentiation of embryonic stem cells, the range of 50-120 MPa PCL-PDMS-PCL showed little influence on the differentiation. Then different size (30-140 μm) of microspheres were fabricated from PCL-PDMS-PCL co-polymer (60-115 MPa) and incorporated within embryoid bodies (EBs). Mesoderm differentiation was induced using bone morphogenetic protein (BMP)-4 for cardiovascular differentiation. Differential expressions of mesoderm progenitor marker KDR and vascular markers CD31 and VE-cadherin were observed for the cells differentiated from EBs incorporated with microspheres of different size, while little difference was observed for cardiac marker α-actinin expression. Small size of microspheres (30 μm) resulted in higher expression of KDR while medium size of microspheres (94 μm) resulted in higher CD31 and VE-cadherin expression. This study indicated that the biophysical properties of PCL-based copolymers impacted stem cell lineage commitment and thus should be considered for drug delivery and tissue engineering applications.

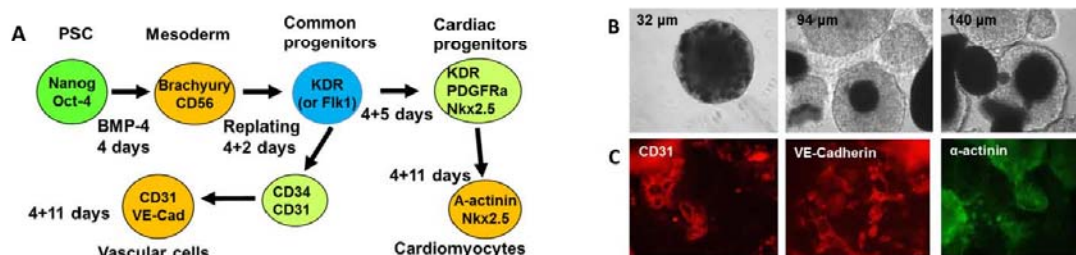
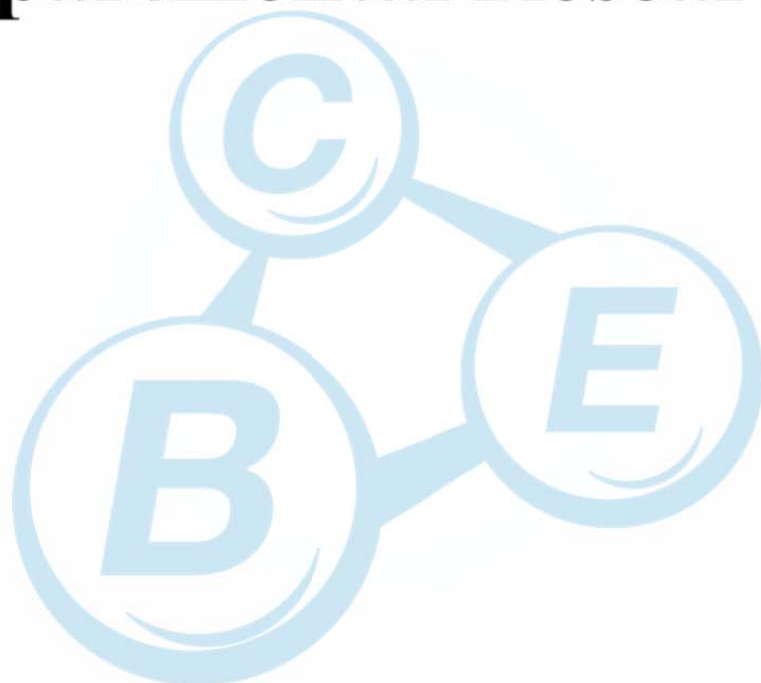


Figure 1. A: Schematic illustration of cardiovascular differentiation of embryonic stem cells. B: Embryoid bodies (EBs) incorporating PCL-PDMS-PCL microspheres of different size. C: The expression of cardiovascular markers in the cells differentiated from EBs incorporated with microspheres.

2015 Departmental Research Day



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