Department of Chemistry and Biochemistry Faculty Research Areas

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Dr. Pradip K. Bhowmik
Materials Chemistry Lab

Our interests focus on organic and polymer synthesis in general. More specifically, we are interested in developing novel light-emitting and liquid-crystalline polymers for their multitude applications in modern technology, including biosensors.

In another project, we are developing ionic liquids and ionic liquid crystals for their better ionic conductivities as electrolytes for next generation batteries. Significant efforts are concentrated on the development organic ionic plastic crystals for the solid state batteries.

Carbon nanotube-based composite materials based on ionic polymers are of significant interest in our group. In recent years, we are also actively pursuing the development of cisplatin analogs for cancer therapy.

Colorful Pyrylium Salts

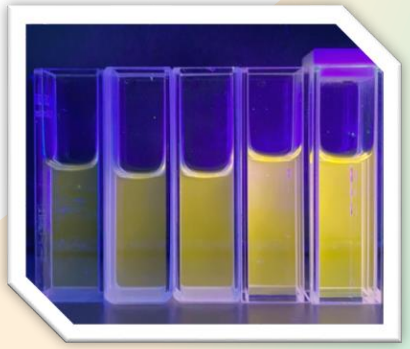
Liquid Crystalline Texture

Fluorescent Pyrylium Solution

Dr. Pradip K. Bhowmik Materials Chemistry Lab

Current Research Interests

- Thermotropic and Lyotropic Liquid Crystalline Polymers
- Polyesters, Viologen Polymers, Poly(pyridinium salt)s
- Fire Retardant Polymers
- Light-Emitting Properties of Polymers
- Photo-responsive Polymers
- Proton and Anion Exchange Membranes
- Oxidation of Carbohydrates by Viologens
- Ionic Liquids, Liquid Crystals, and Plastic Crystals
- Novel Light-Harvesters for Solar Energy Storage
- Fluorescent Molecules for Cell Imaging
- Pyrylium Salt Chemistry
- Lasing Properties in Organic Solvents and Water
- Two Photon Induced Absorption Fluorescent Properties
- Piezochromic Materials
- Magnetic Materials
- Cisplatin Analogues for Cancer Therapy



Polymer Flame Testing

Interfacial Photochemistry

- **Dr. Jared P. Bruce**
- Assistant Professor
- Department of Chemistry and Biochemistry
- Email: jared.bruce@unlv.edu
- Website: jpbruce.faculty.unlv.edu

Expertise

- Heterogeneous Photochemistry
- Electrocatalysis
- Photocatalysis
- Atmospheric Chemistry
- Surface Chemistry and Interfacial Characterization
- Near Ambient Pressure Photoelectron Spectroscopy

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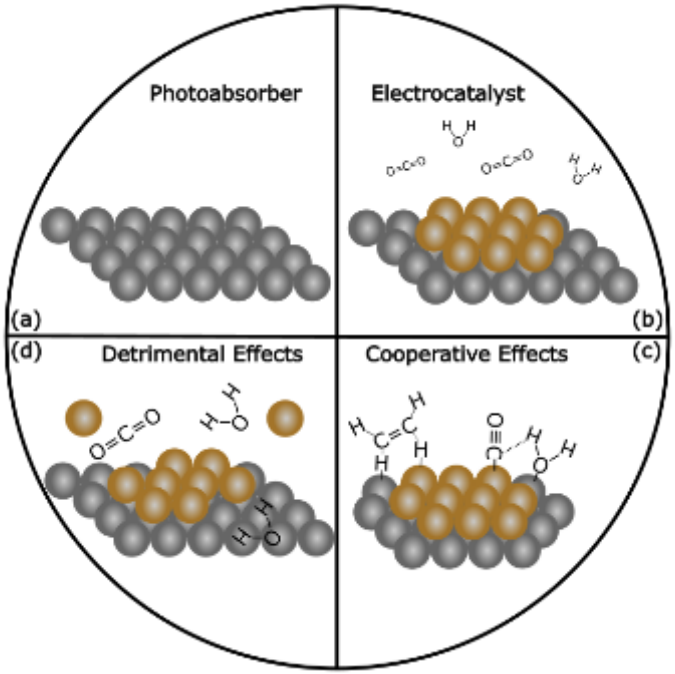
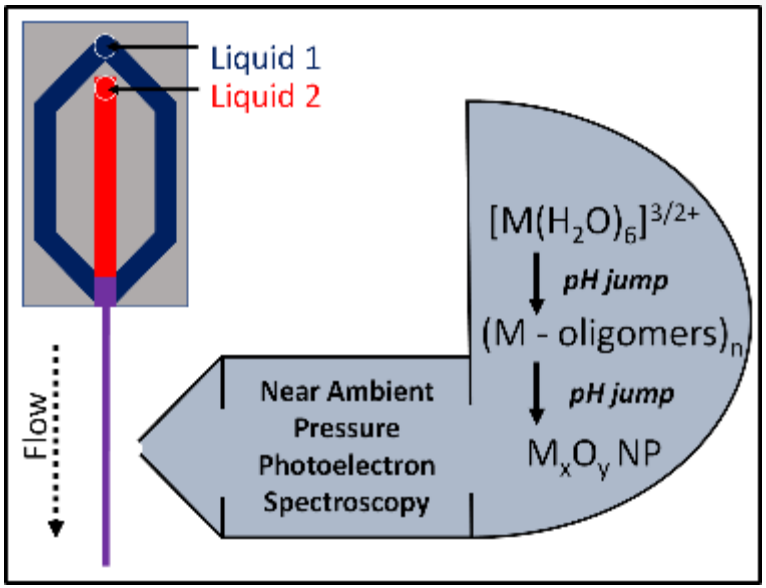
Hybrid Co-Catalyst/Photoabsorber Photochemical Interfaces



- Metals often make good electrocatalysts
- Semiconductors make good photoabsorbers
- The combination of the two create a new, complex interface that can be leveraged to increase the efficiency of co-catalyst/photoabsorber devices

Mixing Liquid Jet Photoelectron Spectroscopy



- Dynamic processes are tricky to study at the liquid surface
- A small liquid jet (20µm dia.) is used to investigate the liquid surface
- Microfluidic chips provide mixing chamber to induce chemical reactions

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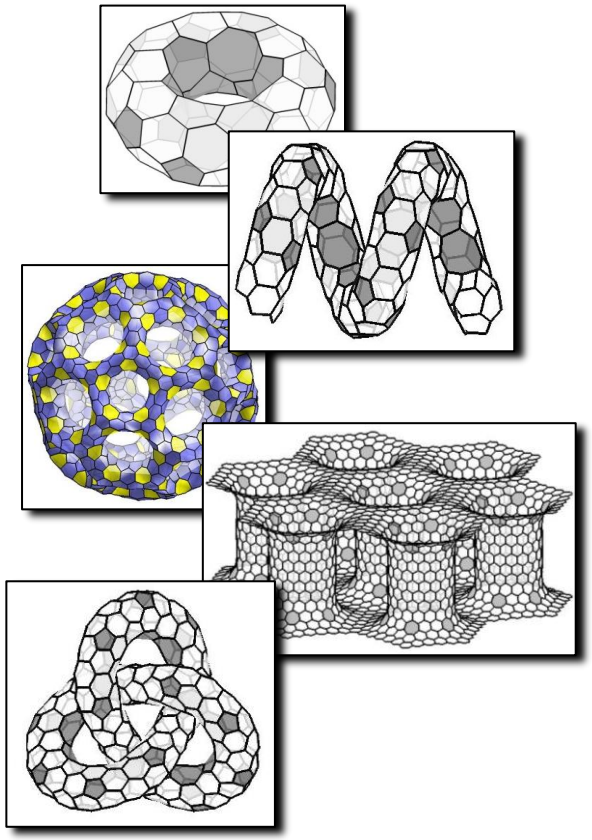
Theoretical chemical physics

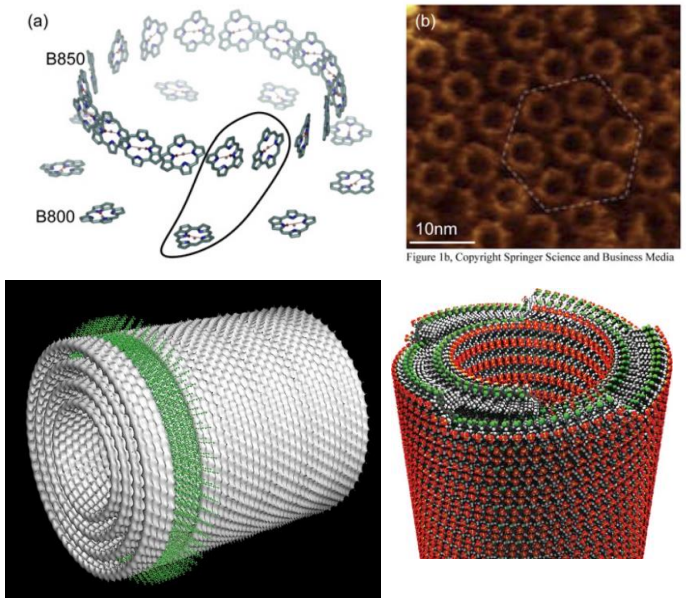
- Dr. Chern Chuang,
- Assistant Professor, Department of Chemistry and Biochemistry
- Email: chern.chuang@unlv.edu
- Website: http://cchuang.faculty.unlv.edu/Home.html

- Expertise
  - Open quantum system dynamics and spectroscopy
  - Photophysics and photochemistry of materials
  - Quantum transport
  - Quantum effects in biology
  - Exotic geometries and topologies of low dimensional materials

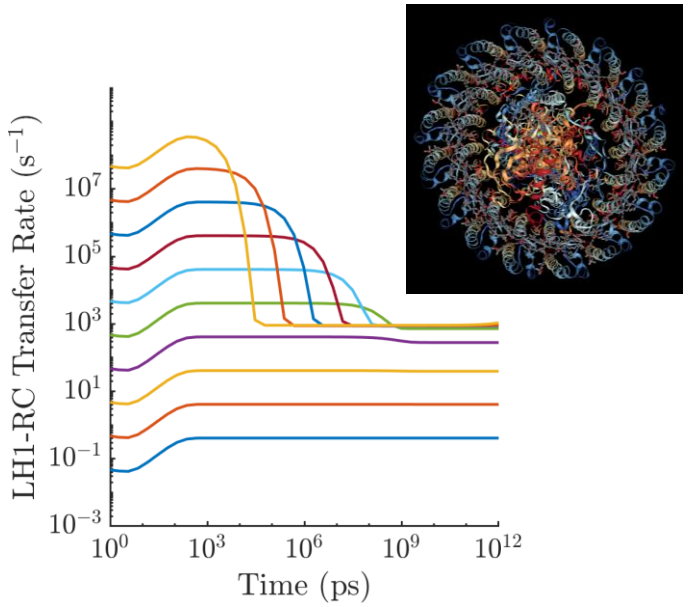
Theoretical chemical physics

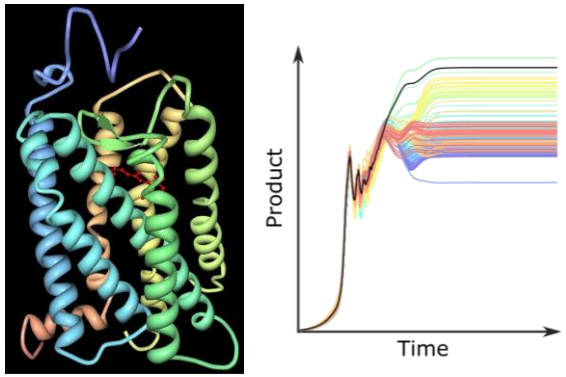


Exotic low-dimensional materials



Photophysics of organic materials





Photochemistry under environmental control

Radiochemistry

Paul M. Forster
Department of Chemistry and Biochemistry
Radiochemistry

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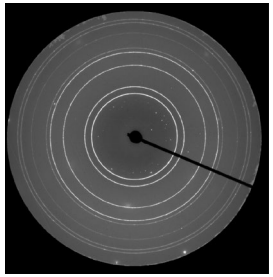
Expertise:

-Structure determination (X-ray and neutron diffraction, total scattering)



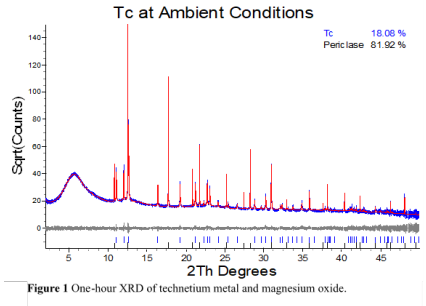
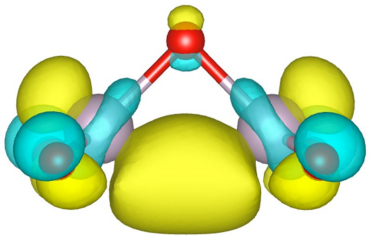
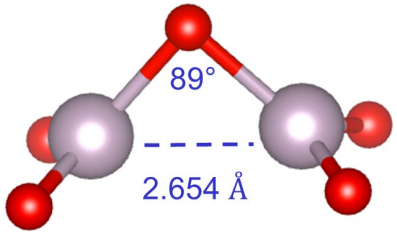


Figure 1 One-hour XRD of technetium metal and magnesium oxide.

-Structure-property relationships, integrated simulation

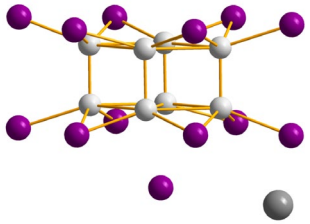


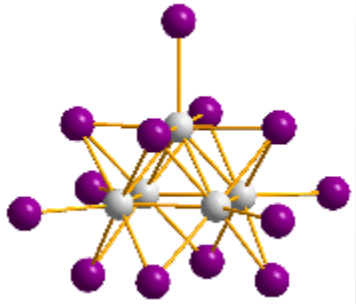


Probable identification of a gas phase technetium oxide molecule

-Hydro/solvothermal synthesis

Technetium iodide compounds prepared solvothermally





Paul M. Forster
Department of Chemistry and Biochemistry
Radiochemistry

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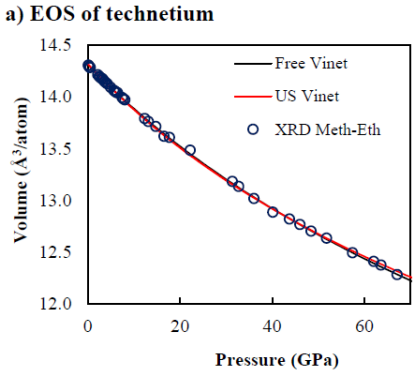
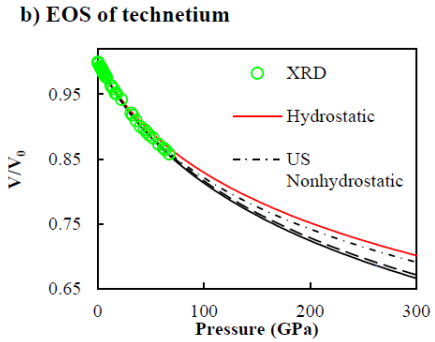
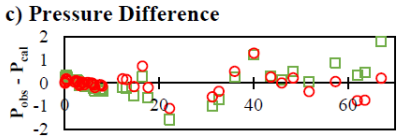
Relevant projects:

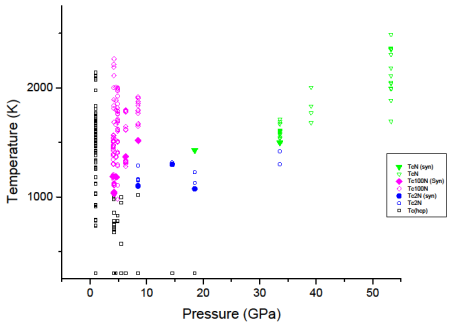
First diffraction-based equation of state for elemental Tc

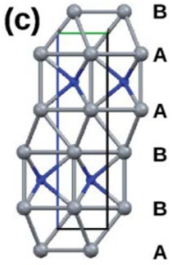


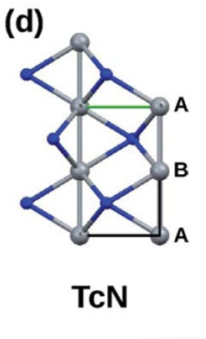




Discovery of new binary Tc nitrides







Paul M. Forster
Department of Chemistry and Biochemistry
Radiochemistry

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Art Gelis

Director, Radiochemistry Program

Actinide Separations and Recovery

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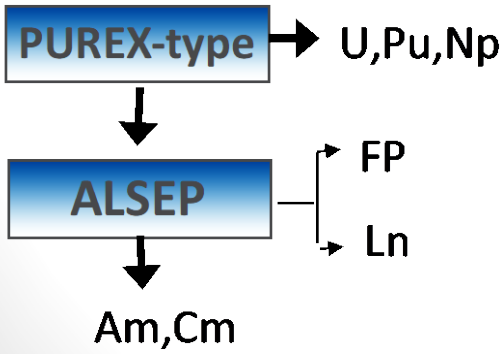
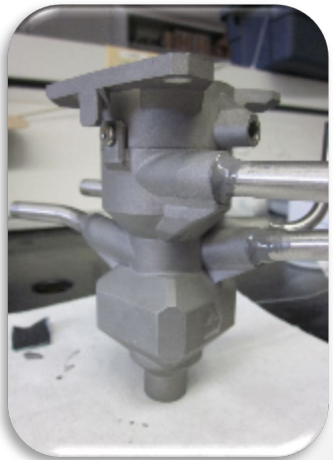
Design and Testing of Advanced Separation Processes using Additive Manufacturing

- **Liquid-Liquid Extraction and Separation of Plutonium, Uranium, Minor Actinides, Lanthanides and Fission Products**
- **Twenty-seven 3D-printed acrylic centrifugal contactors (CC), fabricated at Argonne National Lab are available at UNLV**
- **Contactors can be 3D-printed in stainless steel or any alloy**
- **Solvent extraction separations can be tailored to a specific goal**
- **Example: Actinide Lanthanide SEParation process - ALSEP, designed and tested for DOE-NE**



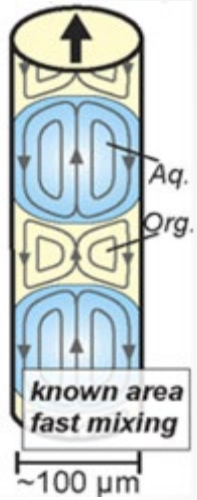
10+1 acrylic CC

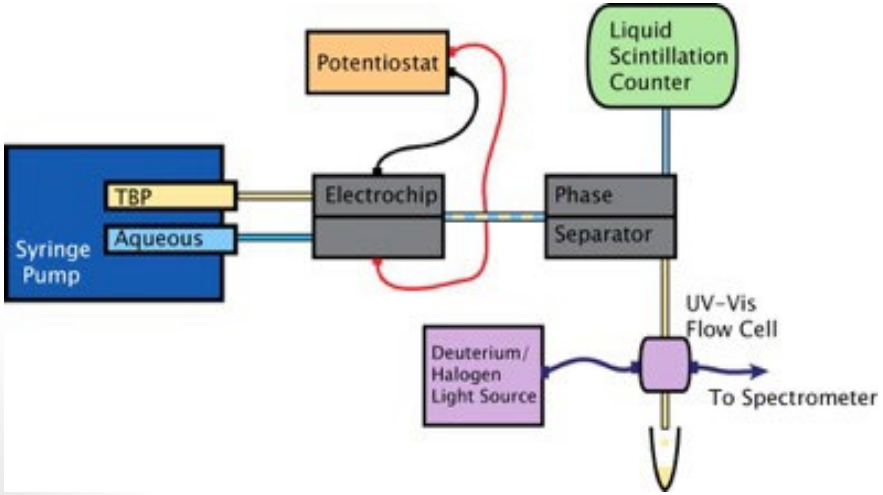
Steel CC

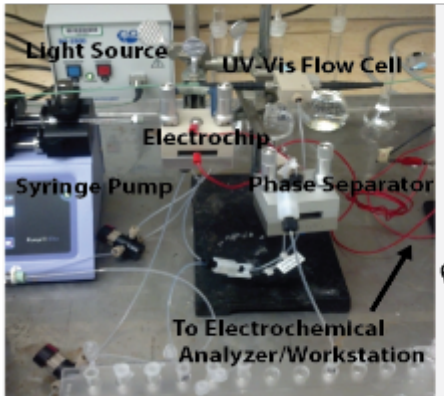


Microfluidic Systems for Rapid Radionuclide Separation and Detection

- **Microfluidic device to combine aqueous and organic phases, rapidly mix, then separate phases, following by analysis**
- **Selective Extraction of radionuclides on a very small scale**
- **Can be implemented either as a bench-top setup or as a portable detector**
- **Potential applications: rapid Pu separation and detection from Uranium and FP for safeguards; ”dirty bomb” analysis**







Strategic Materials Analysis and Recovery – David Hatchett and Ken Czerwinski

Dissolution of UF_6 into IL at 0 hours, 24 hours, 30 days, and the recovery of UF_6 salt.

Expertise:

- Actinide, Lanthanide, and Li materials recovery from Ionic Liquids (Ils).
- Electrochemical, Spectrocopic, and thermal analysis of Radioactive materials.
- Radiochemistry and Analytical Chemistry.

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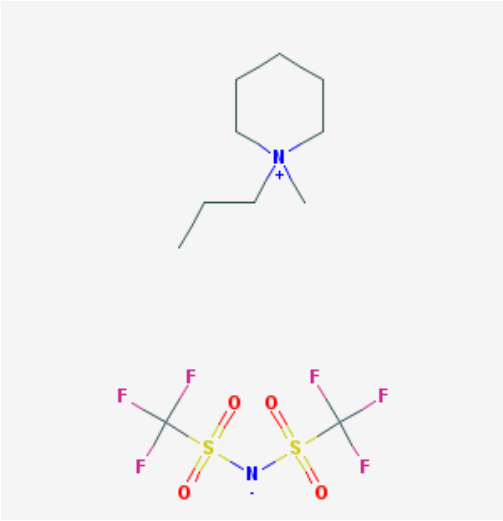
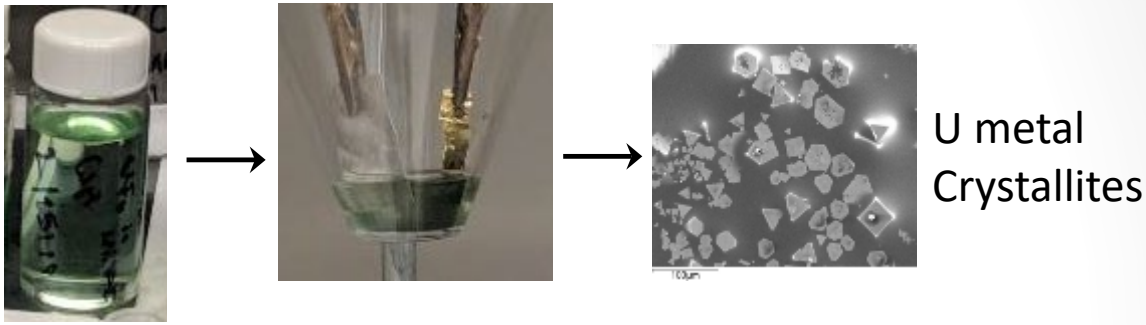
Strategic Materials Analysis and Recovery – David Hatchett and Ken Czerwinski



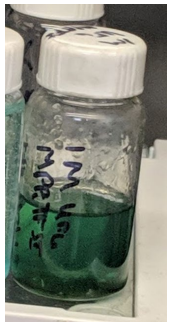
1-methyl-1-propyl piperidinium bis(trifluoromethylsulfonyl)imide [MPPi][TFSI]

Electrochemistry

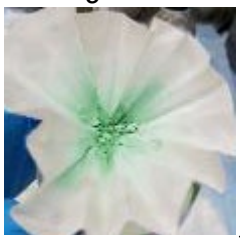


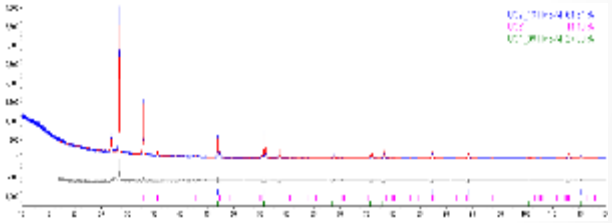
U metal Crystallites

Low Concentration 0.1 M



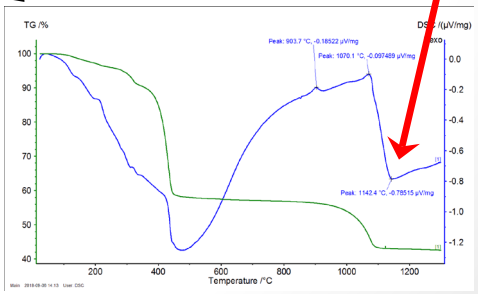
UF_6 salt





Air

U metal



$$UF_6 + 2\ TFSI^- \rightarrow UF_6^{2-} + 2\ TFSI\cdot$$

$[MPPi]_2[UF_6]$

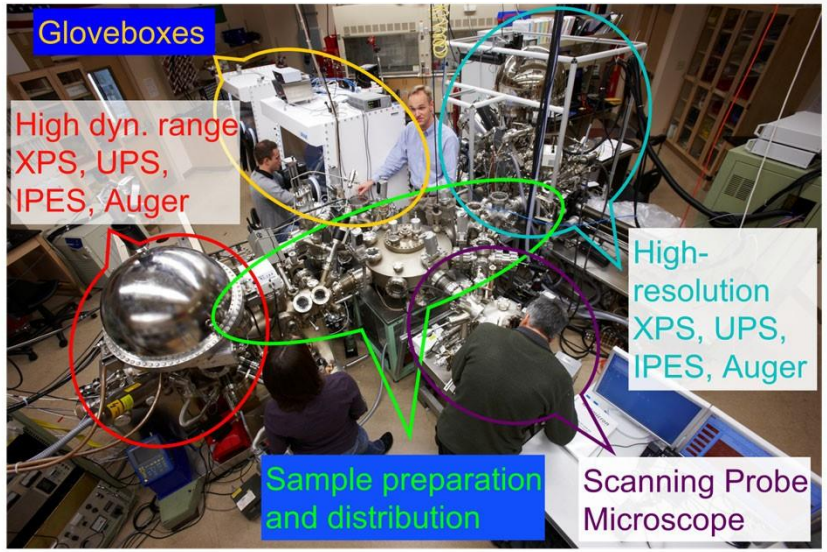
UF_6 salt

High Concentration 0.95 M

Paths to U recovery from UF_6 dissolved in IL

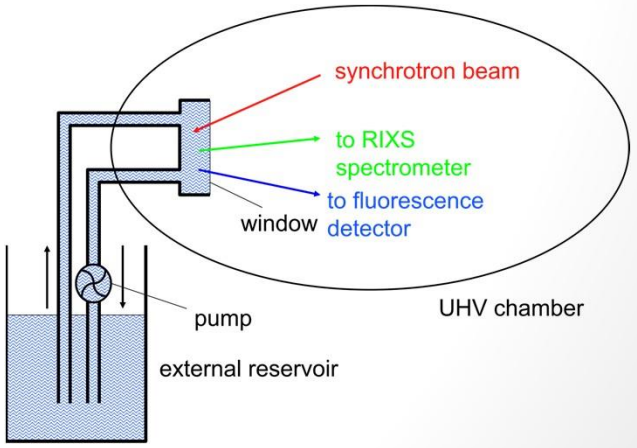
Surface and Interface Characterization of Materials for Energy Conversion

- **Dr. Clemens Heske**
- Professor
- Department of Chemistry and Biochemistry
- Email: heske@unlv.nevada.edu
- Website: https://heske.faculty.unlv.edu//



Expertise

- Electronic and Chemical Structure of Energy-Conversion Materials
- Surface and Interface Characterization
- Soft x-ray and Electron Spectroscopy
- Scanning Probe Microscopy
- Synchrotron Radiation



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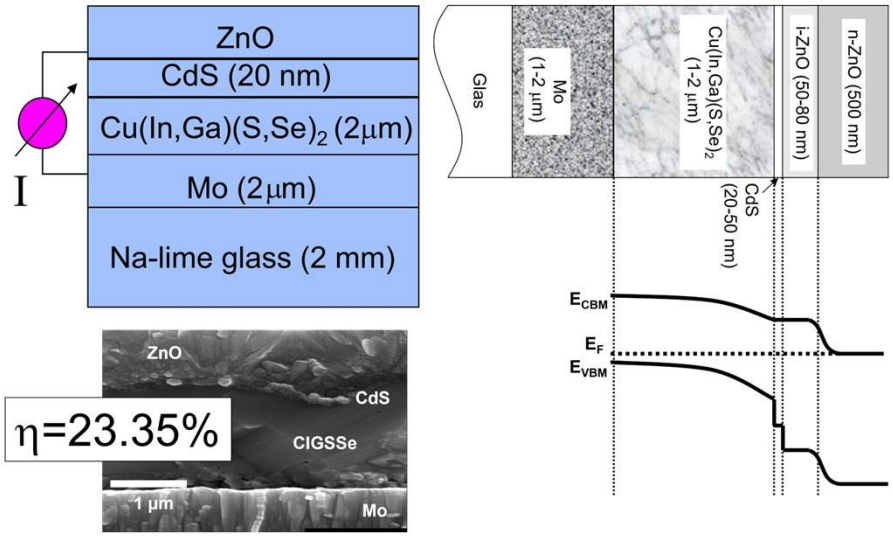
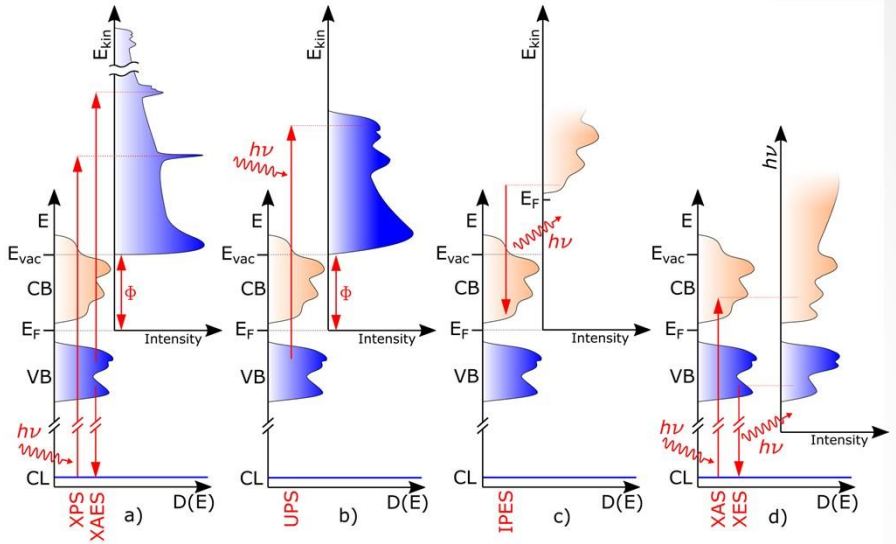
Surface and Interface Characterization of Materials for Energy Conversion

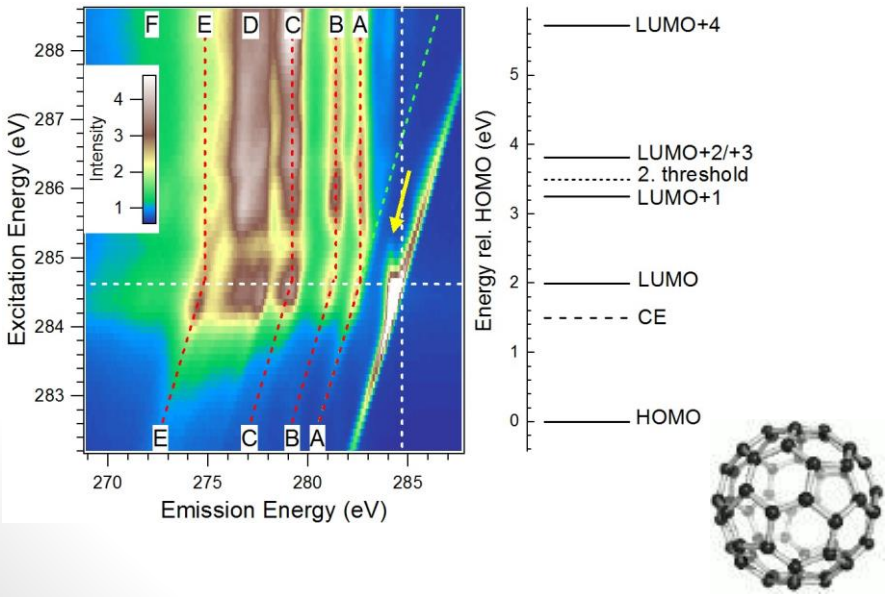
Cu(In,Ga)(S,Se)$_2$ Thin-Film PV Device



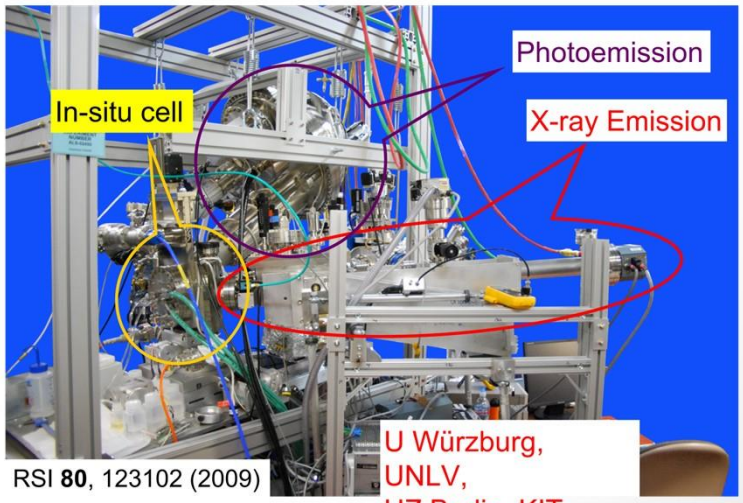
Method development



Electronic structure of C_{60}



SALSA: Solid And Liquid Spectroscopic Analysis



RSI **80**, 123102 (2009)

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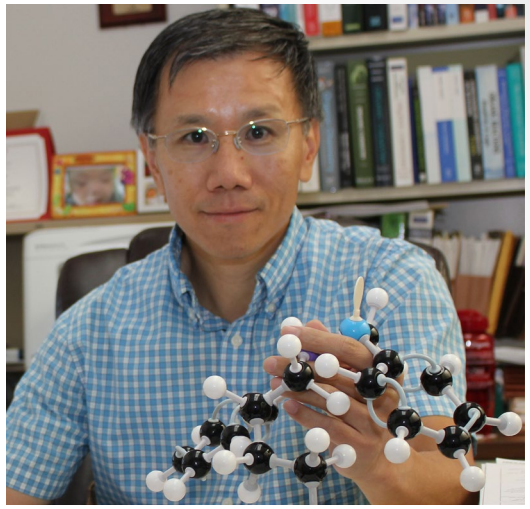
Jun Yong Kang

- Assistant Professor, Department of Chemistry and Biochemistry
- Ph.D., Chemistry, Texas A&M University, College Station, TX
- CHE 217B, junyong.kang@unlv.edu
- http://jkang.faculty.unlv.edu/?page_id=110



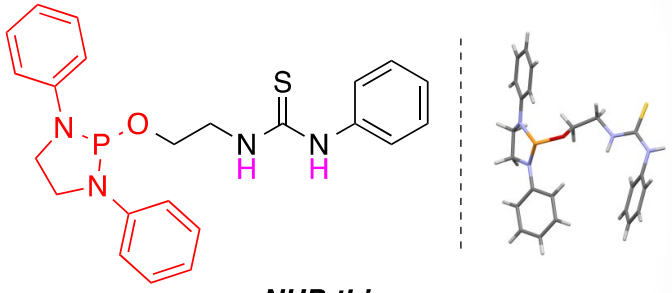
Areas of Expertise

- Synthetic organic chemistry
- Development of new synthetic methodology
- Asymmetric organocatalysis
- Organophosphorus chemistry
- Synthesis of bioactive small molecules

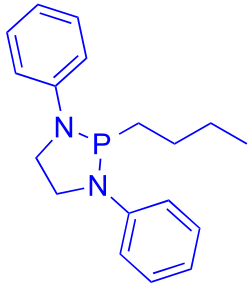
Research Summary:

The development of new synthetic methodologies plays a key role in medicinal chemistry, biochemistry, and materials chemistry. Professor Kang and his group have been developing novel synthetic transformation and new chemical reagents such as commercially available NHP-thiourea and NHP-butane to apply for pharmaceuticals and bioactive molecules.

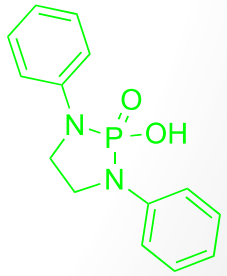
Kang's reagents-commercially available at Kerafast



NHP-thiourea
(phosphonylation reagent)



NHP-butane
(organocatalyst)



NHPA
(organocatalyst)

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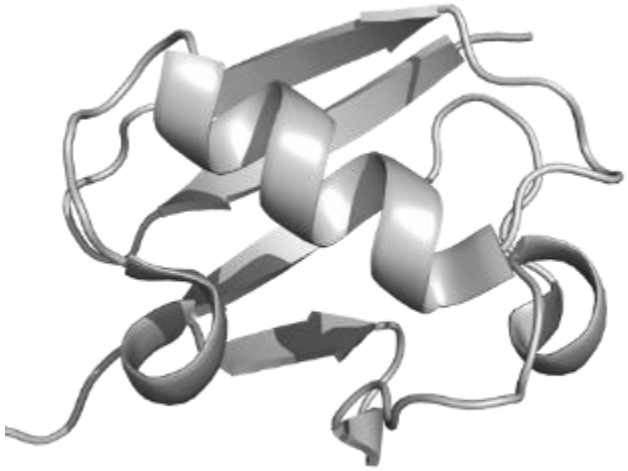
Ubiquitin-mediated protein degradation

Dr. Gary Kleiger
Professor and department Chair
Department of Chemistry and Biochemistry
gary.kleiger@unlv.edu
https://kleiger.faculty.unlv.edu



Expertise

- Structural biology
- Proteomics
- Enzyme kinetics and biophysical assays
- Cell biology

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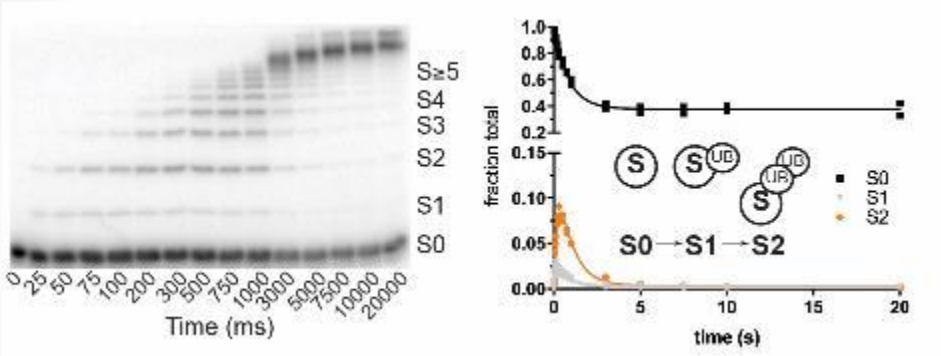
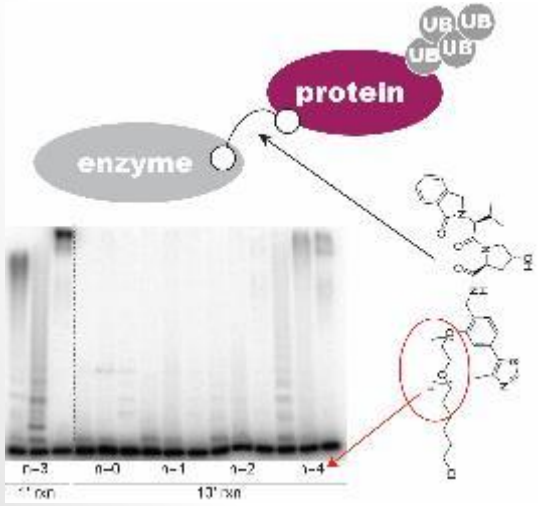
Uncovering how the enzymes that promote protein degradation function in human cells.

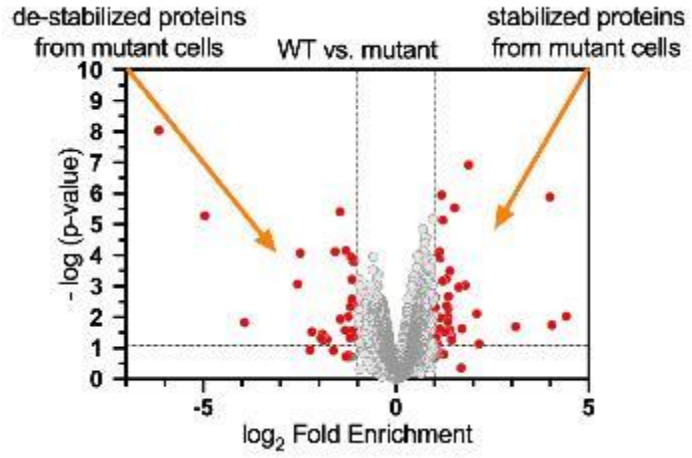
Kinetics help us understand how enzymes select protein targets for modification with ubiquitin.





Small molecule inducers of protein degradation can be used to treat human disease. We study the mechanism of how they function both in test tubes and cells.

High-resolution mass-spectrometry tells us how mutations in enzymes that lead to human disease affect the stabilities of key human cellular proteins.



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Organic Materials Chemistry

Dong-Chan Lee, Ph.D.

Associate Professor

Department of Chemistry & Biochemistry

Phone: 702-895-1486

Email: dong-chan.lee@unlv.edu

Expertise

- Organic semiconductors with tunable electronic properties
- Self-assembly (nanomaterials, organogels, etc.)
- All organic room-temperature phosphors
- Materials development for solid-state emission with high quantum yield

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Electronic-Property Tuning with Smart Molecular Design

E_{LUMO}

-3.16 eV

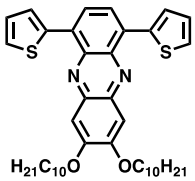
-3.26 eV

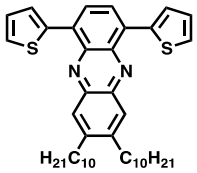
-3.22 eV

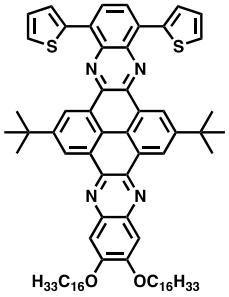
-3.89 eV

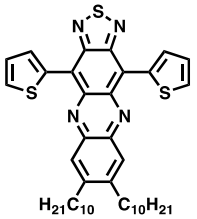
-3.80 eV

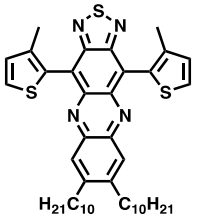
-3.84 eV

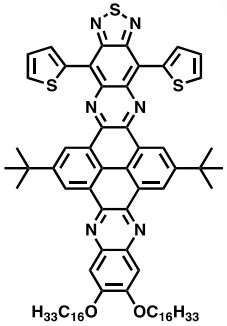












E_{HOMO}

-5.43 eV

-5.45 eV

-5.49 eV

-5.32 eV

-5.51 eV

-5.40 eV

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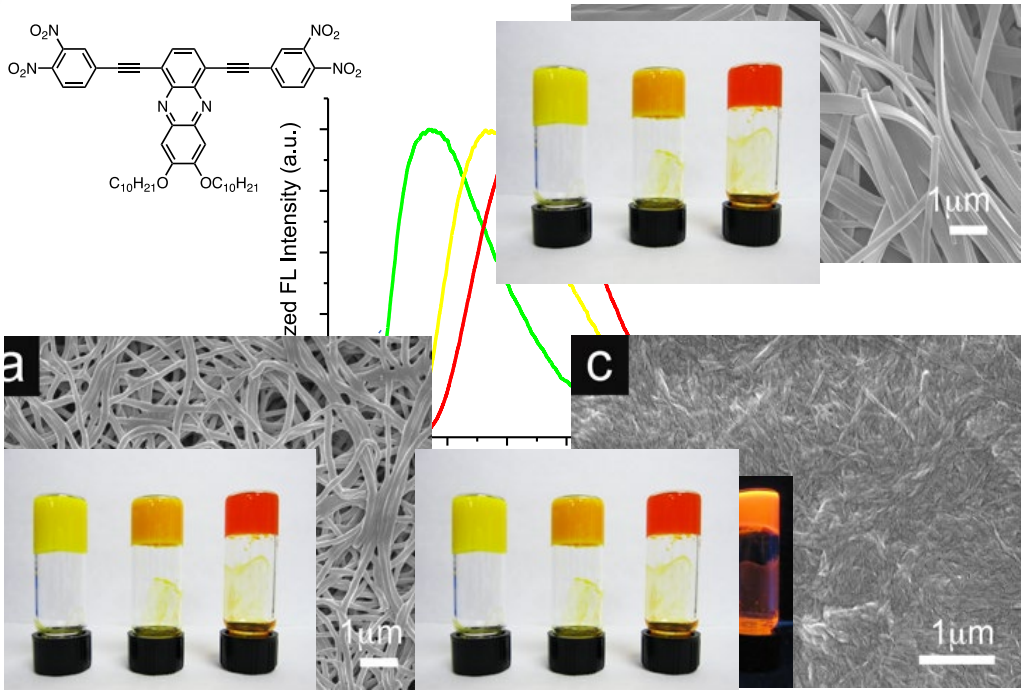
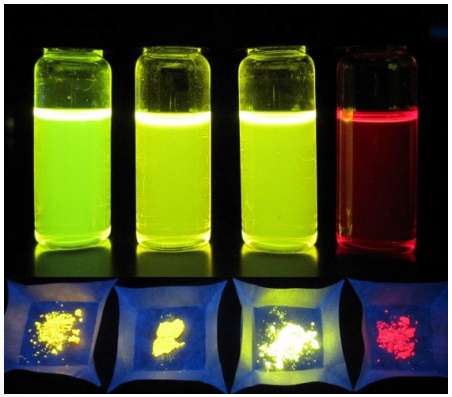
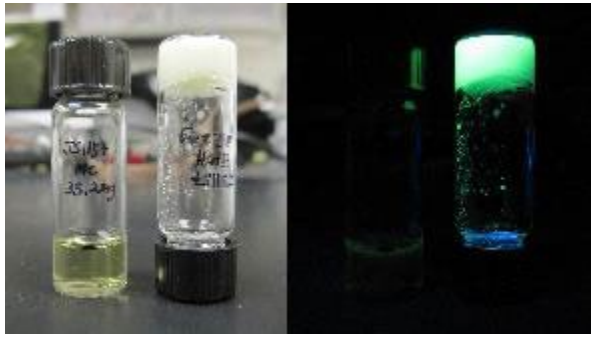
Solvent-Dependent Morphology Control through Organogelation





Solid-State Emission with High Quantum Yield



Gel-Induced Room Temperature Phospho-rescence

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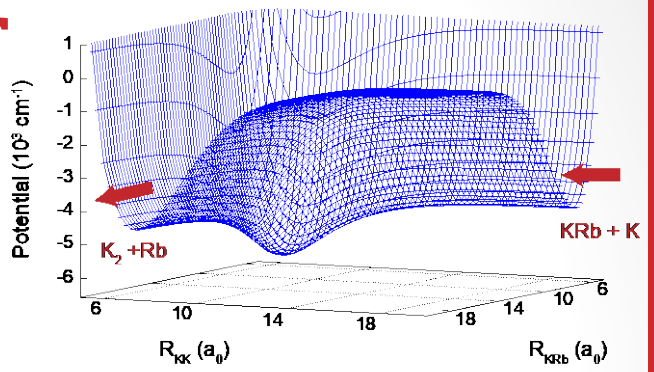
Quantum Information and Quantum Control of Chemical Reactions

Balakrishnan Naduvalath
Department of Chemistry & Biochemistry, UNLV



Chemical reaction pathway in ultracold K+KRb collisions. Quantum engineered KRb molecules have been prepared at 300 nK. Ultracold polar molecules such as KRb are potential candidates for quantum computing and quantum information processing.

Areas of Expertise

- Ultracold Molecules
- Ultracold Quantum Engineered Chemistry
- Quantum control of chemical reactions
- Geometric phase effect in chemistry
- Stereodynamic control of chemical reactions

$$$: NSF, DOD, NASA

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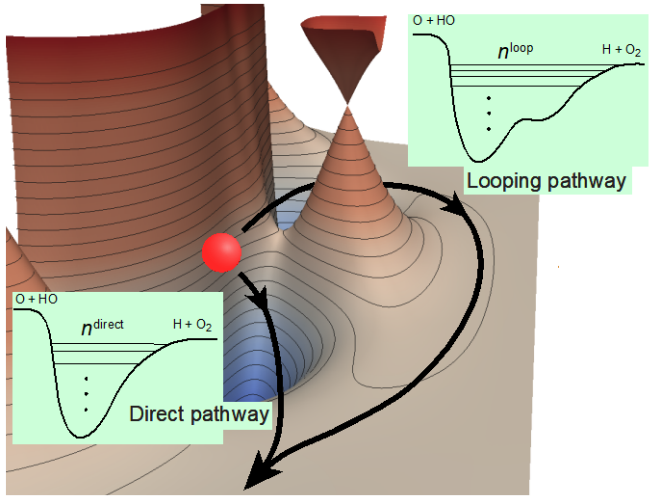
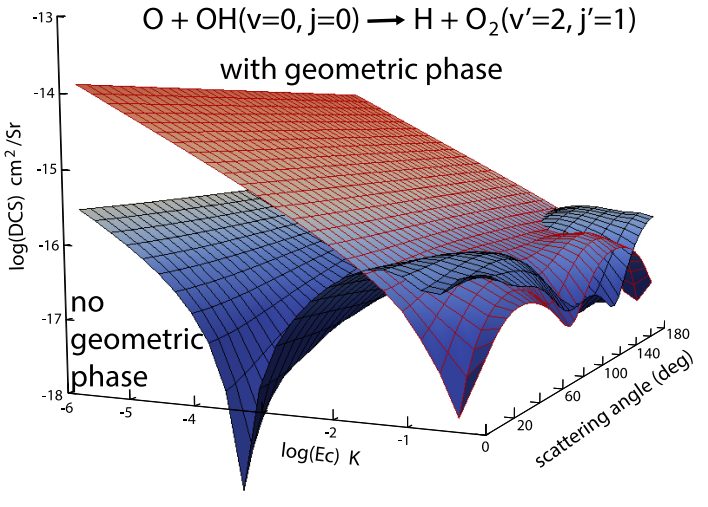
Controlling reaction outcome through quantum interference



Left panel: Two paths for a chemical reaction. These two paths can interfere constructively or destructively, maximizing or minimizing the reaction rate. This quantum effect becomes magnified in the ultracold regime (Kendrick, Hazra, and Balakrishnan, Nature Comm**. 6**, 7918 (2015).



Right panel: The nature of the interference can be controlled by including “geometric phase”. In the image on the right, inclusion of the geometric phase enhances the reactivity. The geometric phase (that correctly describes the sign of the wave function near a conical intersection with an excited electronic state) acts as a “quantum switch” (Hazra, Balakrishnan, and Kendrick, J. Phys. A **119**, 12291 (2015)

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- J. F. E. Croft and N. Balakrishnan, Controlling rotational quenching rates in cold molecular collisions, J. Chem. Phys. **150**, 164302 (2019).
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- J. F. E. Croft, N. Balakrishnan, M. Huang, and H. Guo, Unreveling the stereodynamics of cold controlled HD-H_2 collisions, Phys. Rev. Lett. **121**, 113401 (2018). (**Editor's choice**).
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- B. K. Kendrick, J. Hazra, and N. Balakrishnan, The Geometric Phase Controls Ultracold Chemistry, Nature Communications **6**, 7918 (2015).

MaryKay Orgill

Professor

Department of Chemistry and Biochemistry

- Ph.D., Chemistry, Purdue University
- Fellow, Royal Society of Chemistry
- Fellow, American Chemical Society
- Former Chair, ACS Division of Chemical Education
- Email: MaryKay.Orgill@unlv.edu
- https://www.unlv.edu/people/marykay-orgill

Areas of Expertise

- Chemistry Education
- Biochemistry Education

Research Summary:

I am interested in using qualitative research techniques to examine and improve undergraduate chemistry teaching and learning. Currently, this involves looking at how students understand concepts and solve problems in chemistry classes, how they visualize different chemical concepts, how they use language to make sense of chemical concepts, and how a systems thinking approach to chemistry teaching might be used to help students learn chemistry more meaningfully. I have also been involved in a number of projects that provide professional development opportunities to faculty and K-12 teachers.

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The Journal of Negro Education, 88 (3), 249-268

Postsecondary Underrepresented Minority STEM Students' Perceptions of Their Science Identity

Schetema Nealy Charles R. Drew University of Medicine and Science
MaryKay Orgill University of Nevada, Las Vegas

Journal of Research in STEM Education
ISSN:2149-8504 (online)
Vol 1, No 1, July 2015, PP 30-44
J-STEM

RESEARCH REPORT

Faculty Perceptions of the Factors Influencing Success in STEM fields

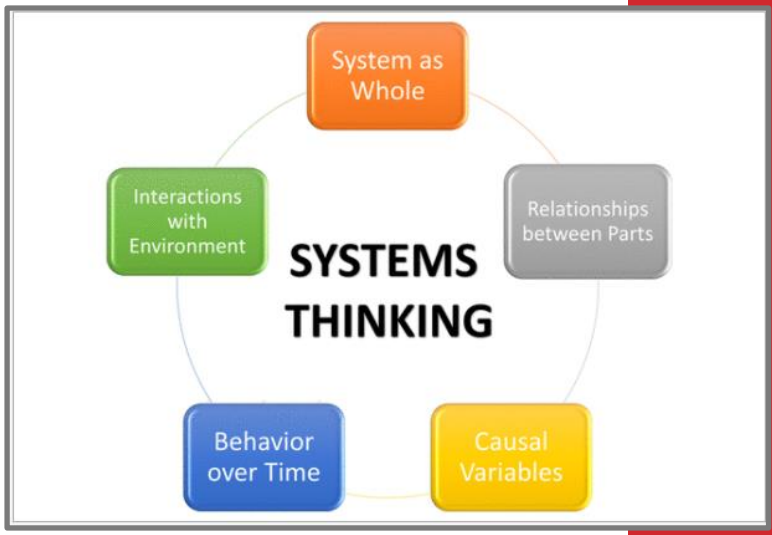
Eshani Gandhi-Lee[1], Heather Skaza, Erica Marti, PG Schrader, MaryKay Orgill
University of Nevada, Las Vegas, USA

JOURNAL OF CHEMICAL EDUCATION
Cite This: J. Chem. Educ. 2019, 96, 2720–2729
pubs.acs.

ACS Editors' Choice

Introduction to Systems Thinking for the Chemistry Education Community

MaryKay Orgill,*,† Sarah York,† and Jennifer MacKellar‡
†Department of Chemistry and Biochemistry, University of Nevada, Las Vegas, Las Vegas, Nevada 89154, United States
‡ACS Green Chemistry Institute, American Chemical Society, Washington, D.C. 20036, United States

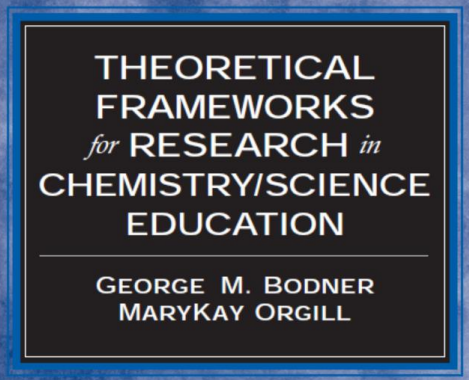


Multicultural Education

Supporting English Language Learners in College Science Classrooms

Insights from Chemistry Students

Eshani N. Lee, MaryKay Orgill, & CarolAnne Kardash



DOI: 10.1039/C4RP00256C (Paper) Chem. Educ. Res. Pract., 2015, **16**, 731-746

Biochemistry instructors' perceptions of analogies and their classroom use

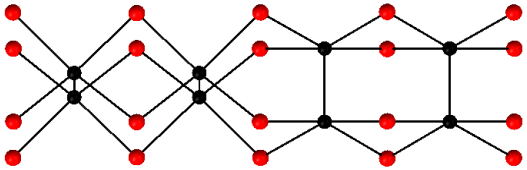
MaryKay Orgill *[a], **Thomas J. Bussey** [b] **and George M. Bodner** [c]
[a]*Department of Chemistry and Biochemistry, University of Nevada, Las Vegas, USA. E-mail: marykay.orgill@unlv.edu*
[b]*Department of Chemistry and Biochemistry, University of California, San Diego, USA*
[c]*Department of Chemistry, Purdue University, USA*

Technetium and Uranium Chemistry

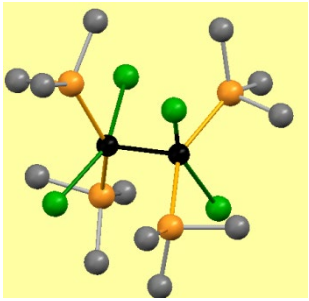
Frederic Poineau, PhD
Radiochemistry

→ Synthetic and coordination chemistry

Technetium binary and ternary halide compounds
Compounds with multiple metal-metal bonds



$TcCl_2$: a unique structure-type



$Tc_2Cl_4(PMe_3)_4$

→ Chemistry relevant to remediation and fuel cycle applications

Separation, vitrification, and waste forms (alloys)

Demonstration of the separation of
uranium from technetium for fuel cycle application

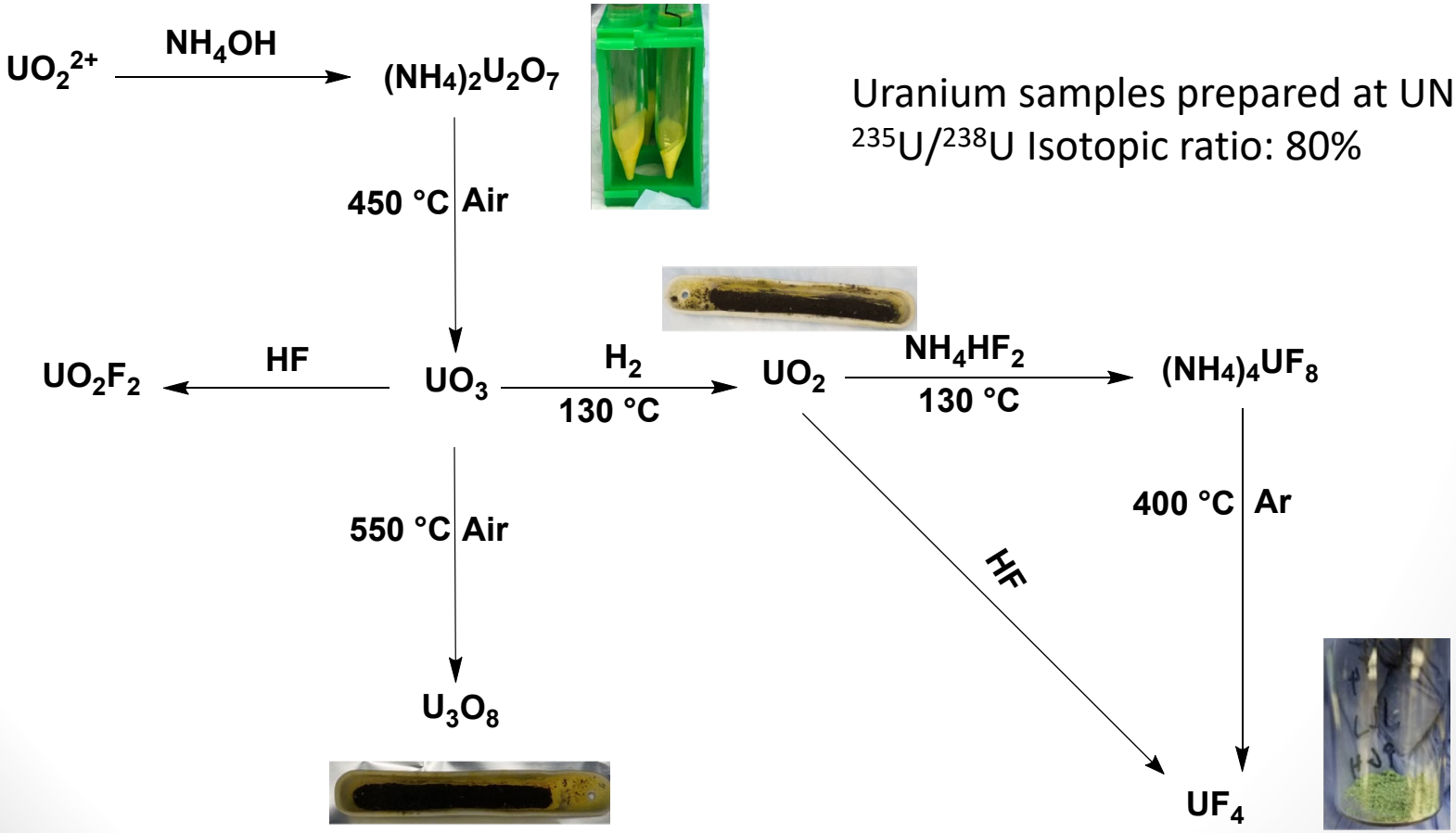
Preparation of U-Tc alloys by arc melting

Frederic Poineau, PhD
Radiochemistry

→ Collaborative work relevant to nuclear forensics

Analysis of Uranium Isotopic Ratios by Thermal Ionization Mass Spectrometry (TIMS)

- Uranium compounds found throughout the fuel cycle (UO_2, U_3O_8, UF_4) prepared at UNLV
- $^{235}U/^{238}U$ isotopic ratio measurements using TIMS at LANL



Uranium samples prepared at UNLV
$^{235}U/^{238}U$ Isotopic ratio: 80%

Inorganic Radiochemistry

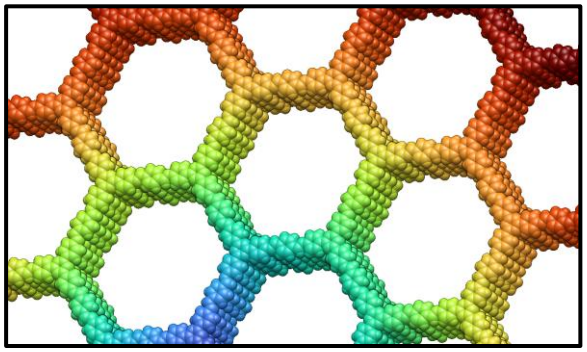
- **Dr. Matt Sheridan**
- Asst Professor - Radiochemistry
- Department of Chemistry and Biochemistry
- Email: matthew.sheridan@unlv.edu
- Research works: https://scholar.google.com/citations?user=axFxtuQAAAAJ&hl

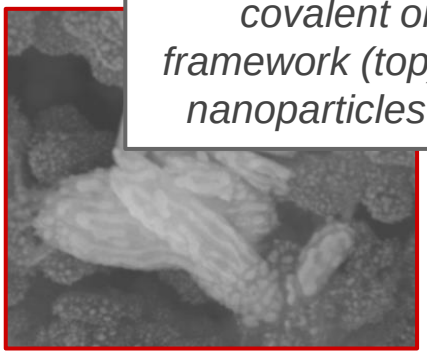
- **Materials chemistry:**

  metal organic frameworks (MOF), covalent organic frameworks (COF), oxide electrodes, uranium and actinide nano-materials
- **Electrochemistry & photochemistry:**

  actinide redox chemistry, photoactive materials, molten salts, artificial photosynthesis
- **Radiochemistry:**

  fuel cycle chemistry, actinide separations, actinide coordination chemistry, scintillation materials





covalent organic framework (top); uranium nanoparticles (bottom)

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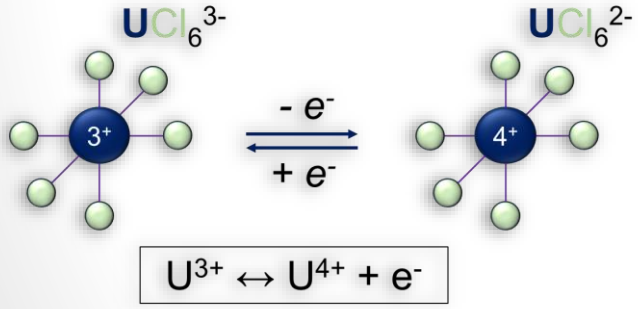
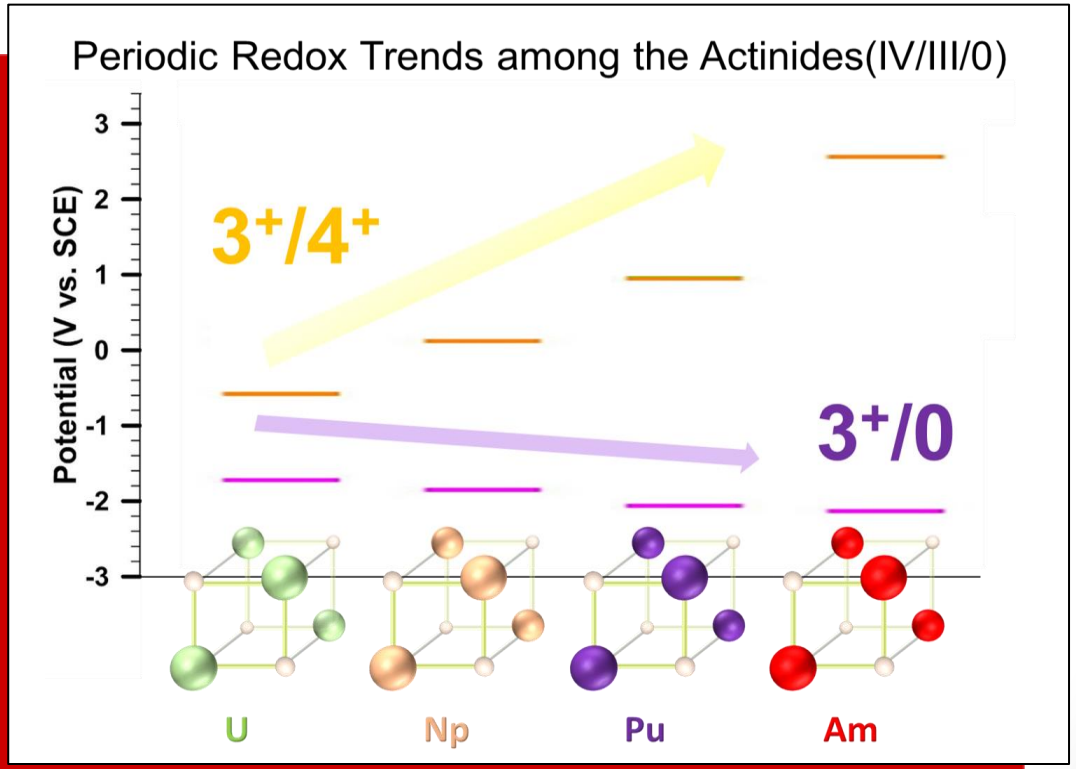
Sheridan Group Projects

Developing New Materials: MOFs, COFs, actinide complexes and nanoclusters
Studying Redox Radiochemistry: Molten salt electrochemistry, actinide oxide materials semiconductor properties

The actinides–uranium (**U**), neptunium (**Np**), plutonium (**Pu**), and americium (**Am**)–**undergo rich redox chemistry**





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Biochemistry – Interrogate Cell Signaling Pathways by Molecular, Genetic and Proteomic Approaches

Dr. Hong Sun
Associate Professor
Department of Chemistry and Biochemistry
Telephone: (702) 774-1485
Email: hong.sun@unlv.edu

Expertise

Cell signaling
Cancer cell biology
Stem cell biology
Mouse conditional knockout models

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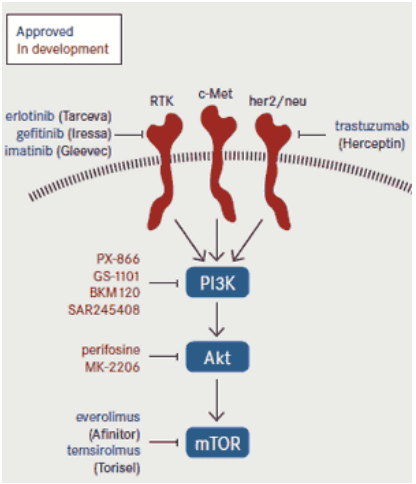
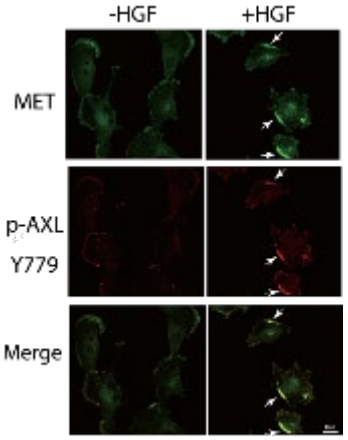
Regulation of cell surface receptor RTKs localization and activation

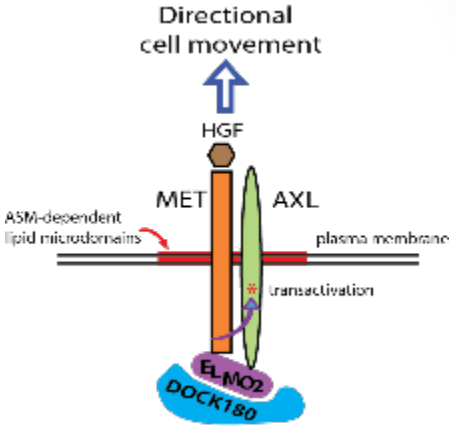
Problem: cancer cells often have multiple receptors (RTKs) activated on cell surface, making targeting inefficient



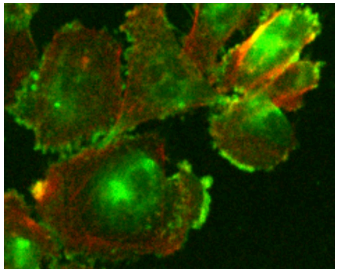
Co-activation of AXL-MET RTKs:
HGF (ligand for MET) also activates AXL, detected by antibodies for p-AXL-Y779



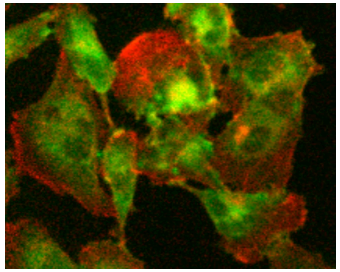
A novel mechanism discovered for RTK-Co-activation and signaling for cancer cell migration and invasion



Li et al., J. Biol. Chem. (2018) 293:15397-15418.

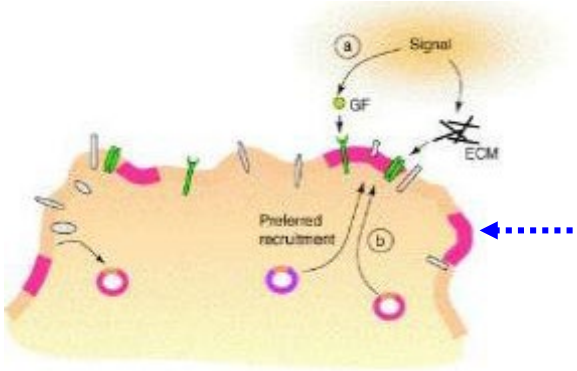


Vehicle



ASM Inhibitor

ASM inhibition prevents the MET RTK to be transported to the cell surface, as revealed by immunostaining (MET, green label; and a control cell surface protein, red label).
Zhu et al, J. Cell Science (2016) 129, 4238-4251.

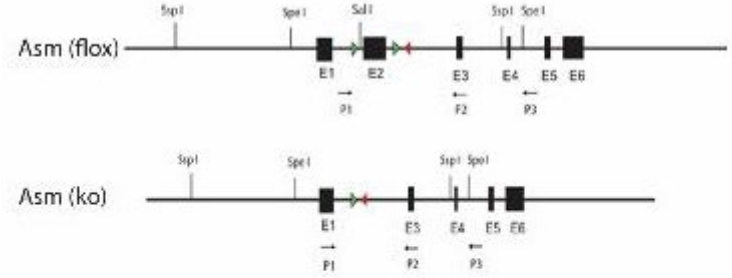


ASM-dependent
lipid microdomains

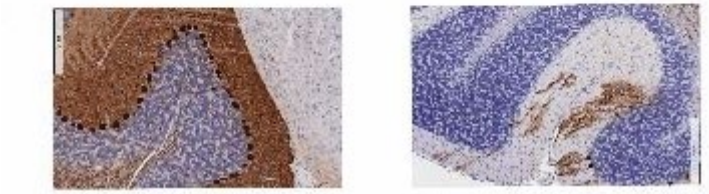
Mass-Spectrometry analyses revealed that the ASM-regulated local lipid microdomains were enriched with many signaling molecules.
Xiong et al. Biol. Open (2019) 8, bio040311.

Regulation of stem cell maintenance: insights from the genetic studies in novel mouse knockout models

A. Gene locus

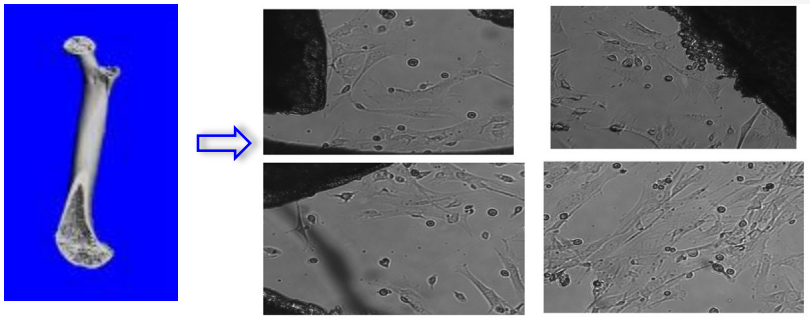


B. Loss of Purkinje neurons in cerebellum



Purkinje neurons immunostained with D28K antibody.

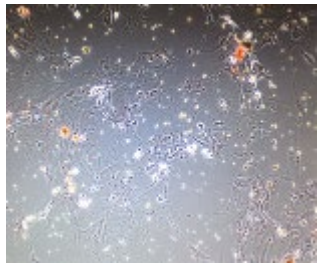
C. Mesenchymal stem cells (MSCs) cultured from bones



D. ASM mutant MSCs failed to become bone-forming cells

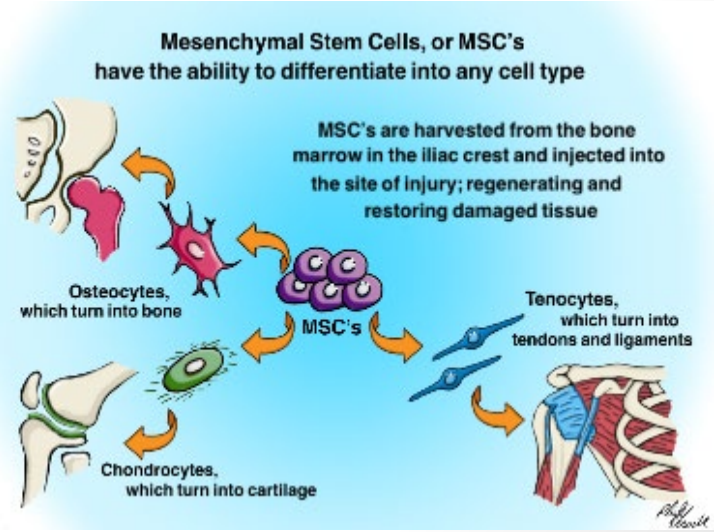
Wild-type MSCs

ASM mutant MSCs



(*in vitro* differentiation assay, then stained with alizarin red)

E. Potentials of MSCs for tissue repair



Stem Cells, Genetic and Epigenetic Inheritance, Cancer

Dr. Hui Zhang
Associate Professor
Department of Chemistry and Biochemistry
Phone: (702)774-1489
Email: hui.zhang@unlv.edu

Expertise:

- Biochemistry and developmental regulation of pluripotent embryonic stem cells, adult stem cells, and related diseases

- Regulation of chromatin structure, epigenetics, and transcription by protein methylation and ubiquitin enzymes

- DNA replication, DNA repair, cell cycle, genome instability, and cancer

- Targeting the vulnerability of human cancers

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Current research areas in Zhang Laboratory:

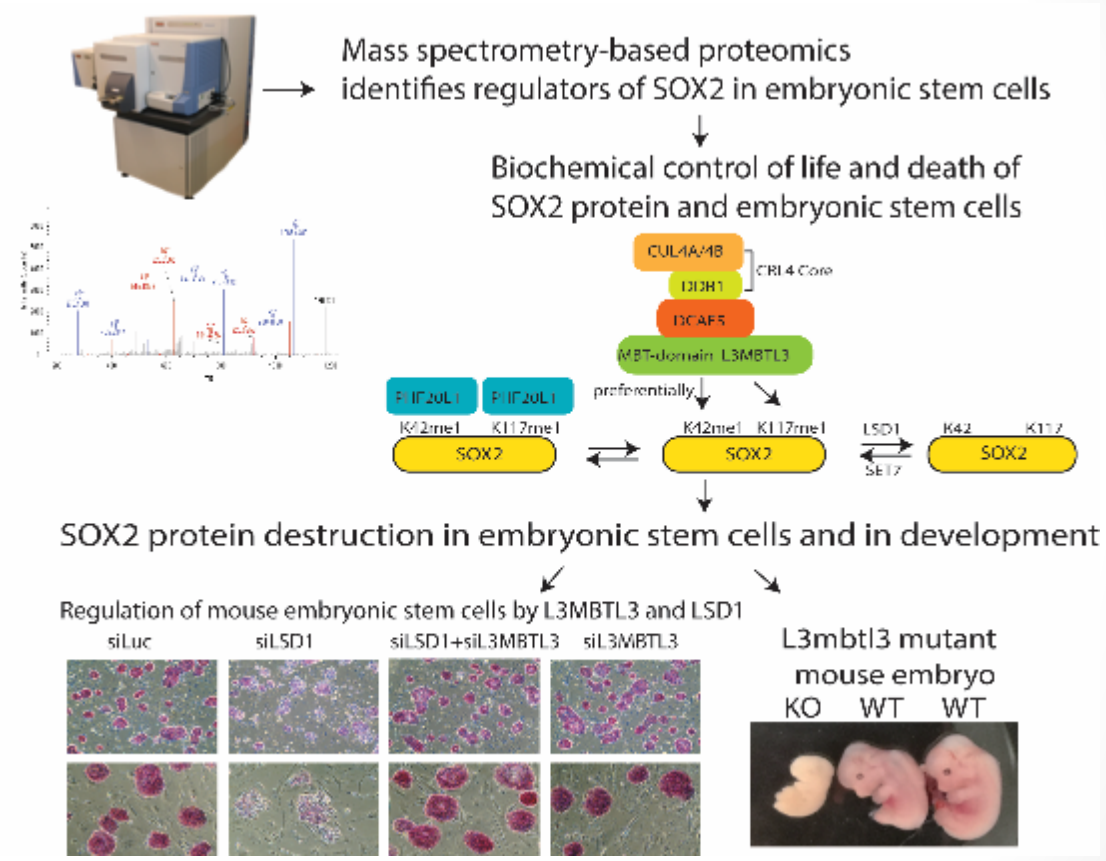
• Discover novel proteins essential for stem cell regulation, examples:

How SOX2 is regulated in embryonic stem cells and many other stem cells in development?

- Sox2 is a master stem cell protein that controls the self-renewal and pluripotency of embryonic stem cells that can develop into any tissue types of cells in development.

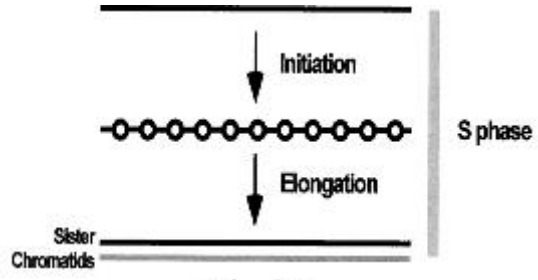
- SOX2 is also a master regulator of many adult stem cells including the stem/progenitor cells for brain, lung, colon, breast, liver, cochlea/ear, skin, retina, ovary, bladder, esophagus, and testes for tissue repair/regeneration.

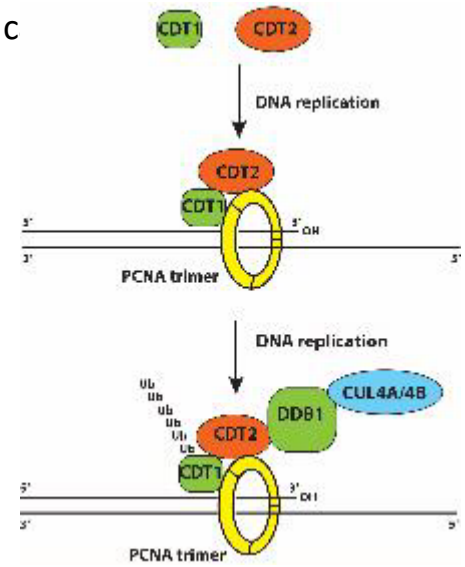
- Artificial Sox2 expression (together with Oct4 and accessary Klf4, and Myc) can virtually convert any differentiated cells, such as skin or blood cells, into induced pluripotent stem cells (iPSCs), the embryonic stem cell-like cells.

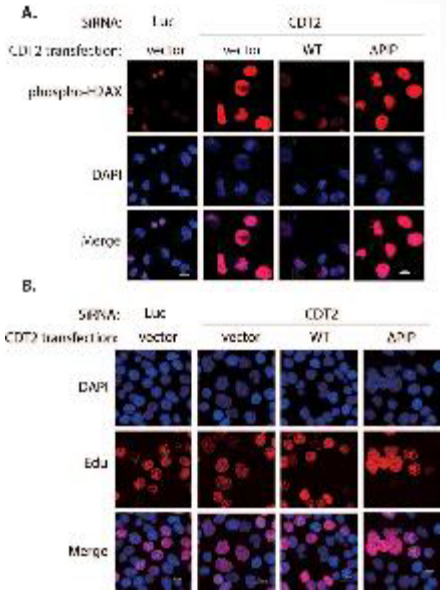


- Discover novel proteins important for epigenetic and cell cycle regulation, examples:
- **Regulation of DNA replication and DNA methylation in normal and cancer cells**

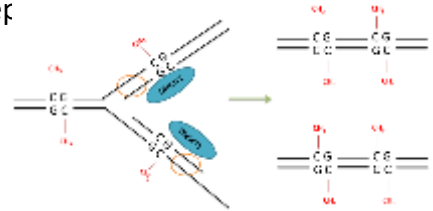
  - How DNA replicates only once in one cell cycle in animal cells? How re-replication is prevented that causes genome instability and c





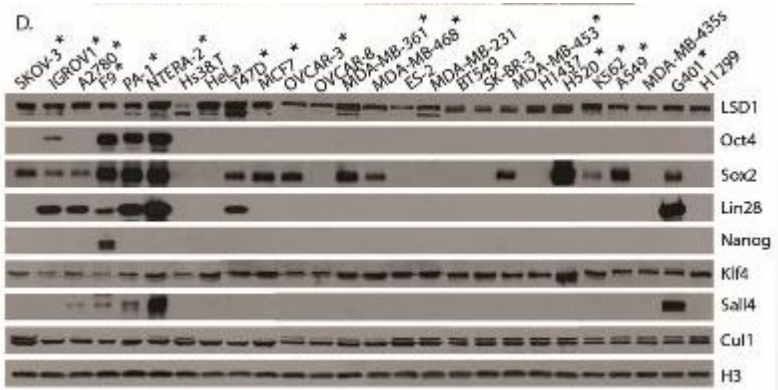


  - How the fidelity of epigenetic DNA methylation is maintained during DNA rep



- **Cancer Biology and therapy development**

Elevated SOX2 levels cause many cancers including cancers of lung, brain, breast, and ovary. These cancers are hard to treat because they behave like stem cells due to SOX2 expression. We are developing novel LSD1 chemical inhibitors that target the epigenetic vulnerability of these cancer cells.



The presence of SOX2 in different types of cancer cells is responsible for sensitivity towards our LSD1 inhibitors. *: Sensitive to LSD1 Inhibitors

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