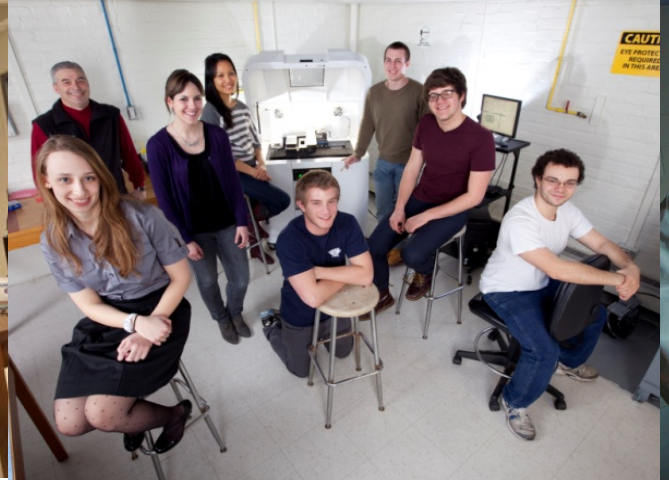
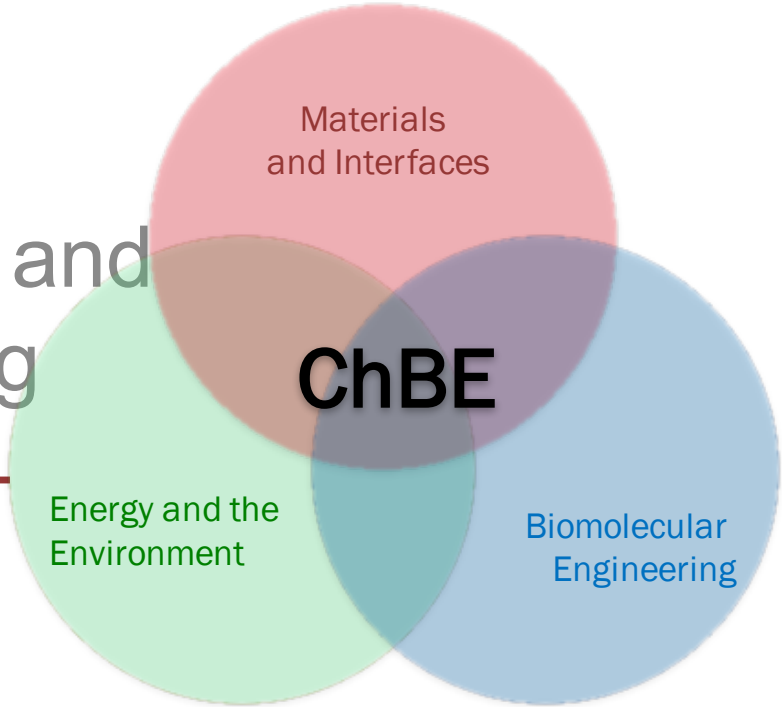




Undergraduate Research Opportunities

Department of Chemical and Biomolecular Engineering



Research for Pay:
The EXCEL Scholars Program

- Enables high-performing students to **assist faculty members with their scholarship**.
- **Encourages collaboration in learning between faculty and students**.
- Student work must be research- oriented and not administrative in its primary emphasis.
- EXCEL Scholars may work part-time during the academic year or full-time during the Summer and the Interim Session.
- Participation in the EXCEL Program is an honor reserved for those who have achieved academic distinction.
  - Students must have completed their first year at Lafayette with a cumulative GPA maintained above 3.25

Research for Pay:
Clare Booth Luce Scholars Program

- "Since it's inception in 1989, the Clare Boothe Luce Program has been one of the most significant sources of support for women seeking to study or teach science, engineering, and mathematics."

- Participation in the CBL Program is an honor reserved for **female** students who have achieved academic distinction in **engineering** at Lafayette.
  - To be eligible, students have completed their first year at Lafayette, be a US Citizen, and should maintain a cumulative GPA maintained of 3.25

- Students should contact participating faculty and will be asked to write a personal statement and get a letter of recommendation to be submitted to the Engineering Division

Research for Credit:
CHE 392/393: Independent Research

- Independent Research in Chemical Engineering serves to provide students with a **high quality *hands-on* student-faculty research experience** for a range of technical topics. Before registering, a research proposal must be submitted to a faculty member who serves as the adviser and to the Scholarship Committee for approval. Each student is required to submit a course Portfolio for course credit.

- Course Hours:
  - One hour per week meeting with Instructor (minimum)
  - Ten hours per week course work (minimum)

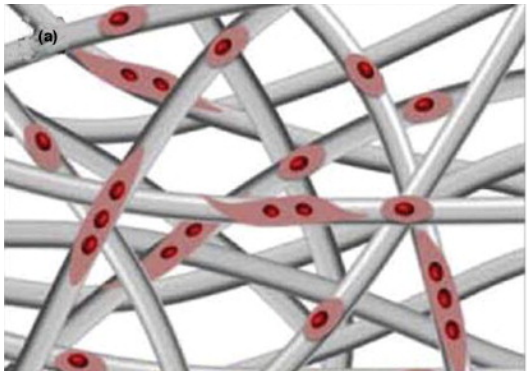
- CHE 392/393 satisfies a free elective in chemical engineering.

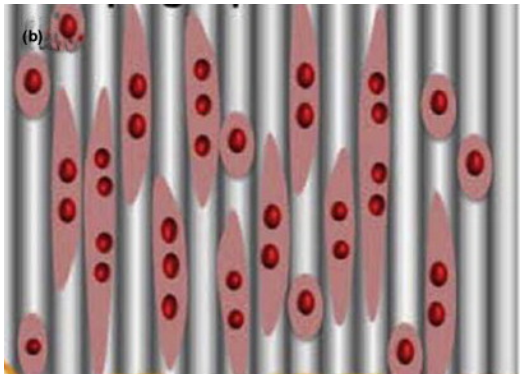
Research for Credit: CHE 495/496: Honors Thesis

- An Honors Thesis in Chemical Engineering serves to provide outstanding students with a **high quality student-faculty research experience during the senior year**. Candidates for honors must have and must maintain a cumulative GPA of 3.00 and ChBE Departmental GPA of 3.20. The specific research topic of the Honors Thesis should be discussed well in advance of the senior year with the Instructor.

- Course Hours:
  - One hour per week meeting with Instructor (minimum)
  - Ten hours per week course work (minimum)

- CHE 496 satisfies a chemical engineering elective.





Engineering the cell-surface interaction

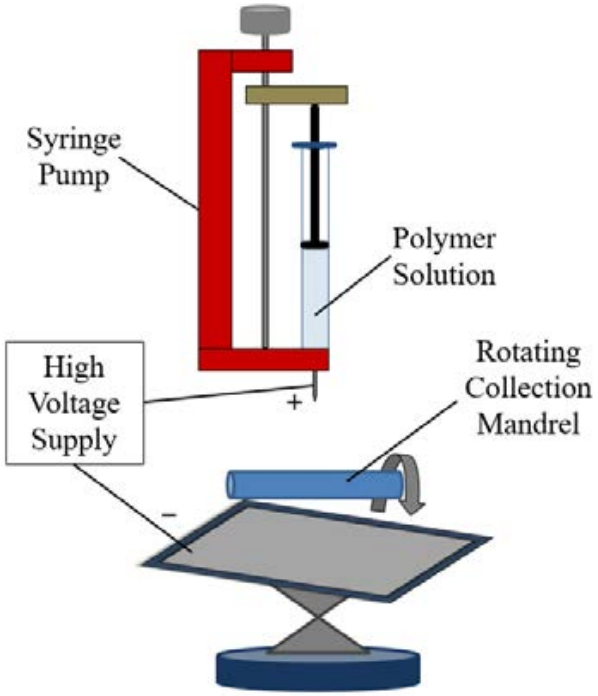
Overarching principle:

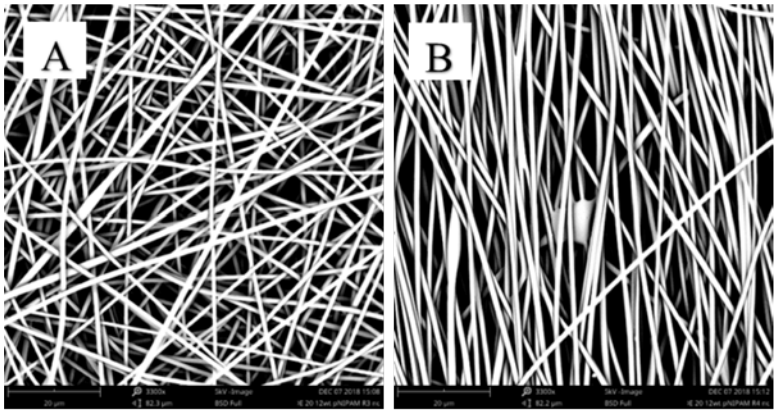
Manipulate biomaterial properties to selectively control the cell-material interaction.

- For the relevant cell type, evaluate the following parameters on the biomaterial:
  - Cell morphology: microscopy, image analysis (spreading, circularity)
  - Cell adhesion: microscopy, immunofluorescence, adhesion assays
  - Cell differentiation: gene and protein expression, soluble signaling
  - Cell proliferation: DNA quantification, proliferation assays
  - Cell-vitality: live/dead assays

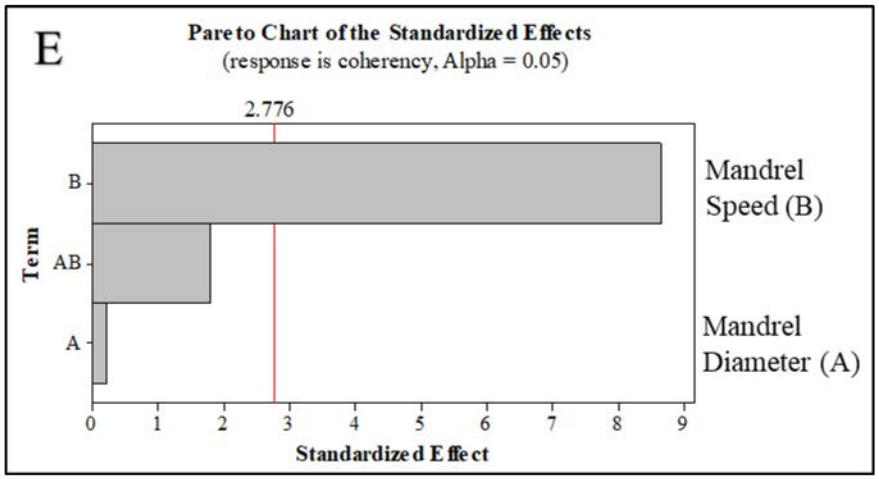
Wang et al. 16(6), 2013, 229-241

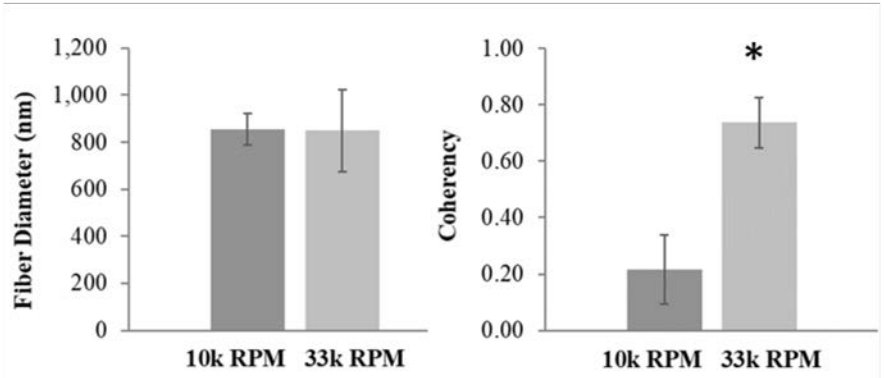
Process of Electrospinning

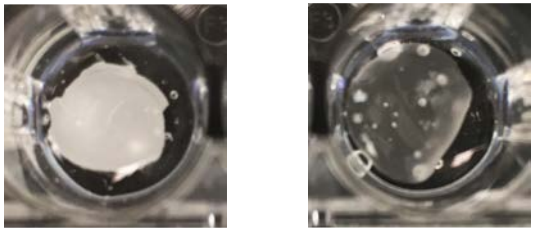




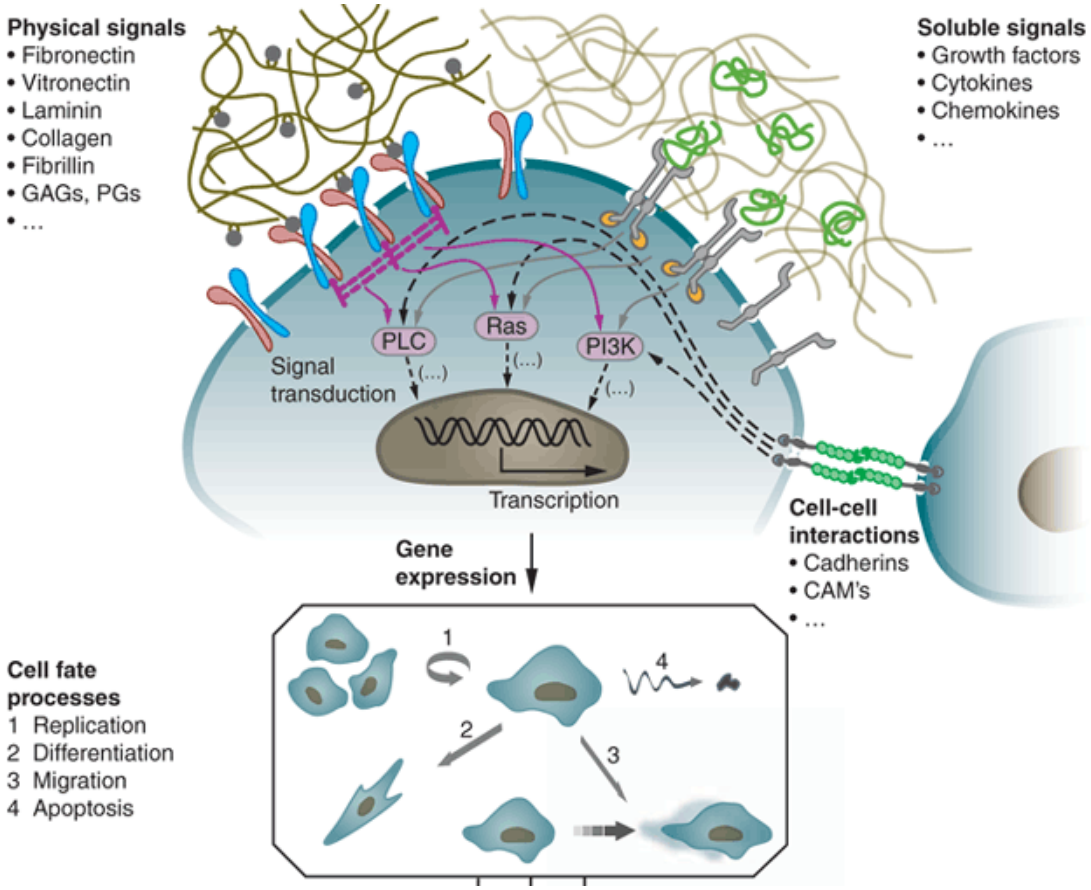
Optimizing Polymer Nanofibers for Cell Culture Applications







Investigation of protein expression and cell function in biomolecular engineering applications



CELL STIMULUS

↓

GENE EXPRESSION

↓

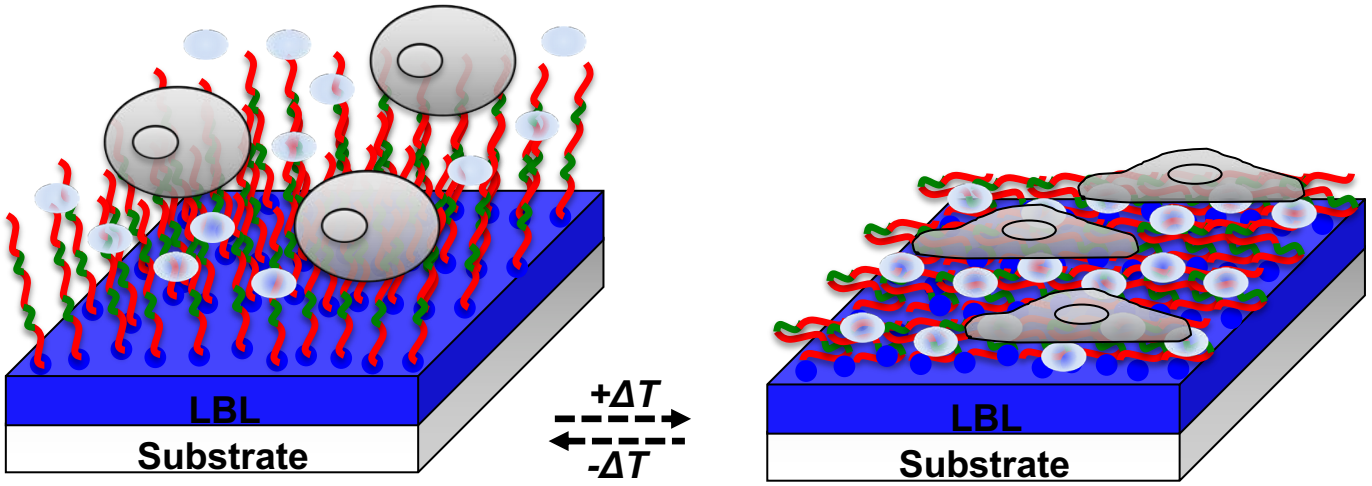
PROTEIN EXPRESSION

↓

CELL RESPONSE

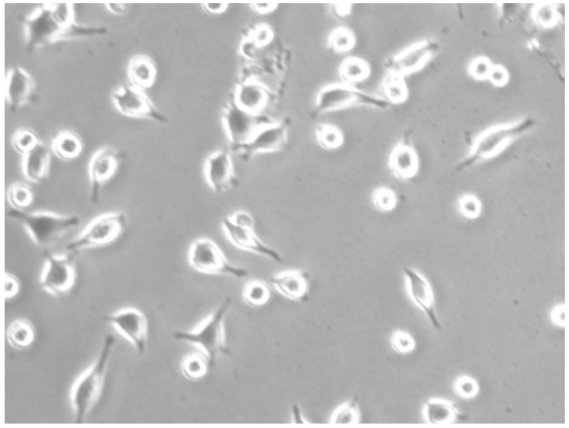
Central question: How does the regulation of cell protein expression affect cell function and inform the engineering of better materials?

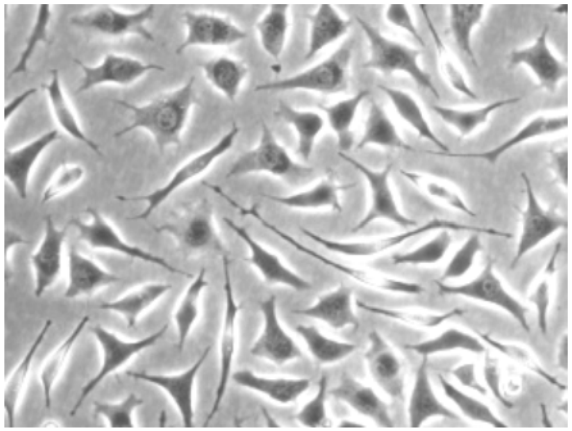
Protein Adsorption and Cellular Responses to Thermoresponsive Polymer Substrates



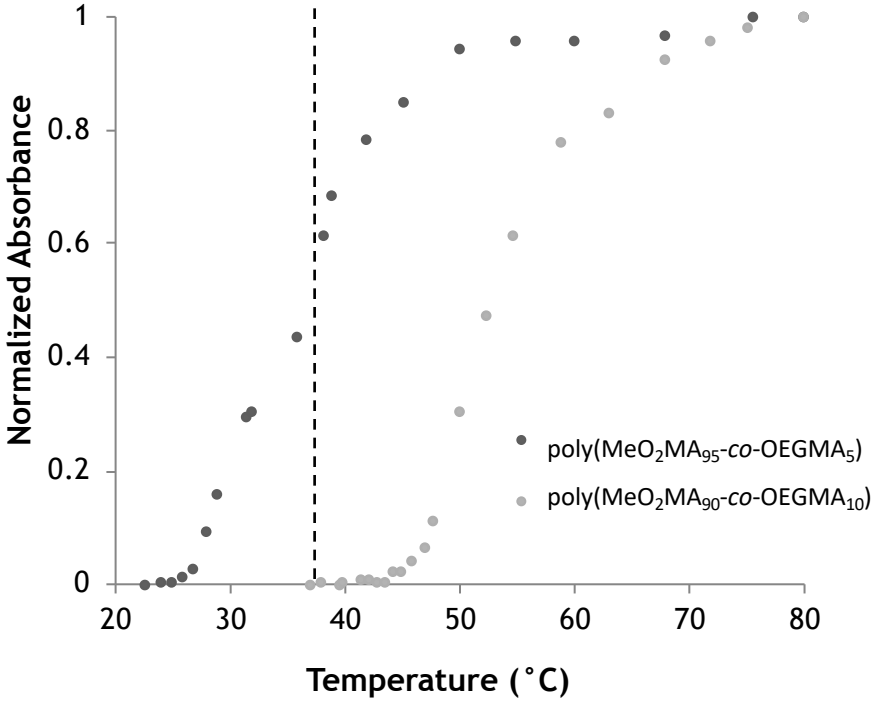
$T < LCST$

$T > LCST$



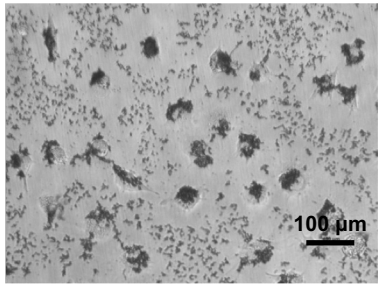


Cellular Responses to Functionalized Nanoparticles

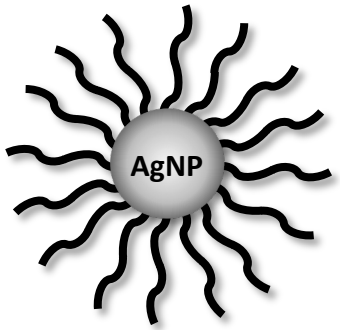


Ag-(MeO_2MA_{95}-*co*-$OEGMA_5$)

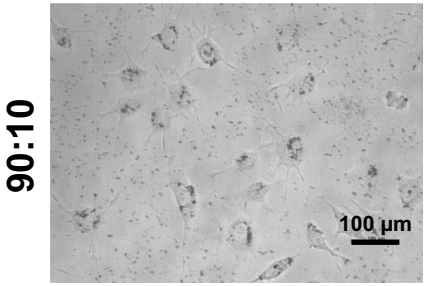
T > LCST @ T = 37°C



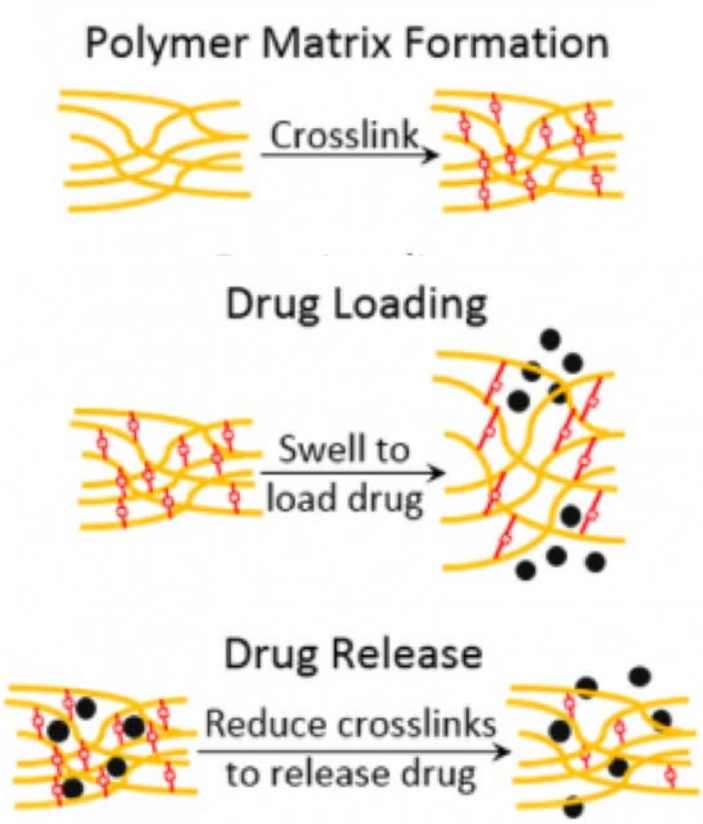
Ag-(MeO_2MA_{90}-*co*-$OEGMA_{10}$)

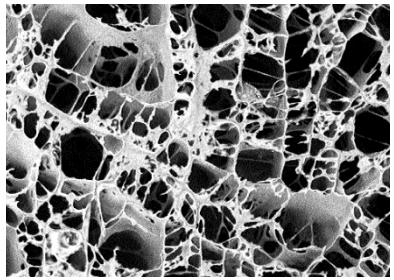


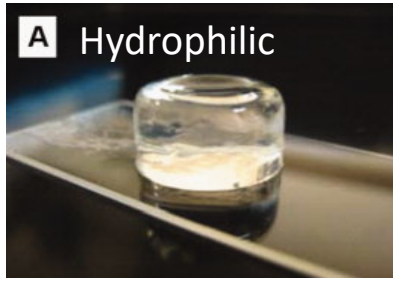
T < LCST @ T = 37°C

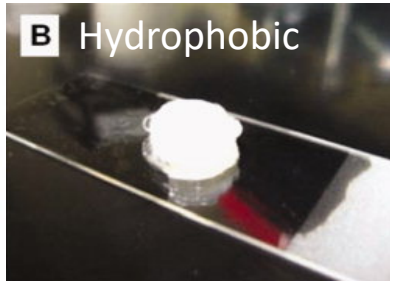


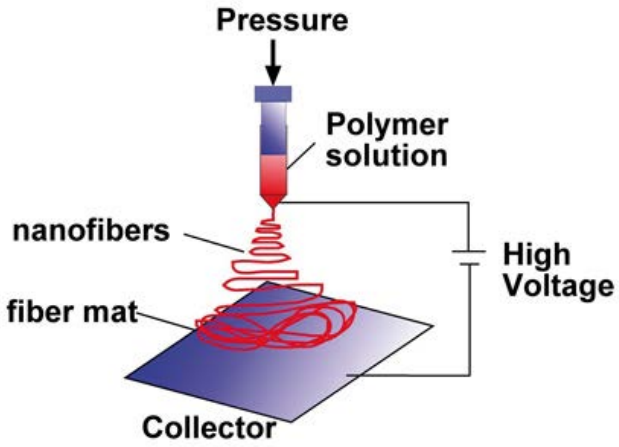
Biomaterials for Drug Delivery and Tissue Engineering

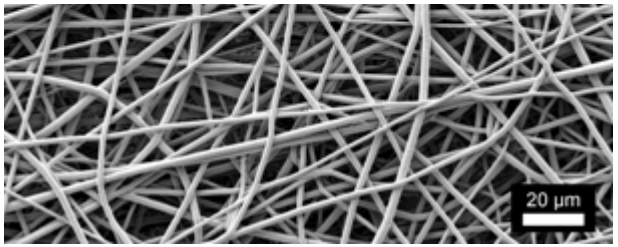


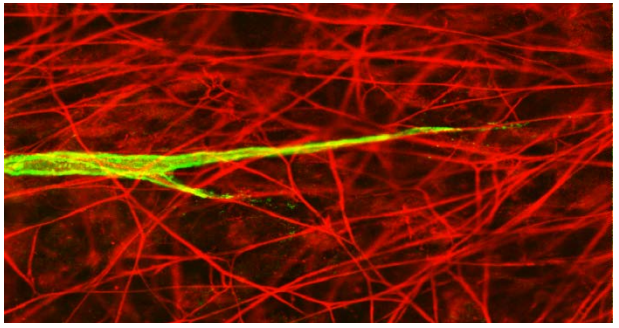








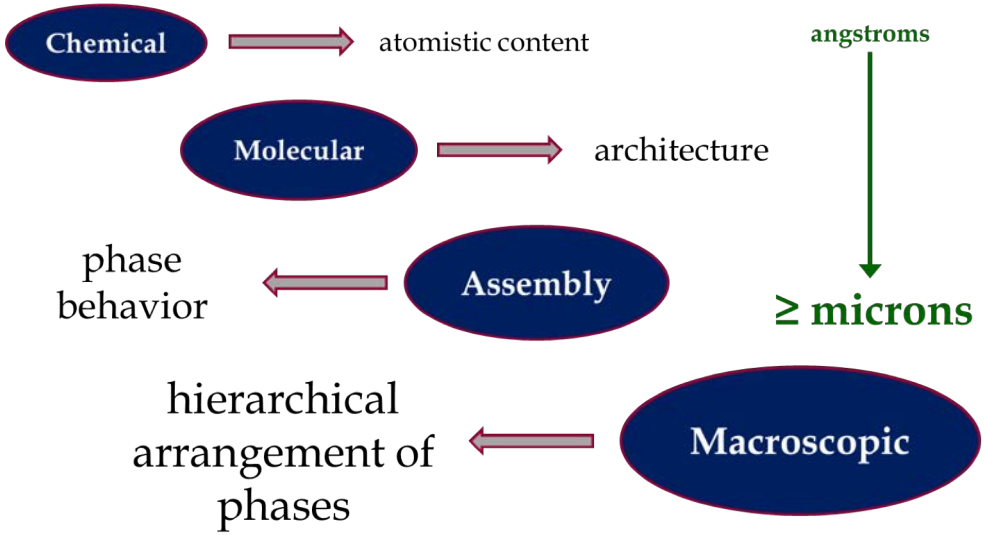


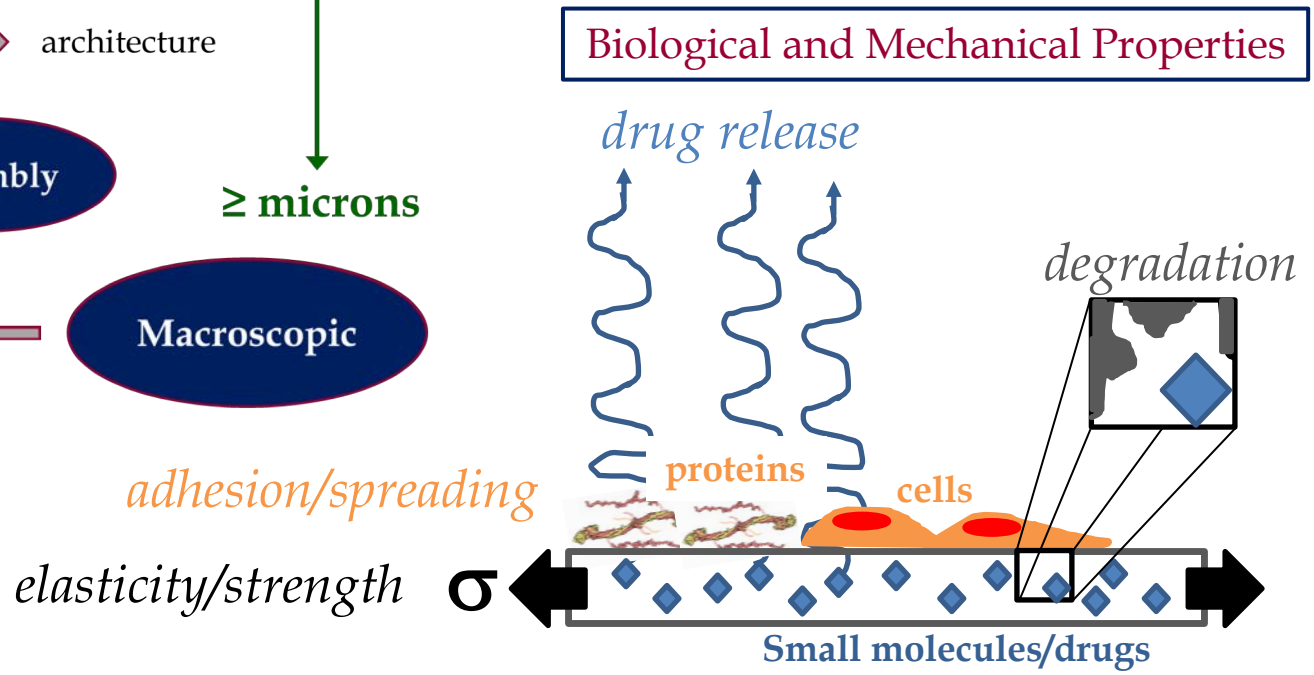


Experimental skills:

- Sterile cell culture
- Immunohistochemistry
- Confocal microscopy
- Protein adsorption assays
- Fluorescence spectroscopy
- In vitro cell function assays

Structure and Biologically-Relevant Properties of Polymer Films

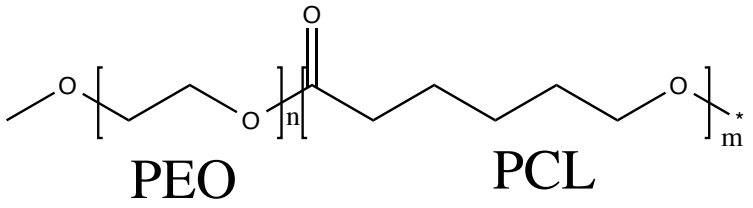




<u>Goal:</u> To engineer a film with tailored properties by careful design of various fabrication parameters

What We Do and Why We Care

PROPERTY (Application): Degradation Rate

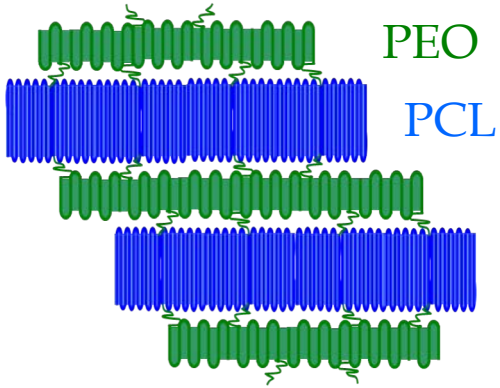


Biocompatible, amphiphilic
PCL is biodegradable
Common, FDA approved polymers

Degradation Mechanism

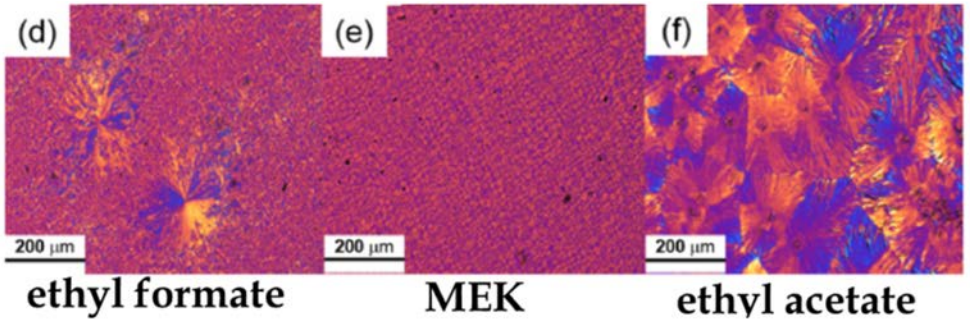
1. Water uptake
2. Chemical rxn
3. Mass loss

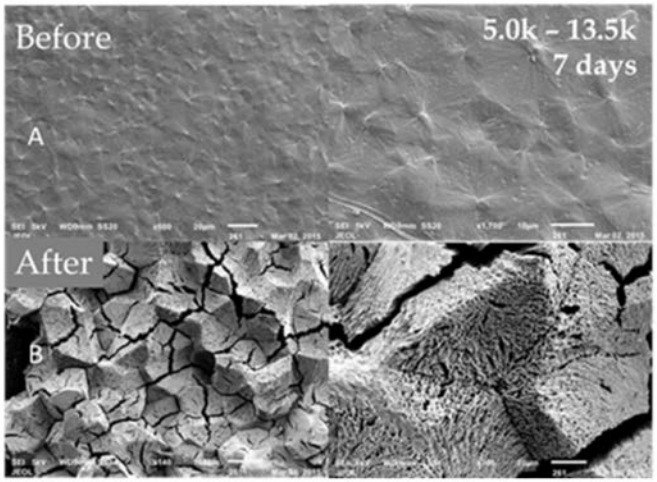
- PCL slow degrading (hydrophobic)
  - pH dependent (usually hydroxide attack)
- PEO (hydrophilic) incorporation increases Step 1
  - Balance between uptake and dissolution
- Rate is dependent on physical structure



Why You Should Too

- Analytical Techniques
  - Structure: DSC, POM, and FTIR (others?)
  - Properties: Gravimetric, UV-Vis (others?)
- Skills
  - Experimental Design
  - Film Preparation
  - Multi-technique Analysis
  - Teamwork





Positions Available:
Summer '19 (see me for application)
AY '19-'20: Honors Thesis, EXCEL, and Ind. Study

Engineering Bio-inspired and Bio-based Polymers

Polymers touch nearly every aspect of our everyday lives

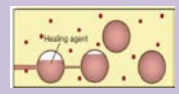





Motivated by Nature

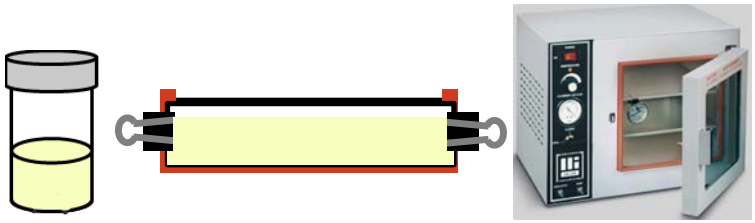
- **Phototropism** 
- **Contraction of pupils in response to light** 
- **Healing after a cut** 
- **Strengthening of bone** 

For Many Applications

- **Self-Healing Materials** 
- **Responsive Coatings** 
- **Controlled Drug Delivery** 
- **Shape Memory Materials** 

M. A. C. Stuart, W. T. S. Huck, J. Genzer, M. Muller, C. Ober, M. Stamm, G. B. Sukhorukov, I. Szleifer, V. V. Tsukruk, M. Urban, F. Winnik, S. Zauscher, I. Luzinov, S. Minko, *Nat Mater* **2010**.
O. Azzaroni, A. A. Brown, W. T. S. Huck, *Angew Chem Int Edit* **2006**.
S. R. White, N. R. Sottos, P. H. Geubelle, J. S. Moore, M. R. Kessler, S. R. Sriram, E. N. Brown, S. Viswanathan, *Nature* **2001**. S. Mura, J. Nicolas, P. Couvreur, *Nat Mater* **2013**.

Techniques



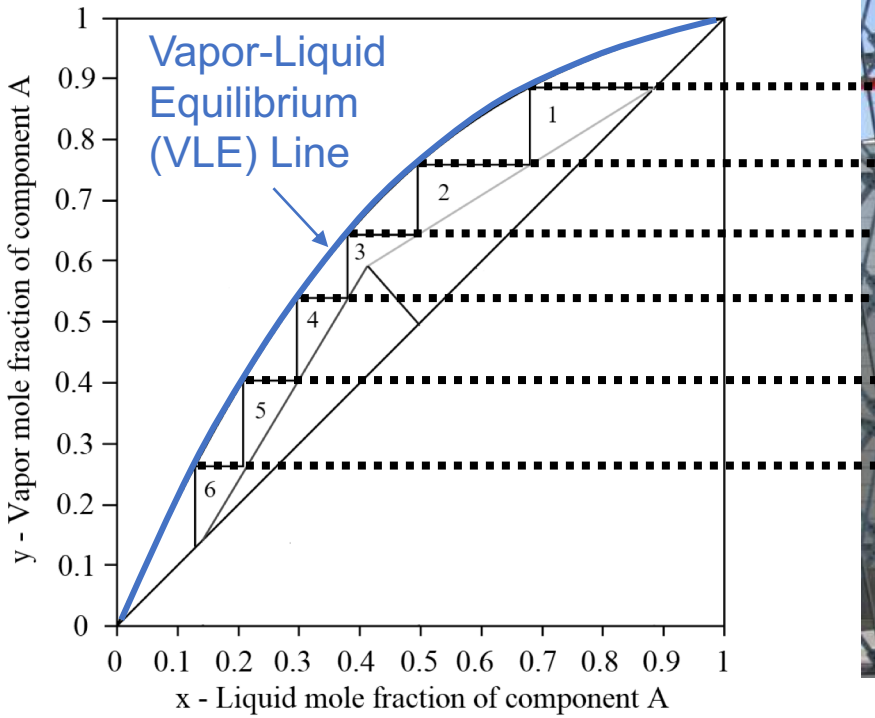
Network Formation

Stereolithography 3D printing

Dynamic Mechanical Analysis

Thermogravimetric Analysis

Thermodynamic Modeling of Hydrogen Bonding

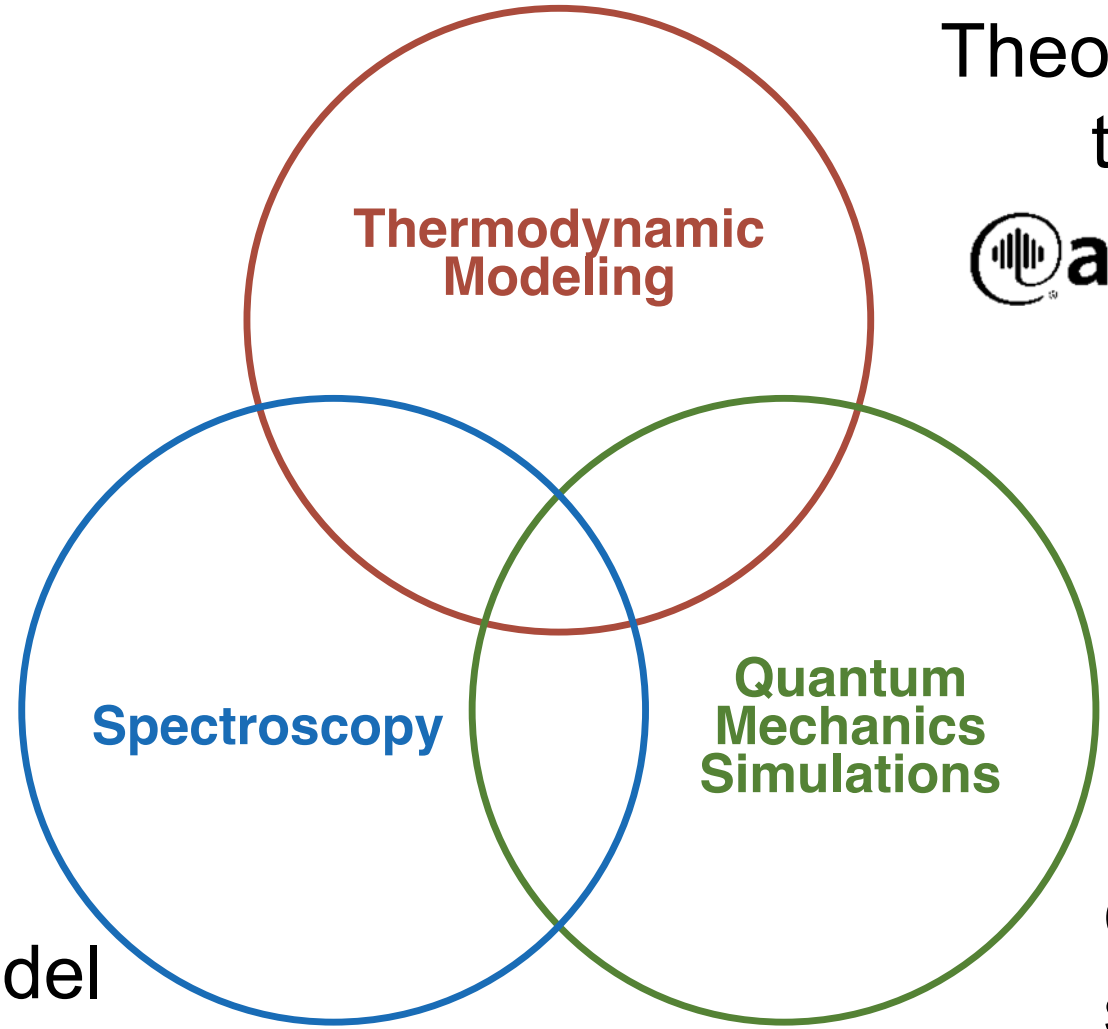


Stage calculation for design of distillation columns

Distillation column

Weak models ⇨ Extended pilot plant stage to collect data ⇨ Increased development time/costs

Project Objectives



Theory + Model testing

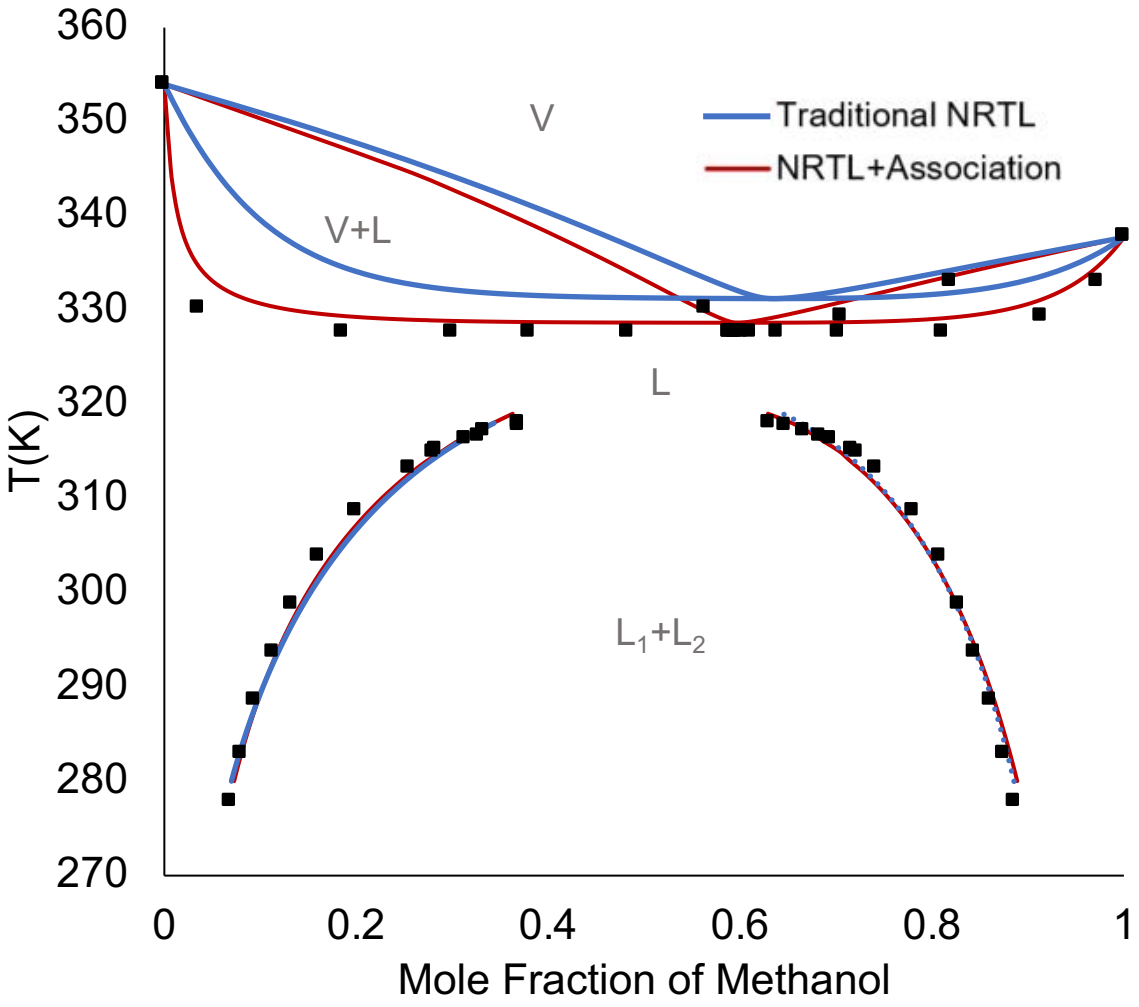
aspentech

Obtain model parameters

QM/MM simulations

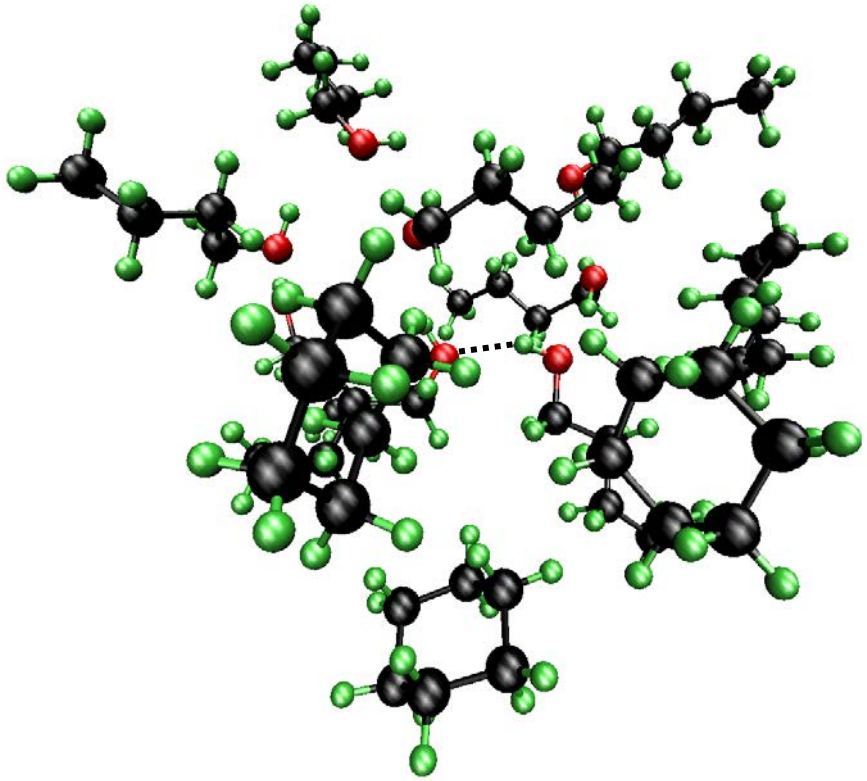
Comparison of Models

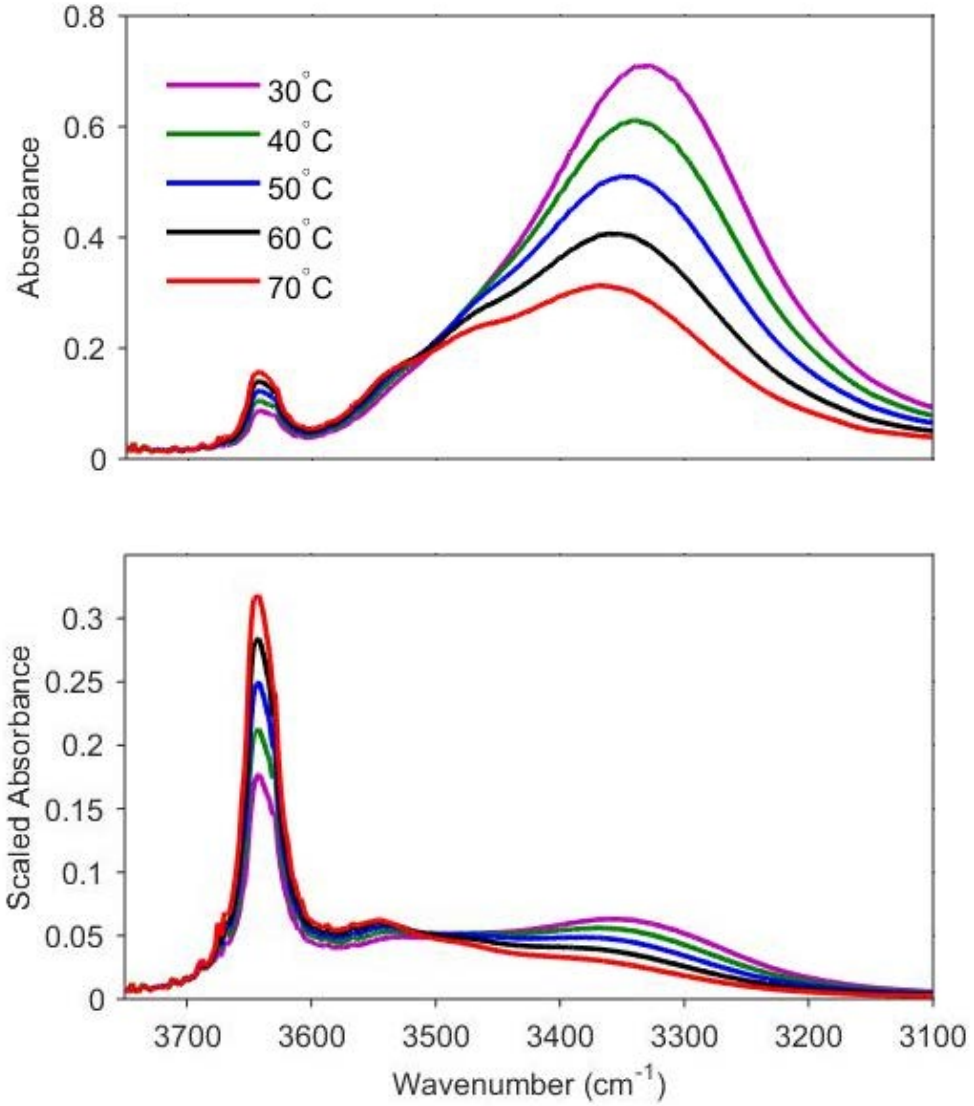
- Traditional NRTL
- NRTL
  + WAG



VLE-LLE diagram for methanol-cyclohexane at P=1 bar

Spectroscopy and Simulations

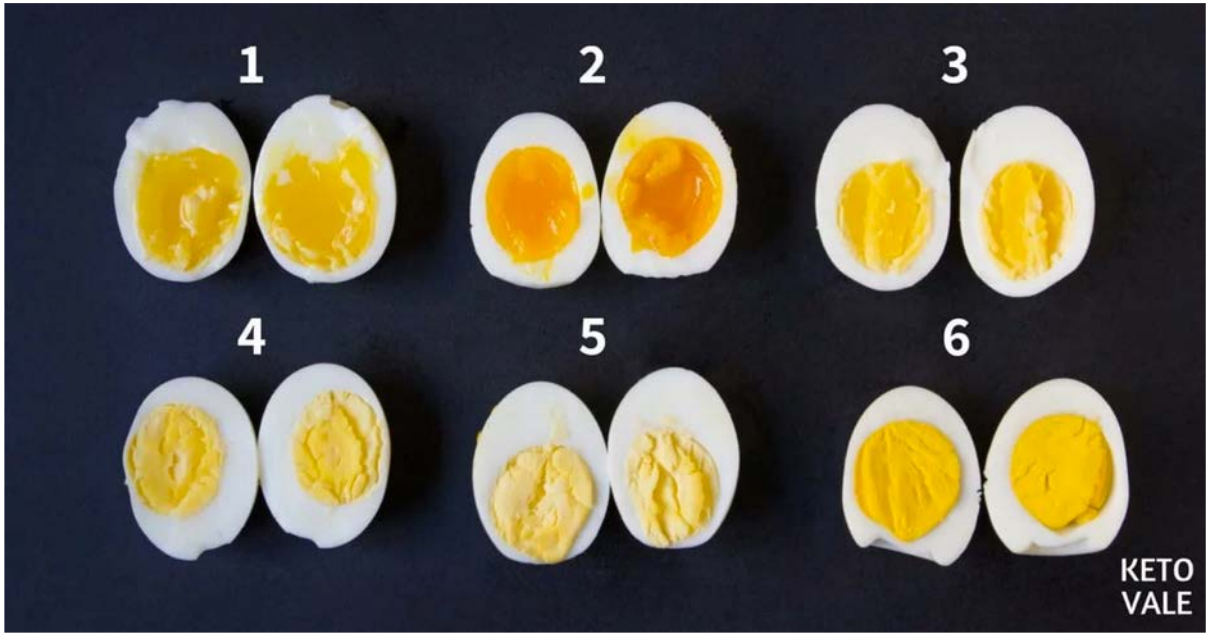




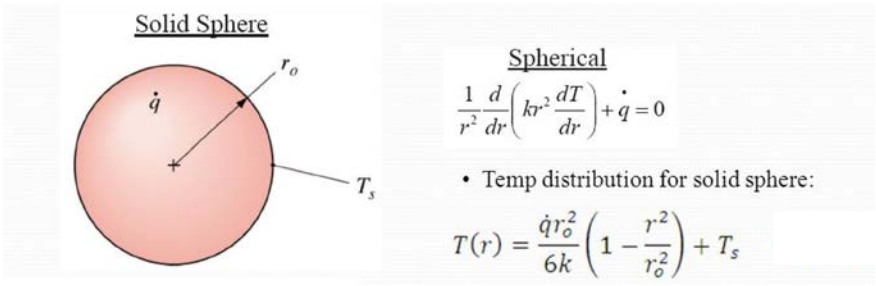
Professor Polly Piergiovanni

- Engineering Education
- Food Science and Engineering

Spring 2019 Independent Study

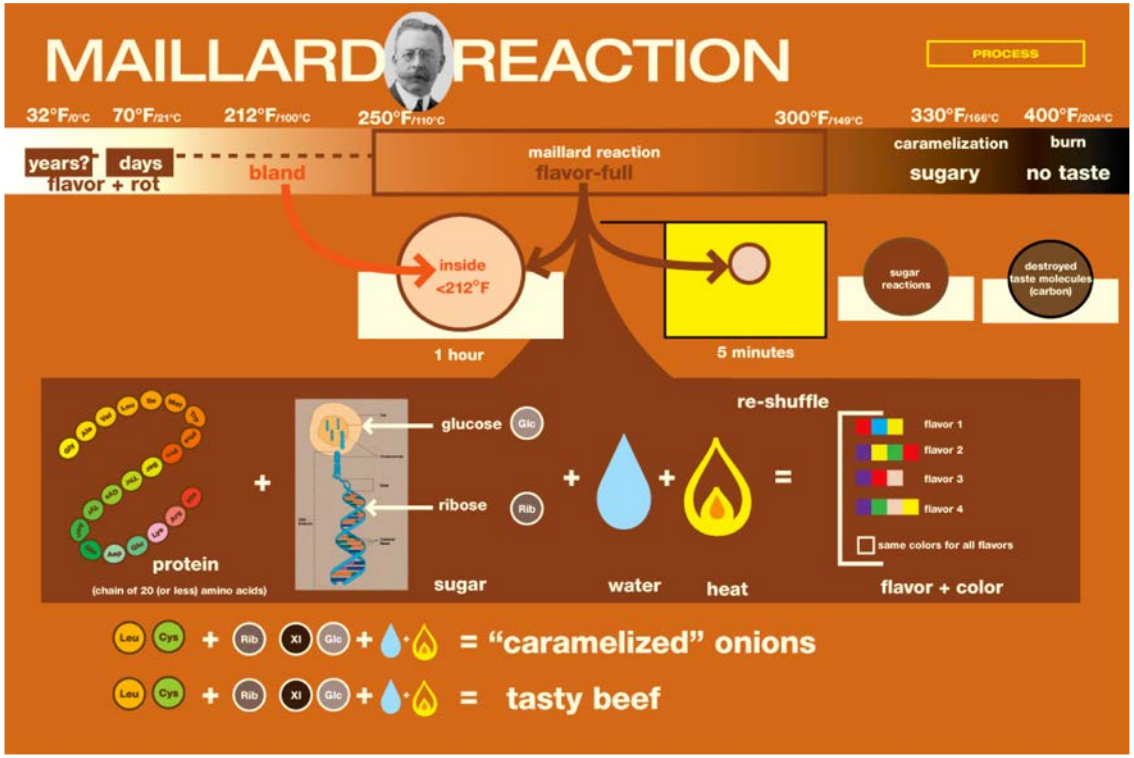


https://www.ketovale.com/recipe/how-to-boil-eggs-perfectly/



https://slideplayer.com/slide/4125339/13/images/18/Chapter+3c+%3A+One-dimensional%2C+Steady+state+conduction+%28with+thermal+energy+generation%29.jpg

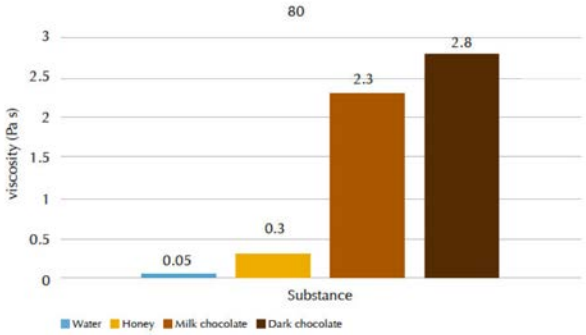
Summer 2019



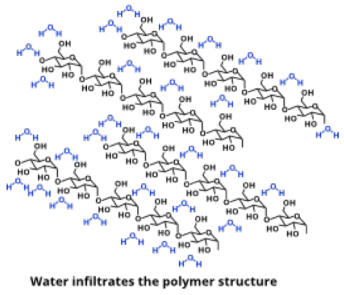
http://thechefstudio.org/maillard-science-browning-aroma-flavor/

Independent Study / Research Opportunities During the Semester

Pizza Physics: Why Brick Ovens Bake The Perfect Italian-Style Pie

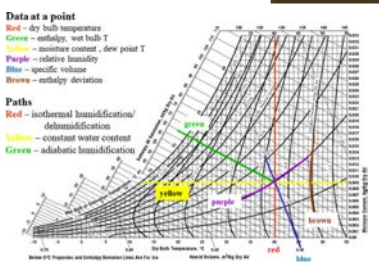


Pasta Chemistry



Chocolate material properties

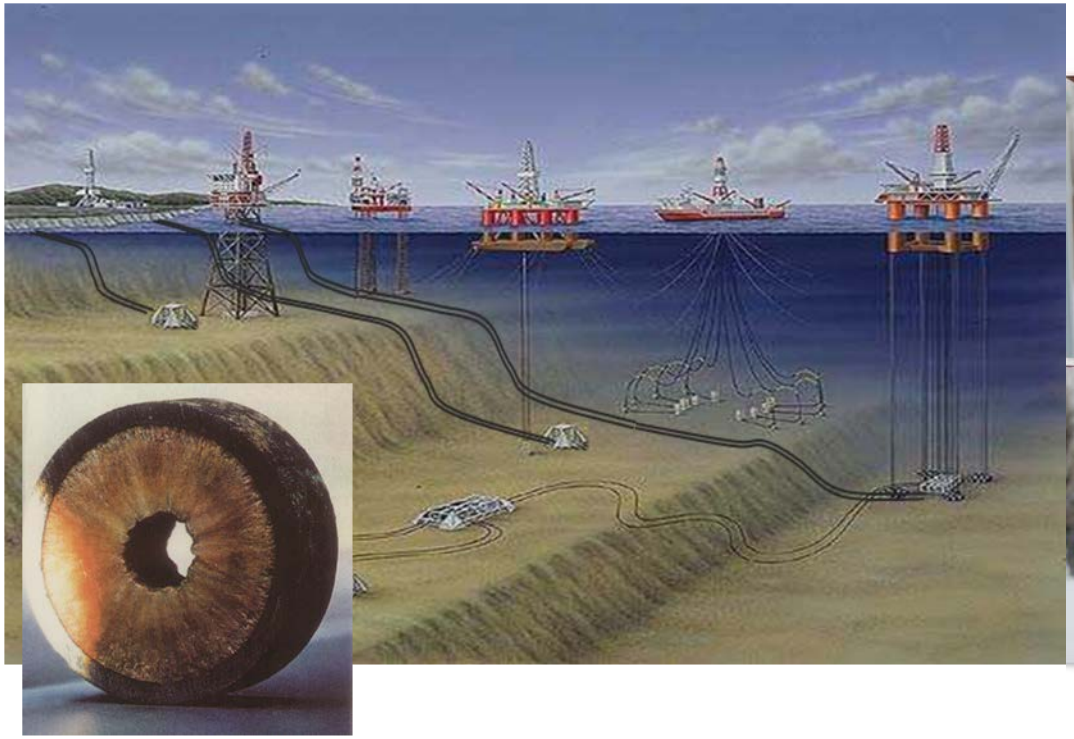
Dehydration



Getting Things Moving: Studying Cold Flow Properties

- As the name indicates, studying how fluids move at low temperatures
- Particular interest: fuels
- What can happen?
  - Changes in viscosity
  - Changes in phase (liquid → solid)
  - Leads to gel formation

Where Is This Issue Seen?



- **Petroleum:** Subsea oil transportation
- **Biodiesel:** Engines and other equipment
- Composition, mixtures and additive can greatly influence properties.

Equipment/Skills

- Conducting measurements of flow properties important in the energy industry.
- Rheometry
- Differential scanning calorimetry

Opportunities available (1-2):

EXCEL and CBL scholars (SU 19 and AY 19-20)

Honors Thesis and Independent Study (AY 19-20)

Atmospheric Aerosol Chemistry

What are aerosols?

- **Small (<1mm) particles suspended in gaseous surroundings** (e.g. smoke, mist, haze, clouds)

Impetus:

Aerosol chemistry and formation is crucial in the understanding their **climatological and public health effects**.

What we need to know:

- **Mechanisms and rates** of formation
- **Physical properties** of aerosols after formation / aging

Atmospheric Aerosol Chemistry

Experimental Work:

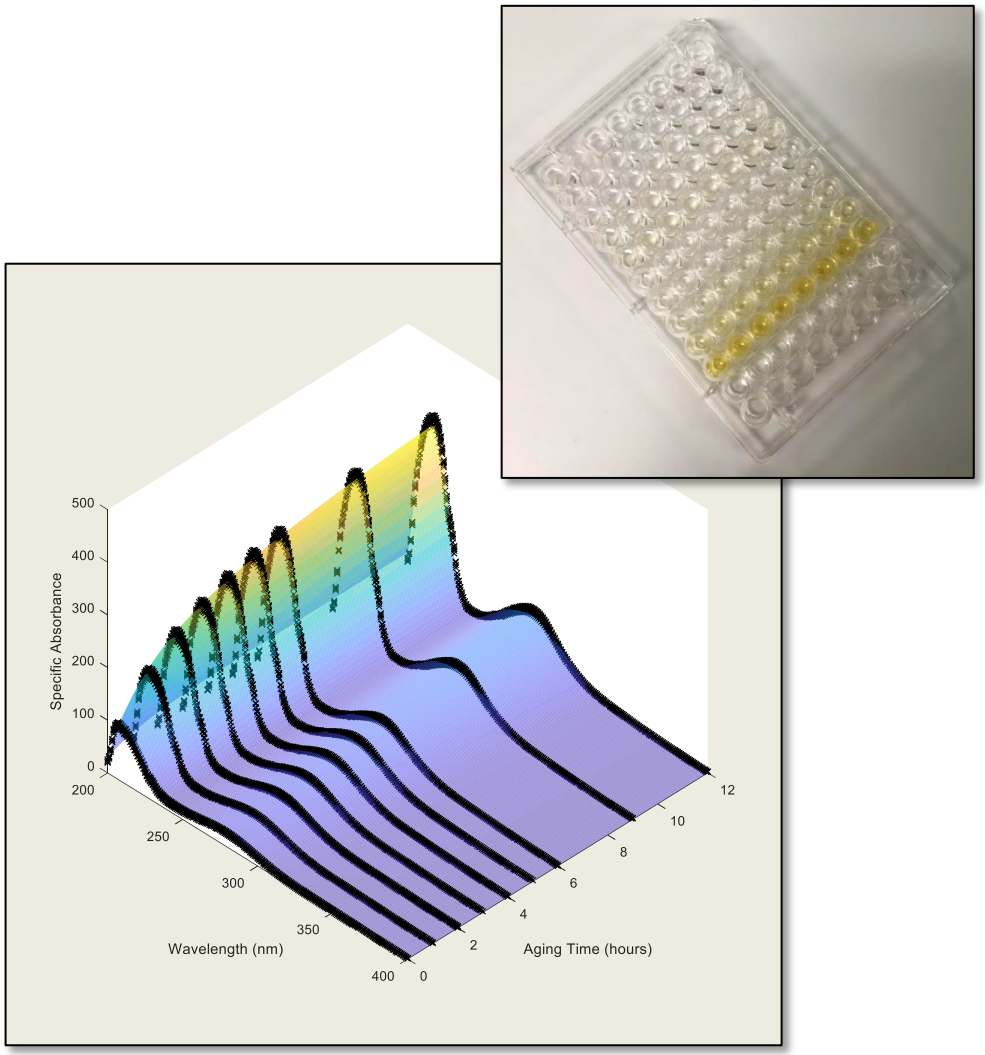
- Aerosol mimic solution characterization
- Measurement of light-absorbing properties

Computational Work:

- UV-visible absorbance spectrum deconvolution using MATLAB

Skills to Learn/Develop:

- UV/Visible spectroscopy
- MATLAB programming

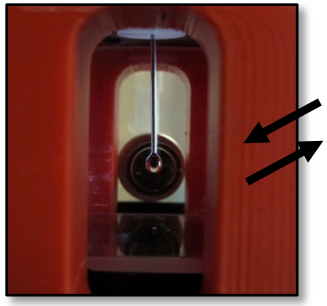


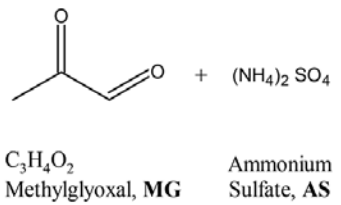
0 – 1 Student, Fall 2019

Atmospheric Aerosol Chemistry

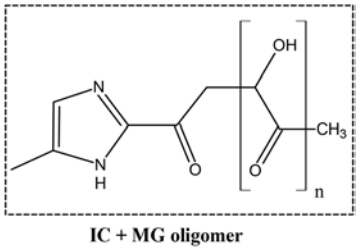
Experimental Work:

- Aerosol mimic solution characterization
- Dynamic surface tension measurements of aerosol mimic solutions





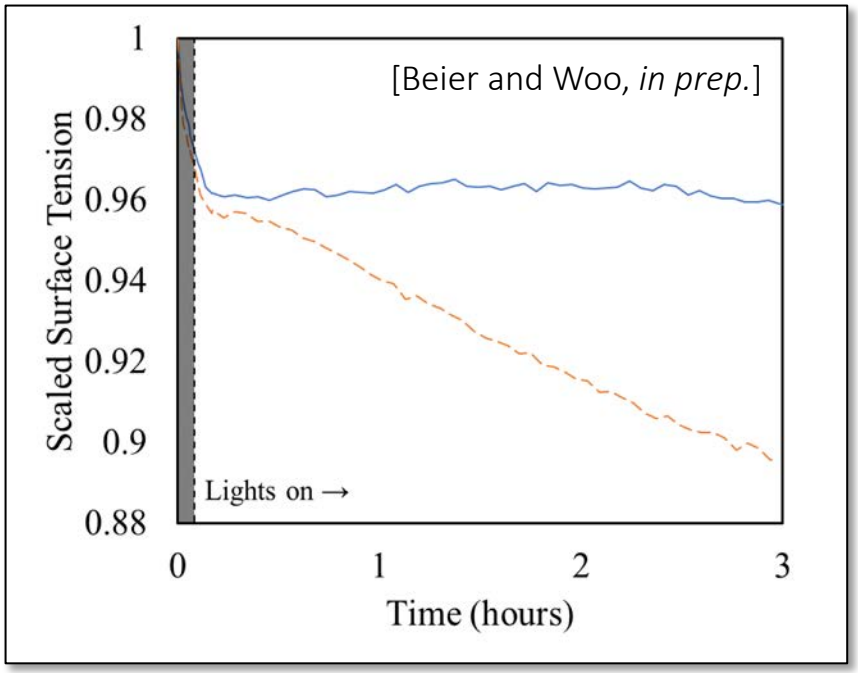
[Aiona et al. 2017]



IC + MG oligomer

Skills to Learn/Develop:

- Experimental Development
- Tensiometry (surface chemistry)
- LabVIEW, MATLAB



0 – 1 Student, Fall 2019

Atmospheric Aerosol Chemistry

Experimental Work:

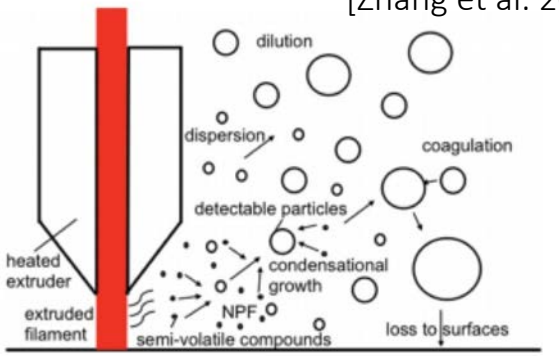
- 3D Printer particle emission
- Measurement and characterization of particle concentration and emission rates

Skills to Learn/Develop:

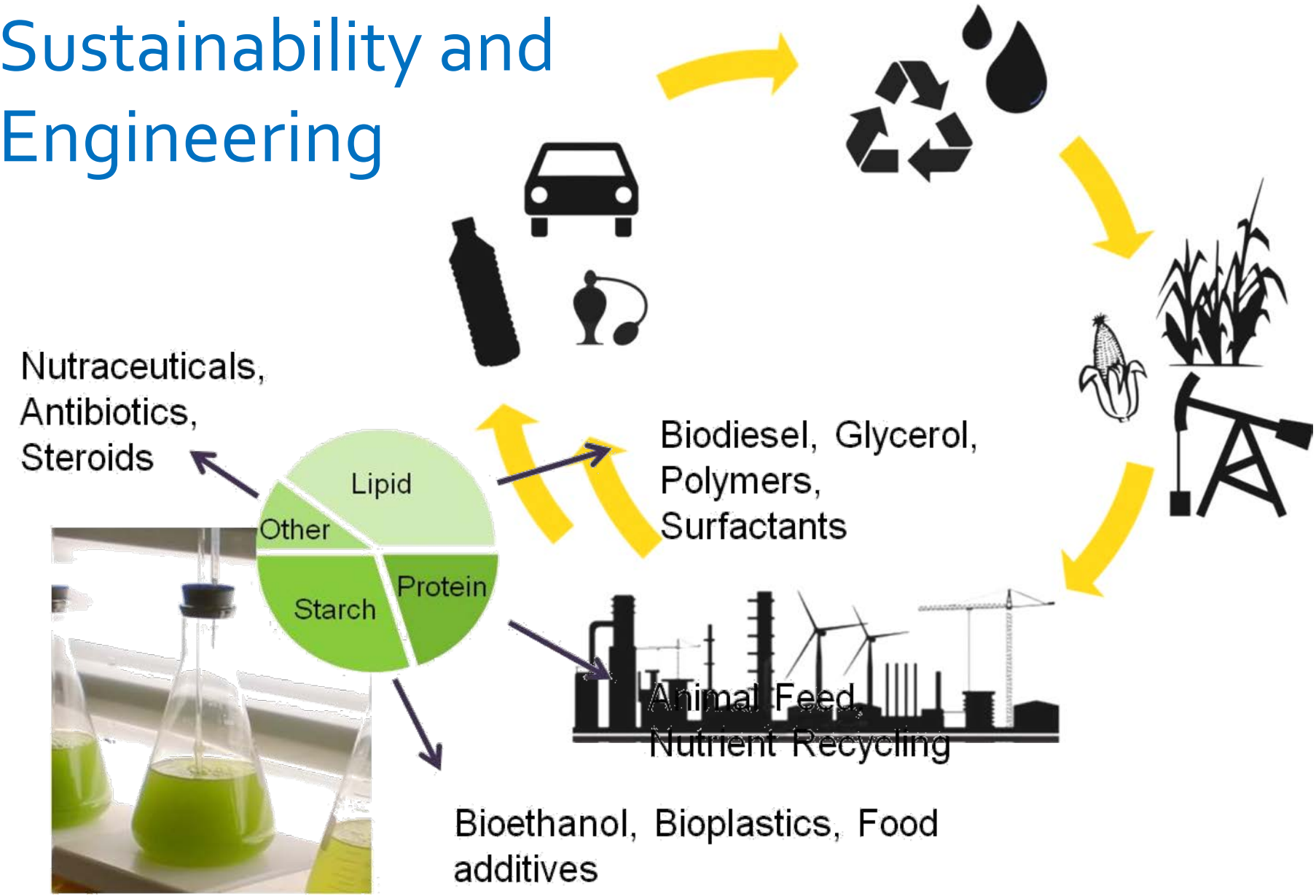
- Aerosol characterization
- 3D Printing (Fused Deposition Modeling)
- MATLAB

1 Student, Summer 2019

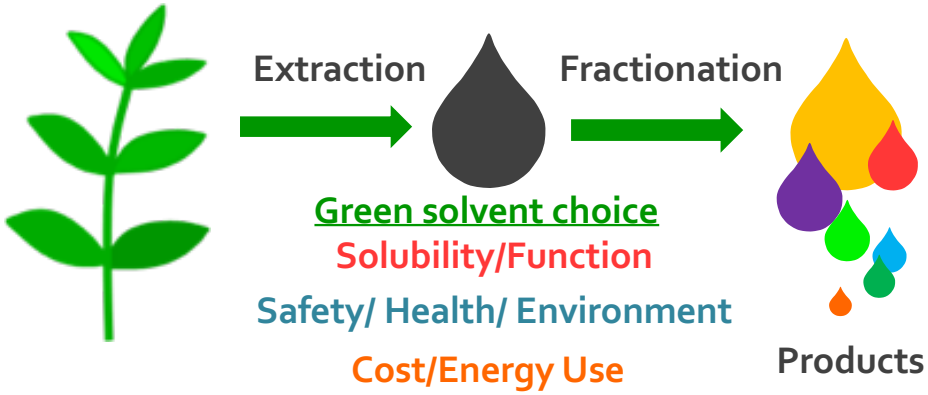
[Zhang et al. 2017]

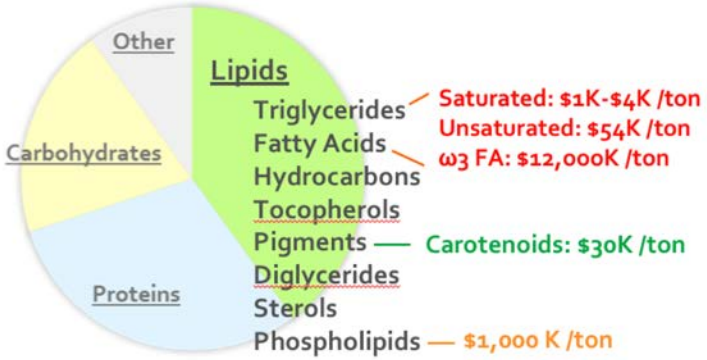


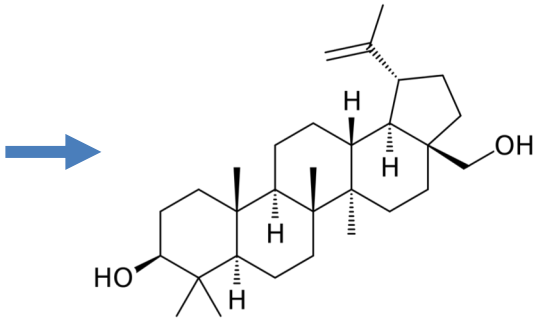
Sustainability and Engineering

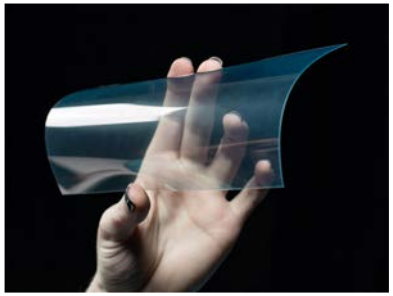


Green Engineering Applications

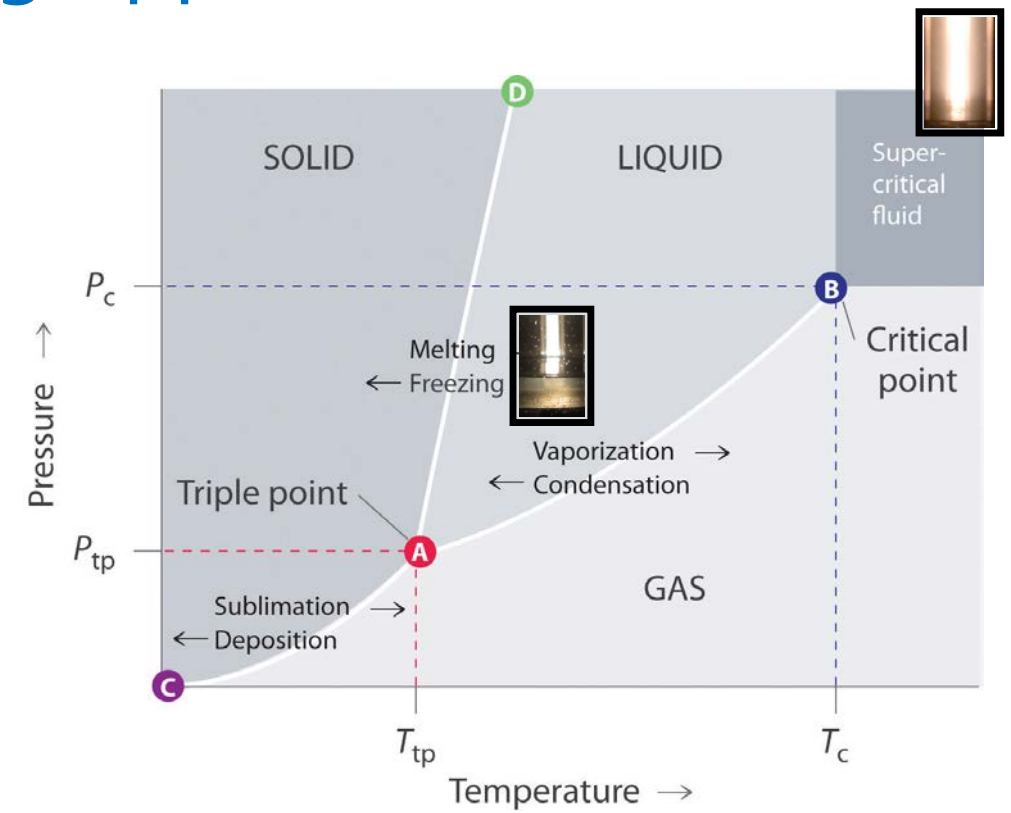








Green Engineering Applications



Skills

1. Experimental Design
2. Reactions at ambient and supercritical conditions
3. Analysis with (Gas/SCF) chromatography
4. Biomass extraction

Availability

Excel Scholar/CBL (1 joint Summer '19)
Independent Study (Spring '20)

I’m interested – what do I do next?

- **Summer EXCEL and CBL Scholars (pay)**
  - SU19:Talk to faculty ASAP
  - Deadlines: Excel - March 4. CBL - February 28
  - AY 19/20: Decision by late summer

- **Independent Research (credit only)** AY 19/20:
  - Limited to faculty availability; discuss with faculty over the summer.

- **Honors Thesis (seniors only, credit only)**
  - Plan early
  - For non-seniors, get research experience