CHEM seeks to understand, control and predict the assembly of multi-hierarchical materials of industrial relevance. Reinforced elastomers, paints, inks, biomaterials, surfactants, detergents and coacervates, semi-crystalline polymers, block copolymers, catalysts, filters, membranes, skin. Time dependence in processing/application, 4D.

Synergy: Understanding, simulation methods, dynamic and static properties understood for one field of application could be adapted to another field. Rheology simulation methods from polymers to detergents to paints.

Parallelism and Convergence: Similar solutions for different applications. Aggregate pigments and aggregate reinforcing fillers both rely on micron scale networks in application.
Prof. Jinsang Kim

Jinsang Kim, Synthesis, Polymers, Sensing

Ron Larson, Rheology, Modeling, Nanocomposites, Surfactants, Pigments

Nick Kotov, Nanoparticles, Hierarchical Assembly, Surfactants, Biomed delivery

Anish Tuteja, Surfaces, Coatings, Adhesives, Nanocomposites, Surfactants

Kim Group Research Projects - Rational Molecular Design & Synthesis

Molecular Design for Plastic Electronics

Liquid Crystalline CPs
Field Effect Transistor
Thermoelectric

Nat. Mater. 2013
Chemical Sci. 2015

Organic Light Absorbers and Emitters

Organic Phosphors
LED, Sensors, Solid-state Lighting

Nat. Chem. 2011
J. Am. Chem. Soc. 2013
Angew. Chem. 2014
Chem. Mater. 2014
Nat. Commun. 2015
Angew. Chem. 2017

Optical Biosensors

Circulating Tumor Cell Detection
Platelet Activation Monitoring
miRNA Detection

Chemical Sci 2016

Designer Functional Organic and Polymer

Heat Management in Polymer Supercooled Liquid

Nature Materials 2015
ACS Central Sci. 2015
Science Advances 2017
**Designer Polymeric and Organic Materials**
Computation-aid rational molecular design, chemical synthesis, and fabrication engineering

**Project 1: Thermally Insulating Additives**
- Highly branched architecture
- Diverse atomic composition
- Porous hollow nano particles

**Project 2: Patternable Surface Functionalization**
- Instant robust thin film formation by photochemistry
- High density functional groups
- Patterned surface functionalization via photomasks

**Project 3: Polymers for Sustainable Pavement**
- Interface adhesion engineering
- Versatile dopamine chemistry
- Excellent weatherability

**Project 4: Tailor-made Optical Materials**
- Instant robust thin film formation by photochemistry
- High density functional groups
- Patterned surface functionalization via photomasks
Larson group: Multi-Scale Modeling of the Rheology of Micellar Solutions

Jinsang Kim, Synthesis, Polymers, Sensing

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$10^{23}$ degrees of freedom!

http://www.ifnh.ethz.ch/vt/research/projects/vivianel
Larson group: Multi-Scale Modeling of the Rheology of Latex Coatings

Jinsang Kim, Synthesis, Polymers, Sensing

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Multiple Particles

100 nm

10 nm

“HEUR”: PEO chains with alkane end “stickers.”

R = C10 to C18 alkane

from Li et al. 2016

Prof. Ron Larson
**Supraparticles: Hierarchical Assemblies of Nanoparticles**

**Known:** Micelles, organic components, 100 nm assemblies

**Emerging:** Supraparticles, inorganic components, 100 nm assemblies made from 100-300 nanoparticles

**Why:**
Versatile, Monodispersed, Robust, Catalytic, Inexpensive
Combined organic + inorganic + biological functionalities
Dispersable in both hydrophobic and hydrophilic media

Jinsang Kim, Synthesis, Polymers, Sensing
Ron Larson, Rheology, Modeling, Nanocomposites, Surfactants, Pigments
Nick Kotov, Nanoparticles, Hierarchical Assembly, Surfactants, Biomed delivery
Anish Tuteja, Surfaces, Coatings, Adhesives, Nanocomposites, Surfactants

http://en.wikipedia.org/wiki/Micelle

Prof. Nick Kotov
Omnidispersable Hedgehog Supraparticles

Numerous catalytic materials can be assembled into spiky shapes: ZnO, FeSe, AuS, CdS, SiO₂, TiO₂, Fe₂O₃, Co₃O₄, and many others.

They disperse equally well in hydrophobic and hydrophilic media due to 100 times reduction in inter-particle van der Waals attractive forces.
Surfaces with Extreme Wettability

Jinsang Kim, Synthesis, Polymers, Sensing
Ron Larson, Rheology, Modeling, Nanocomposites, Surfactants, Pigments
Nick Kotov, Nanoparticles, Hierarchical Assembly, Surfactants, Biomed delivery
Anish Tuteja, Surfaces, Coatings, Adhesives, Nanocomposites, Surfactants

Membranes for Liquid-Liquid Separation

Designing Omniphobic Surfaces

Tuteja et al., Science, 2007; Tuteja et al., PNAS, 2008; Kota et al., Advanced Materials, 2012

Kwon et al. Advanced Materials, 2012
Surfaces with Extreme Wettability

Novel Ice-shedding Surfaces
Golovin et al., Science Advances, 2016; Science Advances, 2017; Golovin et al., Science, 2019

Monodisperse, multi-phasic particles

Kobaku et al., ACS Macro Letters, 2019
Electron Microbeam Analysis Laboratory (EMAL)

The University of Michigan Electron Microbeam Analysis Laboratory (EMAL) and X-ray Microanalysis Laboratory (XMAL) is a university-wide user facility for the microstructural and microchemical characterization of materials. This world-class facility now showcases a JEOL 2100F C6 Corrected Analytical Electron Microscope, FEI Helios 650 Nanolab SEM/FIB, FEI Nova 200 Nanolab SEM/FIB, FEI Quanta 3D SEM/FIB, JEOL.

Lurie Nanofabrication Facility (LNF)

The Lurie Nanofabrication Facility (LNF) at the University of Michigan is one of the leading centers worldwide on micro electromechanical systems (MEMS) and microsystems. It provides facilities and processes for the integration of Si integrated circuits and MEMS with nanotechnology, with applications in biology, medical systems, chemistry, and environmental monitoring.

Center for Ultrastd Optical Science (CUOS)

The Center for Ultrastd Optical Science (CUOS) is an interdisciplinary research center in the College of Engineering. Its mission is to perform multidisciplinary research in the basic science and technological applications of ultrashort laser pulses, to educate students from a wide variety of backgrounds in the field, and to spur the development of new technologies. CUOS researchers develop optical instrumentation and techniques to generate, manipulate, and detect ultrashort and ultrahigh-power-light pulses. They use these ultrashort pulses to study ultrashort physical phenomena in atomic, nuclear, plasma, and materials physics, in solid-state electronics, in high-energy-density physics, and in biomedicine.

Michigan Nanotechnology Institute for Medicine and Biological Sciences (MNIMBS)

The Michigan Nanotechnology Institute for Medicine and Biological Sciences is a true multidisciplinary team of chemists, physicists, engineers, toxicologists, physicians, biologists, pharmacists, and (bio)informatics specialists collaborating on nanoscale technology in biology and medicine. The Institute involves approximately 60 faculty in a “no-walls” model using facilities in the Engineering, Medical and LSA schools to enhance competitiveness for externally funded grants and contracts.

Center of Solar and Thermal Energy Conversion (CSTEC)

The Center for Solar and Thermal Energy Conversion is an Energy Frontier Research Center (EFRC) supported by the US Department of Energy (DOE). The goal of CSTEC is to discover and develop the science necessary to maximize the energy conversion efficiencies of photovoltaic (PV) and thermoelectric (TE) devices through integrated theoretical, experimental, and computational strategies.

The Michigan Institute of Plasma Science and Engineering (MIPSE)

MIPSE is a community of faculty, staff, and students at the University of Michigan whose research and education programs are devoted to the advancement of the science and technology of plasmas. The breadth of research is impressive, from laser-produced plasmas for particle acceleration to plasmas in the earth’s magnetosphere. We take pride in the excellence of the research and in the resulting societal benefits.