Bio. Matthew Helgeson is an assistant professor in the Department of Chemical Engineering at University of California, Santa Barbara, where he is also a faculty member and IRG co-leader of the Materials Research Laboratory (an NSF MRSEC). He received his B.S. in Chemical Engineering at Carnegie Mellon University in 2004, and Ph.D. in Chemical Engineering at the University of Delaware in 2009. He performed postdoctoral research at MIT before joining the faculty at UCSB. Helgeson’s research focuses on designing and processing complex fluids with well-specified nanostructure, especially those involving colloids in structured liquids. His research has been recognized with a number of awards, including Early Career Awards from both the National Science Foundation (2013) and Department of Energy (2015), a Hellman Foundation Faculty Fellowship (2016), the Northrop Grumman Excellence in Teaching Award (2015), and both the Victor K. LaMer Award (2011) and the Unilever Award (2016) from the American Chemical Society.

Complex Nanoemulsions for Engineering Novel Soft Nanoparticles with Applications in Nanomedicine

Emulsions have long been a foundational technology for the solution-phase synthesis of functional particles and materials. More recently, methods to create emulsions with complex internal droplet structure have opened up an entire new design space of complex, multi-phase droplets and particles with potential advantages for foods, consumer products, and medicine. These applications have yet to be realized due to significant challenges with current emulsification methods for complex droplets, which are mostly limited to large sizes, poor stability and low throughput. Nanoemulsions – metastable suspensions of nanoscale droplets – overcome these limitations through their scalable processing and metastable nature. However, their engineering is complicated by emergent colloidal and interfacial behavior when droplet sizes are driven to the nanoscale. In this seminar, I will summarize our recent efforts to understand this behavior, and exploit it for the creation of complex nanodroplets and nanoparticles using relatively simple design principles. In particular, we have demonstrated the synthesis of novel nanogel particles with independent control of particle size, internal composition, and mechanical properties that provide unique opportunities for nanomedicine. As a demonstration of their utility, we show how complex nanogels can be used to determine the influence of mechanical properties on the biological transport of nanoparticles. The results indicate particle softness as a critical yet underexplored design parameter for nanobiotechnology, with significant implications for blood circulation, biodistribution, barrier penetration and cellular internalization.