How can we characterize the properties of a complex interface?

It has long been known that liquid interfaces can be manipulated by adhered molecules and particles to create interfacial viscosity, elasticity, and plasticity. These so-called complex interfaces affect bulk stability of Pickering emulsions, flow of emulsions during oil recovery, formation of pellicles, and a range of other commercial/industrial applications. However, only in the last two decades have experimental and modeling techniques been developed that allow robust characterization of complex interfaces. In the Christopher lab, we have attempted to understand the mechanisms that dictate interfacial viscoelasticity for a range of systems through the use of specialized techniques including a modified interfacial rheometer, advanced microscopy, microfluidics, and computer simulations:

- Particle laden interfaces are responsible for stabilizing Pickering emulsions. To characterize these interfaces, we use a combination of Bessel Beam microscopy, simultaneous interfacial rheology and visualization, and Stokesian dynamics simulations. These techniques allow us to understand first how a population of particles adsorb to an interface, then how interparticle forces affect initial microstructure of such interfaces, and finally how microstructure and flow interact to create interfacial viscoelasticity. Our results indicate that the properties of particle laden interfaces can be manipulated in a controlled and predictable way.
- Pellicles, which are biofilms at a/w or o/w interfaces, impact both disease and industrial applications. Interfacial rheology provides a robust way to characterize the development of these films. Studying *P. Aeruginosa* and *E. Coli,* we have shown that the liquid interface fundamentally changes pellicle behavior in comparison to solid surface biofilms, by allowing non-biologically mediated attachment through surface tension and negating the effects of surface motility on microstructure. Taking advantage of these observations, we have successfully adjusted the growth of pellicles by modifying the properties in the interface through addition of surfactants and particles.
- Asphaltene is a major component of crude that adsorbs to the o/w interfaces, creating an emulsion which is difficult to extract and demulsify. Using microfluidics, we have studied how such emulsions/interfaces can be better driven out of a porous network by use of non-Newtonian fluids. Using interfacial rheometry, we have examined how to create an asphaltene interface that more accurately captures actual crude interfaces, and how addition of demulsifiers effects the size of asphaltene aggregates and their interfacial viscoelasticity.

By taking advantage of a range of different experimental techniques, we have been able to better understand the complex mechanical response of these interface and the mechanisms that control these responses. As we move forward, we hope to tie these interfacial responses to bulk behaviors using new bulk rheology, visualization, and simulation techniques.

Dr. Christopher has been is an Associate professor in the Department of Mechanical Engineering at Texas Tech University, where he has worked since 2011. He received a BS in Mechanical Engineering (2002) and a BA in Film (2003) from Columbia University. He attended Carnegie Mellon and graduated with a PhD in Mechanical engineering and a MS in Chemical Engineering in 2008. Afterwards, he spent 2 years in the Polymers Division of the National Institute of Standards and Technology as a NRC Postdoc. His research focuses on the development on study of complex fluids and interfaces rheology and flows through the development of novel techniques, including microfluidics, interfacial rheology, and bulk rheology. Since beginning work at Texas Tech, he has been named a Whitacre Research Fellow and won the TA Distinguished Young Rheologist award.