Complex fluids consisting of multiple interspersed phases are everywhere. Food, pharmaceuticals, cosmetics and personal care products are all complex multiphase fluids that have been designed with specific functionality to satisfy customers' needs. Complex multiphase fluids are also regularly found in a variety of industrial processes, ranging from coatings to the production and processing of commodity chemicals.

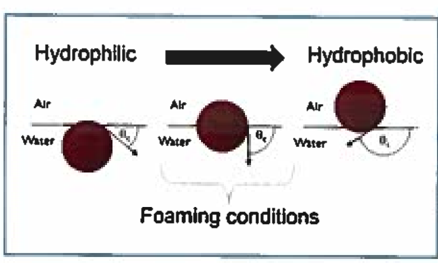
Existing in various forms — suspensions (solid/liquid), emulsions (liquid/liquid), or foams (gas/liquid) — these mixtures are each considered complex multiphase fluids. As part of the Department of Chemical and Biomedical Engineering, the Wirth Lab works to engineer materials for existing and next generation applications. With this $110,000 Doctoral New Investigator Grant from the American Chemical Society Petroleum Research Fund, Dr. Christopher L. Wirth seeks to develop new foam technology for the unconventional recovery of gas and oil.

New foam technology would prove timely for the gas and oil industries as they move toward shale fracturing and enhanced oil recovery (EOR). Shale fracturing, commonly known as fracking, is a process in which water containing sand and chemical additives is injected into a well to create fractures within rock formations to release natural gas contained within shale. As natural gas is a cleaner fuel source than other carbon-based sources, it is considered to be a potential "Bridge Fuel" as the U.S. moves towards a more low-carbon energy economy. EOR involves pumping gas or liquid into a reservoir to release additional hydrocarbon following the initial depletion stage. Gases, including carbon dioxide, nitrogen, or air, are often more effective for EOR than liquids as gases tend to have higher sweep efficiency than liquid-based EOR. However, gases do not have a high volume sweep efficiency.

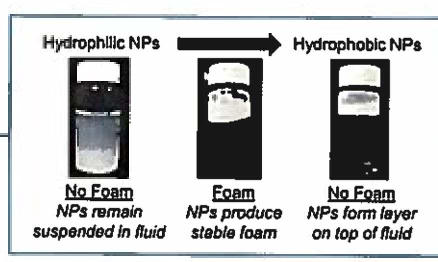
Dr. Wirth's funding will help develop new foams to increase process efficiency, while decreasing environmental impact. One of the most significant environmental concerns with shale fracturing is the enormous volume of water used in each well. Greater efficacy of foam fracking fluids will substantially reduce the volume of water required for unconventional natural gas drilling. Additionally, the rheological and mechanical properties of foams are also suitable for use in EOR as effective displacing fluids, as well as sweeping fluids for environmental remediation.

During the grant period, Dr. Wirth's lab will develop and utilize foams stabilized by nanoparticles. Nanoparticle stabilized foams have many properties that make them desirable, including strong stability in the presence of oil. One of the project's goals is to optimize the nanoparticle surface chemistry to achieve a foam that has a microstructure and transport properties tailored for each application. Until now, there has been very little work on how particle properties and interfacial microstructure influences the transport of nanoparticle stabilized foams in porous media, which is crucial for implementation in real world applications.

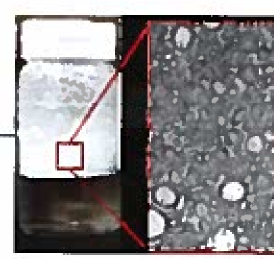
Dr. Wirth is actively seeking both federal and commercial partners to continue this work beyond the initial two-year grant period. Given the omnipresence of complex multiphase fluids, the technologies developed in CSU's Wirth Lab could potentially have applications beyond the gas and oil industries.



NPs pinned at an interface enhances interfacial stability. The interfacial position of the NPs depends on whether the NP is hydrophilic (water-loving), hydrophobic (water-hating), or somewhere in between.



Complex multiphase fluids following agitation, from left to right: wetted nanoparticles (NPs), partially wetted NPs, and non-wetted NPs.



Internal structure of NP stabilized foam.