



# IFPRI Project Abstract

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## **Dynamic and structural investigation of capillary suspensions**

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Project Start Date: 25 September 2018

Abstract Date: 15 May 2023

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### ***Project Objective:***

Structure and function are inherently related. Using a model system for dense and capillary suspensions, we will investigate the microstructural changes during interesting rheological transitions, e.g. yield, using confocal microscopy. Capillary suspensions, particles suspended in a bulk fluid with a small amount of immiscible secondary fluid added to form a percolating network of capillary bridges between the particles are of particular interest as they show a wide range of rheological behavior.

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### ***Approach:***

Changes to the microstructure of a suspension of fluorescently labelled silica particles are investigated using a confocal microscope in both shear and compression. Using particle detection and semi-local measures, we can compare the structure of the samples with their bulk rheological response.

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### ***Recent Results:***

The rheo-confocal setup now allows us to make simultaneous rheological and confocal measurements where we track both the displacements of clusters and individual bridges. In the present work (soon to be submitted), we show that the deformation near the yield stress is highly localized and that a vorticity displacement precedes the deformation in the flow direction. This occurs for both constant applied stress and oscillatory deformation. Using the sequence of physical processes (SPP) analysis, we further investigate the yielding during oscillation. Just above the LVE, a reversible yielding regime, corresponding to a purely elastic cycle, occurs where the Hertzian repulsion on bridged particles is removed allowing them to rotate without bridge stretching. At higher strains, the bridges begin to stretch and, although  $G' > G''$  on average, the instantaneous  $G'_t < G''_t$  for a part of the cycle, allowing for cluster reorganization and displacement. Finally, above the flow point, bridges begin to break and clusters flow. Interestingly, we can also show the bridge stretching is hysteretic with longer retraction than compression.

We also investigated the influence of compression for both capillary suspensions with and without added nanoparticles. The incorporation of nanoparticles weakens the network strength (decreasing both  $G'$  and  $G''$ ) with varying degree based on the nanoparticle hydrophobicity. The incorporation of the nanoparticles further influences the normal force measured during compression resulting in an apparent lubrication of the particle network. During compression, the displacement without nanoparticles occurs through microparticle force chains with a large degree of lateral motion. With nanoparticles, the displacement is more uniform with little lateral motion. This results in a much larger microparticle volume fraction after compression for the NP system in comparison to the system without NPs.

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***Next Steps:***

Experiments on the rheo-confocal setup will now continue to further refine analysis of particle and bridge motion. We will use this to further quantify the structure of the networks adjacent to yielding zones and incorporate weighting into our network analysis. The focus will be on continuing the system with and without nanoparticles, finishing the system with miscible liquids, and beginning work on anisotropic particles.

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