A model granular suspension in a yield-stress fluid

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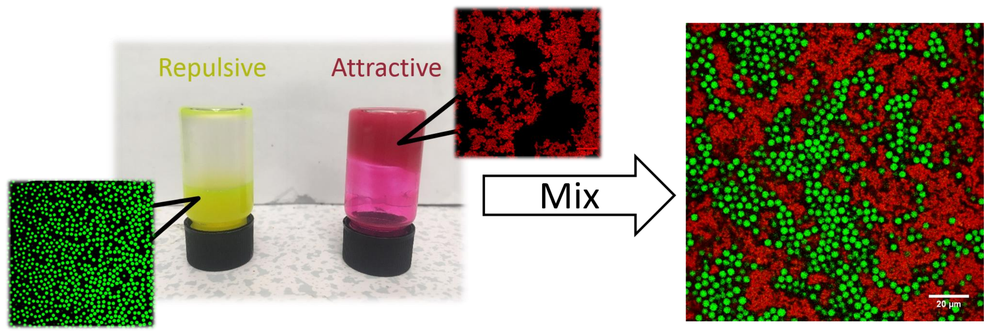
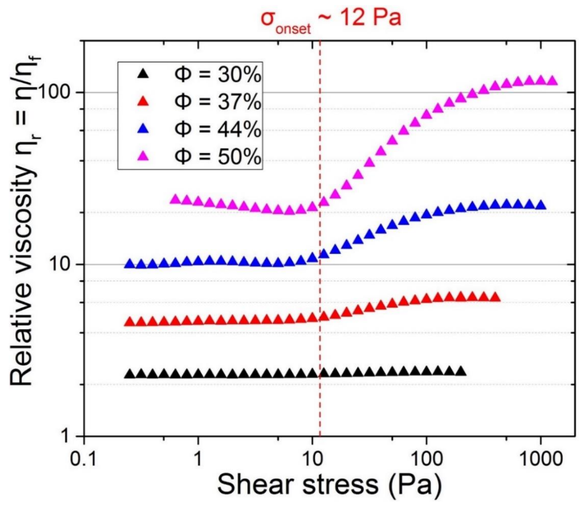
Introduction

- A binary mixed system composed of **non-Brownian, repulsive particles** ($d \sim 4$ μm) and **attractive colloidal particles** ($d \sim 0.5$ μm)
- Repulsive (charge repulsion) particles – shear thickening
  Attractive (hydrophobic attraction) particles – colloidal gel background
- Stöber silica particles for tuneable surface chemistry and index-matchability



Large Particles: Shear Thickening

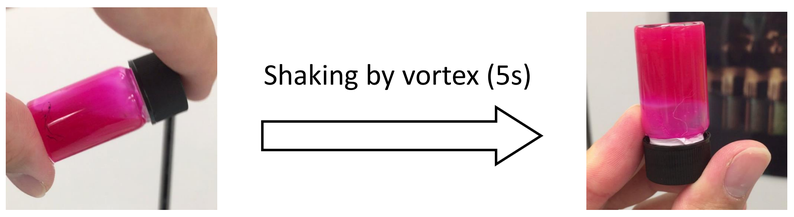
- Silica particles ($d \sim 4$ μm) in water/glycerol mixture
  Surface charge: electrostatic repulsion
- Transition from frictionless → frictional contacts drives viscosity increase [1-3]
- Onset stress keeps constant when varying volume fraction ϕ



[1] Seto, Mari, Morris, PRL 2013, JoR 2014; [2] Wyart and Cates, PRL 2014; [3] Guy, Herms, Poon, PRL 2015

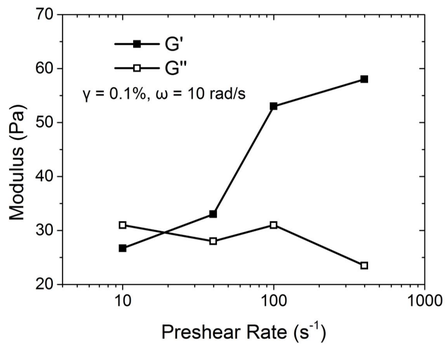
Mixed System

- Mixed system : $\phi_{attractive} = 10\%$; $\phi_{repulsive} = 35\%$
  Colloidal gel : $\phi_{attractive} = 10\%$
- Highly dependent on shear history (rheopexy?)

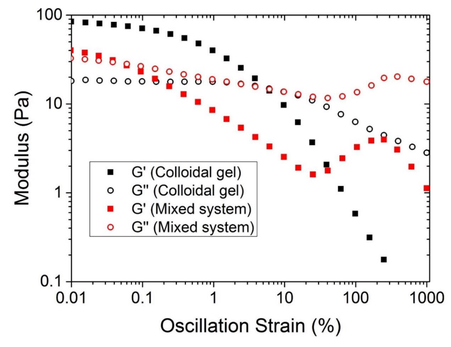


Liquid-like — Solid-like

High-shear mixing arrests suspension



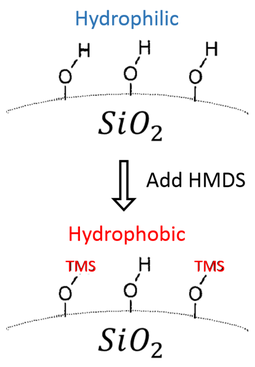
Higher preshear → higher G'



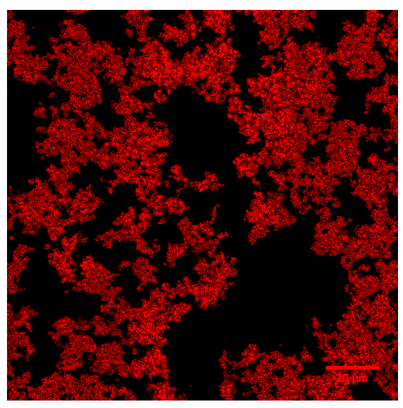
A modulus peak at large strain

Small Particles: Colloidal Gel

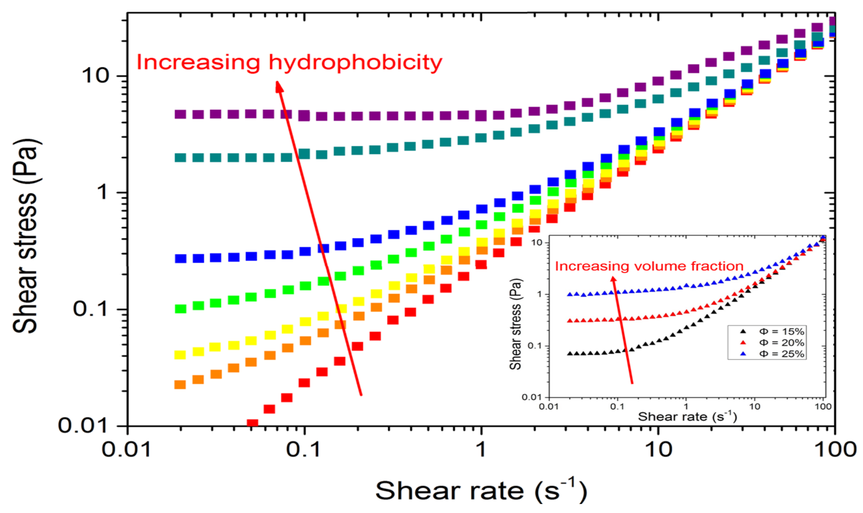
- Colloidal silica particles ($d \sim 0.5$ μm)
- Trimethylsilyl (TMS) coating induces hydrophobic attraction
- Attractive interaction → Colloidal gel → Yield stress



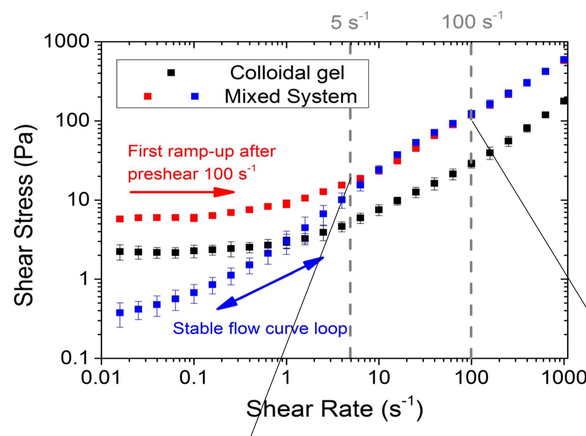
TMS coating by hexamethyldisilazane (HMDS)



Percolated gel network (confocal 2D)



Tuneable rheology

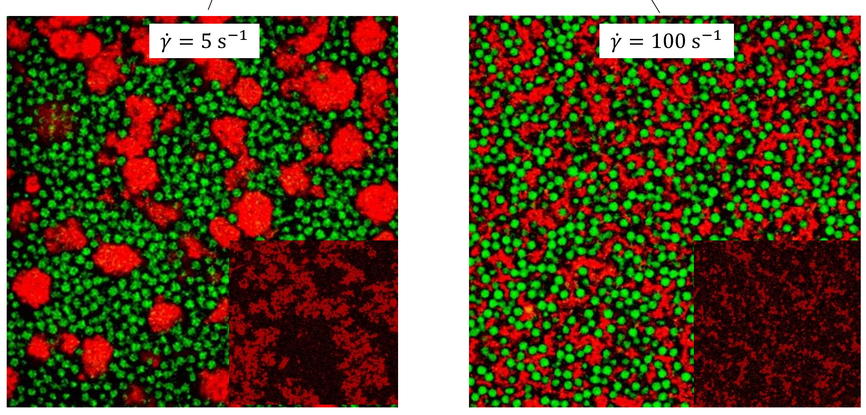


High σ_{yield} after high preshear

Reproduce same curve after first ramp-up

Rheo-imaging reveals structure change at moderate shear

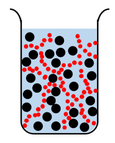
- Gel collapse
- Compact clusters



In-situ rheo-imaging (insert is colloidal gel without large particles).

Conclusions and Future Work

- The addition of large particles produces compact clusters at moderate shear
  - Related to shear thickening?
  - Same collapse in oscillatory shear?



- Formation of compact clusters makes it history-dependent