RESEARCH HIGHLIGHT

PURDUE MATERIALS ENGINEERING

Structure-Property Relationships of Soft Materials and Complex Fluids

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Our mission is to better understand how soft materials and complex fluids deform and flow in response to externally applied forces. We achieve this through experimental study of model materials with well-defined chemical and physical structures and through rheometry coupled with in-situ flow visualization.

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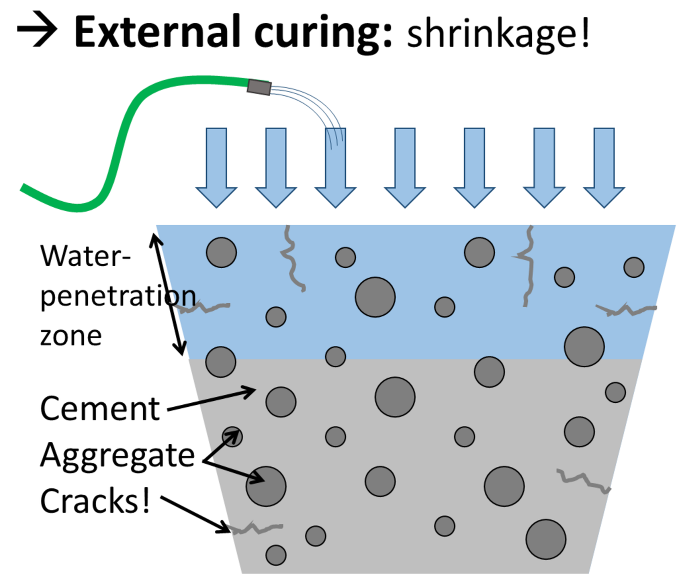
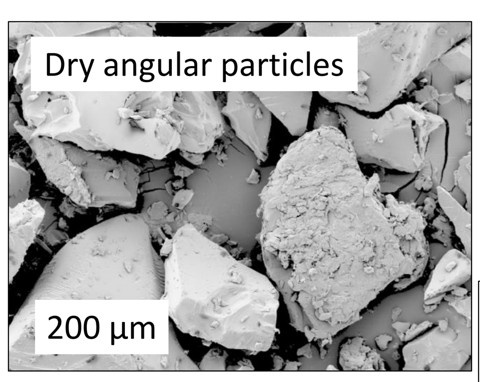
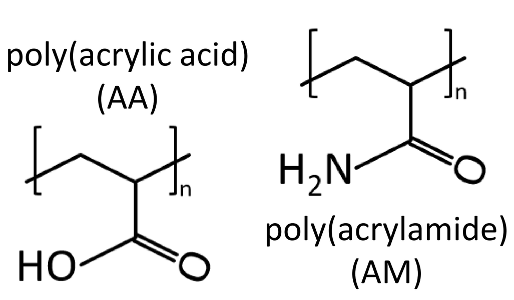
Polymeric Materials for High-Performance Concrete

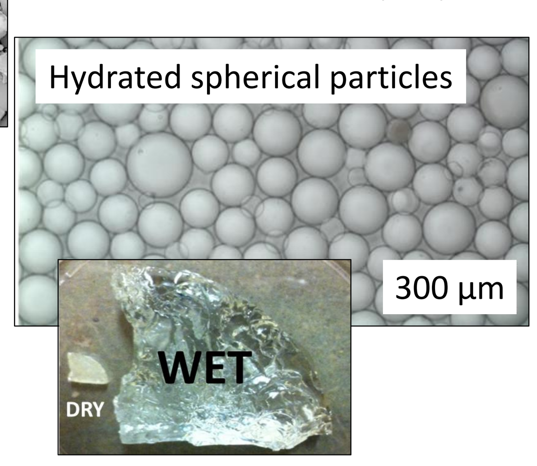
Water released from hydrogel particles used as internal curing agents leads to beneficial reductions in volumetric shrinkage and cracking of concrete.

→ **External curing:** shrinkage!



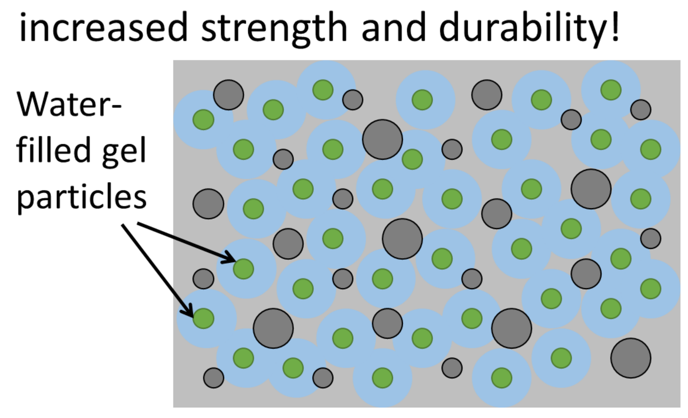




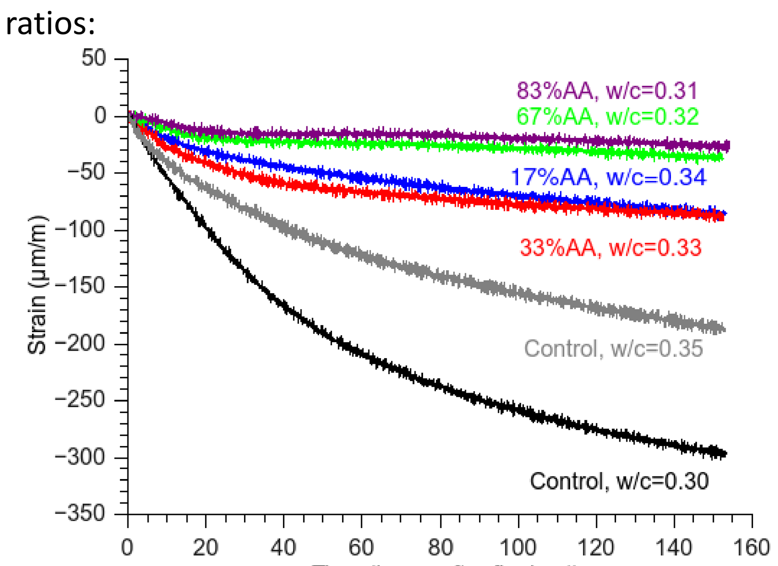


Hydrogel particle chemistry, shape, and size are controlled through different synthesis methods. Swelling behavior is strongly dependent on hydrogel chemistry (AA:AM).

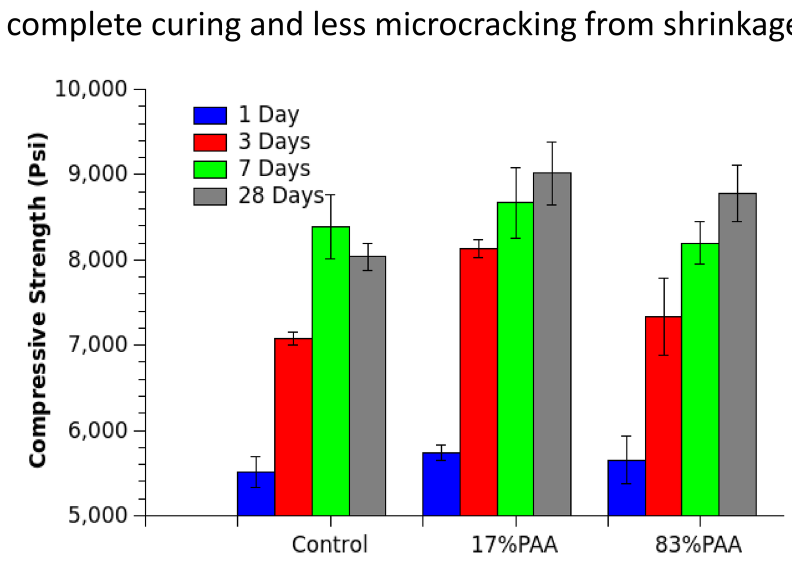
→ **Internal curing with gels:** increased strength and durability!

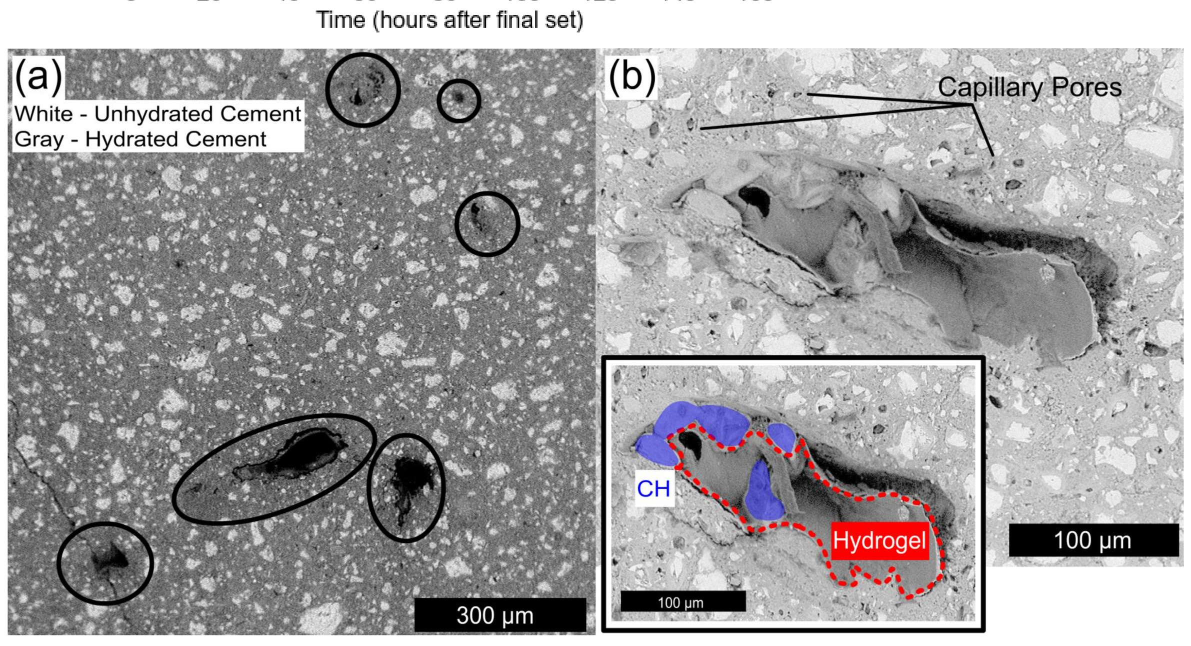


Addition of hydrogel particles significantly reduces mortar shrinkage, even at low water-to-cement (w/c) ratios:



Despite voids remaining from deswollen hydrogels, mortar strength increased at 28 days, implying more complete curing and less microcracking from shrinkage:



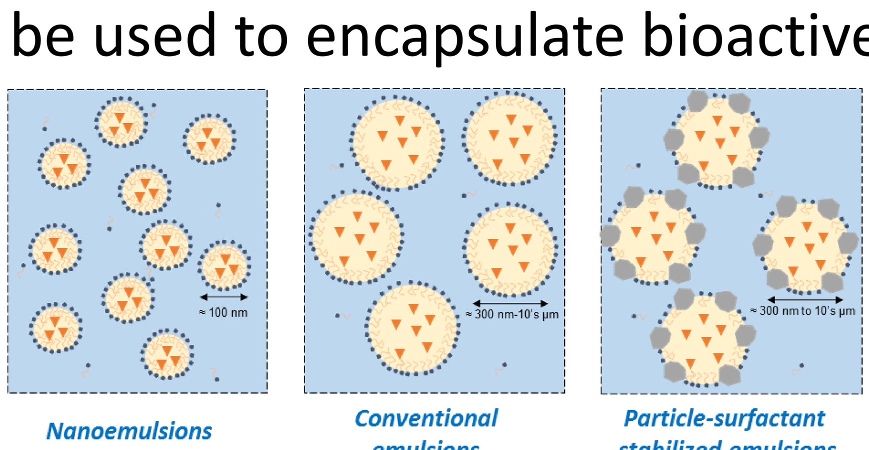


The hydrogel chemistry directly impacts the formation of inorganic phases in the cement microstructure.

Majority-acrylamide hydrogel particles result in void space that is partially refilled with calcium hydroxide (CH) and calcium-silicate-hydrate phases.

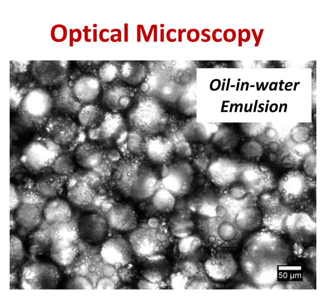
Dynamics of Surfactant-Stabilized Oil-in-Water Emulsions

Oil-in-water emulsions stabilized by surfactant molecules can be used to encapsulate bioactive compounds.

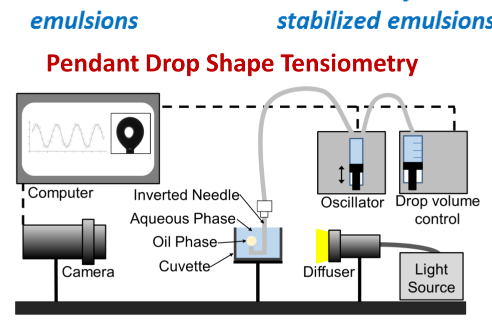


Characteristics which govern emulsion stability (including droplet size distribution, phase separation resistance, and interfacial elasticity) can be quantified using several techniques:

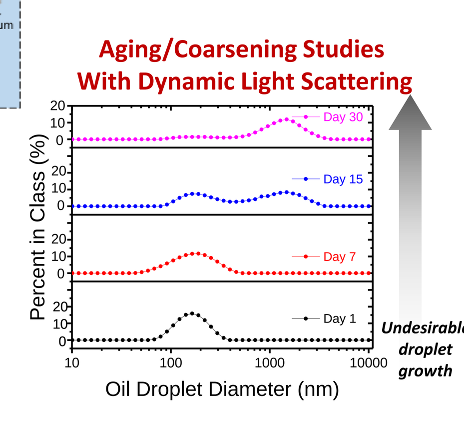
Optical Microscopy



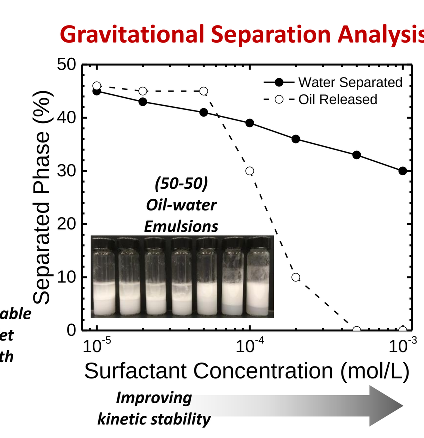
Pendant Drop Shape Tensiometry



Aging/Coarsening Studies With Dynamic Light Scattering

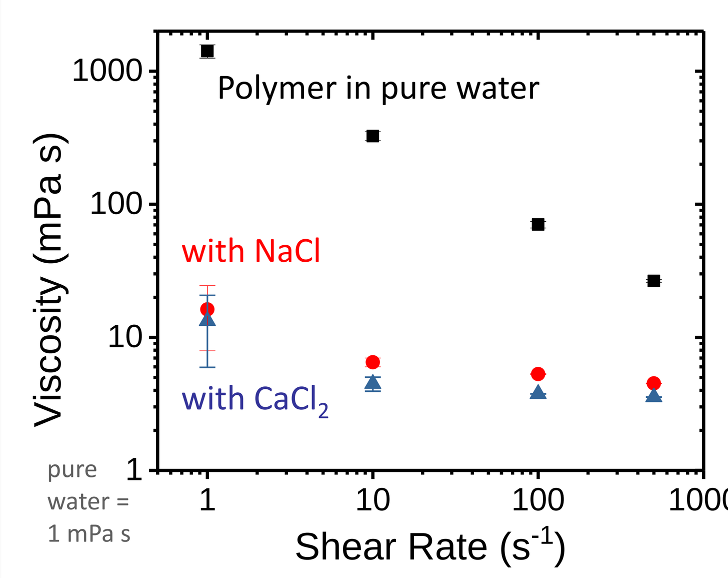


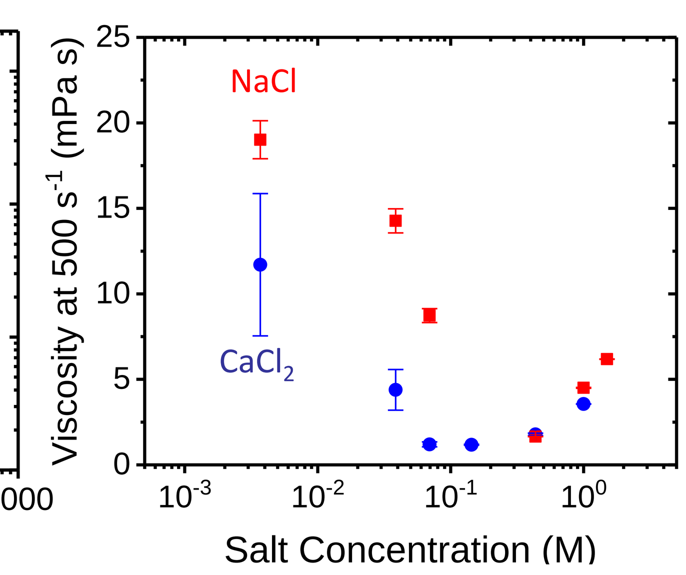
Gravitational Separation Analysis



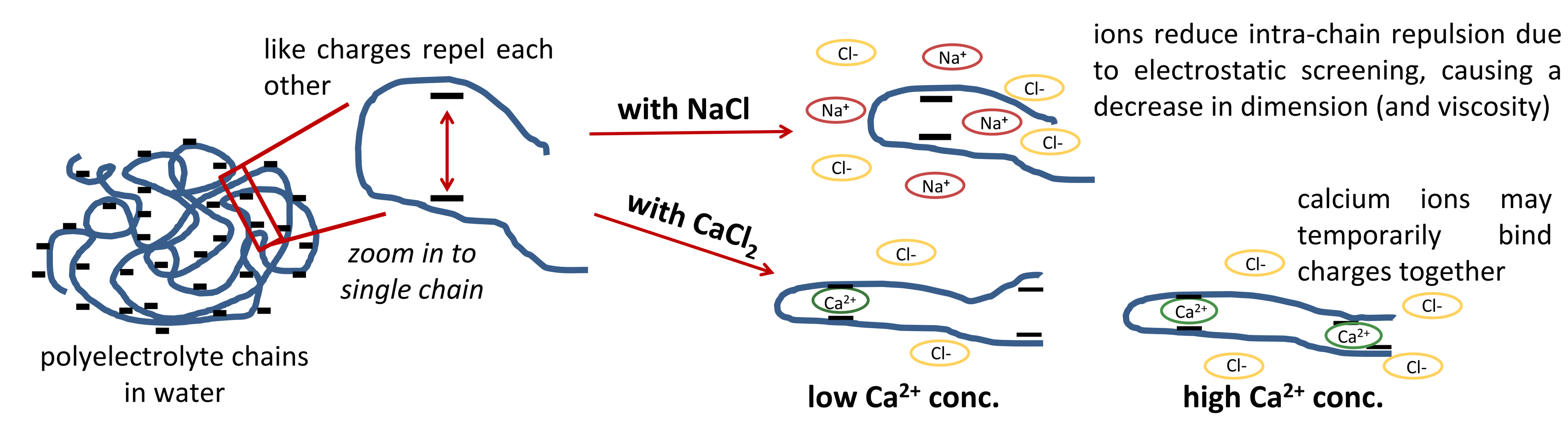
Flow Behavior of Polymer and Surfactant Solutions

Shear rheometry measurements are used to quantify the flow behavior of polymer solutions used for enhanced oil recovery.





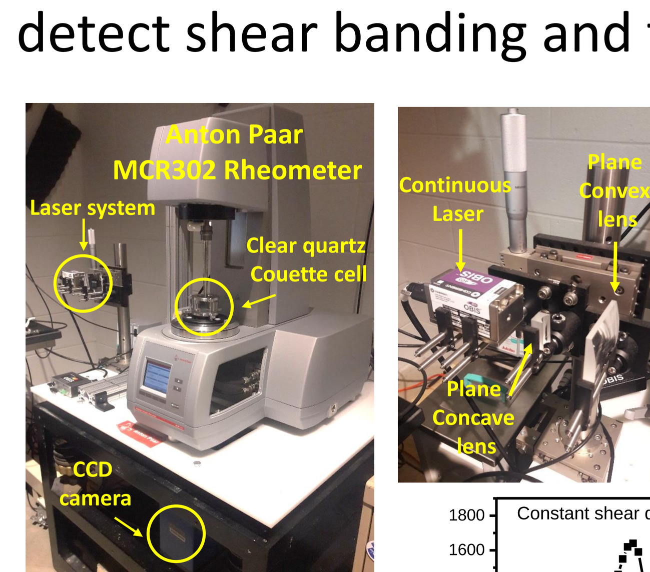
Polymers make aqueous solutions more viscous. Dissolved salts (ions) in the water can reduce this viscosity increase. Calcium ions reduce the viscosity more than sodium ions.

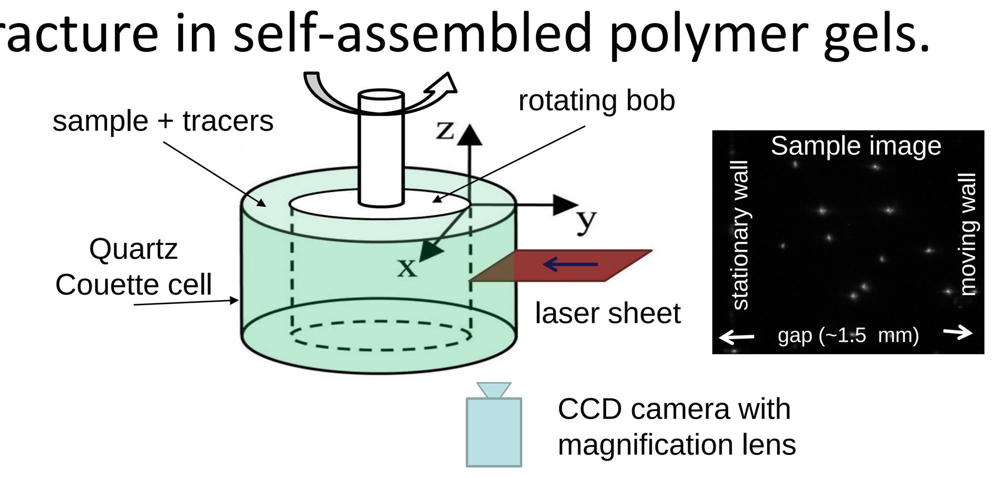


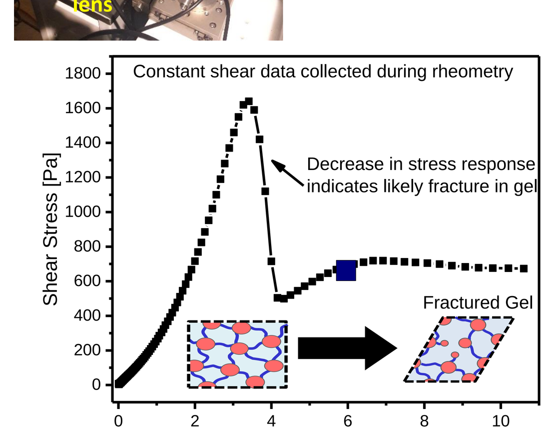
Rheo-Physical Instruments To Visualize Flow Fields

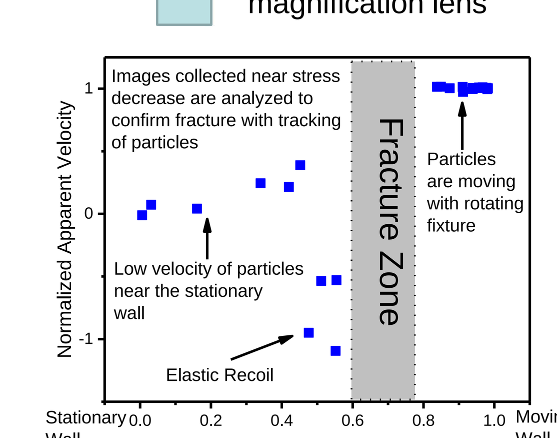
Custom-built flow visualization equipment allows for rheometry data to be collected and directly correlated with a sample's macroscale deformation response.

→ **Particle tracking velocimetry** (for transparent samples), used to detect shear banding and fracture in self-assembled polymer gels.

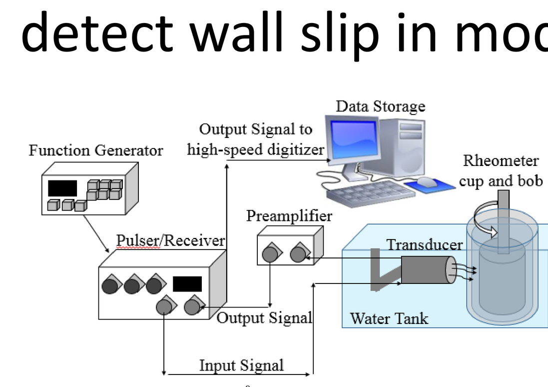


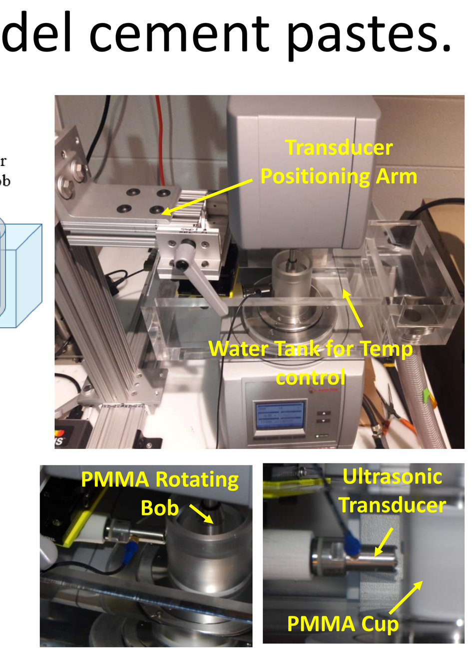




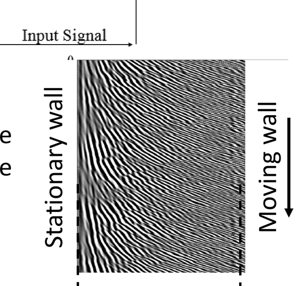


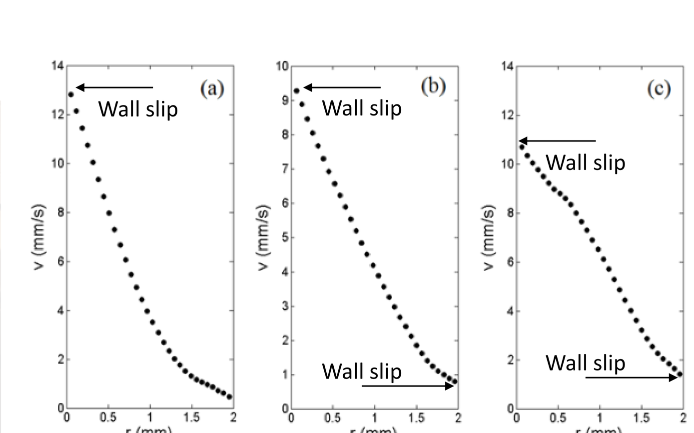
→ **Ultrasonic speckle velocimetry** (for opaque samples), used to detect wall slip in model cement pastes.





Grey scale speckle image from sample:





USV particle velocity profiles for MgO suspensions with PAA-PEO for 0% (a), 20% (b), and 50% PEG by weight of PAA-PEO (c). r = 0 indicates the moving wall surface of the Taylor-Couette fixture and r = 2 mm indicates the stationary surface of the outer cylindrical cup of the fixture. The shear rate is 10 s^{-1} and the corresponding velocity of the rotating cylinder is 20 mm/s.