Lecture 8

Particle charge and Rheology

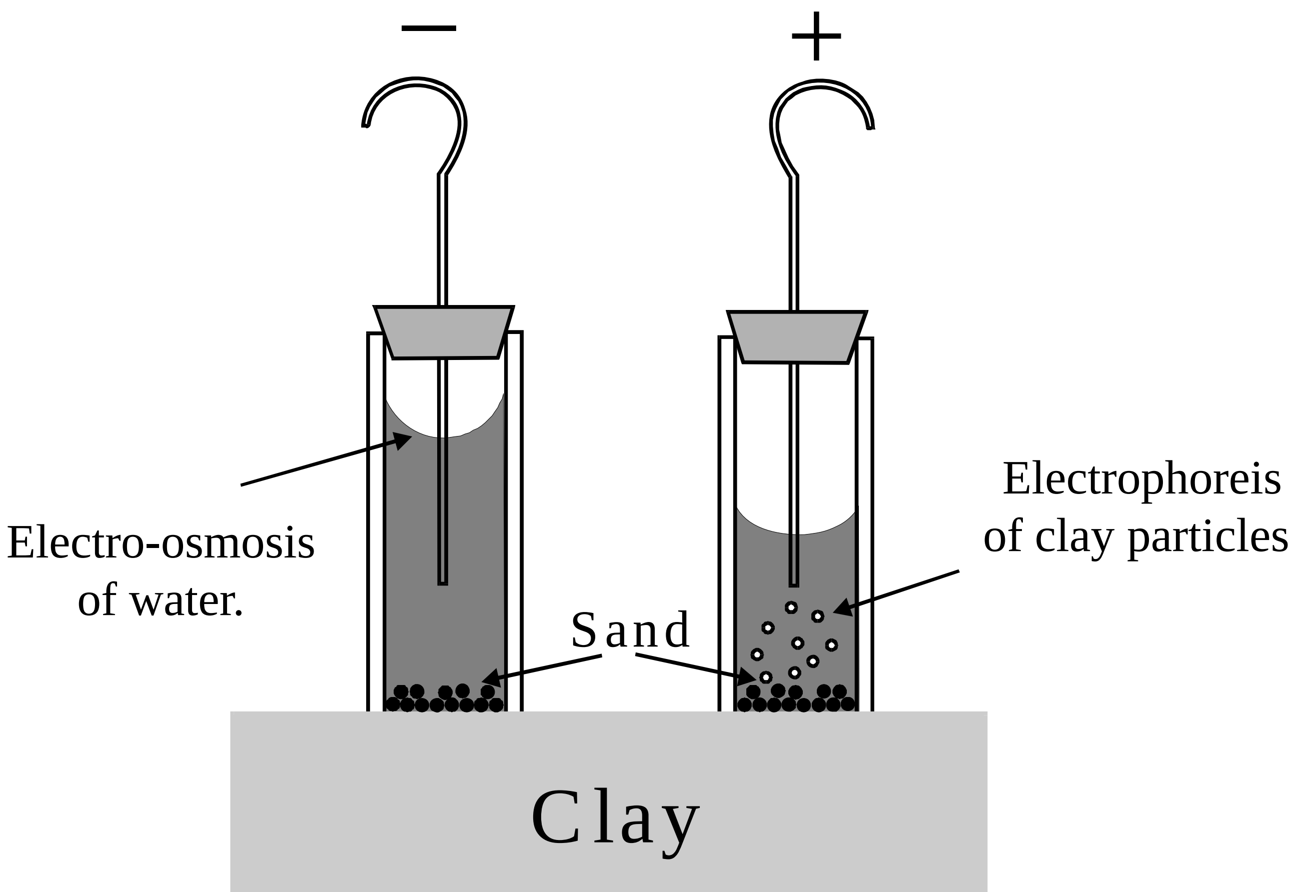
Dispersions in liquids: suspensions, emulsions, and foams

Electro-osmosis and electrophoresis

Voltaic reports the “pile” in 1800. Steady power.

Napoleon rewards Volta 1801.

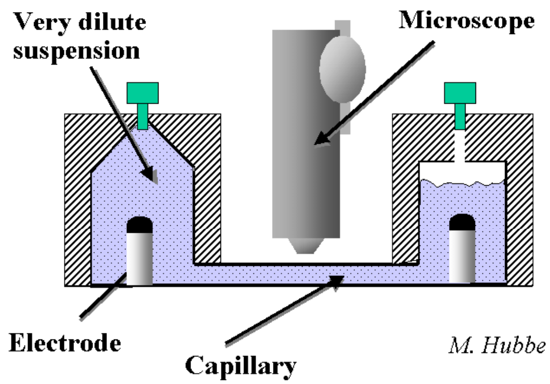
Reuss reports this experiment in 1809.



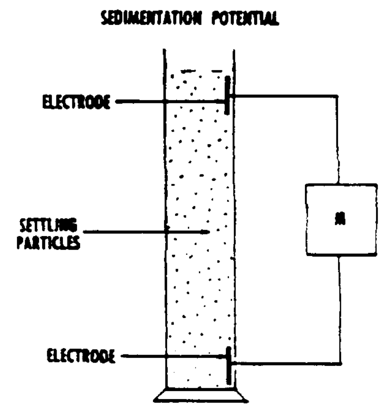
Electrokinetic measurements

http://www4.ncsu.edu/~hubbe/DefnitnGIFs/Slide31.GIF

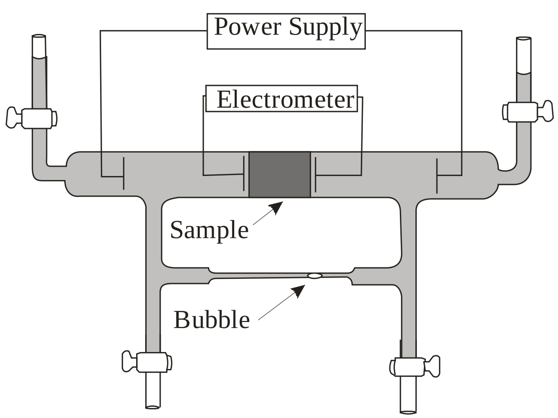
Microelectrophoresis



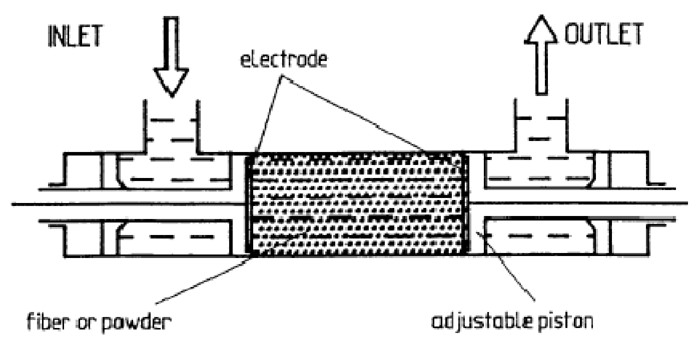
Sedimentation potential



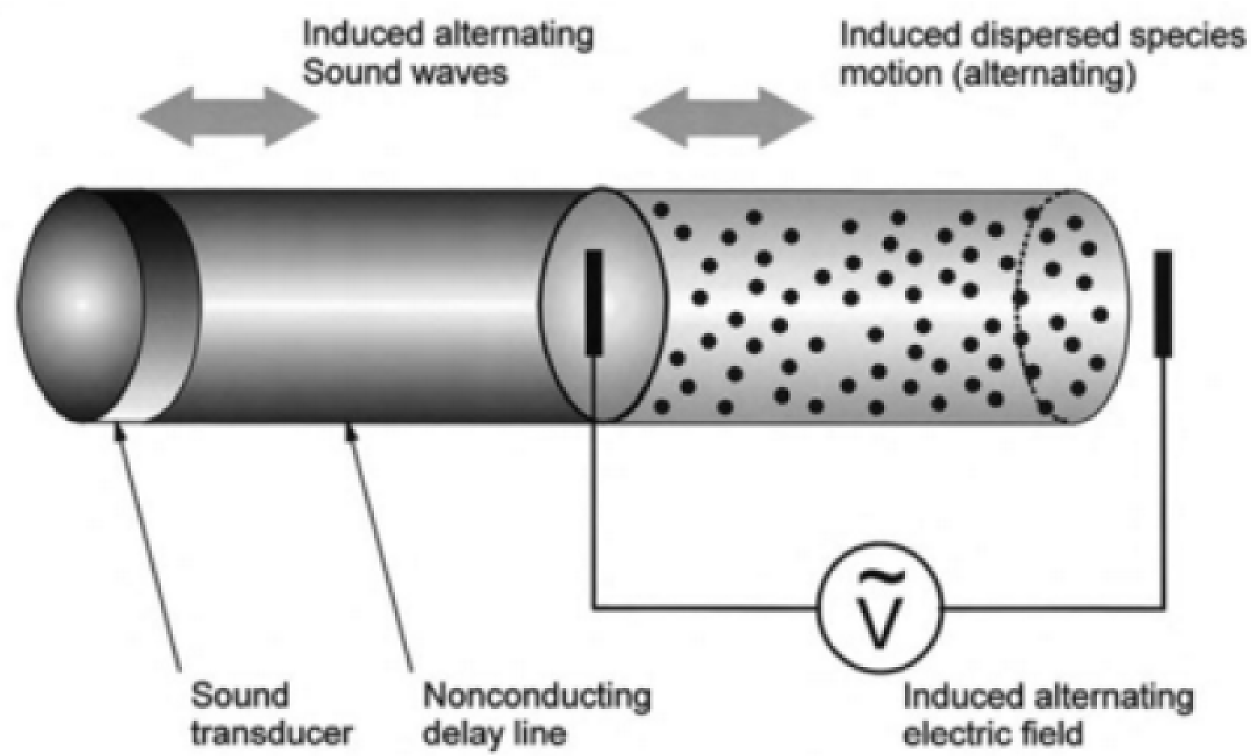
Electro-osmosis



Streaming potential (BIC)



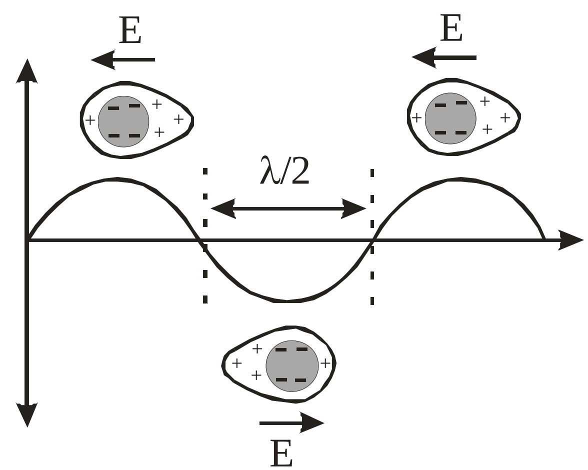
Particle charge – Electroacoustic measurements by ESA



The ESA effect is measured by applying a field to the electrodes and listening for the sound in the transducer.

The great advantage is its use at high particle concentrations

Particle charge – Electroacoustic measurements by CVP



The technique uses an ultrasonic pressure wave to perturb the equilibrium double layer. This polarization generates an alternating electric field called the Colloid Vibration Potential:

$$CVP = \frac{2p\varphi}{\lambda_0}\left[\frac{\rho_2 - \rho_1}{\rho_1}\right]\frac{\varepsilon_0 D\zeta}{\eta}$$

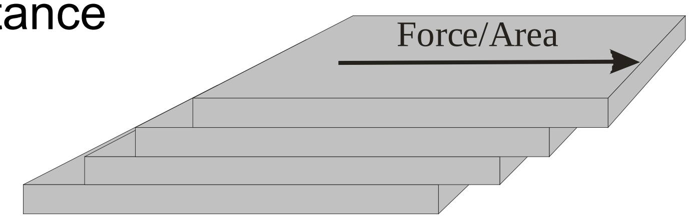
The great advantage is its use at high particle concentrations

Rheology – The science of flow

Shearing stress = Force/Area = F/A = Newton/m^2

Rate of shear = Change of velocity with distance

= dv/dx = sec^{-1}

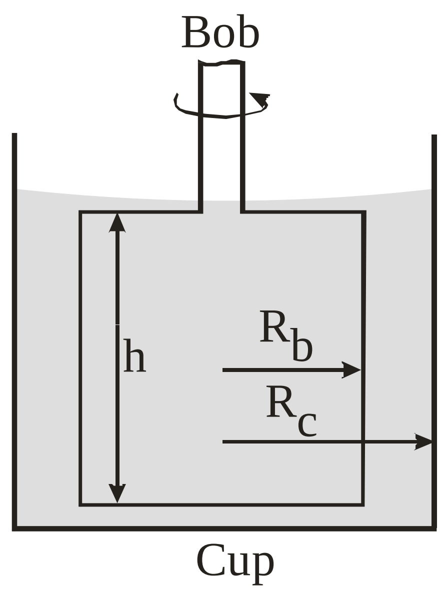


Newton's equation for viscous flow: $$\frac{F}{A} = \eta \frac{dv}{dx}$$

$$\eta = \frac{\text{shear stress}}{\text{shear rate}} = \frac{\text{Newton} \times \text{sec}}{\text{m}^2} = \text{Pascal-sec}$$

Kinematic viscosity = Newtonian viscosity/density = Stoke

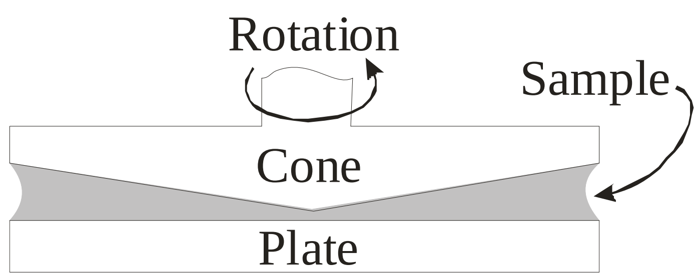
Couette viscometer



In modern Couette viscometers the bob is either driven with a known stress and the resulting angular velocity measured or it is driven at a known angular velocity and the required stress measured. The first provides viscosity as a function of shear stress, the latter provides viscosity as a function of shear rate.

CW Macosko "Rheology: Principles, Measurements, and Applications" VCH:New York, **1994**.

Cone and plate rheometer

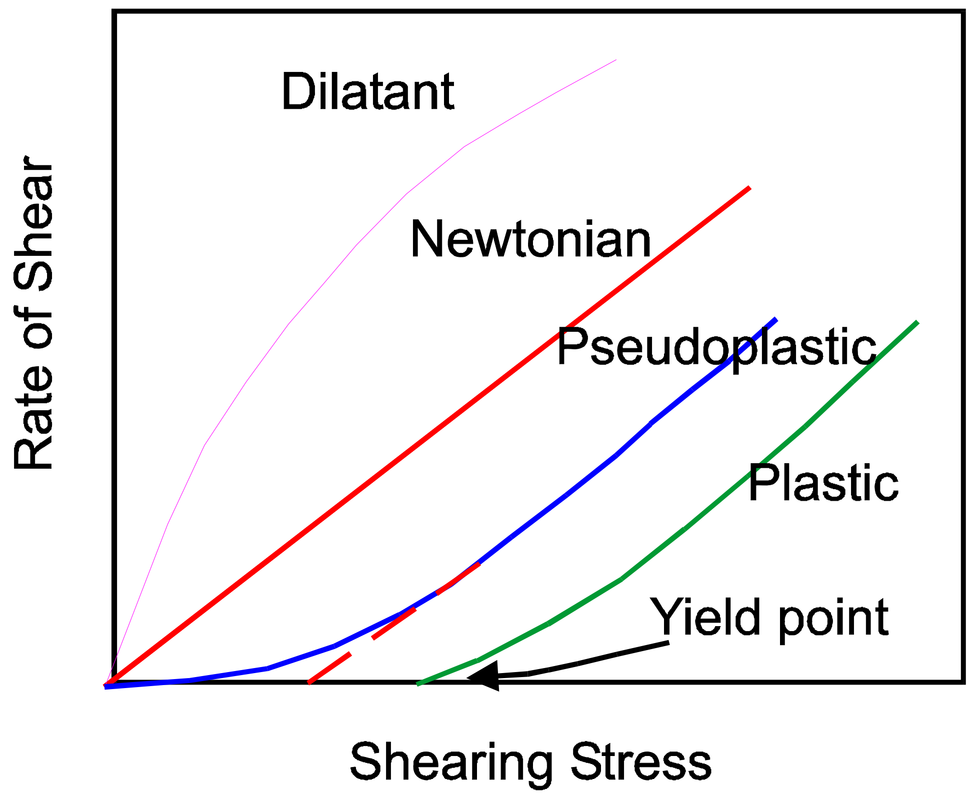


Consists of a flat plate and a cone with an apex angle of nearly 180^{o}

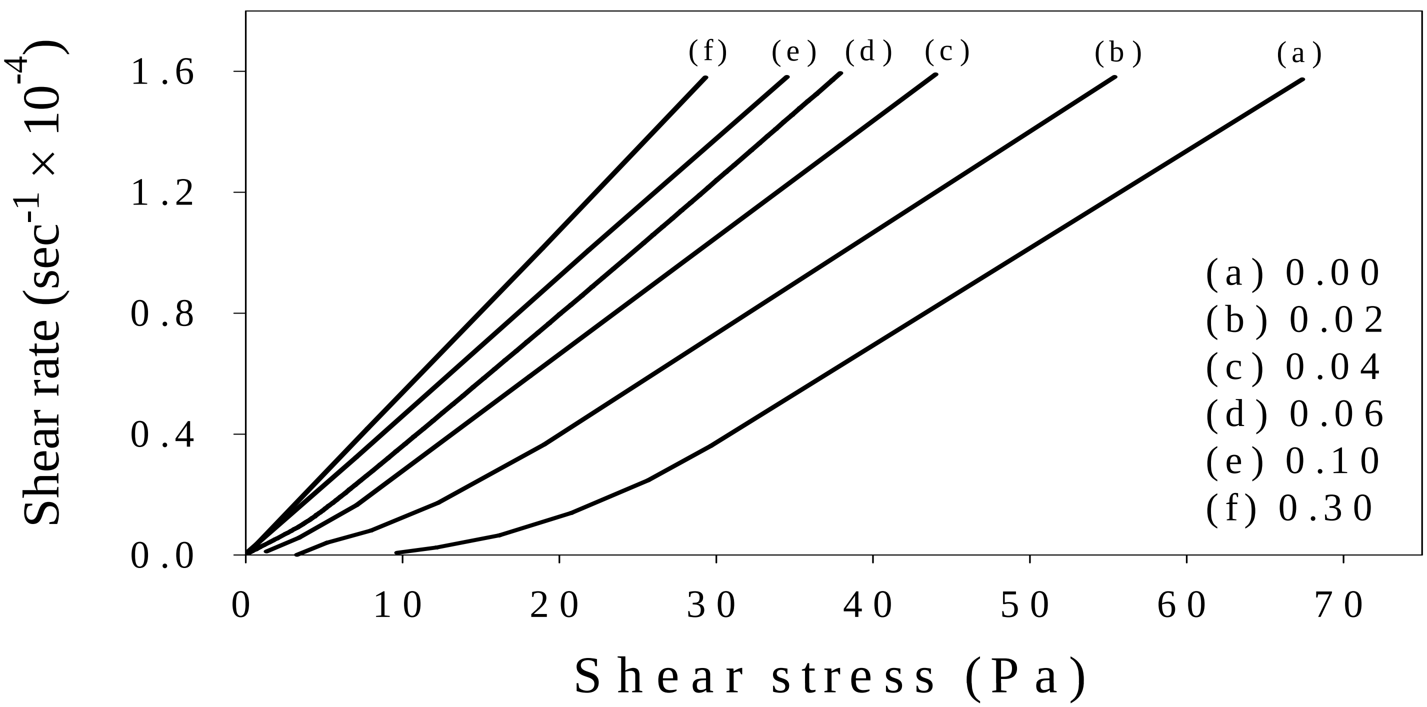
For such a geometry, the rate of shear is very nearly constant over the entire sample so that a well defined viscosity is measured.

The rate of shear is changed by changing the rotational velocity of the cone.

Rheological behavior

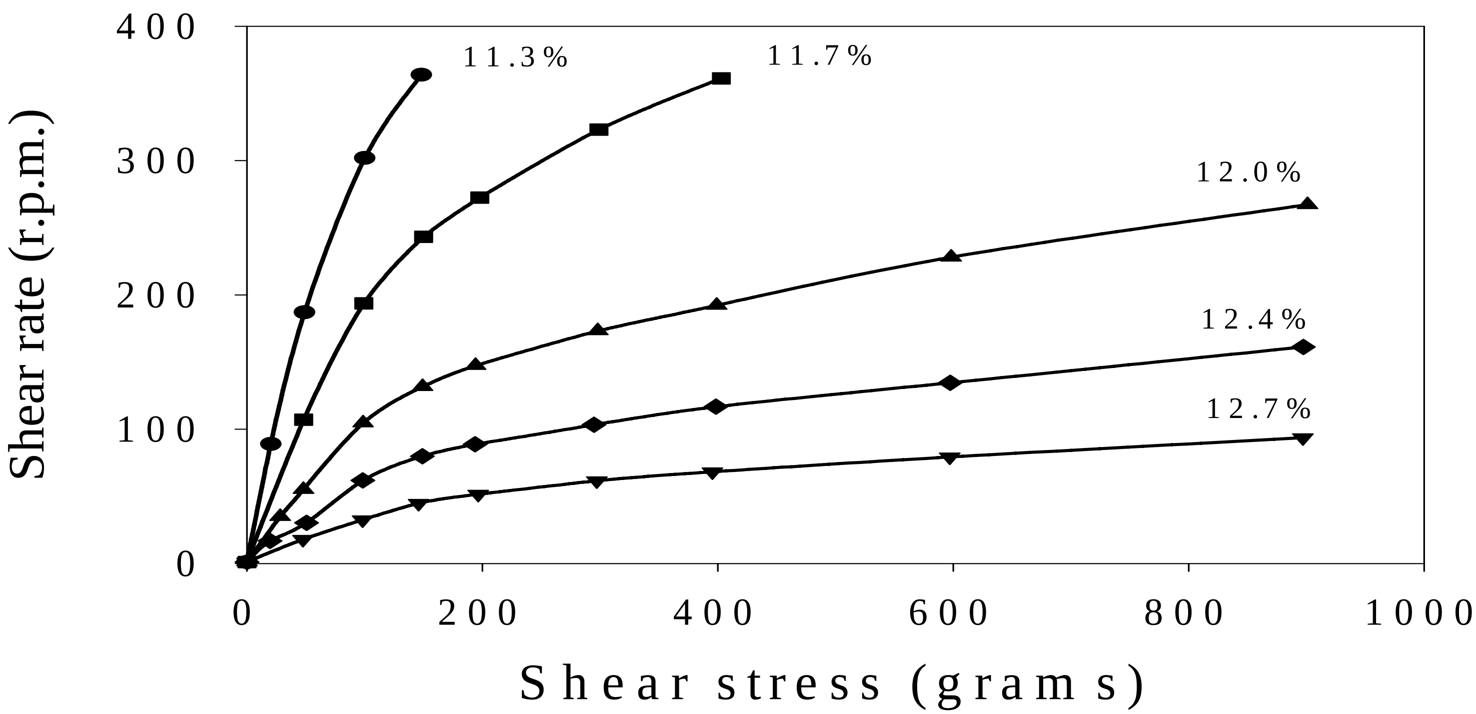


Pseudoplastic flow



Rheograms of 20 w% deionized kaolin slurries at several levels of tetrasodium pyrophosphate* addition. The figures on the curves indicate percent TSPP per weight of clay. An extrapolation of the linear region determines an apparent yield point. *$Na_4P_2O_7$

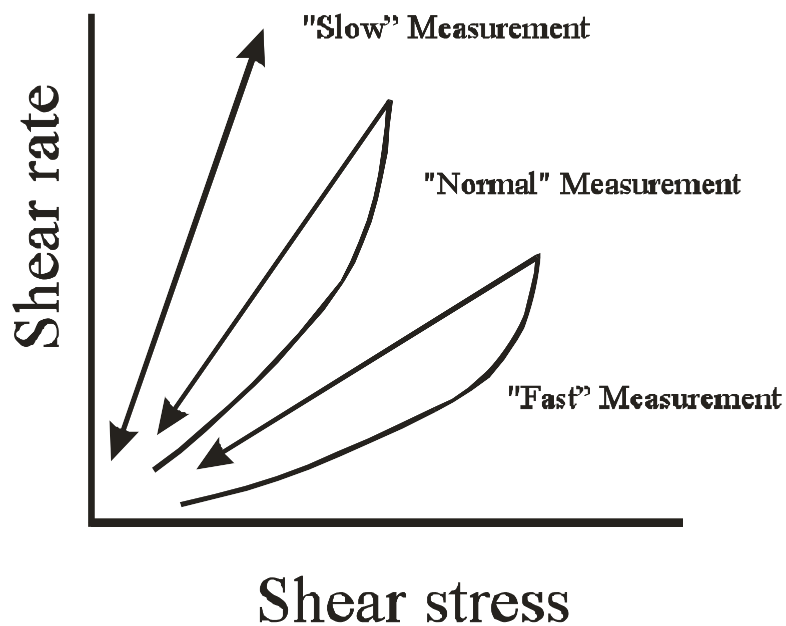
Dilatancy



Dilatant flow of a series of suspensions of red iron oxide in an aqueous solution of sodium lignin sulfonate at 10% concentration at 30° C. The volume concentrations of solids are noted on the curves.

Fischer p. 200

Thixotropy



Thixotropic behavior is a temporary destruction of structure by stirring or shaking, and may be measured as the time required to "heal." The diagram depicts rheological behavior of a thixotropic system as measured with a rotational viscosimeter. The area and nature of the thixotropic loop depends upon the type of instrument and the circumstances of measurement.