Yield Stress Fluids, Meeting #3

I. The Camps

II. A True Yield Stress at Last?

III. Thixotropy: Rejuvenation, Aging

Sarah Bates
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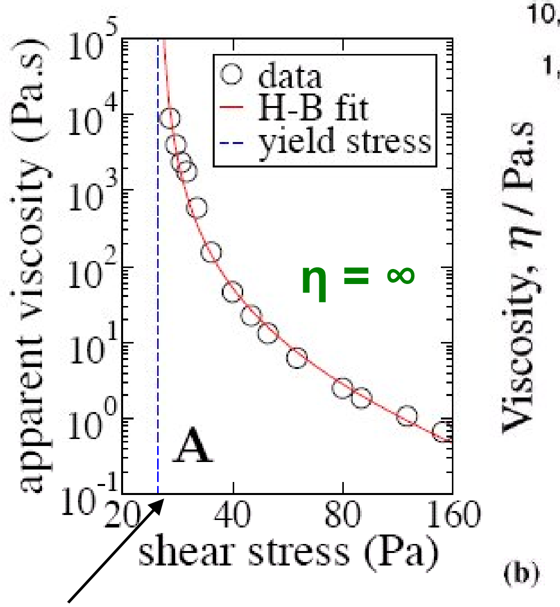
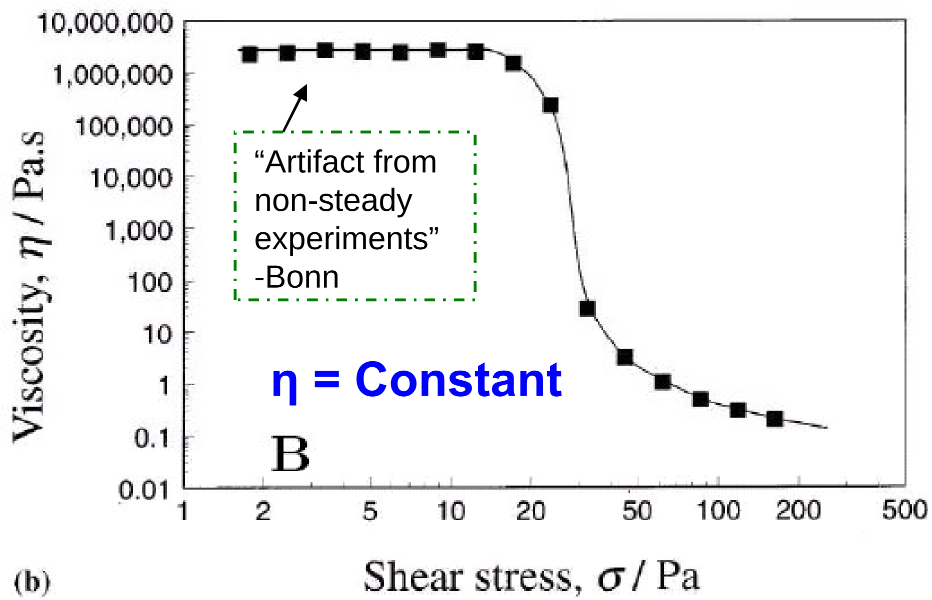
Part of the summer 2009 Reading Group:
Yielding, Yield Stresses, Viscoelastoplasticity
Non-Newtonian Fluids (NNF) Laboratory, led by Prof. Gareth McKinley

Two views of Yield Stress



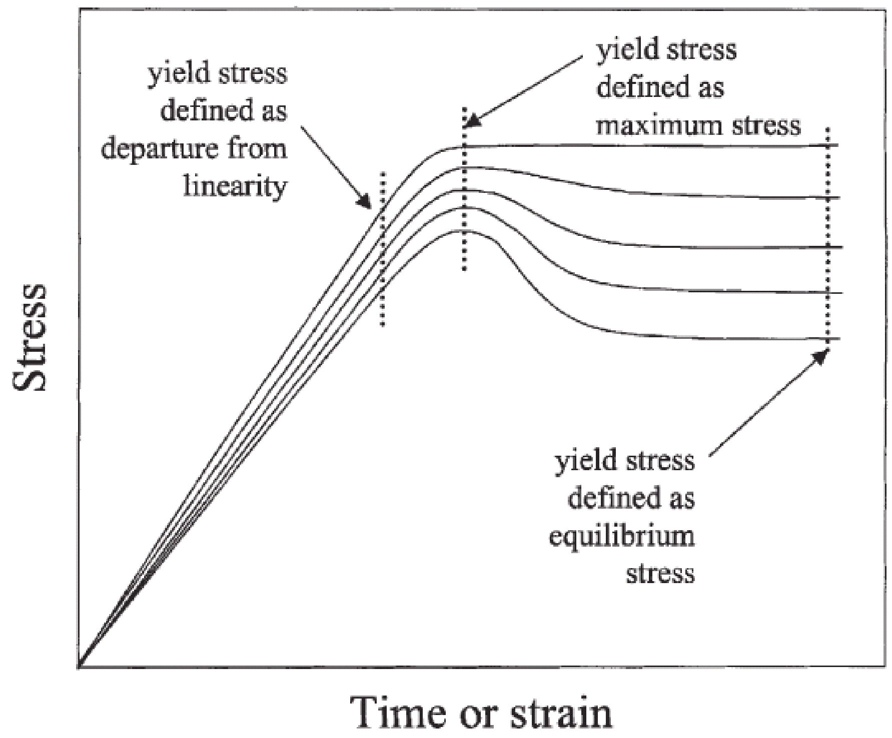


"A figment of extrapolation" - Barnes

A) Transition between liquid state and solid state (Bonn)

B) Transition between liquid state and liquid state (Barnes)

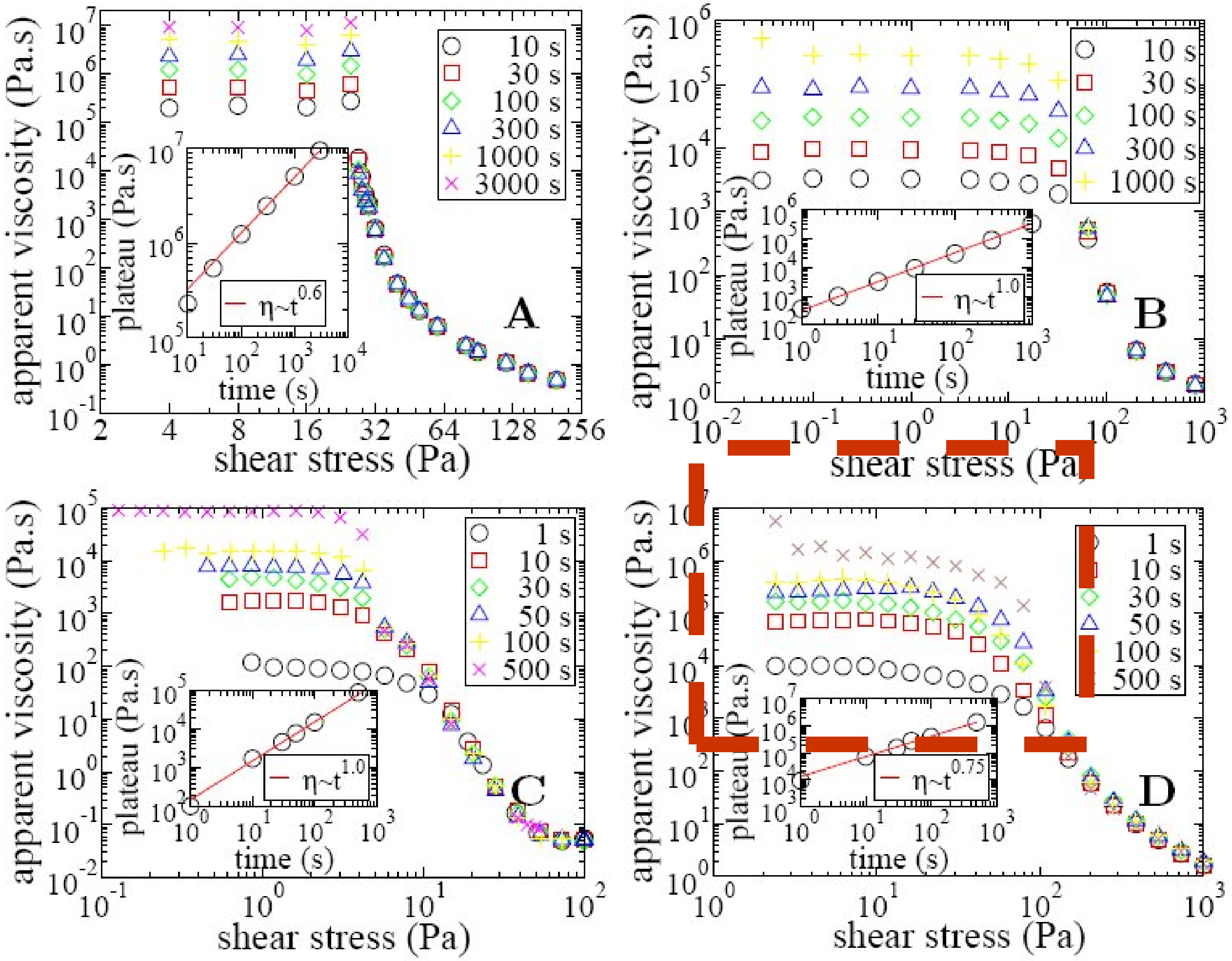
Defining the Yield Stress



- What information about the material does the yield stress convey?

- What are engineering uses of this word versus academic uses of this word?

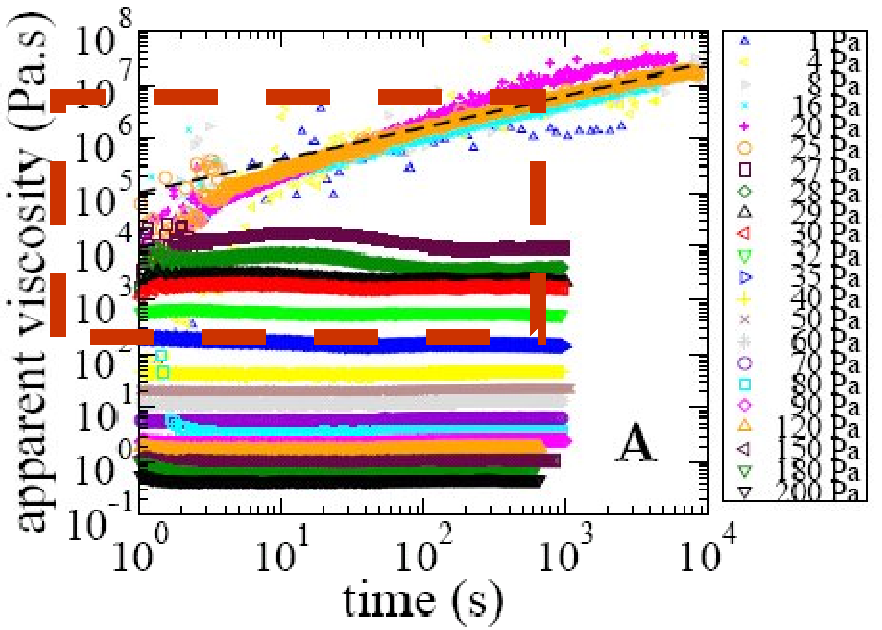
Time varying Newtonian plateau



4 Carbopol based fluids are tested with a variety of rheometer + geometry combinations

➔ The Newtonian viscosity plateau found by Barnes varies with the duration of the measurement

Apparent viscosity plateau: a measure of patience



➔ Bonn should investigate this region as viscosity dynamics change so drastically

Will apparent viscosity rise forever?

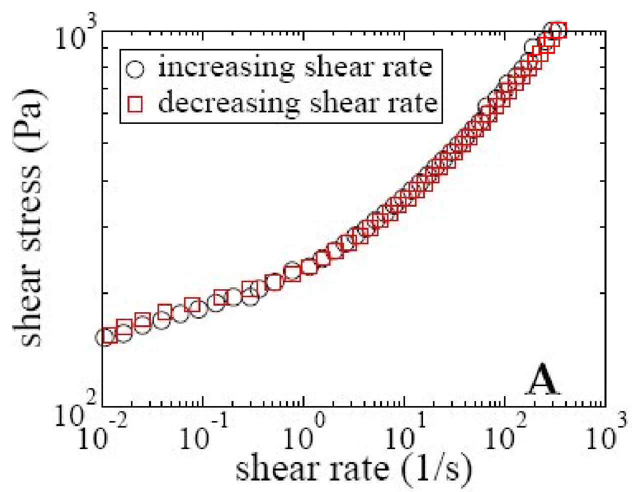
Is $\eta \sim t^{\mu}$ an artificial result or is it physically realizable?

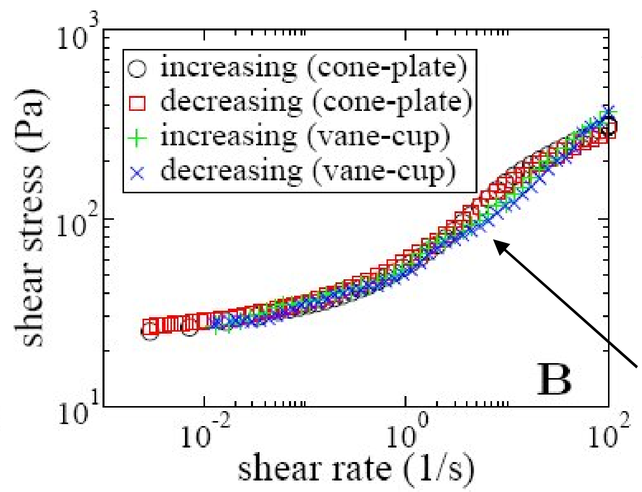
Thixotropy

Microstructure in Fluids

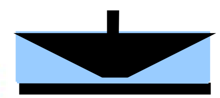
Resists large rearrangements → Yield Stress

Destruction by Flow → Thixotropy

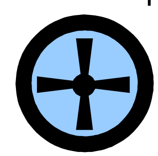




Cone and Plate



Vane - Cup



Good Agreement!

Bonn's fluids are the first reported fluids that age when under slow flow but not when at rest

They offer an alternate definition of the yield stress as a stress at which the structuring and de-structuring processes are balanced.

Barnes: Yield Stress Materials

Bonn's microstructural picture is in line with a proposed "true yield stress" Barnes had presented for simple and flocculated suspensions.

- Bonn should use one of the models to compare the dynamics of the viscosity with that predicted in one of these models.

Simple 'non-interacting' suspensions

$$\eta = \eta_s [1 - \frac{\phi}{\phi_m}]^{-[\eta]\phi_m}$$

η is the viscosity of the continuous phase
ϕ is the phase volume of the particles
ϕ_m is the maximum phase volume
$[\eta]$ is the intrinsic viscosity

Material with microstructural kinetics

$$-\frac{dn}{dt} = k_1 n(\dot{\gamma})^a - k_2 (n_0 - n)(\dot{\gamma})^b$$

n is the number of active bonds
n_0 is the number of initial bonds
k_1 is the rate of structure breakdown
k_2 is the rate of structure build-up
$\dot{\gamma}$ is the shear rate

Flocculated suspensions