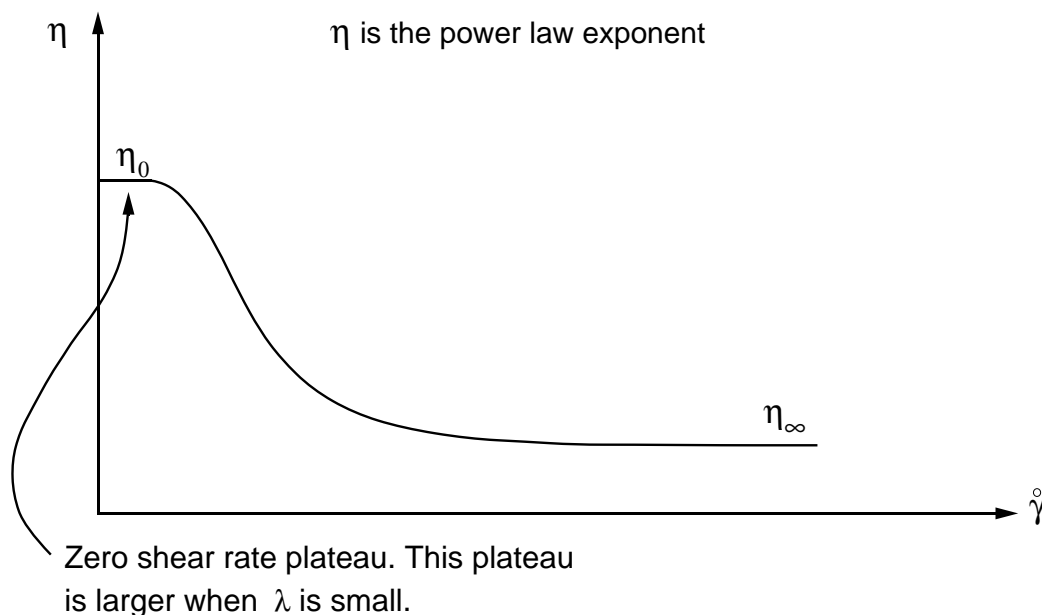# Memo

From: Dan Joseph

To: M. Asadi, Glenn Penny, Mike Conway at STIMLAB

(1) Zero shear viscosity

To characterize the settling velocity of solid particles in a fluid it is necessary to know the viscosity. If the fluid shear thins the fluid viscosity will get smaller as the particle settles because the falling particle shears the fluid. In general, fluids which shear thin do not thin when the shear rate is small; there is a zero shear rate plateau. The Carreau formula is often used

$$\eta - \eta_\infty = (\eta_0 - \eta_\infty)[1 + (\lambda \overset{\circ}{\gamma})]^{\frac{n-1}{2}}$$

So we avoid the effect of shear thinning for particles which are settling slowly when there is a pleateau.

η η is the power law exponent

η_0

η_∞

$\overset{\circ}{\gamma}$

Zero shear rate plateau. This plateau
is larger when λ is small.

(2) Recovery time

This is a dynamic effect which we can characterize with a recovery time; a recovery time is not a relaxation time. When you shear Borate cross linked 35 lbs/thousand gallons in water it shear thins. Shear thinning is very common but the crossed linked fluids not only shear thin, *they have a memory of shear thinning*. If you measure the viscosity of such a fluid shortly after shearing, the viscosity will be low. In other words, the fluid remembers that it was sheared. The reason is that the molecular arrangements of the molecules are upset. The fluid can heal by reverting to the old molecular arrangement after cessation of shearing. It takes time to heal; measure the viscosity after say one, two, three etc. minutes. Say the original viscosity is η_0 and after shearing it's η_1. Then the recovery time is λr. If the structure is permanently damaged $\delta \neq 0$.
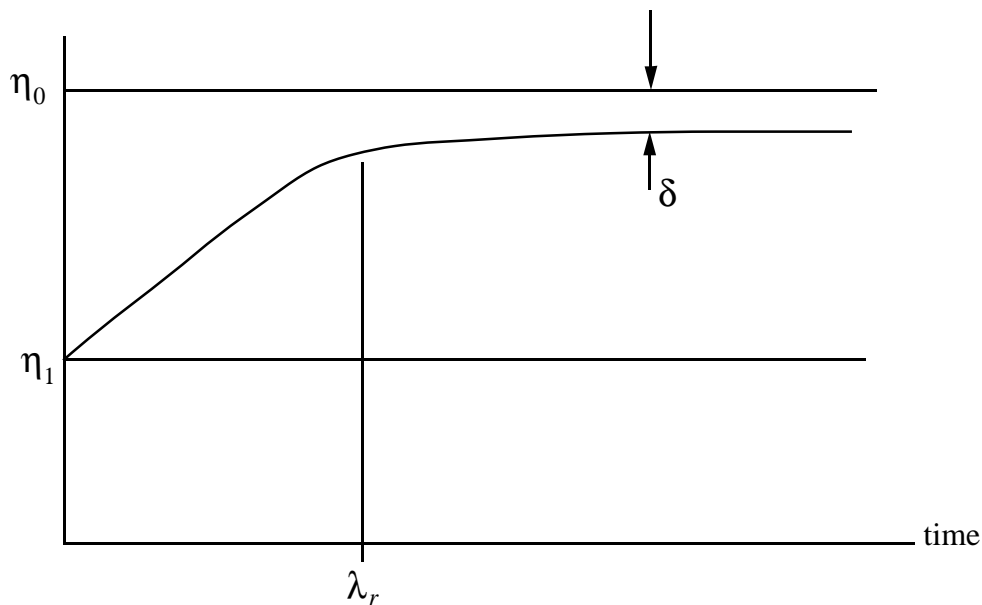
(3) Gelled solutions with breakers.

We have ultimately a three phase material plymer, water and breaker. You start with polymer in water (I guess that you make a gel). Then you add the breaker and watch the viscosity change. I think that you should measure the viscosity without breaker (you do this). Then you should mix the water and breaker and only then

dissolve the polymer. This should give the fluid that you get by adding breaker. Measure the rheological properties of

1. Polymers in (water).

2. Polymers in (water plus breaker).