ABE 304
Bioprocess Engineering Laboratory

PRELAB: RHEOLOGY

Read sections 7.3-7.8 in Bioprocess Engineering Principles and answer the following questions.

You need to address the following topics for your pre-lab report:
Provide all information in your own words and with more depth than the background provided here.

1. Brief background on viscosity and its importance in biological engineering applications.
2. Describe the operating principles for the Brookfield viscometer.
    a) How does this instrument work?
    b) What are the key outputs?
3. How will the presence of cells influence the viscosity of a fermentation broth?
4. How will you recognize if a fluid is time-dependent based on the graph of shear rate versus shear stress? What special considerations are needed if a fluid is time-dependent?

The pre-lab needs to be saved as a single document – either a Word document or a PDF. Your TA will check your notebook before the start of class for your procedure and data tables.

BACKGROUND

The flow of a ***Newtonian fluid*** can be calculated by the Equation 1:

$$\tau = \mu\dot{\gamma} \tag{1}$$

τ is shear stress (in Pa), $\dot{\gamma}$ is shear rate (in 1/s), μ is viscosity (in Pa·s)

For Newtonian fluids, shear stress is directly proportional to the shear rate, and the viscosity is the involved physical parameter of that relationship. Viscosity is a parameter that is highly dependent on temperature.

For ***non-Newtonian fluids***, shear stress is not directly proportional to shear rate, and the relationship between shear stress and shear rate is more complicated than that expressed in Equation 1.

Viscous food and biomaterial fluids are known as pseudoplastics, described by the Equation 2:

$$\tau = k\dot{\gamma}^n \tag{2}$$

The equation is known as ***the power-law*** model and in fact can describe shear thickening fluids ($n > 1$) in addition to shear thinning fluids ($n < 1$). The flow consistency index, k, dimensions $Pa \cdot s^n$, where n is called the flow index and has no units. When $n = 1$ the material is Newtonian (and $k = \mu$); when $n < 1$ the material is shear thinning; when $n > 1$ the material is shear thickening.