Rheology of suspension of potato starch with silicon oil (PDMS)

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OBJECTIVE

- To study the rheological properties of potato starch suspension in silicone oil(PDMS) by varying the concentration of potato starch in PDMS solvent and observing the change in viscosity of the suspension.
- Fitting our experimental data with the values obtained from Krieger Dougherty equation.

PROCEDURE

Materials used:-

1. Potato starch
2. Silicone oil (PDMS)
3. A balance or scale to measure weights
4. Mixing containers (beakers, jars, etc.)
5. Stirring rods or utensils.

Method:

Determine the Desired Concentration(10%,20%,30%,40%,50%,60%).

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The gap between the plates is fixed to be 0.3mm.

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Mixing of starch with PDMS.

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Homogenize (might need magnetic stirrer)

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Final Mixing and Testing.

Krieger Dougherty Equation

Equations applicable

Einstein Equation

Einstein Equation	Krieger Dougherty Equation
The Einstein equation is primarily valid for dilute suspensions of small particles in a Newtonian fluid. This means that it is suitable for systems where the following conditions hold:	The Krieger and Dougherty equation is particularly useful for complex fluids that involve non-Newtonian behavior due to the presence of solid particles. It is often applied to concentrated suspensions, slurries, and pastes in which the particle volume fraction is significant and particle interactions play a more substantial role. However, there are certain assumptions and limitations to consider:
• The concentration of suspended particles is relatively low, so that particle-particle interactions are negligible.	• The equation is most suitable for suspensions with relatively spherical particles. It may not be as accurate for non-spherical particles or particles with complex shapes.
• The fluid behaves as a Newtonian fluid, meaning its viscosity remains constant with shear rate and does not exhibit non-Newtonian behavior.	• The equation assumes that particle interactions are significant and can be described by the fitting parameter.
• The particles are much smaller in size compared to the mean free path of the fluid molecules.	• It may not be as accurate for extremely dilute suspensions or when the particle concentration is very low.

EINSTEIN EQUATION

$$\eta = \eta_0(1 + 2.5\varphi)$$

The overall viscosity depends on the initial viscosity of the bulk phase (η_0)and the volume fraction of the dispersed component (φ).

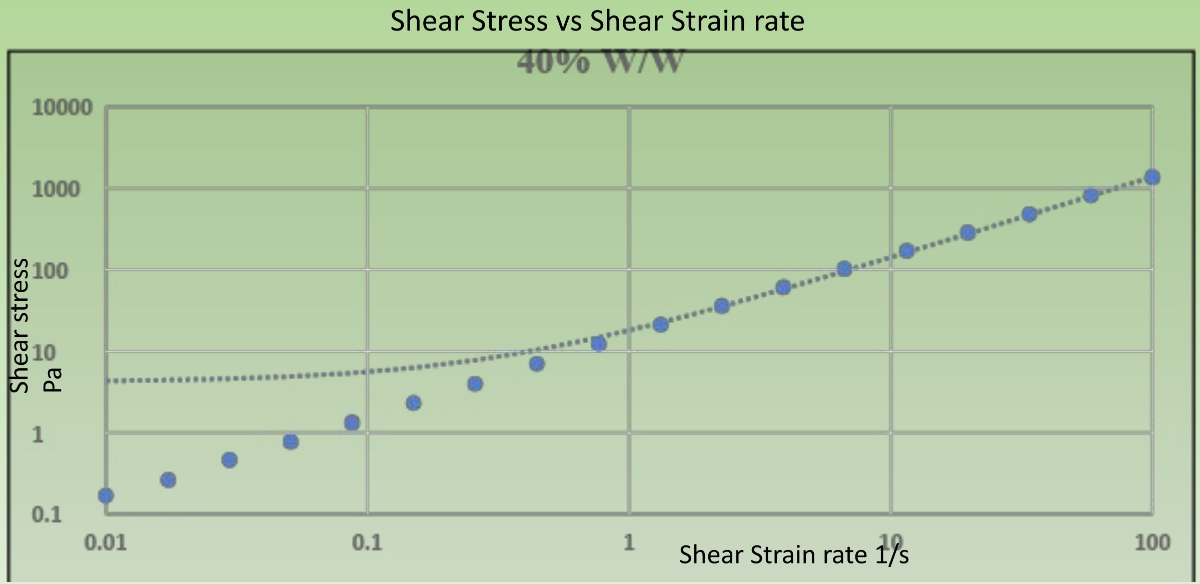
KRIEGER DOUGHERTY EQUATION

$$\eta = \eta_0\left(1 - \frac{\varphi}{\varphi_m}\right)^{-2.5\,\varphi_m}$$

The Dougherty-Krieger formula is popular but tends to overshoot at high φ values. It incorporates a "close packing" fraction φ_m at which the viscosity becomes infinite. The factor of 2.5 is the default value for the "intrinsic viscosity" term. Because the viscosity rises exceptionally above φ=0.60 (near the random close packing limit) the calculation is not performed above that value.

Upon variation of the concentration of potato starch in the suspension following results were obtained……

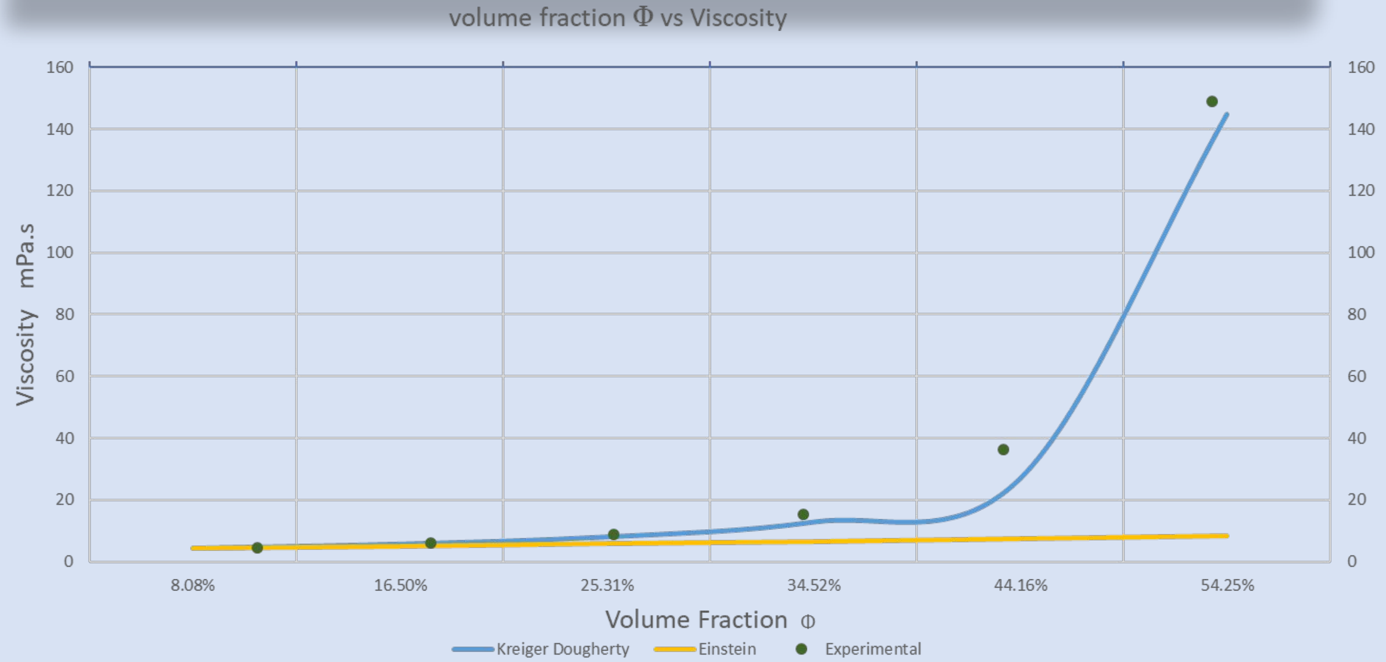
At each concentration, a separate shear strain rate vs stress curve was plotted as per our experimental data and the experimental viscosity was calculated from slope. An example is shown below:-



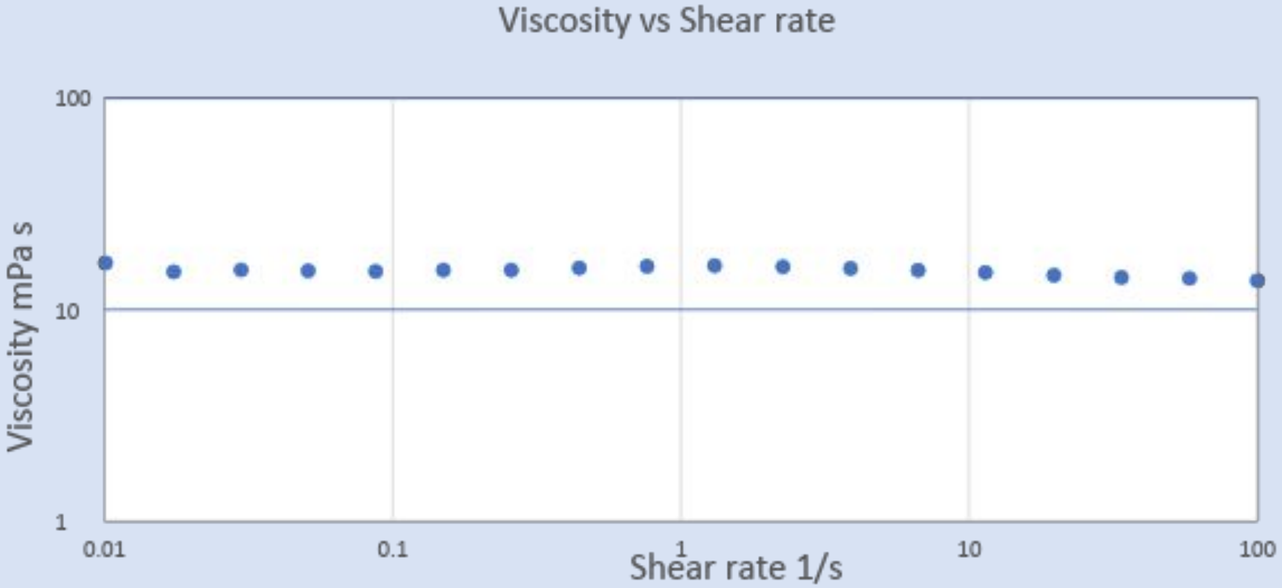
. Viscosity values of different concentrations in different equations:-

Concentration	η-Ex (sample)	η-En (Einstein)	η- KD (Krieger-Dougherty)
8.08%	4.58	4.23	4.37
16.50%	6.04	4.97	5.71
25.31%	8.93	5.75	8.05
34.52%	15.24	6.56	12.89
44.16%	36.24	7.41	26.95
54.25%	148.84	8.30	144.93

Viscosity vs Volume Fraction (*Einstein, Krieger Dougherty* VS *Experimental data*)



Viscosity vs shear rate for 40% w/w suspension



The **Krieger and Dougherty equation** consists of three parameters that have physical significance:

- **The dynamic viscosity of the fluid phase,**
- **The maximum packing fraction,**
- **The intrinsic viscosity of the particles (disperse phase).**

The dynamic viscosity of the fluid phase can be measured with greater or lower precision depending on the degree of complexity that it has in terms of being able to be considered in this phase, again, as a suspension. The shape and the size distribution of the particles are the parameters on which the maximum packing fraction of the dispersed solid phase(φm) depends.

Conclusion

- From the obtained plot we can say that the suspension of potato starch in PDMS closely fits the Krieger-Dougherty curve.
- The K-D equation is useful when the particles are concentrated and interact significantly with one another and the surrounding liquid. The equation helps describe how the intrinsic viscosity of the suspension changes with increasing particle concentration.
- Einstein's equation does not function at higher concentrations of starch in suspension, so the profile remains straight.