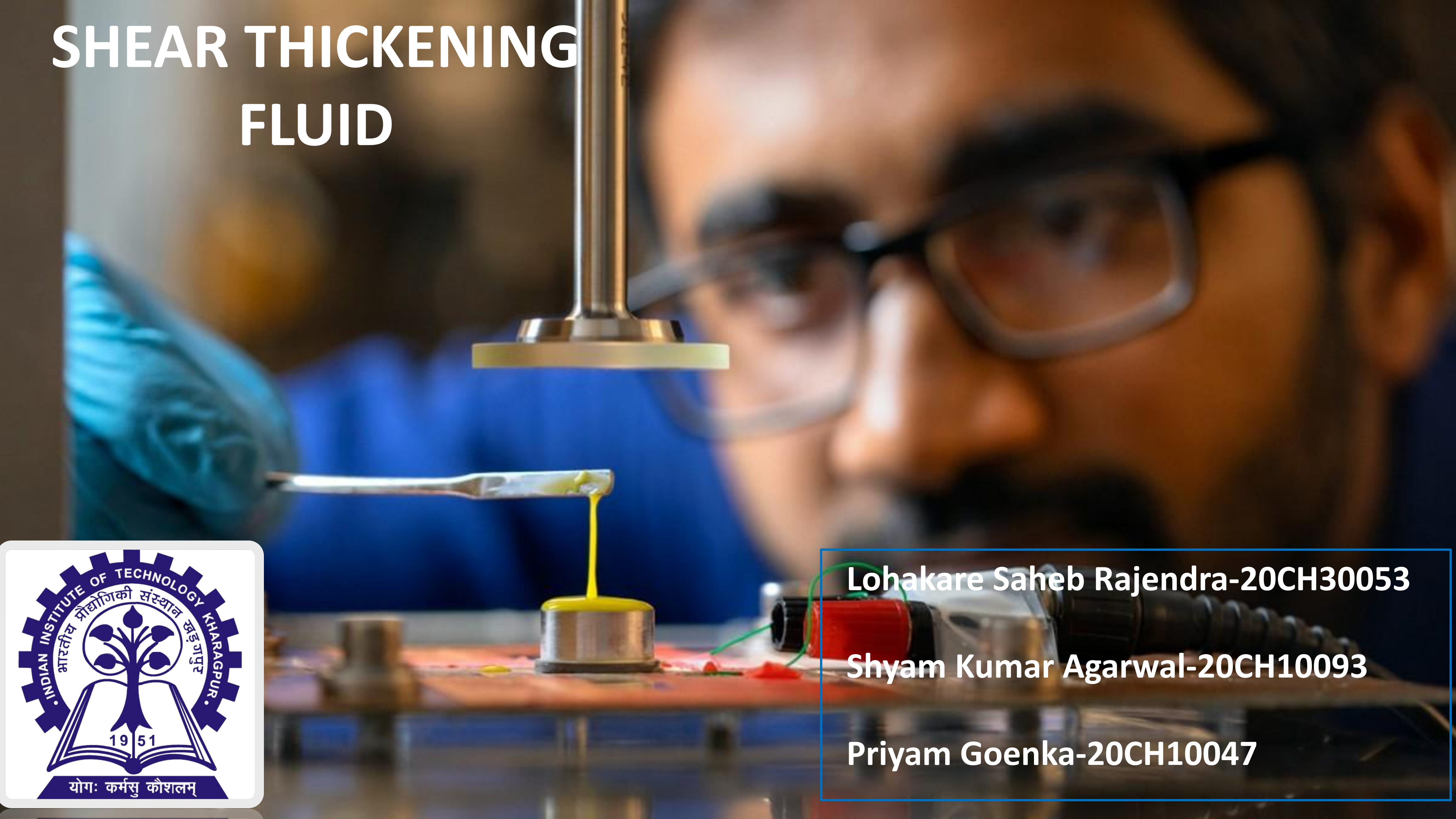

# SHEAR THICKENING FLUID

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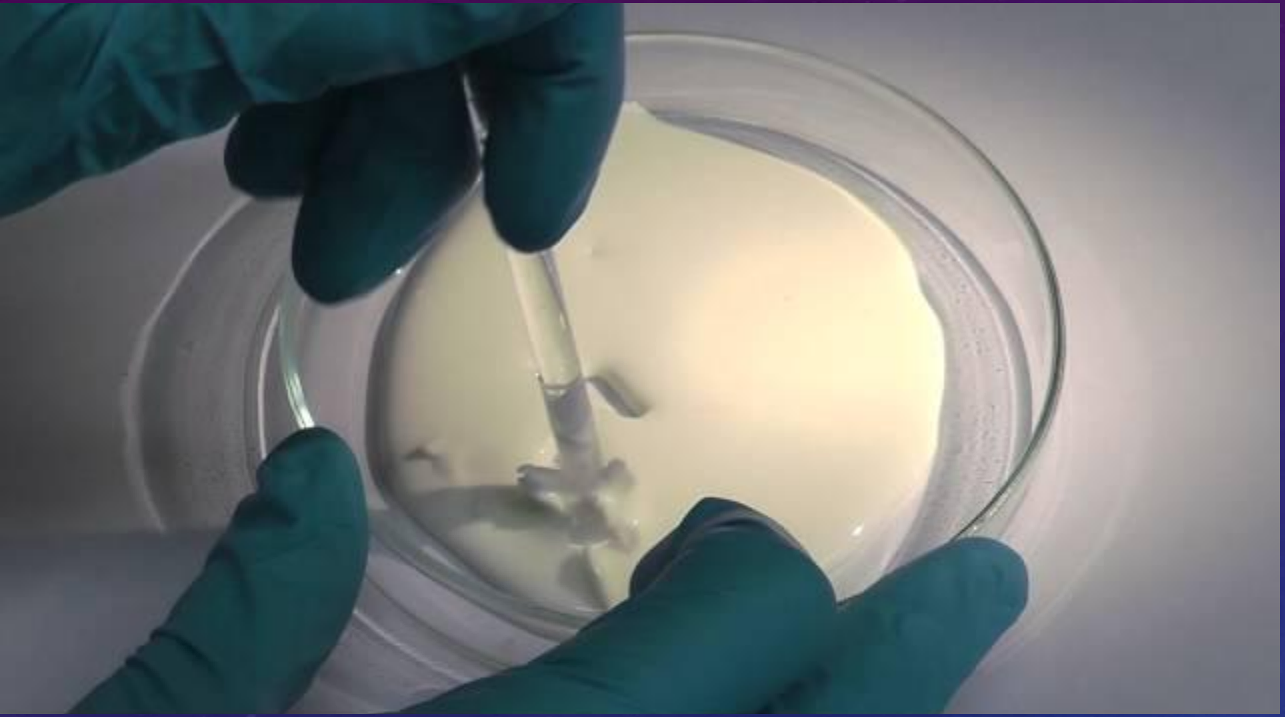
# Table of contents

- Introduction
- Shear Thickening Theories
- Factor Affecting Shear Thickening
- Experiment Conduction
- Observation
- Application
- Conclusion

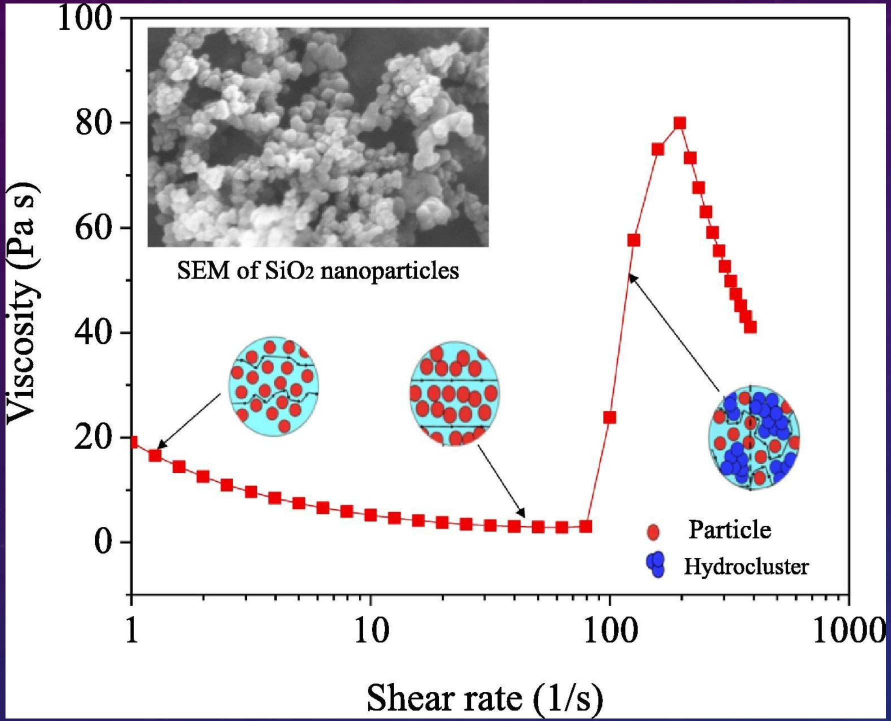
# INTRODUCTION :



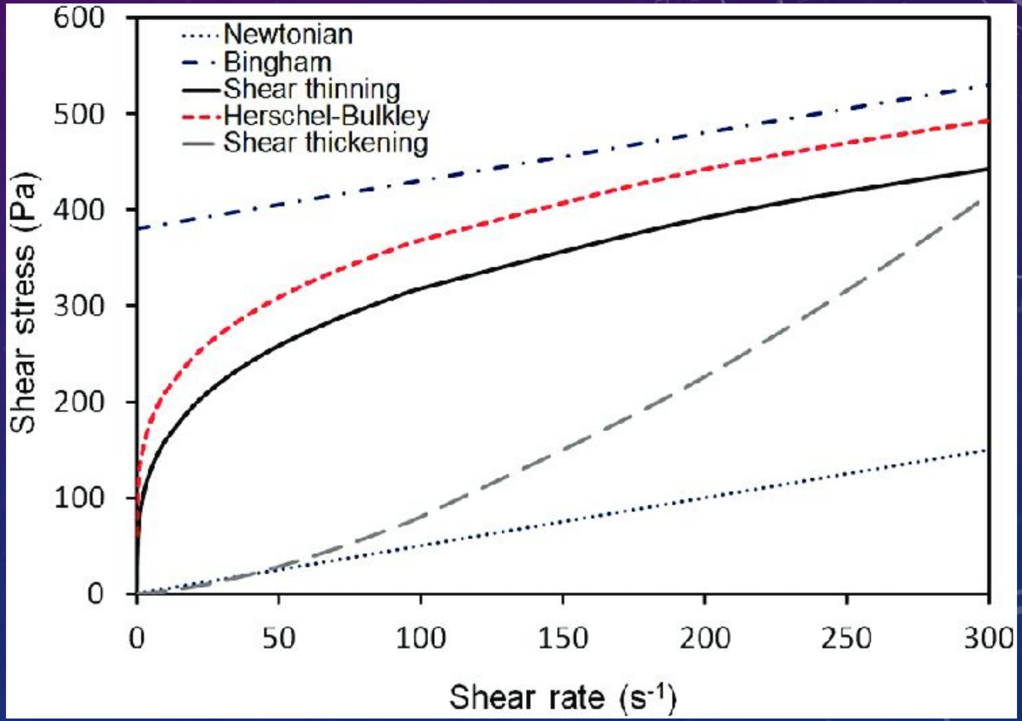
Shear Thickening Fluid (STF) is a unique suspension with a viscosity that sharply increases with higher shear rates or stress

Key Characteristics: Exhibits Shear Thickening (ST) behavior: viscosity rises with increasing shear rate. Similar to intelligent materials like Electrorheological Fluid (ERF), Magnetorheological Fluid (MRF), and Shape Memory Alloy (SMA).

# INTRODUCTION :



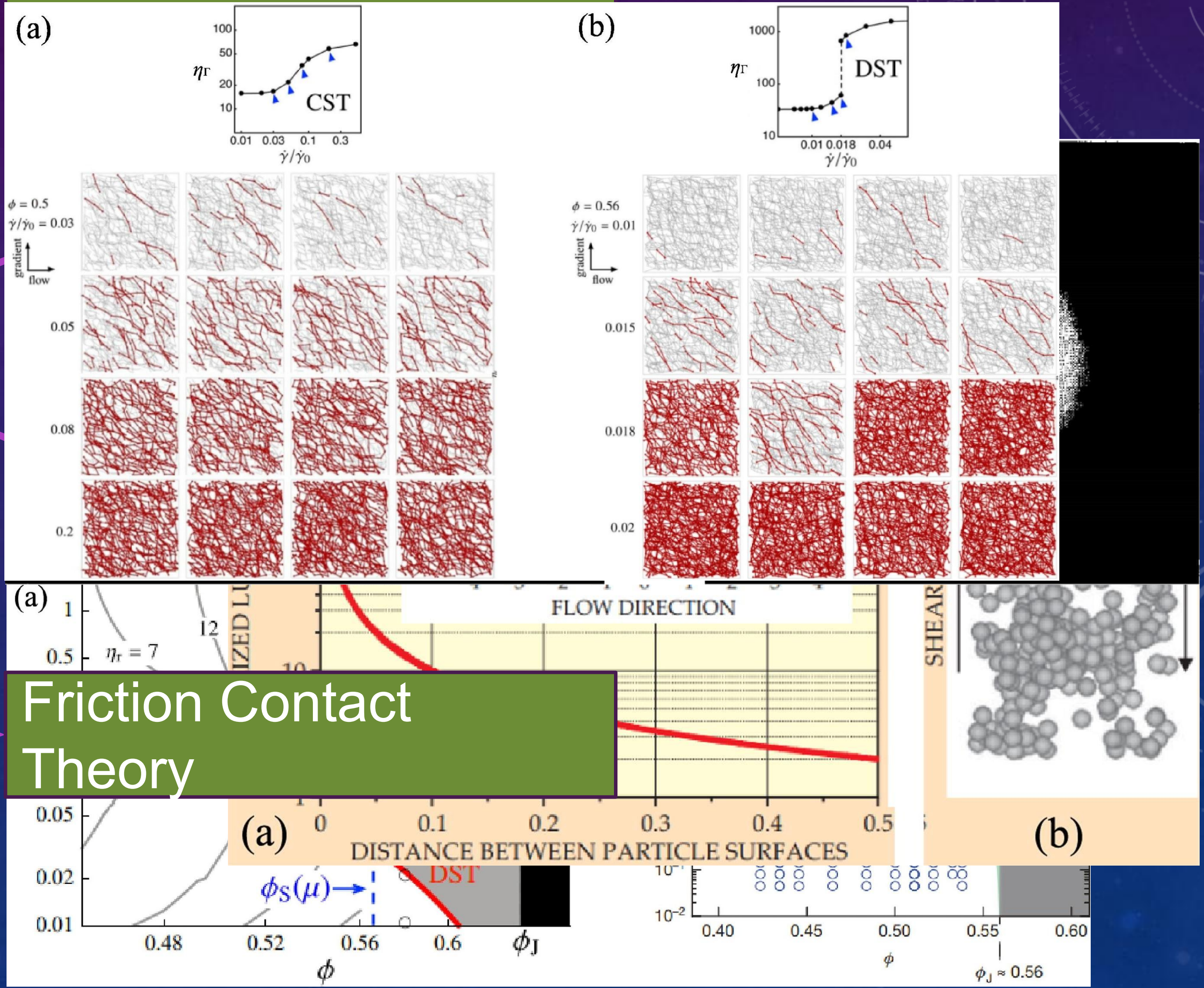

Viscosity V/S Shear Rate




Shear Stress V/S Shear Rate

# Shear Thickening Theories

Order-disorder

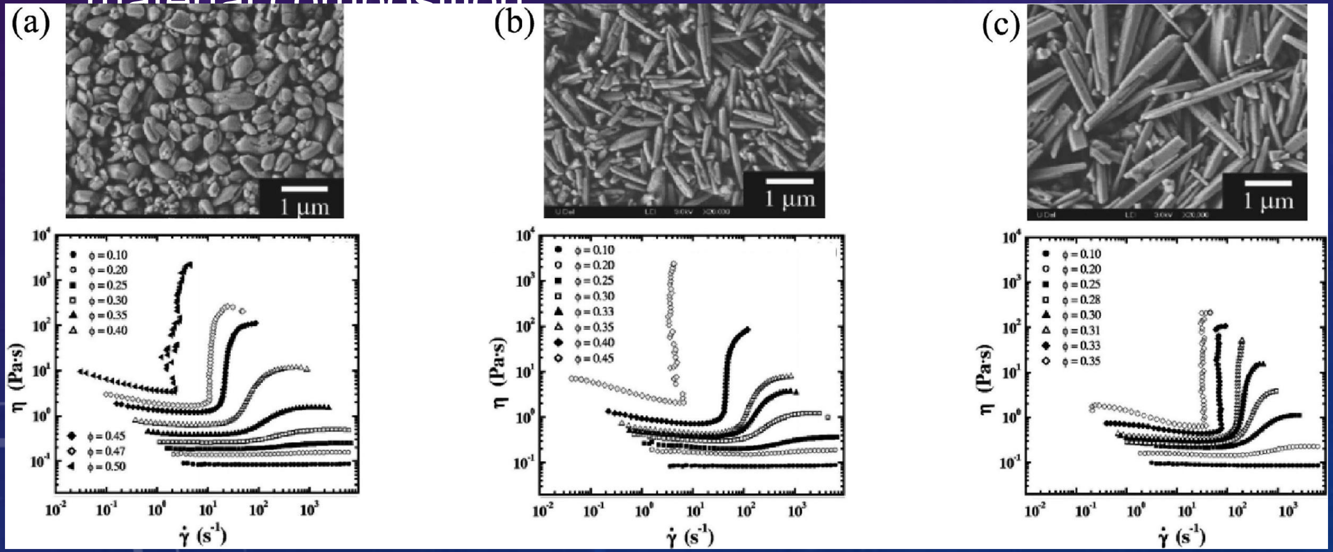



Friction Contact Theory

# FACTORS AFFECTING SHEAR THICKENING

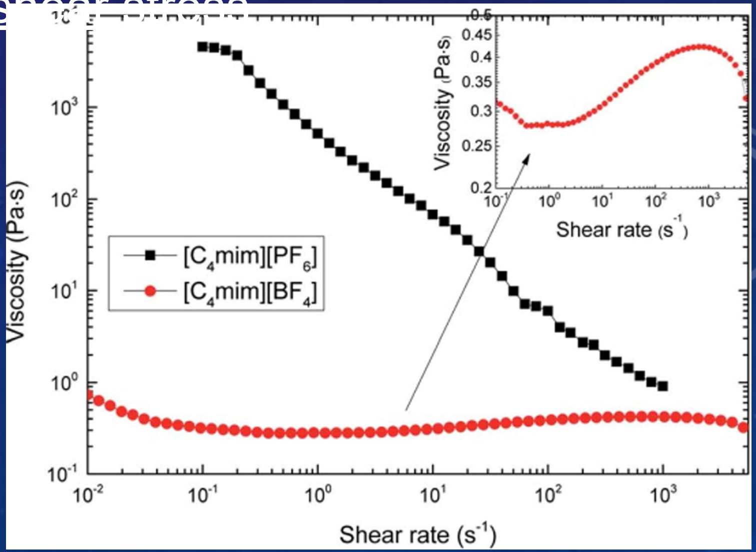
1. Effects of dispersed particles on the STF

- The physical properties, shape, and size of the dispersed phase particles significantly affect the rheological properties of STF.
- The dispersed phase particles can be classified into natural mineral, natural deformable polymer, metal, and <u>synthetic polymer</u> particles according to the material composition.




2. Effects of dispersed particles on the STF

- The polarity, <u>molecular weight</u>, viscosity, and <u>steric hindrance</u> of the dispersion media have certain effects on the rheological properties of STF.
- Conversely, the increase in the <u>molecular chain</u> of the dispersion media can increase the viscosity, weaken the Brownian action, and reduce the <u>critical shear stress</u>.



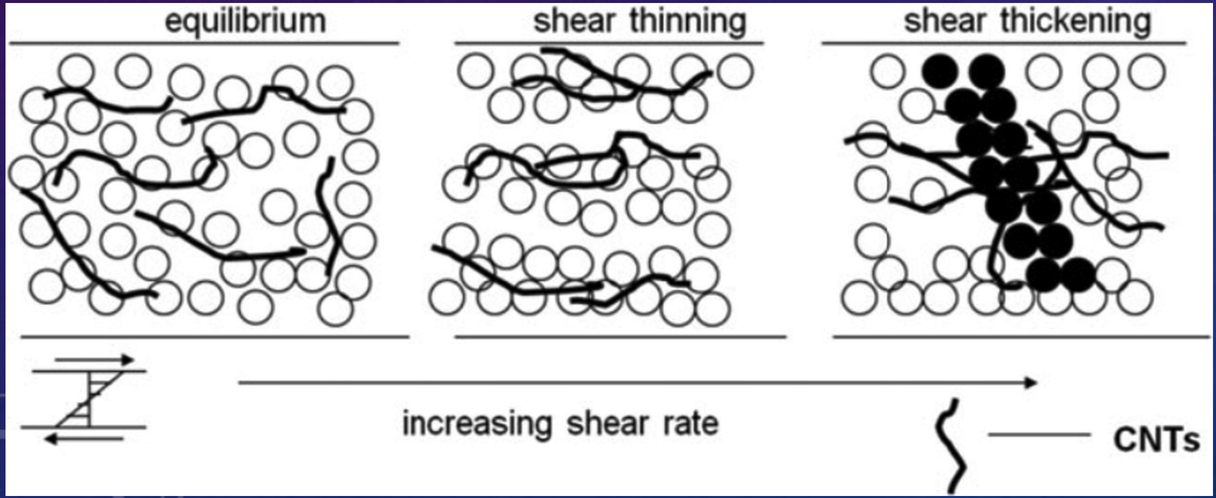
# FACTORS AFFECTING SHEAR THICKENING

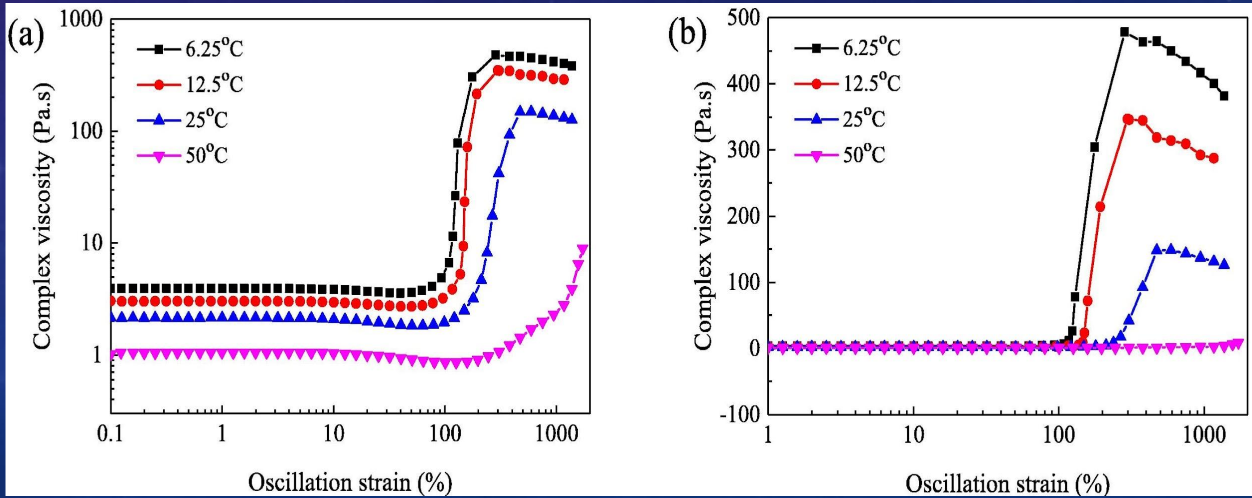
3. Effects of additive on the STF

- In addition to the dispersing particle and medium, adding additives to the preconfigured STF is an important method for adjusting its ST performance.
- The reason for the change in ST performance differs from the aforementioned mechanism, and it is due to the addition of nanoparticles.

4.Effects of external environment

- The rheological properties of STF are sensitive to the external environment. Hence, these can be controlled by external fields, such as temperature and electric and magnetic fields.



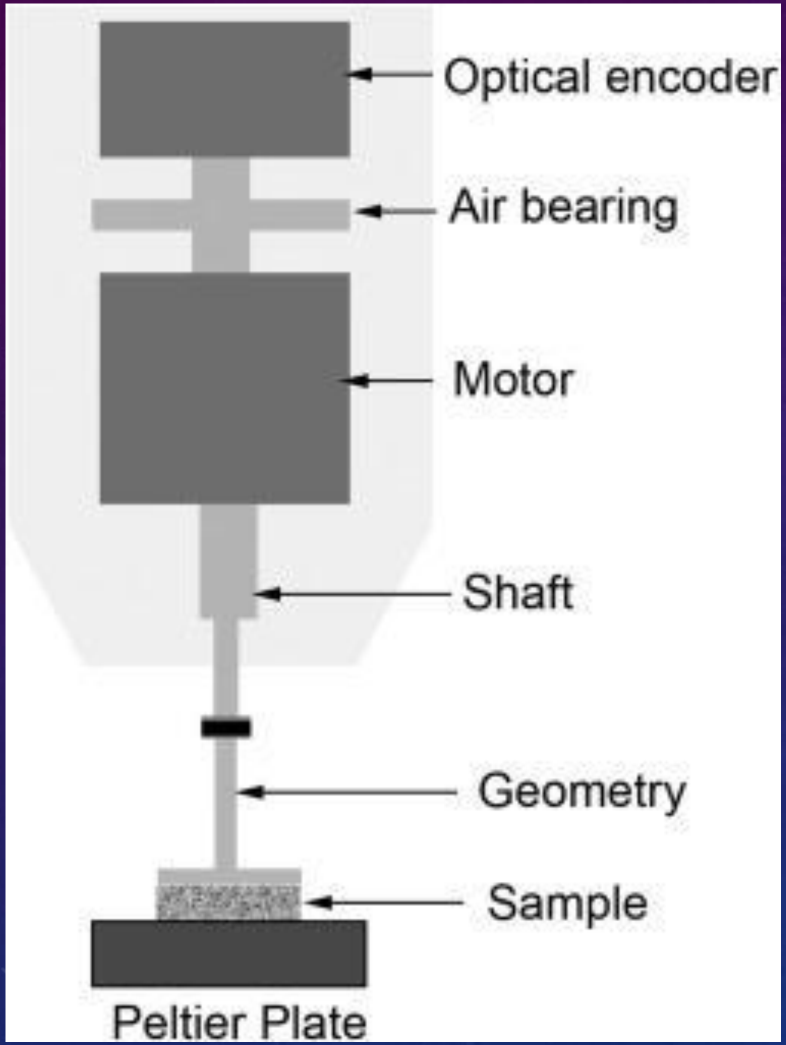
# APPARATUS


A rheometer is a precision instrument that contains the material of interest in a geometric configuration, controls the environment around it, and applies and measures wide ranges of stress, strain, and strain rate.

What is the principle of a rheometer?

The working principle of rheometer is based on rotational motion working principle, that is to attain the simple shearing flow, to control the strain rate, that is in the terms of applied control strain rate, which is rotation, and then measuring the resulting couple or torque.

# APPARATUS




This rheometer has three main components:

(1) The main unit mounted on a cast metal stand that supports the geometry
(2) An electronic control circuitry contained in a separated box (electronic box)
(3) The sample holder (Peltier plate)

# PROCEDURE OF EXPERIMENT

Shear Thickening Fluid is put in the rheometer

Two types of shear-thickening fluid along with different weight percentages have been used to calculate the shear-thickening output:

- Silica with weight percentages of 25 and 30
- Corn starch with weight percentages 44, 42 and 40

Each STF is provided with a shear rate from 1/second to 400/ second and for each shear rate input is maintained for 5 second

The shear rate should be kept lesser( less than 600 per second) otherwise STF will spill out

Note: Shear rate means the number of times the plate rotates in 1 seco

# Observation for Corn Starch

44 wt%

| Point No. | Shear Rate | Shear Stress | Viscosity |
|---|---|---|---|
| 1 | 1 | 1.6804 | 1677.5 |
| 2 | 1.27 | 1.0481 | 824.79 |
| 3 | 1.61 | 0.95655 | 593.01 |
| 4 | 2.05 | 1.0043 | 491.05 |
| 5 | 2.59 | 1.1122 | 428.72 |
| 6 | 3.29 | 1.1664 | 354.55 |
| 7 | 4.17 | 1.2641 | 302.82 |
| 8 | 5.3 | 1.4439 | 272.56 |
| 9 | 6.72 | 1.5182 | 225.85 |
| 10 | 8.53 | 1.6784 | 196.75 |
| 11 | 10.8 | 3.1259 | 288.58 |
| 12 | 13.7 | 3.1829 | 231.88 |
| 13 | 17.4 | 7.6518 | 439.03 |
| 14 | 22.1 | 9.9471 | 450.51 |
| 15 | 28.1 | 20.763 | 739.9 |
| 16 | 35.6 | 23.431 | 657.59 |
| 17 | 45.2 | 41.107 | 910.17 |
| 18 | 57.4 | 68.116 | 1187.3 |
| 19 | 72.8 | 80.27 | 1102.6 |
| 20 | 92.4 | 1484 | 16063 |
| 21 | 117 | 189.67 | 1618.2 |
| 22 | 149 | 837.88 | 5634 |
| 23 | 189 | 1441 | 7638.4 |
| 24 | 240 | 1301 | 5431.7 |
| 25 | 304 | 1453.7 | 4784.4 |
| 26 | 386 | 1020.4 | 2645.1 |
| 27 | 490 | 1051.1 | 2147 |
| 28 | 621 | 584.58 | 941.39 |
| 29 | 788 | 802.48 | 1018.3 |
| 30 | 1.00E+03 | 985.83 | 985.86 |

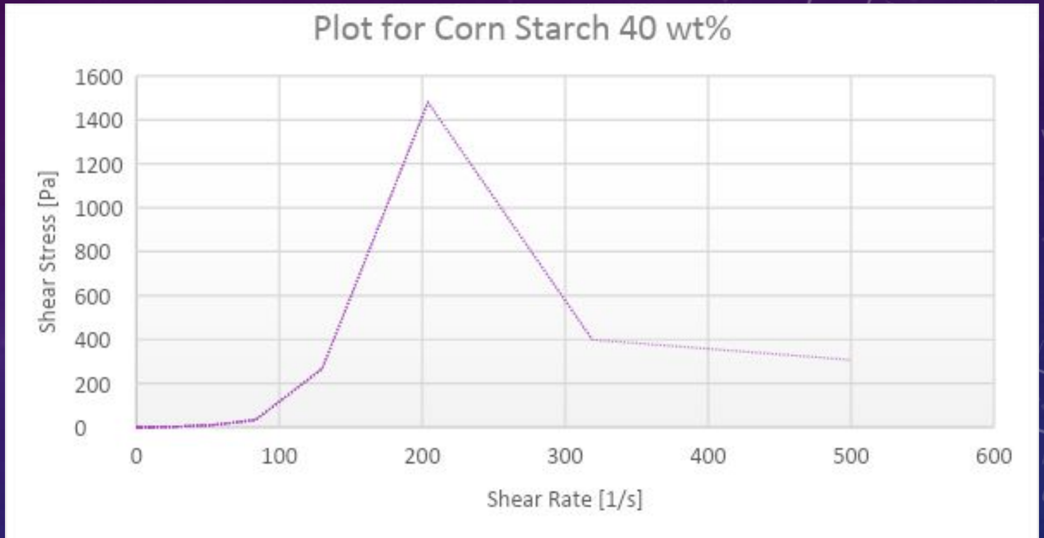
42 wt%

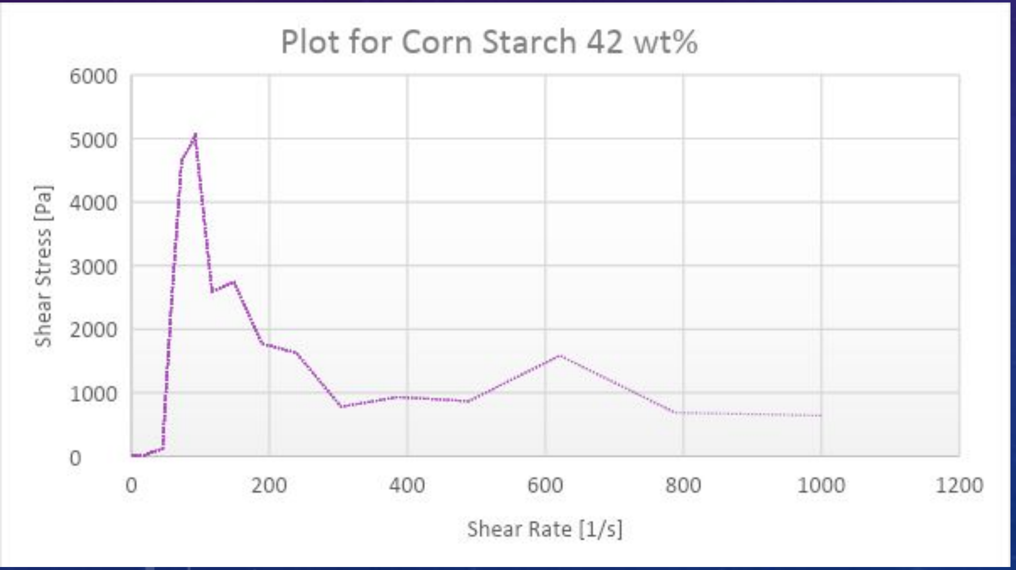
| Point No. | Shear Rate | Shear Stress | Viscosity |
|---|---|---|---|
| 1 | 1 | 1.2321 | 1229.9 |
| 2 | 1.27 | 0.91015 | 716.17 |
| 3 | 1.61 | 1.0791 | 669.03 |
| 4 | 2.05 | 1.3355 | 652.59 |
| 5 | 2.6 | 1.1853 | 456.59 |
| 6 | 3.29 | 1.3374 | 406.53 |
| 7 | 4.15 | 13.557 | 3263.4 |
| 8 | 5.3 | 1.7795 | 335.93 |
| 9 | 6.72 | 2.0947 | 311.6 |
| 10 | 8.53 | 2.754 | 322.84 |
| 11 | 10.8 | 6.241 | 577.01 |
| 12 | 13.7 | 6.2787 | 457.09 |
| 13 | 17.4 | 13.211 | 757.91 |
| 14 | 22.1 | 24.358 | 1101.3 |
| 15 | 28.1 | 62.388 | 2220.5 |
| 16 | 35.6 | 81.235 | 2281.4 |
| 17 | 45.2 | 120.33 | 2662.1 |
| 18 | 57.4 | 2289.7 | 39909 |
| 19 | 72.8 | 4642.6 | 63763 |
| 20 | 92.4 | 5045.6 | 54620 |
| 21 | 117 | 2594.5 | 22145 |
| 22 | 149 | 2741.1 | 18429 |
| 23 | 189 | 1772.6 | 9392.9 |
| 24 | 239 | 1628.5 | 6802.1 |
| 25 | 304 | 778.47 | 2562.7 |
| 26 | 386 | 931.15 | 2414.7 |
| 27 | 489 | 867.69 | 1773.2 |
| 28 | 621 | 1584.8 | 2552.4 |
| 29 | 788 | 686.04 | 870.5 |
| 30 | 1.00E+03 | 640.54 | 640.5 |

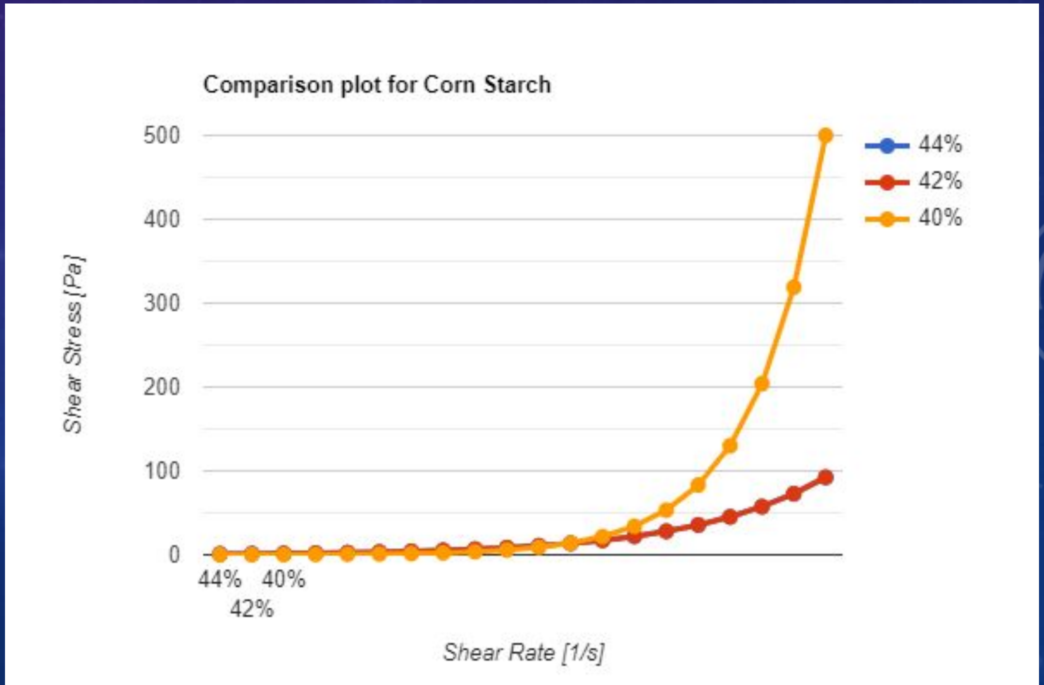
40 wt%

| Shear Rate | Shear Stress | Viscosity |
|---|---|---|
| 0.1 | 0.041245 | 411.11 |
| 0.157 | 0.05147 | 328.49 |
| 0.245 | 0.058958 | 240.29 |
| 0.384 | 0.073978 | 192.69 |
| 0.601 | 0.090338 | 150.28 |
| 0.941 | 0.11815 | 125.52 |
| 1.47 | 0.16371 | 111.1 |
| 2.31 | 0.22972 | 99.571 |
| 3.61 | 0.33378 | 92.465 |
| 5.65 | 0.48467 | 85.771 |
| 8.85 | 0.77385 | 87.47 |
| 13.9 | 1.3001 | 93.863 |
| 21.7 | 2.2528 | 103.88 |
| 34 | 4.1644 | 122.66 |
| 53.2 | 10.447 | 196.53 |
| 83.2 | 32.502 | 390.53 |
| 130 | 266.75 | 2047.2 |
| 204 | 1480.5 | 7256.5 |
| 319 | 398.57 | 1247.7 |
| 500 | 306.49 | 612.9 |

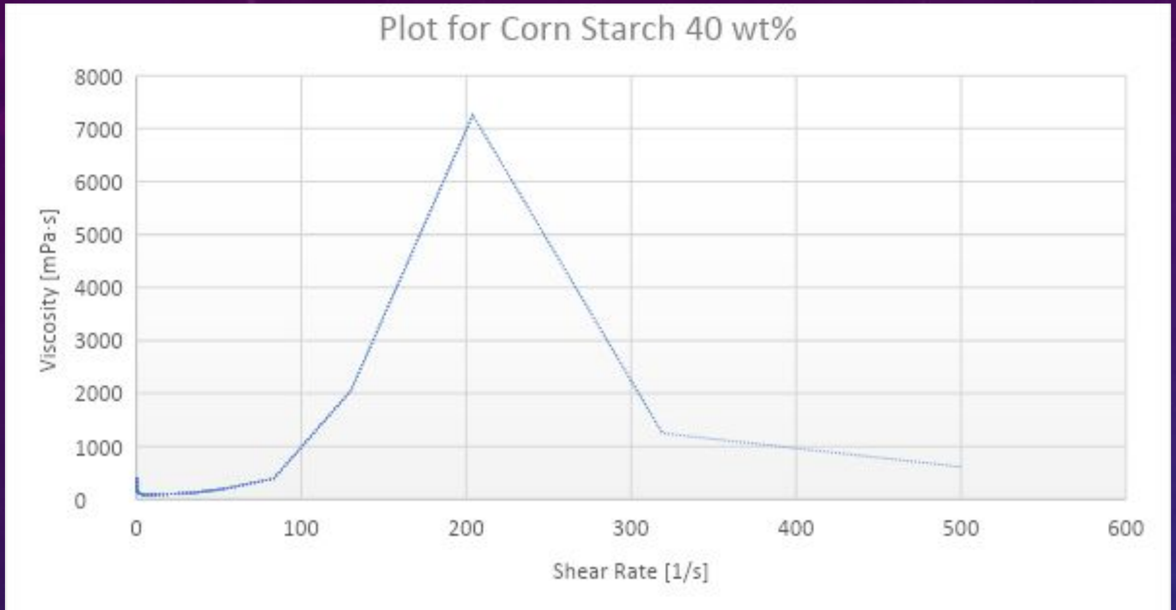
# Shear Stress and Shear Rate Plot for Corn Starch for Different Weight Percentage

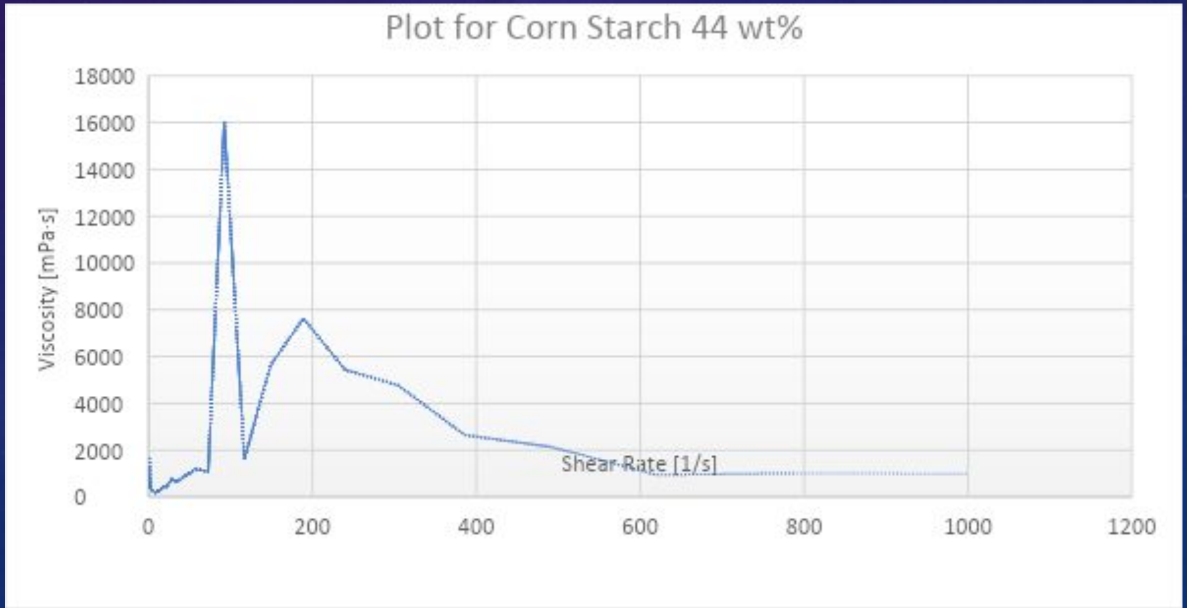



# Shear Rate and Viscosity Plot for Corn Starch for Different Weight Percentage







# Observation for Silica

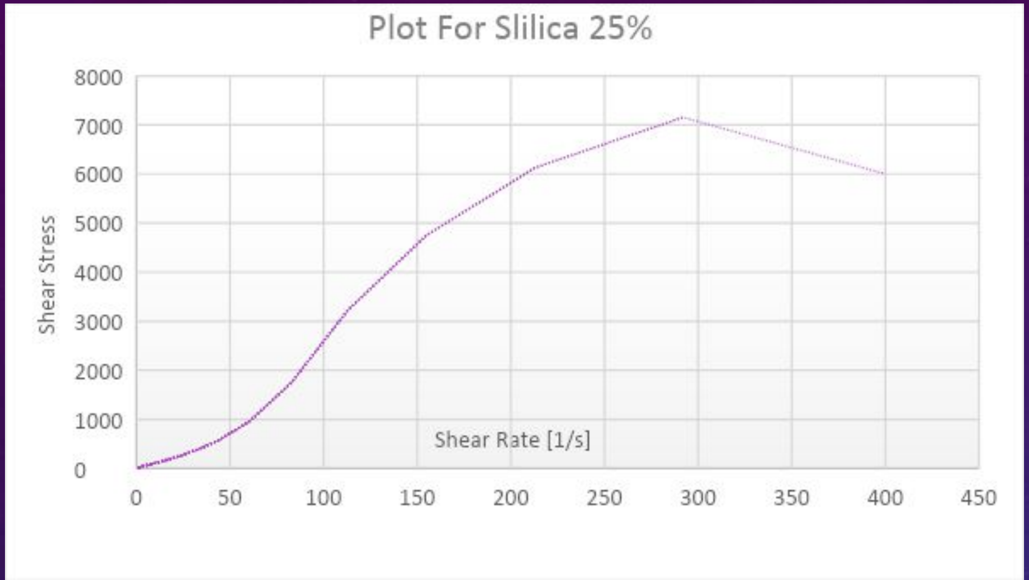
25 wt%

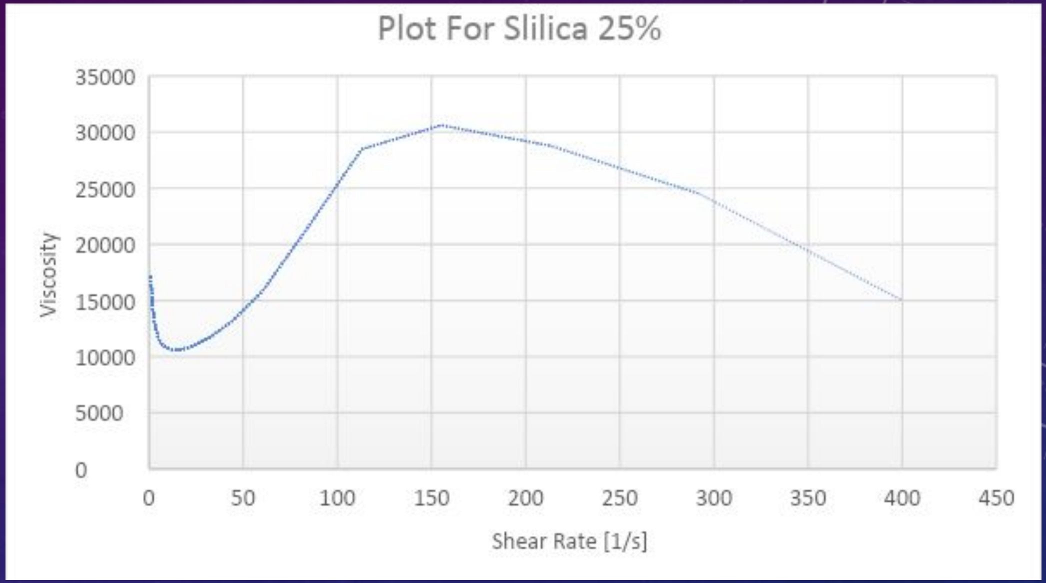
| Shear Rate | Shear Stress | Viscosity |
|---|---|---|
| 1 | 17.168 | 17153 |
| 1.37 | 21.727 | 15828 |
| 1.88 | 27.301 | 14504 |
| 2.58 | 34.635 | 13423 |
| 3.53 | 44.241 | 12517 |
| 4.84 | 56.948 | 11763 |
| 6.63 | 74 | 11155 |
| 9.09 | 98.121 | 10792 |
| 12.5 | 132.2 | 10608 |
| 17.1 | 181.4 | 10619 |
| 23.4 | 256.39 | 10950 |
| 32.1 | 375.59 | 11702 |
| 44 | 578.05 | 13139 |
| 60.3 | 955.3 | 15840 |
| 82.7 | 1745.2 | 21112 |
| 113 | 3227 | 28478 |
| 155 | 4754.4 | 30608 |
| 213 | 6129.8 | 28790 |
| 292 | 7154.8 | 24516 |
| 400 | 6002.1 | 15004 |

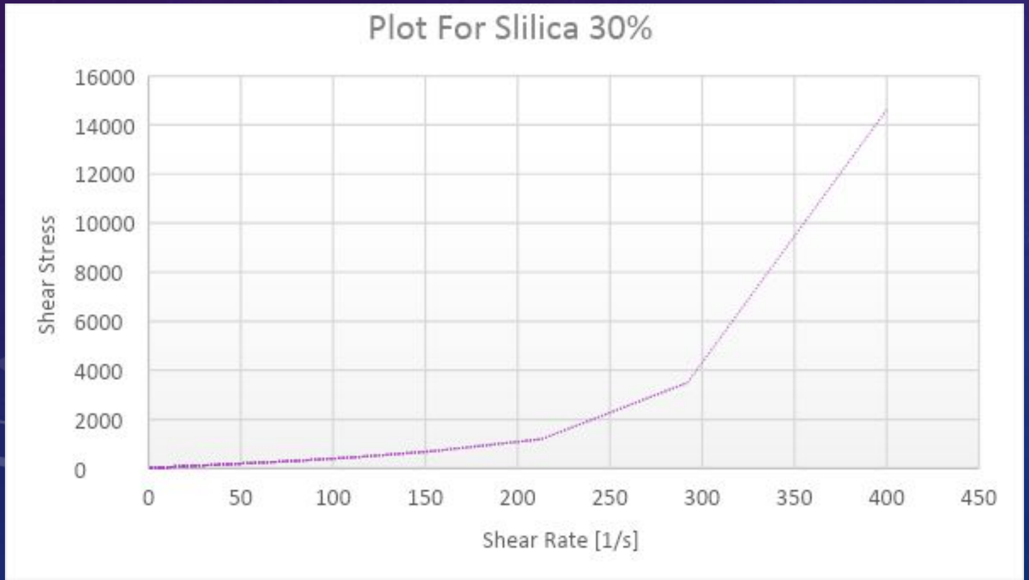
30 wt%

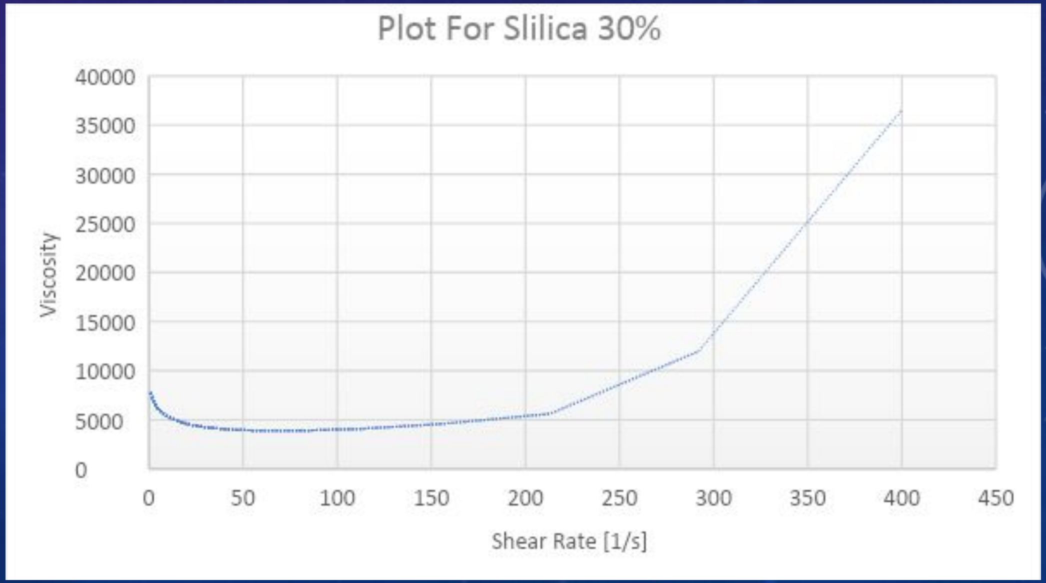
| Shear Rate | Shear Stress | Viscosity |
|---|---|---|
| 1 | 7.7994 | 7774.6 |
| 1.37 | 10.265 | 7467.7 |
| 1.88 | 13.503 | 7171.2 |
| 2.58 | 17.689 | 6858.6 |
| 3.53 | 22.973 | 6504.7 |
| 4.84 | 29.742 | 6145.4 |
| 6.63 | 38.358 | 5783 |
| 9.09 | 49.357 | 5429.2 |
| 12.5 | 63.286 | 5078.5 |
| 17.1 | 81.201 | 4753.6 |
| 23.4 | 104.33 | 4455.7 |
| 32.1 | 134.87 | 4202.1 |
| 44 | 175.97 | 3999.8 |
| 60.3 | 235.17 | 3899.7 |
| 82.7 | 323.54 | 3914 |
| 113 | 464.52 | 4099.7 |
| 155 | 711.6 | 4581.7 |
| 213 | 1196.6 | 5620.6 |
| 292 | 3496.2 | 11980 |
| 400 | 14619 | 36542 |

# Silica Plot for Different Weight Percentage

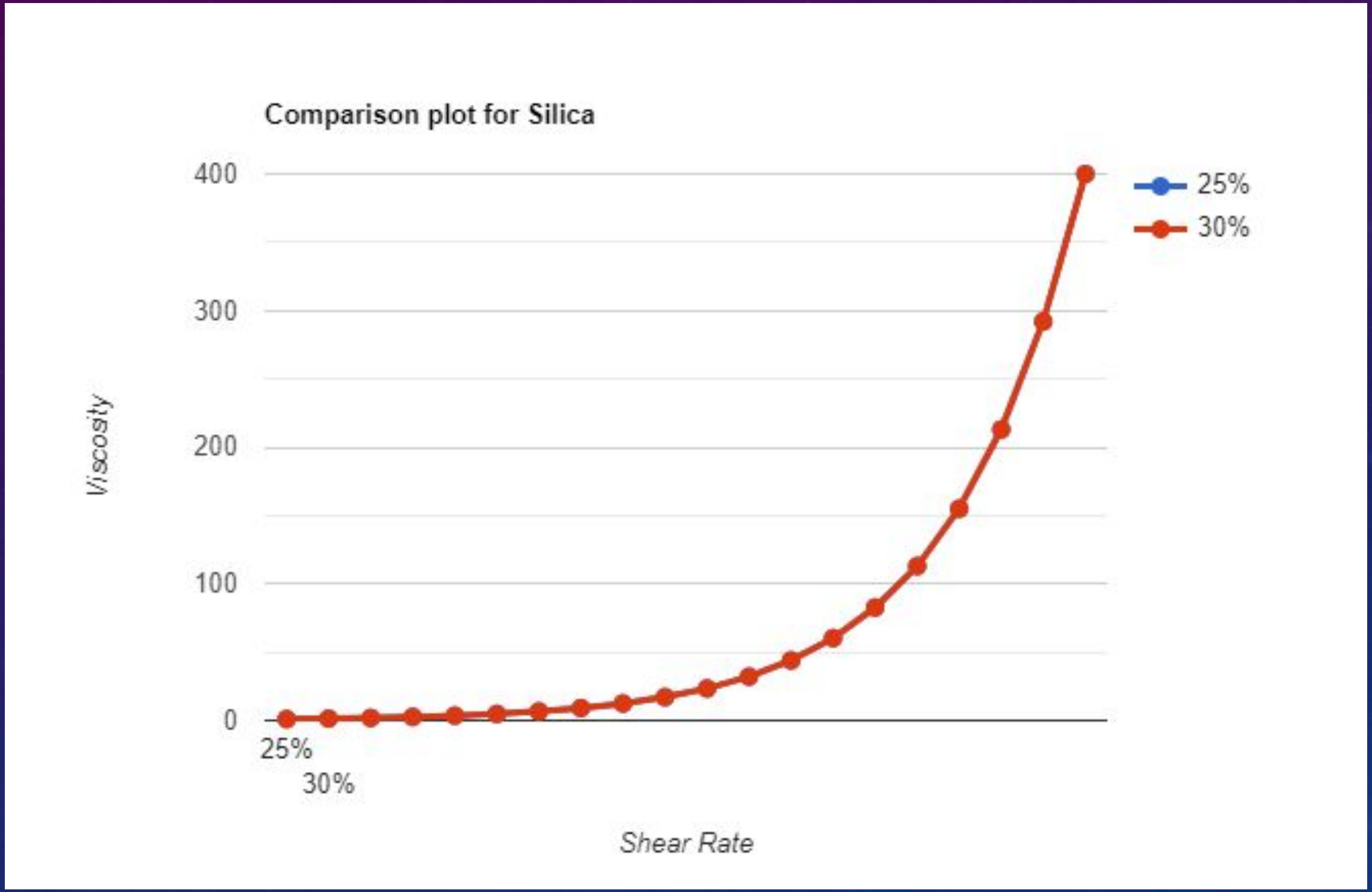


# Comparison Plot for Silica



# Conclusion

- Shear Thickening Commonality: Both cornstarch and silica mixtures exhibit increased shear stress with increased shear rates, indicative of shear thickening behavior.

- Concentration Dependency: The shear thickening effect is more pronounced at higher concentrations for both materials, as shown by steeper curves in the shear stress plots for higher weight percentages.

- Viscosity Variation with Shear Rate: The viscosity of both materials increases with shear rate, but the effect is more significant in mixtures with higher concentrations of the dispersed phase (cornstarch or silica).

- Critical Shear Rate: Each material mixture reaches a critical shear rate where viscosity peaks, with higher concentrations requiring higher shear rates to reach this peak, suggesting better stability under dynamic conditions.

- Implications for Application: The ability to tailor viscosity by adjusting the concentration of cornstarch or silica makes these materials versatile for applications requiring impact resistance and adaptive viscosity, such as in protective gear or smart materials.

# Applications of STF

- Body Armor: Enhances protection in military and athletic gear by stiffening upon impact
- Automotive Safety: Improves shock absorption in seatbelts and airbags during accidents
- Sports Equipment: Used in helmets and pads for better protection against high-impact collisions
- Medical Devices: Applied in prosthetics and orthopedic supports for a balance of flexibility and support
- Vibration Damping: Utilized in industrial machinery and construction to reduce noise and vibrations

Thank You