



Investigation of Renewable Aqueous Surfactant and Hydrotope Solution Viscosities with a Falling-ball Viscometer

Dakotah Stirnweis (PI), Angelo Kaminis (CO-PI), Arden Neer III (CO-PI), Hemil Tavarez (CO-PI), Izah Deang (CO-PI), Lauren Stollenwerk (CO-PI), Qi Jiang (CO-PI), and Dr. Birce Dikici (Advisor)
Mechanical Engineering Department, Embry-Riddle Aeronautical University

OBJECTIVE:

The purpose of this research is to determine the viscosity of surfactants, hydrotopes and surfactant-hydrotpe mixtures using a falling ball viscometer.

INTRODUCTION:

Surfactants are known to affect evaporation performance of solutions and are studied in relation to water loss prevention and heat dissipation.

Surfactants:

Surfactants are compounds that lower the surface tension between two liquids or between a liquid and a solid, and are classified as nonionic, anionic, cationic, and amphoteric.

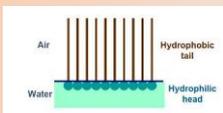


Figure 1: Structure of surfactant agent [1]

Hydrotopes:

Hydrotopes are molecules that when added to a poorly-soluble compound, increases its solubility in water. They contain both hydrophobic and hydrophilic portions, but only a very small portion of the hydrotope is hydrophobic.

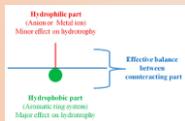


Figure 2: Structure of hydrotopic agent [2]

Viscosity:

Viscosity is a fluids property that is created by the cohesive forces between the molecules in liquids and by the molecular collisions in gases. In one-dimensional shear flow of Newtonian Fluids, shear stress can be expressed by the linear relationship:

$$\tau = \mu \frac{du}{dy}$$

EXPERIMENTS:

Each solution was tested until 3 trials with significantly accurate data (within +- 2 seconds) were obtained. Results that were out of those parameters were not taken into consideration.

Surfactants :

ECOSURF™ EH – 14: A nonionic surfactant. Used as a hard surface, metal or high performance cleaner. Typically used in industrial processing/manufacturing and agriculture formulations.

ECOSURF™ SA-9: A seed oil and biodegradable nonionic surfactant. Used in hard surface cleaners, prewash spotters, as well as paints and coatings. This type of surfactant is easier to handle, process, and form.

Hydrotopes :

TRITON™ H-66: Used to solubilize nonionic surfactants and liquid concentrates. Considered non-toxic in small amounts.

Polyglycol P1000TB: Used as antifoam agents in latex formulations, paper and pulp processing, food production and other industries. Also used as a chemical component to resins, plasticizers, and lubricant bases.

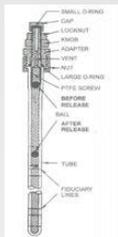
A Falling Ball Viscometer:

A Gilmont Falling Ball Viscometer was used to measure viscosity (right). By using a PTFE screw assembly as featured on the right, the viscometer is able to release a ball and let it fall through a liquid medium. By measuring the time it takes for the ball to fall between the fiducial lines, it is possible to calculate the viscosity of the substance within the viscometer. [4] After the time measurements were taken, they were used to calculate viscosity using the equation given below:

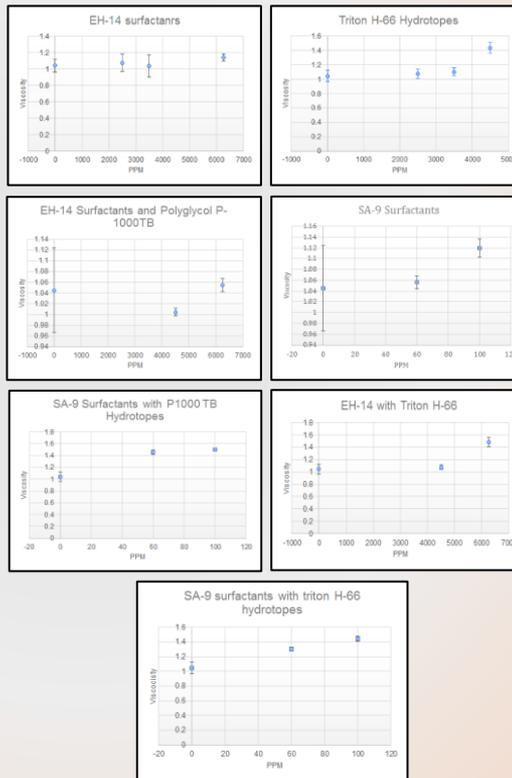
$$\mu = K(\rho_f - \rho)t$$

where:

- μ = calculated viscosity (mPa.s)
- K = viscometer constant
- ρ_f = density of ball (gms/mL)
- ρ = density of liquid (gms/mL)
- t = time (minutes)



RESULTS



CONCLUSION:

When analyzing the results, the mixture solutions achieved higher viscosities on average when compared to individual substances.

Future testing will involve the measurement of the rate of evaporation of each solution, along with a comparison between the rate of evaporation and the equivalent viscosity of the solutions.

DEMONSTRATION:



Figure 3: mixing of surfactants

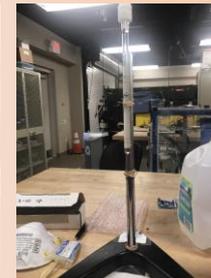


Figure 4: A falling ball viscometer

References

- [1] E.A. Prime "New technology to reduce evaporation from large water storages", Waterlines Report Series, 2012
- [2] V. Dhapte, P. Mehta, "Advances in hydrotopic solutions: An updated review, SSt. Petersburg Polytechnical Univ. (2015) 424-435
- [3] Cengel, Y. A. & Cimbala, J.M. (2018). Fluid mechanics fundamentals and applications fourth edition. McGraw Hill Education.
- [4] Gilmont Instruments, Cole-Palmer Falling ball User's manual