

Viscosity of Salad Dressing Lab

Developed by: Mike Evangelista, Nathan Haden, Alex Jannini, Rowan University,
Department of Chemical Engineering

Edited by: C. Stewart Slater and Mariano Savelski, Rowan University, Department of
Chemical Engineering

Date of Experiment:

OBJECTIVES

- Students will learn about viscosity and viscosity enhancements chemicals
- Students will learn how to use a viscometer
- Students will learn to create and analyze an empirical model

INTRODUCTION

Food texture, mouth feel, and aesthetics are important properties for products in the food industry. The texture of a food and how it feels in the mouth is one of the most important selling factors, along with flavor¹. Usually, the texture of a food can indicate the freshness or quality of the food to the consumer so enhancing the food texture can determine whether or not the product will be purchased. The target texture of the food could be crispy, crunchy, thick, thin, fluffy, etc.

Consumers associate certain textures with quality of the food. Some consumer expectations are that fresh carrots should have a loud crunch, chewing gum should be soft and cohesive, potato chips should be crispy, and bagels should be soft and a little chewy. If the texture of the food does not meet these expectations, the consumer might think it is spoiled or stale. It is this reason that food companies put additives and preservatives in the food to provide a positive experience to the consumer.

Preservatives such as sodium benzoate, BHT, or ascorbic acid are added to help slow down bacteria growth and color decay. Dyes such as Blue #1, Red #40, Yellow # 5 are added to make the food aesthetically appealing, or to offset natural color loss. Flavor enhancers such as monosodium glutamate (MSG), hydrolyzed soy protein, or autolyzed yeast extract are added to enhance a food existing flavor without altering it. Fat substitutes such as olestra, carrageenan, or xanthan gum are added to provide a



Figure 1. Salad dressing often has additives in it that make it thicker.

creamy texture without adding additional fat. Anti-caking agents such as calcium silicate, iron ammonium citrate, or silicon dioxide are added to prevent moisture adsorption in powders². All of these FDA approved food additives are added to enhance the texture of the food to appeal to the consumer.

This experiment will focus on thickening agents used to enhance food texture. The effect of xanthan gum has on salad dressing will be studied. Xanthan gum is a polysaccharide produced through biosynthesis by *Xanthomonas* bacteria³. The bacteria is allowed to grow and ferment and produce the xanthan gum compound with the chemical structure below.

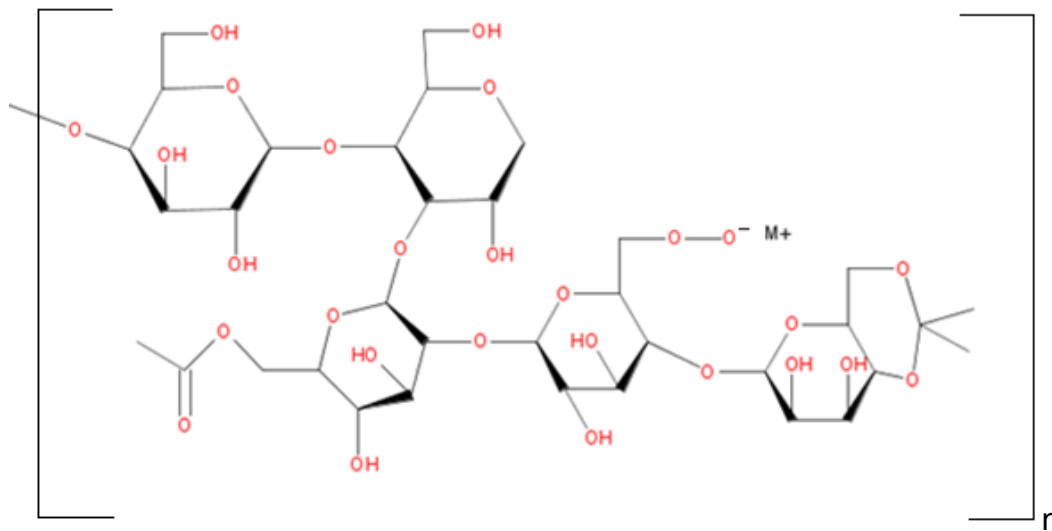


Figure 2. Structure of xanthan gum produced from *X. campestris*

The xanthan gum and solvent mixture undergoes many distillations, filtrations, and dryings to isolate the xanthan gum powder which may be later used in a variety of products.³

Table 1. Common applications of xanthan gum. Table adapted from García-Ochoa, F. et al³

Use	Concentration (%w/w)	Function
Salad dressing	0.1-0.5	emulsion stabilizer, suspending agent, dispersant
Syrups, sauces	0.05-0.2	thickener, heat stability, uniform viscosity
Baked goods	0.1-0.4	stabilizer
Pharmaceuticals	0.1-1	emulsion stabilizer in creams and suspensions
Agricultural	0.03-0.4	improve spray and increased cling in pesticides
Textile printing and dyeing	0.2-0.5	control flow of paste and prevent dye migration
Petroleum production	0.1-0.4	Lubricant in drilling

The most notable effect of xanthan gum is that increases the viscosity of the mixture it is added to. Viscosity is defined as the resistance to flow due to internal friction of the molecules⁴. This can be explained by large molecules such as xanthan gum bumping into or getting tangled with each other which gives extra resistance to free-flowing movement. In a solution, as the xanthan gum concentration increases, the probability that the xanthan gum molecules will interact and inhibit motion will increase which is measured as an increase in viscosity⁴.

The viscometer measures the viscosity of the fluid by measuring the amount of torque needed to rotate the spindle immersed in the given fluid at a set speed. The spindle is driven by the motor through a calibrated spiral spring; the deflection of the spring indicates how much torque is needed and is indicated on the digital display⁴.

Isaac Newton defined viscosity using the equation:

$$F' = \eta * \frac{dv}{dx}$$

Where F' is the shear stress (force per area) on the spindle,, η is viscosity, and dv/dx is the velocity gradient normal to the spindle . Fluids that follow this equation are called Newtonian fluids and give a linear relationship between shear rate and shear stress in addition to constant viscosity at varying shear rates as seen below⁴. Shear rate is the rate at which shear stress is being applied.

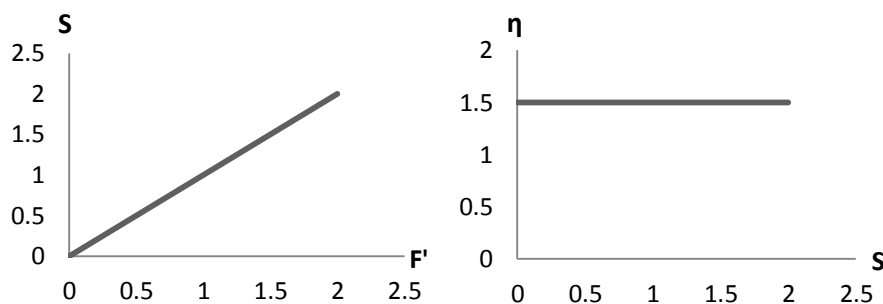


Figure 3. Newtonian Fluids: Shear rate (S) versus shear stress (F') (left) and viscosity (η) versus Shear rate (S) (right)

Non-Newtonian fluids do not have a linear relationship between shear rate and shear stress and the viscosity changes as the shear rate changes.

In this lab, you will be comparing the viscosity of commercial French dressing to homemade dressing. You will be adding xanthan gum powder to the homemade dressing to determine how much xanthan gum is in the original commercial dressing. All viscosity measurements will be done using the Brookfield viscometer.

MATERIALS NEEDED

- 300-400 mL beaker
- Brookfield Programmable DV-II+ Viscometer
- French Dressing*
- Purified Water
- Vegetable Oil*
- Cider Vinegar*
- Corn Syrup*
- Tomato Paste*
- Food Processor/Blender
- 200mL Graduated Cylinder

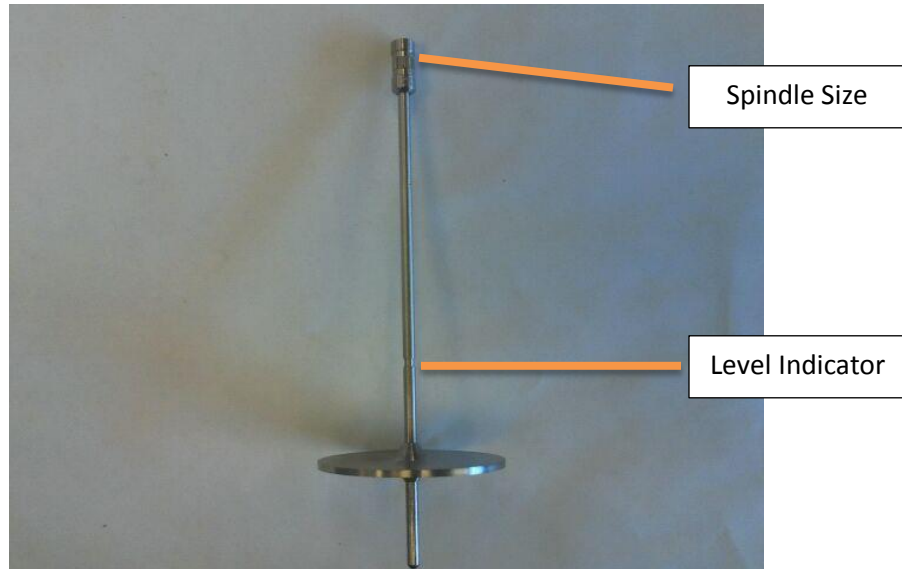
SAFETY CONDITIONS

Always wear safety glasses while in designated lab area. Wear gloves if necessary. Do not consume any food product unless the experiment is performed in a food lab using proper food safety protocols.

PROCEDURE

Commercial Salad Dressing Viscosity

1. Add 200 mL of salad dressing to the beaker
2. Remove any spindle attached to the viscometer
3. Turn on the viscometer and allow it to auto-zero
4. Select and attach the size 4 spindle to the viscometer (Note: The spindle size can be found at the top of the spindle shaft)



5. Place the beaker under the viscometer and lower the viscometer so that the liquid level of matches up to the level indicator on the spindle. Add more salad dressing if necessary
6. Press “Select Spindle” and then “↑” or “↓” and then “Select Spindle” again to enter it so that the display reads “S04”



7. Press “Motor ON/OFF” to start the motor
8. Adjust the rotations per minute (RPM) by pressing “↑” or “↓” then “Set Speed” to enter it at 100 RPM
9. Confirm that the torque % is between 10% and 100% for a valid measurement
10. Record the viscosity in centipoise (cP)
11. Put the temperature probe in the beaker and record the temperature of the solution. (Note: The temperature should be kept constant throughout the experiment)
12. Now use at least 5 different speed settings (RPM) and record the results. Note: The viscometer speed setting ranges from 0-100 RPM.
13. Press “Motor ON/OFF” to turn the motor off
14. Raise the viscometer spindle and thoroughly clean off equipment

Homemade Salad Dressing Preparation

1. Measure out the necessary materials from the formula below

Table 2. Formula for homemade salad dressing

Ingredient	Volume (mL)
Vegetable Oil	160
Vinegar	80
Corn Syrup	40
Tomato Paste	40
Water	10

2. Record the mass of each ingredient using a scale and a graduated cylinder in the results table provided in the RESULTS section
3. Combine materials in a food processor and blend until smooth and uniform throughout
4. Repeat steps in the previous procedure section to measure the viscosity of the mixture using a size 4 spindle at 100 RPM
5. Add 0.1 g of Xanthan gum to the mixture and blend
6. Measure the viscosity and record
7. Repeat steps 5 and 6, incrementally adding 0.1 g of xanthan gum until the viscosity of the mixture can no longer be read by the size 4 spindle at 100 RPM

RESULTS

The tables below has been provided to help record the results of the experiment.

Material	Volume (mL)	Mass (g)
Oil		
Vinegar		
Corn Syrup		
Tomato Paste		
Water		

4. Besides increasing viscosity, what other properties does Xanthan gum contribute to the salad dressing? Be sure to cite your sources.
5. An intern is working for a Shale Oil Fracking company near Big State University. The required viscosity for drilling mud was recorded as 7250 lb/yd-hr by an intern who got decided to get creative with units. Help the intern to determine (a) what is the required viscosity in cP and (b) what is the required xanthan gum mass % of an oil and water based mud that behaves similarly to the salad dressing.
6. Your superior culinary senses are telling you to add xanthan gum to your famous thick and smoky barbeque sauce, but you aren't sure how much to add. You want the barbeque sauce to be thick enough to stay on the food while it is grilling, but not so thick that the texture becomes undesirable. You decide you want the sauce to have twice the viscosity of commercial French dressing. Assuming the xanthan gum has the same effect on barbeque sauce as it has on salad dressing, how much xanthan gum would you need to add to your 500g batch of sauce?

REFERENCES

1. Civille, G. V. Food Texture: Pleasure and Pain. *Journal of Agricultural and Food Chemistry*. **2011**, 59, 1487-1490.
2. Overview of Food Ingredients, Additives & Colors. IFIC and US FDA. Nov 2004. rev April **2011**.
3. García-Ochoa, F. et al. Xanthan gum: production, recovery, and properties. *Biotechnology Advances*. **2000**, 18, 549-579.
4. More Solutions to Sticky Problems. *Brookfield Engineering Labs, Inc.*
<http://www.engr.sjsu.edu/~bjfurman/courses/ME120/me120pdf/MoreSolutionsToStickyProblems.pdf>
5. Xanthan Gum. Essential Depot. essentialdepot.com