“Dancing Tears” Experiment

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1. Introduction

The purpose of this project is to become familiar with what it means to artistically capture flow phenomenon. For an introductory project, there was immediate interest to capture a flow phenomenon that I have been fascinated by for years. I enjoy wine and, in the effort to understand the art of winemaking and tasting, a friend explained how to visualize the “quality” of wine. By swirling the wine in the inside of the glass and allowing the liquid to drop down the sides, one can see the “legs” or “tears” of the wine. This, by some wine drinkers, is meant to correlate with the high quality of the wine. However, this phenomenon correlates with the alcohol level in the liquid and not directly with the overall quality. For this project, I attempted to capture this phenomenon known as the Marangoni effect of the “tears” of alcohol in whiskey (43% alcohol) and red wine (14.2% alcohol).

2. Discussion of Flow

The Marangoni effect has been studied in many applications and specifically the effect present in wine and higher liquor spirits. The alcoholic liquids consist mostly of water and alcohol. Water has a higher surface tension than alcohol. Higher surface tension causes other liquids of lower surface tension to be pulled toward the higher tension areas. When the alcoholic liquid is in the glass the alcohol evaporates on the sidewalls of the glass creating a film of alcohol. The highest evaporation of alcohol takes place at the uppermost part of this film on the sidewall and “the concentration of the alcohol… becomes smaller and smaller” on the sidewall of the glass [1]. This varying concentration of alcohol is referred to as a tension or concentration gradient. The thinnest concentration of alcohol at the uppermost part of the film has the highest surface tension, even more than the water in the beverage. This high surface tension pulls on the low surface tension (but high alcohol concentration) liquid as seen in *Figure 1*. This upward motion of the alcohol can be counterintuitive but creates an artistic effect when the liquid accumulates and then falls back down towards the liquid in the glass. This process happens repetitively as long as there is alcohol that is evaporating along the side walls. For this effect in alcohol qualitative data was found not quantitative.

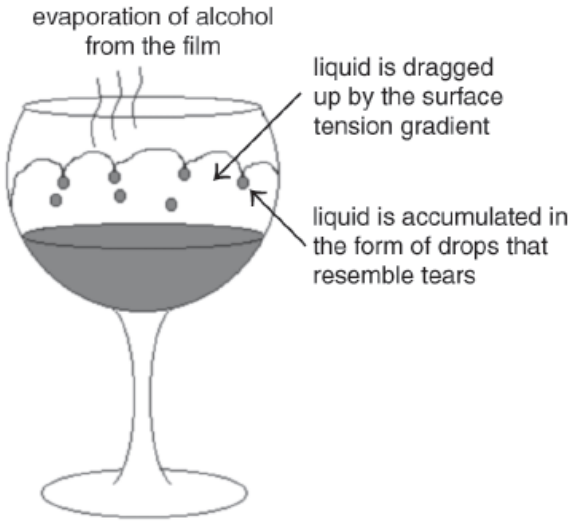

Figure 1. Marangoni effect in a glass of wine [2]

3. Visualization Technique

There were no additive visualization techniques used such as dye or smoke in this experiment. The only liquid involved was the type of alcohol, whiskey or red wine. The whiskey was Breckenridge Bourbon from Breckenridge, CO and contains 43% alcohol. The red wine was Ghost

Pines Cabernet Sauvignon 2014 and contains 14.2% alcohol. The glass was approximately 3 inches tall and the flow occurred within a space of 0.5 inches inside the glass. The lighting was from a headlamp at a maximum brightness of 350 lumens. The light was aimed at a white wall behind the glass and reflected towards the glass, or backlit. This setup can be seen in *Figure 2*.

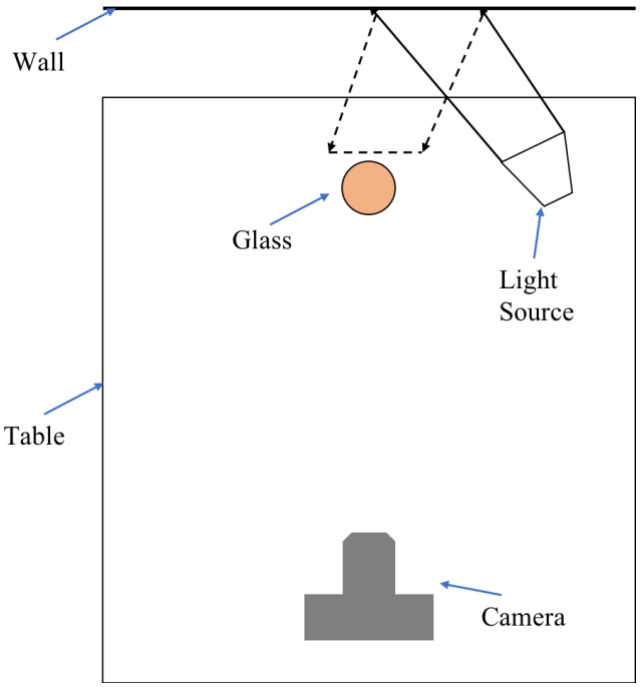

Figure 2. Top View of Setup

4. Photographic Technique

A Canon Rebel T3i EOS 600D DSLR camera was used for filming the phenomena. A 55-250 mm telephoto lens was used and zoomed in to achieve a FOV of approximately 2 inches. The distance from the glass to the camera lens was approximately 2 feet with the glass and camera elevated at 4 inches from the table. The camera settings were as follows: ISO:400, Shutter Speed: 30 fps, Aperture: F5.6. The SD card was also capable of 4k HD videos and had a write speed of 170 MB/s. For the video there was no post processing.

5. Discussion

I believe that the video does a good job of capturing the flow by using a sped-up version of the phenomenon. By speeding up the video, the eye of the viewer is instantly drawn to the "chaotic" motion of the video. Without this alteration to the video, there may not have been enough motion to cause an aesthetic interest. The lighting is something that I had to fine-tune and I wonder if a different angle of backlighting would have helped the red appear in the red wine instead of it being dark as it is in the video. If this experiment were to be revisited or replicated it would be interesting to see the effects of a different shape of the glass that would allow for more alcohol to be exposed to the environment and a different evaporation rate from the sides of the glass. Other research suggests that by adding a temperature element to the experiment the same effect can be achieved since the evaporation of the liquid is still present [3]. It would be interesting to explore the temperature effects compared to the room temperature Marangoni effect observed in this experiment.

References:

[1] Rafael Tadmor, 2008, "Marangoni flow revisited, Journal of Colloid and Interface Science 332 (2009) 451-454

[2] Marcos Gugliotti, 2004, "Tears of Wine", Journal of Chemical Education, Vol. 81 No. 1

[3] Marcos Gugliotti, 2004, "Surface Tension Gradients Induced by Temperature: The Thermal Marangoni Effect", Journal of Chemical Education, Vol. 81 No. 6