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Team Third Image Report

MCEN 5151 – Dec. 2019

Microscopic Coffee – Team Third

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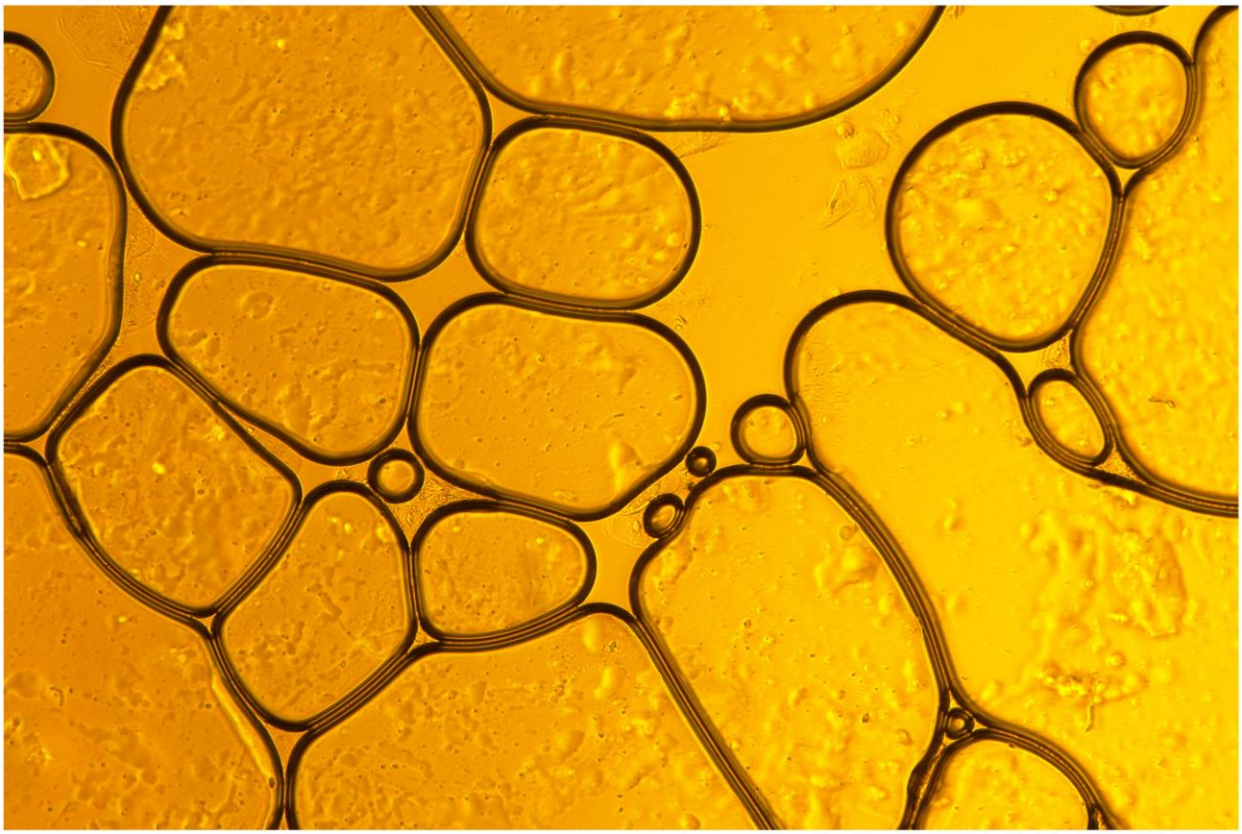

Figure 1: Edited team third image

The above image is a screen capture from the team second video for the Flow Visualization course at University of Colorado at Boulder. The plan for this image was inspired by the Design for Coffee course that Aaron has been taking this semester. In this course, Aaron has been experimenting with proper ways to brew coffee from a scientific perspective, even going so far as to investigate the coffee that they brew under a microscope. It is from this experience that Aaron shared with us where we became interested in doing a photography session of the coffee, to try and capture the aesthetically pleasing images of microscopic coffee. This is one of many photos that we took as a team, I selected this one because of the color gradient, interesting aesthetics and how much it has going on in it.

The image was captured by using Aaron's Nikon D5500 attached to an Olympus BX60 microscope using an AM Scope camera adapter. The image was taken at 45x zoom and highlights the complicated interfaces between coffee oils (the closed bubbles) and the water in

which it is suspended (surrounding fluid). The diagram for the experimental setup is shown below in figure 2:

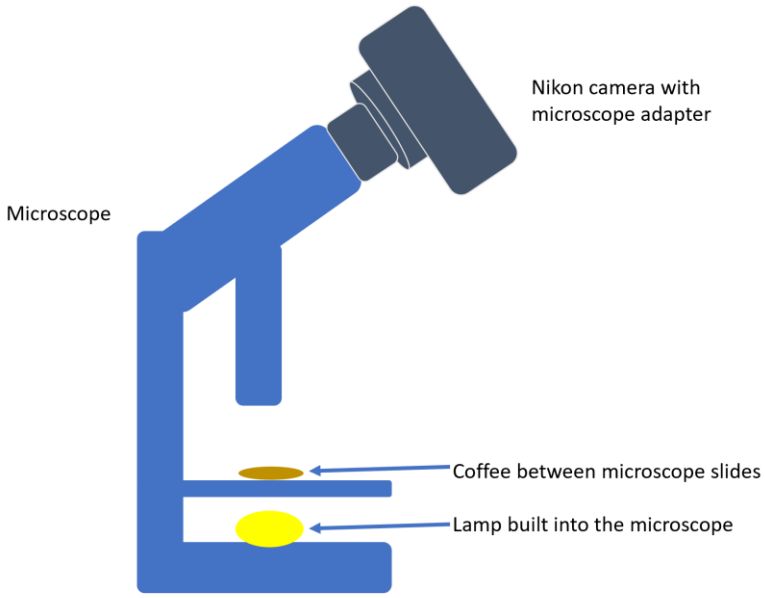

Figure 2: Diagram of experimental setup

This shows that we used a thin layer of coffee spread between two microscope slides. The coffee was deposited onto the slides using a 50 µL pipet. Under the microscope was a strong lightbulb built into the microscope and a series of light filters just above the light. The yellow-orange tint seen in the photo is a result of the filter that we used for a majority of the team photos, however a few were taken with green and blue filters. The experimental setup in reality is shown in figure 3 below, where we are using the pipet to move freshly brewed coffee onto a slide, the camera can also be seen mounted directly into the microscope.

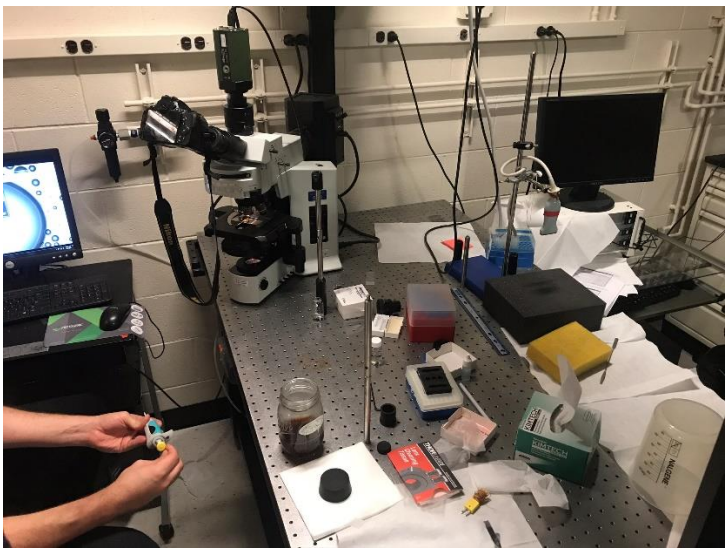

Figure 3: Photo of experimental setup

The flow visualized in the image is the interface between coffee oils and hot water, where surface tension is keeping the oils separate from the water in which it is suspended. The dark lines are the interfaces between oil and water, where the light is bent by a high gradient in the index of refraction in the medium. The phenomenon being captured here is the surface tension within the pockets of oil. Surface tension is a molecular force that causes many fluids, such as water and oils to form into shapes that contain minimum surface area. This effect can be best seen in some of the smaller droplets in the image, where they are close to circular. A food science study investigating coffee produced images very similar to the one that I took for this project, this is seen in figure 4 below:

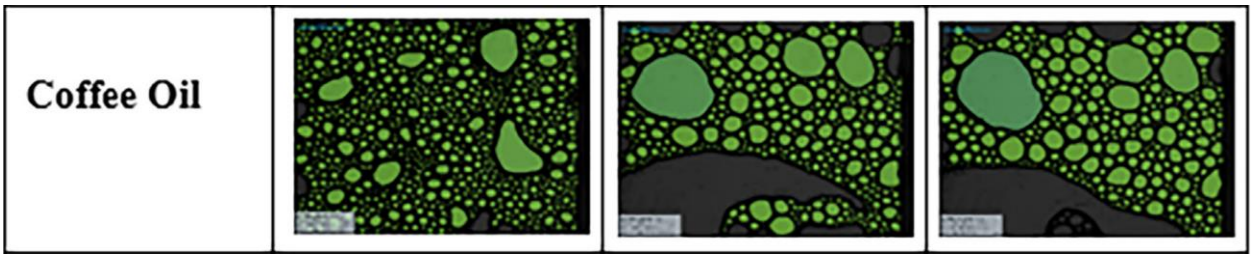

Figure 4: figure from food science study investigating surfactant properties of coffee [3]

It is really pretty remarkable how similar the coffee in this image is to what was captured in mine under similar magnification. This effect arises from the forces acting on a differential fluid element at the edge of a fluid droplet. While the forces on an element in the body of the fluid are balanced by pressure from all sides, the molecular cohesive forces are unbalanced at the fluid boundary. This causes a net force inwards until internal pressure is sufficient to counter the molecular forces from the edges. As a result, drops of fluids with high molecular cohesion tend to be round in shape. This force balance is shown in figure 5:

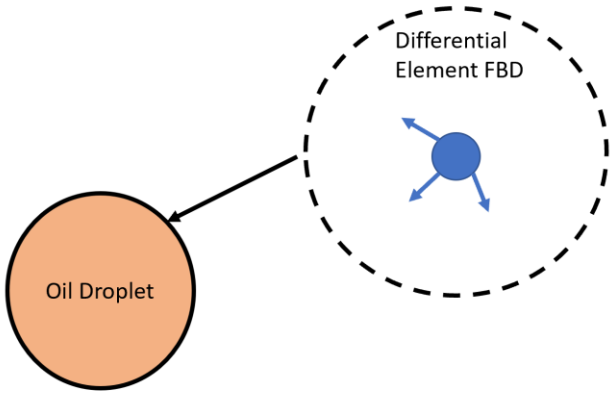

Figure 5: Work being done on a fluid element to extend surface area, courtesy [1]

The effect is slightly undercut in the image due to the number of fluid bodies present in the immediate area. This causes many of the oil bubbles to be misshapen, because the primary

forces acting on them are pressure from each other, causing surface tension effects to be reduced.

The flow visualization technique used in this photo was index of refraction. The barriers between the fluids is only visible because of the change in index of refraction between the oils and the water. The coffee beans were an Arabica dark roast purchased in bulk and ground using an automatic bean grinder in the lab. The coffee was brewed using a large French press, with the water heated up to 190˚F, and steeped for just under 5 minutes. The slides were prepared using a 50 µL pipet to distribute the brewed coffee. The lighting source was the built in incandescent light under the microscope lens, which was passed through a yellow filter before hitting the slide.

The field of view of the camera was dictated entirely by the microscope, as was the zoom, because at a given magnification we had to adjust the microscope position to get the image in focus. There was no lens attached to the camera, but we did use the AM Scope camera to microscope adapter, which attached to the camera body and slid into the eye piece of the microscope. For a camera we used a Nikon D5500 DSLR on manual settings. The photo was 6016 pixels wide by 4016 pixels tall. The shutter speed was 1/200 seconds with an ISO of 400. The editing was relatively minimal, I just used an S-curve in Gimp to lighten the image and to increase the gradient between the light and dark on the right and left sides of the image. The unedited image is shown in figure 6.

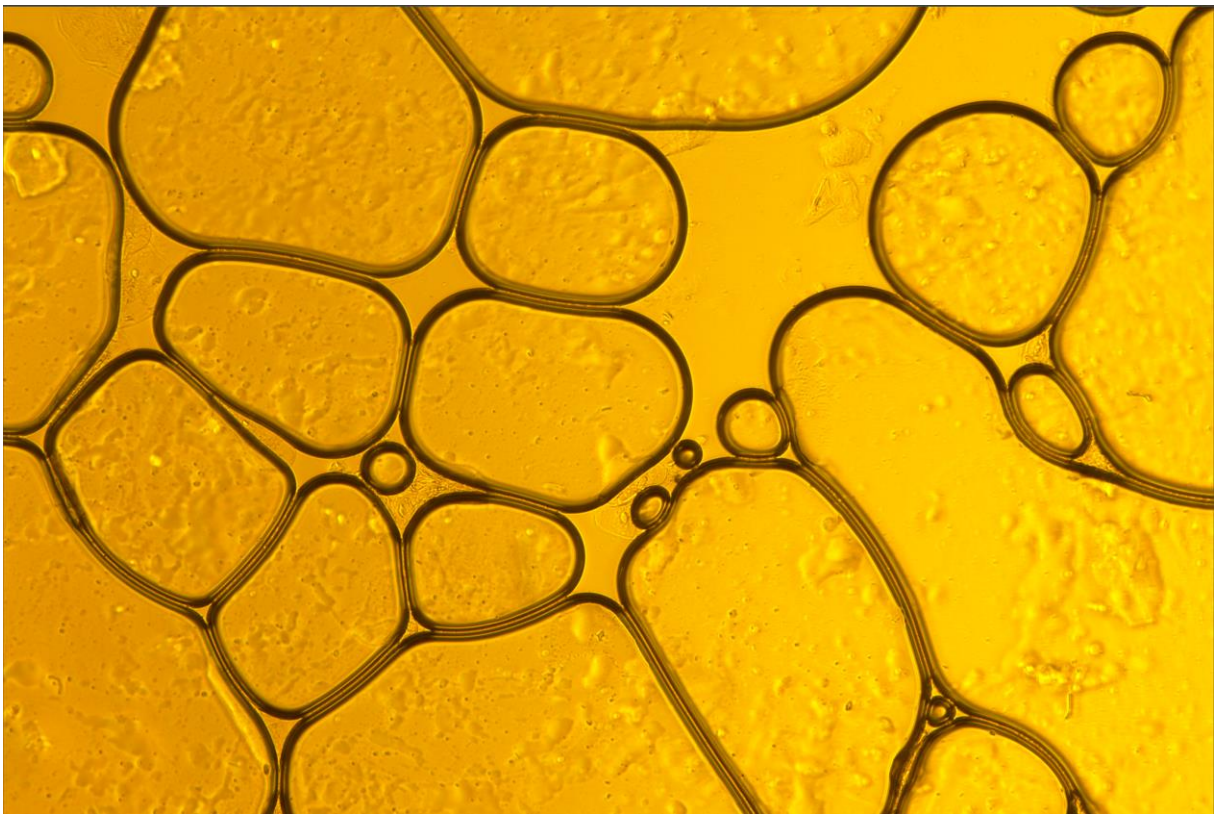

Figure 6: Unedited image directly from the camera

I really like how abstract the image is, and the color scheme is pleasantly simple. I think that the strong diagonal going up the top right gives it a nice effect as well. Overall, other than finding a way to improve the lack of context for the image, I would likely leave it as is. It reminds me of something like cells in a leaf under a microscope. The interesting thing about this image is how truly similar the blobs of coffee oil look to cells.

References

[1] Çengel, Yunus A.; Cimbala, John M.; Fluid Mechanics: Fundamentals And Applications, Third Edition; *McGraw Hill* 2014 ISBN 978-0-07-338032-2

[2] M. Ferrari, F. Ravera, E. De Angelis, F. Suggi Liverani, L. Navarini; Interfacial properties of coffee oils; *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 2010, Vol. 365 Issues 1-3, Pg. *79 – 82. https://doi.org/10.1016/j.colsurfa.2010.02.002.*

[3] Deotale, Shweta M., et al. "Coffee Oil as a Natural Surfactant." Food Chemistry, vol. 295, 2019, pp. 180–188., doi:10.1016/j.foodchem.2019.05.090. Accessed 18 Dec. 2019.