Get Wet Report

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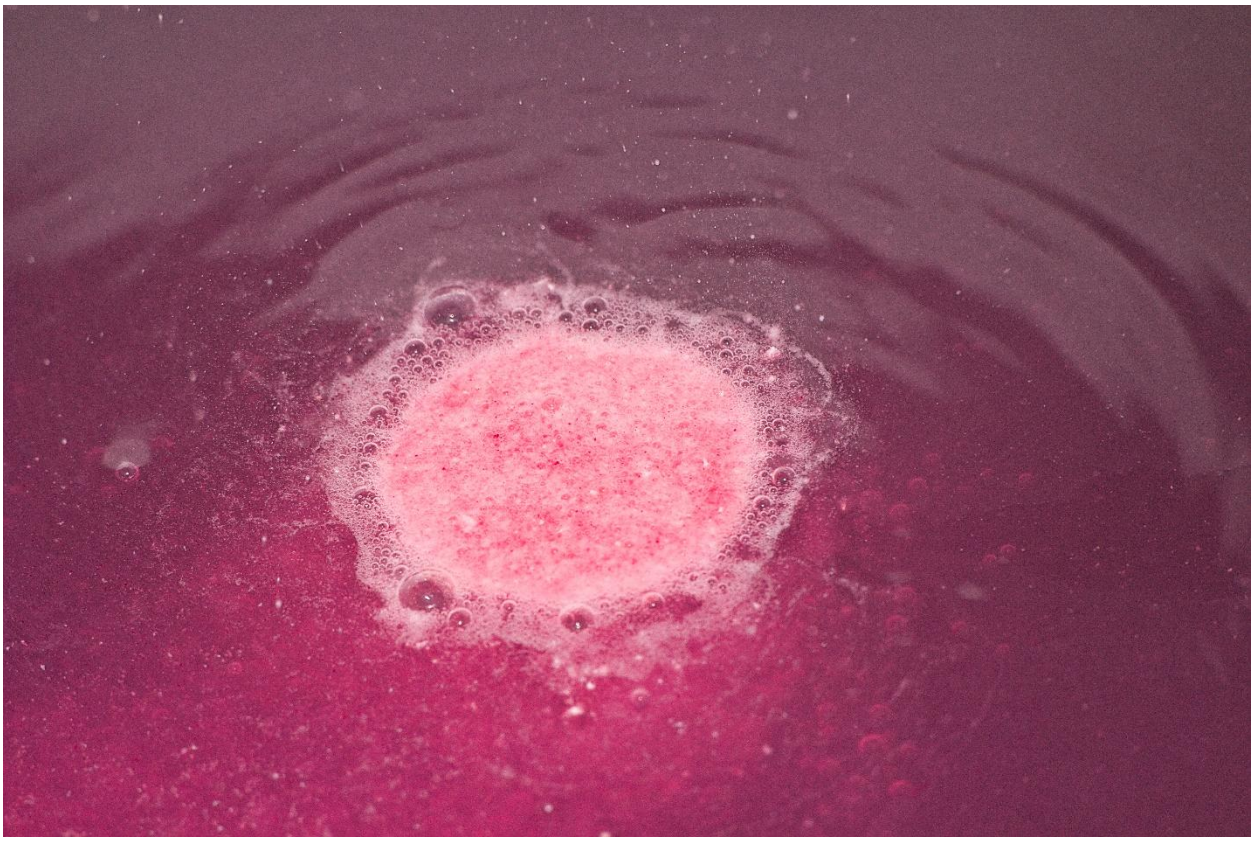

Figure 1. Final image of Pink Effervescent Tablet Dissolving in Water, post-processing done in darktable

Context and Purpose

The “Get Wet” assignment is an introductory attempt at capturing a flow phenomenon. Capturing flow phenomena requires various photography techniques and utilizing manual camera settings such as aperture, iso, and shutter speed, depending on the situation. The goal in this experiment was to record the reaction of an effervescent tablet in water and visualize the effect the tablet has on the fluid. A pink tablet was used to create a clear boundary layer with water; it also created a more visually appealing image. A white tablet would also work to show the phenomena; however, it resulted in a less vivid image. Initially, the goal was to show the tablet dissolving under water and highlight the streamline of bubbles rising from the tablet to the water surface. A clear plastic bowl was used to capture images of the tablet dissolving underwater. After several attempts at photographing the phenomenon from the side of the bowl, I found the bowl was too reflective and the refraction from the water didn’t allow for a clear image of what was taking place. Instead, I used a black plate filled with water and photographed the tablet from above.

Phenomena Captured

The reactants within the tablet include citric acid, sodium bicarbonate and water, they react together to create carbon dioxide, water and sodium citrate.[1] This creates fizzing from the tablet dissolving, releasing carbon dioxide bubbles and solid granules that disturb the water in the plate. This stoichiometric formula for this reaction is below.

$$\text{citric acid} + \text{sodium bicarbonate} \rightarrow \text{water} + \text{carbon dioxide} + \text{sodium citrate}$$

$$C_6H_8O_{7(aq)} + 3NaHCO_{3(aq)} \rightarrow 3H_2O_{(l)} + 3CO_{2(g)} + Na_3C_6H_5O_{7(aq)}$$

The citric acid and sodium bicarbonate are initially in solid granule form compressed into a tablet shape. There is no reaction between the reactants themselves as they require a catalysis (the water).[1] The carbon dioxide bubbles that form from this reaction help break down the tablet faster, they release from the tablet and break free granules in the process. These granules can be seen as specks flying from the tablet in the image captured. Additionally, small waves are captured emitting from the tablet as it breaks down. The waves are produced by the carbon dioxide bubbles forming, making their way to the surface of water and bursting. After, these bubbles burst they leave behind a curved cavity on the surface of the water.[2] These waves can be likened to capillary waves, as they have a short wavelength, small size and the primary restoring force is surface tension.[3]

A Reynolds number is commonly used to classify, flow as turbulent or laminar. For this reasoning, a Reynold number was calculated to characterize the flow of the water from the tablet. The initial Reynolds number for tablet dissolution was calculated using a velocity (V) of 8mm/s from a study simulating tablet dissolution in the human stomach, the radius of the tablet 26mm (L), the density of water 1000 kg/m^3(ρ), and the dynamic viscosity of water (μ) at room temperature .89mPa*s.[5][4] However, as tablet dissolves the diameter decreases and the speed

of the water increases from constant forces acting on its surface, making the Reynolds number vary with time

$$Re = \frac{VL\rho}{\mu}$$

The Reynolds number was calculated to be 233.7, characterizing the flow of water as laminar. This makes sense as there is not a lot of force acting on the water, and it is met with resistance by surface tension.

Experimental Set Up & Process

The setup was relatively simple, it required: three pieces of white gloss paper, a cardboard box, white LED light, a black plate, and a table to place all these items on. The white gloss paper was taped together to form an open box around the black plate, with an LED light shining down on the plate from above. The LED light is not specifically required for this setup, however having a light source shining into the open box did help capture bubbles that were under the water surface. A Canon EOS Rebel T3i camera with 70-300mm macro lens was used to shoot this phenomenon about 1 meter from the plate. An ISO speed of 400 was used due to the amount of light being introduced by the ambient and LED light. Smaller aperture was used (f/16) due to the light in the scene, and to capture the scene near the tablet clearly. Shutter speed was also taken into consideration as this was a very lively picture with many moving parts. The shutter speed used was 1/200 sec.

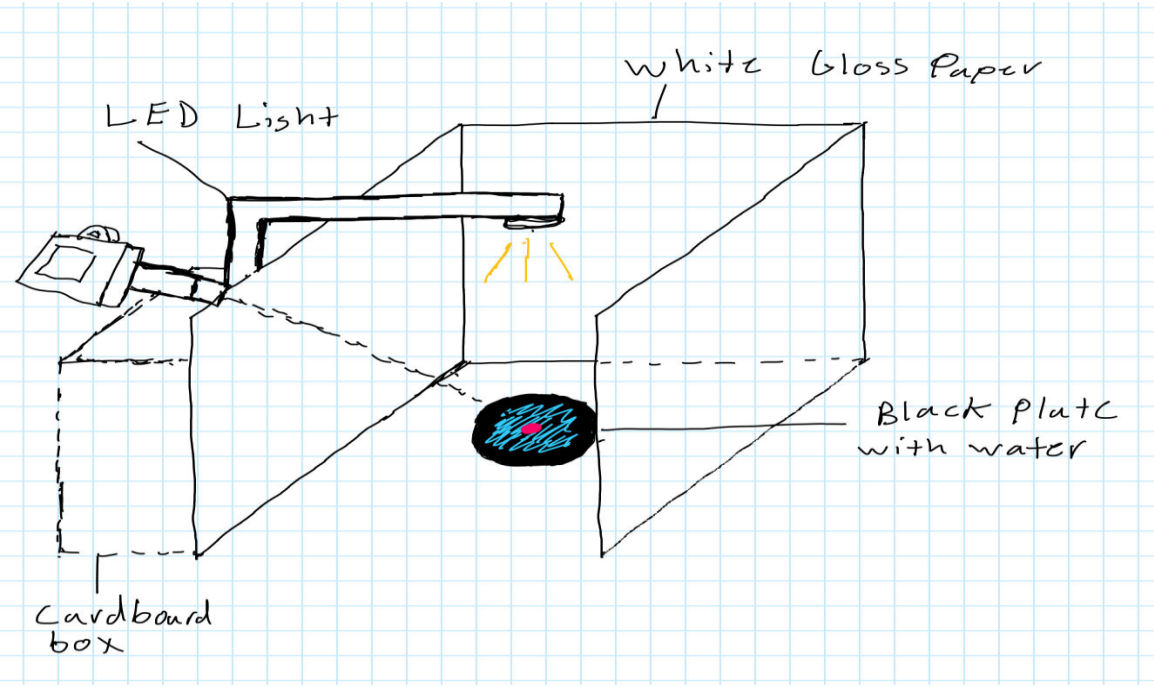

Figure 2. Sketch showing the set up for photographing the tablet

The process was also simple: place the plate in the center of the white pieces of paper, drop the tablet in water and try to capture the tablet as it dissolves. I found it difficult to get the tablet in focus after dropping it in the water. I would recommend having help if this was recreated. With help dropping the tablet in the water your camera can be focused on the general spot the tablet is in without missing a potential good shot.

Post-Processing

The original image was edited in darktable to highlight the phenomenon taking place. The sharpness was increased to show the carbon dioxide in greater detail. The sharpness also emphasized the water ripples emitted from the tablet. The saturation of the pink was also increased to show these bubbles beneath the water surface. Additionally, the brightness of pinks was increased to show these same bubbles. Both the saturation and brightness resulted in a very colorful and interesting image. The original image is shown in figure 3.

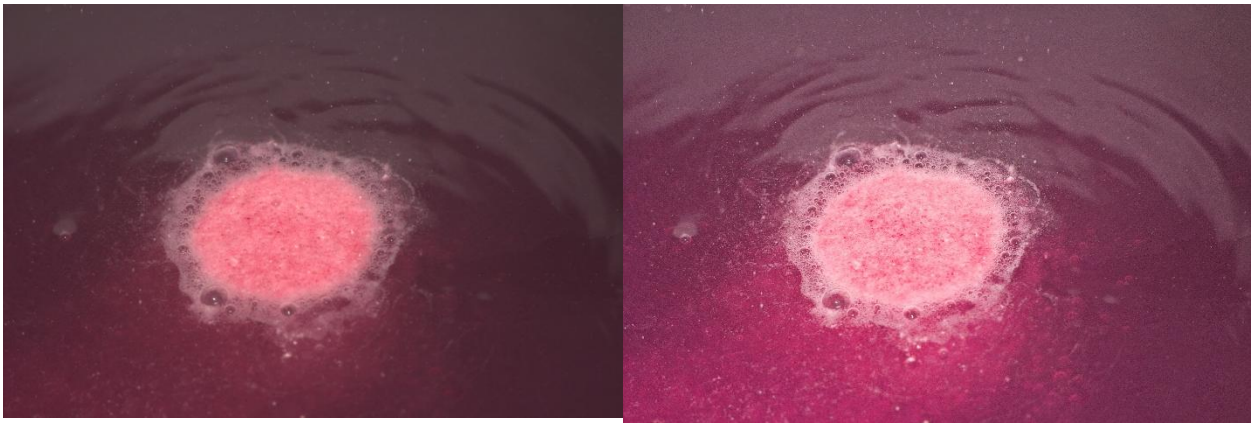

Figure 3: Original image captured of the effervescent tablet (left) and edited on the right

The original image is 5202 x 3464, and the edited photo is 5198 x 3462. The final image captures the phenomenon well, it shows the carbon dioxide bubbles surrounding the tablet, underneath water surface and the granule released from the tablet. It also shows the ripples, indicating flow of water. If this experiment was done again, I would either crop the image to have the tablet in the center or keep this in mind when shooting. The lens used did help capture small details near the tablet, however it was hard to shoot 1 meter away from the plate. This was due to the minimum focus distance that was attributed to the lens. I would either invest in a tripod, or if possible, get a smaller macro lens.

References

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[5] Liu, Xinying & Zhong, Chao & Fletcher, David & Langrish, Timothy. (2023). Simulating Tablet Dissolution Using Computational Fluid Dynamics and Experimental Modeling. Processes. 11. 505. 10.3390/pr11020505.

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