Cloud City

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MCEN 4151
Group Assignment #2

Context

Over the course of this semester, many students have mixed different fluids together, usually involving different colors, to observe the interaction. Such examples include food coloring, India ink, and highlighter fluid. Occasionally viscosity will be changed as is seen in the two-dimensional Hele-Shaw cell. Adam Sokol, Michael McCormac, Ryan Coyle, and I chose this project to see how fluids of different viscosities interact with one another in three dimensions.

Theory

As seen in the two dimensional Hele-Shaw cells, surface tension and cohesion characteristics of the two fluids produce a fingering effect. Cohesion is the force of attraction between molecules of a liquid. This attraction between molecules puts the liquid under tension as seen through the phenomenon more commonly referred to as surface tension. With cohesion in a three-dimensional interaction, the glue should retain its shape and resemble the rope coil instability as usually seen with high-viscosity fluids.

Setup

For this experiment, fill a large rectangular fish tank with cold water from a faucet, and drop white Elmer's glue on top of the water from a height of 2-3 inches. To ensure maximum contrast with the white subject, hang a black sheet behind the fish tank. Position the camera 1-2 feet away from the glass wall of the fish tank above the bottom of the tank but below the water's surface, and aim the camera upward so that the surface of the water is at the top of the frame. This permits the viewer to see the glue's behavior both at and below the water's surface. Light the subject with a halogen light bulb placed to one side of the tank in addition to the room's normal fluorescent lighting. With natural reflection and refraction characteristics of glass and water, the subject will be relatively well lit.

Photographic Technique

With the Canon EOS REBEL T2i placed next to the fish tank, set the focus by dipping a hand into the center of the fish tank. Once the focus is set, start dropping glue onto the water at a slow rate and move the bottle around a small area, approximately 1.5 inches wide. The glue will sit on the surface until enough has accumulated that it sinks below the water's surface. Snap photos repetitively while pouring glue on the water. To drastically reduce motion blur for this image, an exposure time of 1/100 second, ISO-800, and f/5.6 were chosen. Since no exposure bias was used, the original image (Figure 1) was rather dark despite the bright halogen light and overhead fluorescent lighting. Post-processing blacked out the background, brightened the image, increased contrast, shifted the hue toward blue and increased the saturation. Finally, the image was flipped 180°.

Analysis

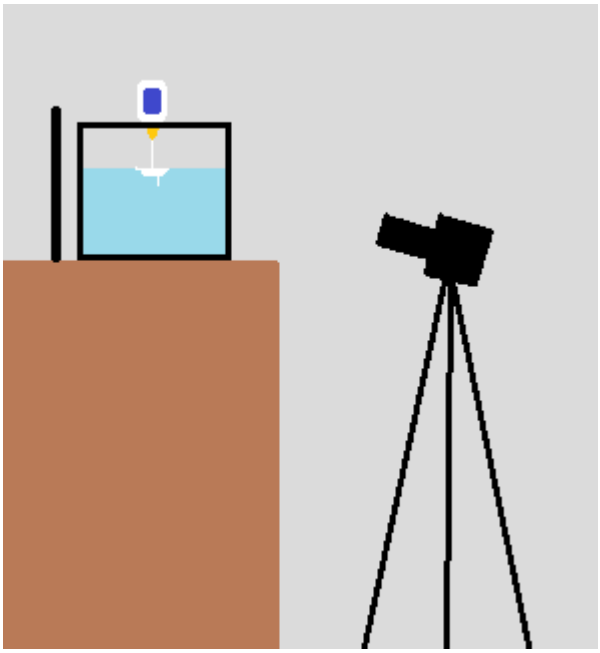
This image shows how the combination of surface tension and cohesion characteristics of the glue and water prevent the two from mixing. The spire seen in the image is probably the result of the initial impact of the glue on the water before the glue started to collect on the water's surface. An unintentional bonus of this image is the reflection of the glue on the water's surface. This is known as total internal reflection which occurs when light hits a boundary between media of different refractive indices at an angle greater than a certain critical angle dictated by Snell's Law.

Appendix

Figure 1

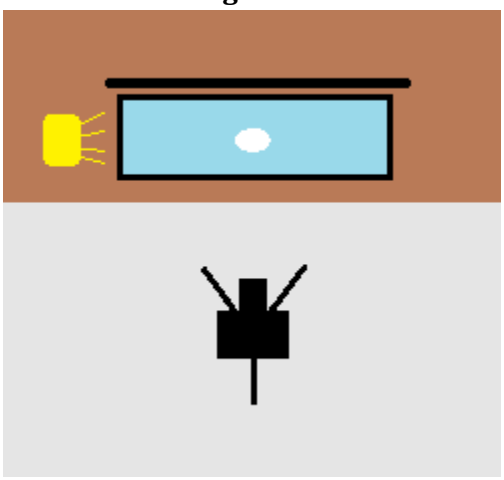
The original image before post-processing

Figure 2



The setup when viewed from the side.

Figure 3



The setup when viewed from the top.