Glow Sticks and Water

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Flow Visualization

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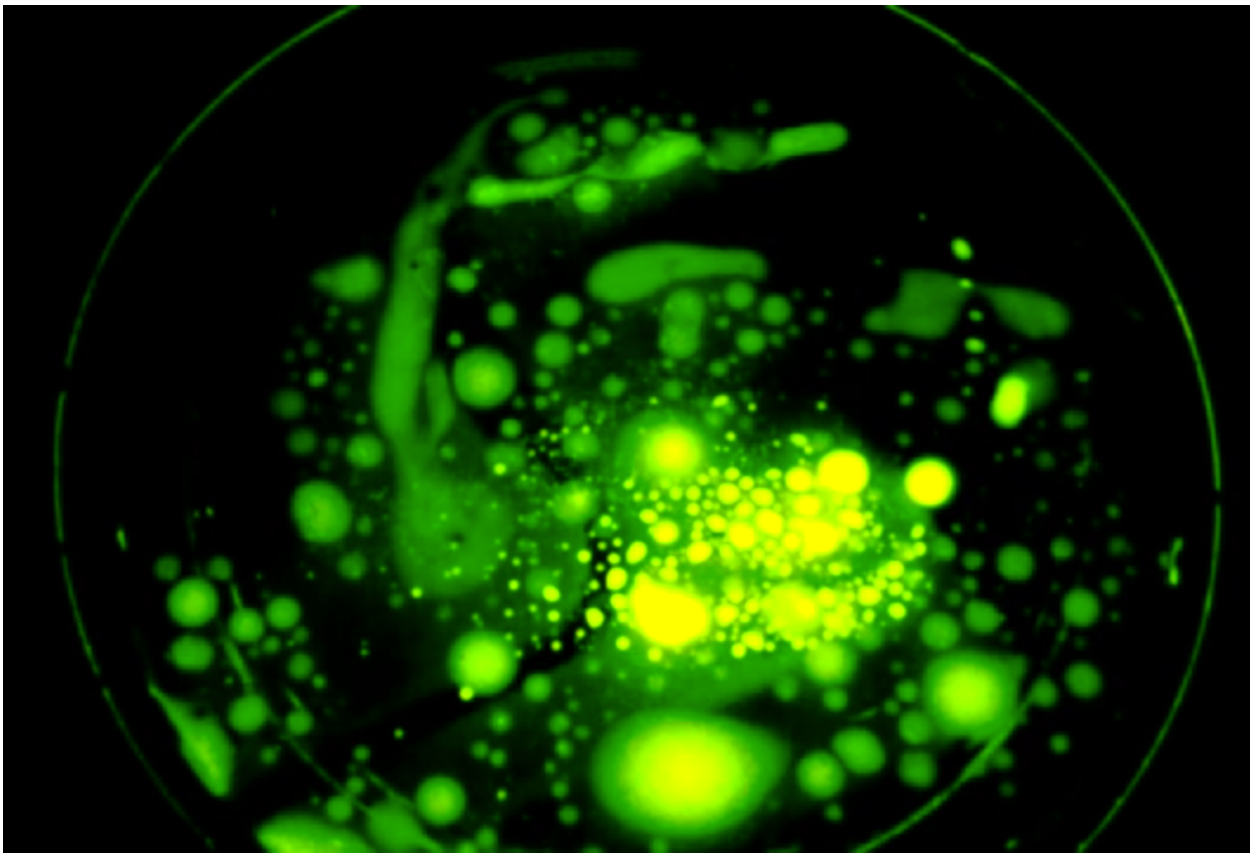

https://vimeo.com/139174524

The initial intent of this video was to observe the mixing of dibutyl oxalate and concentrated hydrogen peroxide which are the reactants in a glow stick. However, the method used to get this shot did not yield interesting fluid flows. During clean up, I noticed far more interesting reactions between the glow stick fluid and water taking place. In order to further understand the interactions of glow stick fluid with water, this video was created demonstrating three different ways in which they interact. These include dripping the fluid into water from a height of one foot, injecting the glow stick fluid directly into the water, and finally using soap to break the waters surface tension isolating the glow stick droplets.

To achieve these results, a 11.5 inch glass microwave tray was placed on a white surface with about 1/8 inch deep room temperature water in it. Next the glow stick was cracked and cut and the fluid was sucked into a 50 ml syringe. Gloves and extreme caution were used throughout this process due to the hazard of broken glass swell as dubiety oxalate has been known as a skin, eye and respiratory irritant as well as cause birth defects and infertility.[1] For the first film section, the glow stick fluid was dripped into the water from a height of around 1 foot. As the drops of glow stick struck the water it seemed to vanish for around two seconds before reappearing on the surface as a large disc. This disappearing effect is believed to happen due to the impact of the glow stick fluid drop breaking the fluid into nano particles and eliminating the droplets surface tension. Once the droplets are broken up under the waters surface, it is free to diffuse within the water until it accumulates at the waters surface in a large disc. The dibutyl oxylate and hydrogen peroxide mixture is slightly less dense than water allowing it to

float on the surface. Once on the surface, the concentration will increase making the glow stick fluid to reappear. The surface tension begins to break up the smooth laminar disk into smaller units. Next, the glow stick fluid was directly injected below the surface of the water using a hypodermic needle. This did not however cause the glow stick fluid to dissolve and diffuse in the water as seen before, it caused turbulence which broke the fluid flow into smaller spherical droplets contained by their own surface tension. They also did not float as seen before since the hydrophobic dubiety oxalate would stick to the glass plates surface. Finally, a drop of dish soap was dripped directly into the plate's center. This drop of soap broke the surface tension of the water which was interacting with the surfaced glow stick fluid. As surface tension broke, the glow stick fluid jumped away from the center and made the glow stick fluid's surface tension more dominant, contracting the droplets to aspherical shape. These three interactions all show interesting dynamics between surface tension amongst water and a hydrophobic fluid, diffusion, and turbulence.

To obtain a more vibrant shot an AmeriGlow 30 minute ultra brite yellow glow stick was used. These type of glow sticks are obtainable at most hardware stores. These glow sticks are marketed as non-toxic however there are still some health and safety concerns as mentioned above. Since the glow stick fluid reaction provided the light, no light sources were used and the film was shot in complete darkness. The illumination from the glow stick so vibrant the only post processing done was a slight brightness increase.

The hardware used to obtain this shot was a digital Nikon D5200 with a AF-S Nikkor 18 - 55 mm 1:3.5-5.6G lens. For this shot the camera was placed 2.5 feet above

from the experiment on a tripod. The focal length of the lens was set to 55 mm and the ISO was turned up to 3200 to achieve maximum detail and brightness. Final editing was done using iMovie since the image was only cropped from 4496 x 3000 pixels to a size of 3300 x 3000 pixels and brightened.

I really enjoyed conducting these experiments and how well the footage shows the different ways this amazing fluid can interact with water depending on how they are mixed. This footage seems to show both expected flow characteristics as well as strike awe and wonder into the audience with the disappearing droplets. This diffusion phenomenon is still mysterious to me as to why it becomes invisible, and why it diffuses so uniformly without yielding a high light concentration in the center of the disk. These unseen diffusion physics may be more visible through use of a higher ISO or a slow motion camera. Playing with glow stick fluid as was done here is not a common experiment, and has ultimately intrigued me with interesting physics and new experiments.

Reference

1. Zhang, M., Wang, Q., & Zhuang, H. (2006). A novel competitive fluorescence immunoassay for the determination of dibutyl phthalate. Original Title. doi:2006