

Oobleck and Dry Ice

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The image below in *Figure 1* is a submission for the Flow Visualization course assignment "Group 3 Image". The motivation for this image was mud pots; they are commonly seen in Yellowstone National Park and have peculiar behavioral characteristics. The thought was that oobleck and dry ice would mimic that behavior. The intent of the image was to capture the fluid flow of oobleck when dry ice was introduced. The group was expecting bubbles to form slowly and to pop violently, similar to that of a mudpot; however, it quickly became apparent that what the group expected was not going to occur. The group then changed its focus to the slow forming and slow deflating bubbles. The image in *Figure 1* captures what happens to the dry ice induced oobleck bubbles nicely. This image was taken as part of a group effort in which the following people were involved: Faith Batrack, Christopher Francklyn and Jiffer Harriman.



Figure 1: Final edited image for oobleck and dry ice

Oobleck is a non-Newtonian fluid that is made by mixing cornstarch and water together. A non-Newtonian fluid is a fluid with varying viscosities. There are different types of non-Newtonian fluids, the main ones being: dilatant, pseudoplastic and Bingham plastic [1]. Of these different types, oobleck is a dilatant, which means it is a shear thickening material [2]. In other words, if agitated or put under pressure, the viscosity increases, so much to the point it behaves like a solid; however, if left freely, it will act similar to that of a liquid. The group used the recipe of 2 parts cornstarch to every 1 part of water. It was mixed together by kneading it with our

hands because the oobleck wouldn't allow for anything else. The setup of the image taking process can be viewed in *Figure 2* to the right. Two 100-watt bulbs set 5 feet above the ground were used to provide the lighting during the photo-shoot. A black back drop was put up behind and under the 9 x 13 x 2 inch pan the oobleck sat in. In the beginning, a few small dry ice pieces were put into oobleck, but the oobleck and dry ice didn't want to mix together, the oobleck almost slid off the dry ice pieces. To work around this, chunks of oobleck were taken from the edges of the pan and placed on top the dry ice pieces. The CO₂ the dry ice gives off, builds up pressure under the oobleck until a bubble forms, then when the pressure exceeds what the surface tension of the fluid can withstand, the bubble pops at its weakest point. An interesting point to note in *Figure 1* is that the bubble didn't pop at the top where one would think it would pop. It popped on the side near the top.

Figure 2: Schematic of the setup

Different colors of neon food coloring were used to visualize the fluid flow. Blue green, red and pink were the colors that were used throughout the image taking process. A few drops were added as each of the bubbles was formed. Blue and red were the two main colors used; the red, being a vibrant color, added a nice contrast to the image. The area being photographed was well lit the entire time. In addition to the ceiling lights, two flood lights, each with 100W bulbs were pointed towards the pan of oobleck the entire photo shoot. Refer to *Figure 2* to see the full setup.

Photographic Technique

The following are the parameters used in the creation of the image:

- Type of camera: Nikon D40
- Focal length: 55 mm
- Aperture: f/5.6
- Shutter speed: 1/500 s
- ISO: 800
- Final image size: 2057 x 1672 pixels
- Original image size: 3008 x 2000 pixels
- Field of view: 4 inches x 3 inches
- Distance from object to lens: 18-24 inches

The Nikon D40 camera allows the user to switch between controlling the aperture and the shutter speed but not both at the same time. Those two settings are

inversely related to one another. The shutter speed was not as important compared to the depth of field, so at the time of the image was taken, the camera was set aperture driven. An aperture of $f/5.6$ was used to get a mid-range depth of field so that more of the oobleck could be in focus at any given time. As stated earlier, the bubbles were slow to form and deflated slowly as well so a high shutter speed wasn't essential for capturing the image. The ISO in this image was higher than it needed to be, a lower ISO should have been used. There was a lot of available light for the camera and the noise in the image could have been reduced if the ISO was lowered. The original image can be seen in Figure 3. The brightness was slightly enhanced to bring out the vibrant colors and give the image a happier tone. Cropping was done to the image as well to give it a better composition and to crop out the blurry edges seen on the top of the original image.



Figure 3: Original un-edited oobleck and dry ice image

This image reveals a lot behind the physics of oobleck, especially when compared to Newtonian fluids. The popping of the bubble on the side, rather than the top shows that the sides are the thinnest and weakest point in the bubble rather than the top. I really like this image because the bubble has been popped, CO_2 is rushing out and yet the bubble is still retaining its shape in the image. Also, I like the color of the main bubble, it reminds me of the shiny skin of an apple. I feel the intent of the image was fulfilled in displaying the interaction of oobleck and dry ice. If I could improve the image, I would lower the ISO on the camera and make a lot more

oobleck. To expand on this idea, I think it would be interesting to explore the flow of actual mud pots, which was the original motivation for creating this image.

Sources:

- [1] White, Frank M. *Fluid Mechanics*. 7th ed. New York, NY: McGraw Hill, 2011. Print. Pages 26-31
- [2] Nelson, Carl. "Oobleck – a Non-Newtonian Substance : Imagination Station." *Imagination Station*. RSS, 2010. Web. <<http://www.imaginationstationtoledo.org/content/2010/12/oobleck---a-non-newtonian-substance/>>.