Effervescent Tablet Dissolving in Water

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For the third team project assignment the goal for the group was to use a high speed camera in order to capture different flow phenomena in slow motion. The inspiration for this came from seeing the slow motion videos done by other groups for previous projects in this course. For the Get Wet assignment one of my ideas was to image an effervescent tablet dissolving in water. However a still image was insufficient to show the true nature of the flow. Hence for this project it was decided that for my image we would use the high speed camera to capture an effervescent tablet dissolving in water. The footage combined with some music provided for an excellent clip showing the bubbling effect of the tablet.

In order to create the video of the effervescence, antacid tablets were used with water to illustrate the dissolution process. To do this a drinking glass was filled with cold tap water and the tablet was subsequently dropped in. As soon as the tablet is immersed in the water bubbles begin to form at the surface of the tablet. This process is known as effervescence. The tablet then sinks to the bottom of the glass and the bubbles rise to the surface. The three main components to the antacid tablets are aspirin, citric acid, and heat treated sodium bicarbonate [1]. The aspirin doesn't contribute to the effervescent process but is present for its medicinal uses [2]. The bubbles released are from a chemical reaction between three elements: the water, the citric acid, and the sodium bicarbonate [1]. The process is seen by the following chemical reaction [2]:

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

citric acid + sodium bicarbonate → water + carbon dioxide + sodium citrate

Hence the bubbles that are created are composed of carbon dioxide. The effervescence process continues to create bubbles until the entire tablet is dissolved and no more citric acid or sodium bicarbonate remains. This process is not the only way for effervescence to occur. There are many processes that do not require anything to be added to the liquid as the carbon dioxide is already dissolved into the liquid. These liquids include soda beverages, beer, and champagne as well as others. These processes do require nucleation sites as well as exposure to the atmosphere [3]. Champagne in particular can be a fantastic tool for studying the rising, expanding and collapsing of the bubbles [3]. Effervescence also has applicable value in combustion physics as it can improve the efficiency of the combustion process [4]. This is done by using the bubble creation process as a means for atomization of the fuel with oxygen to increase the combustion rate [4].

In visualizing the effervescent tablet dissolving in water the setup consisted of two halogen lamps, a black backdrop, and a high speed camera in addition to the drinking glass containing the water and tablet. A Kroger brand effervescent antacid tablet (similar to *Alka-seltzer*) was used with cold tap water. The video was then shot at room temperature. The two halogen lamps were placed about 30 cm directly overhead of the drinking glass to illuminate the flow. The camera was placed in such a way that the glass was in the center of the frame. Simultaneously the tablet was dropped into the glass as the record button was pushed to start the recording process. The camera then recorded the tablet dissolving and when it was done the recording process was stopped.

In photographing the video for this project the field of view was about 20 centimeters wide and about 15 centimeters tall. The distance from the glass to the lens was about 45 centimeters. The high speed camera that was used for the project was an Olympus iSpeed 2 camera. The focal length of the lens was the standard focal length for the high speed camera. The aperture was adjusted so that the maximum depth of field could be obtained while capturing enough light to visualize the flow. Although the camera can shoot up to 33,000 frames per second it does this at a cost of resolution and need for more light. It was determined that 200 frames per second was sufficient for visualizing the flow in slow motion. With the footage captured the next step would be to take the raw footage and post process it. iMovie HD was used on a Macintosh computer to post process the footage. First, a fade in and fade out were added to the footage. The video was then made black and white removing the color from the footage. Text was then added to the end of the video for proper attribution. The final step was to add music. *The Blue Danube* composed by Johann Strauss II performed by the Berlin Philharmonic Orchestra was chosen as it worked well with the footage and gave it an “outer space” feeling. With the post processing the video ended up being one minute and ten seconds in length with a frame height of 480 pixels and width of 720 pixels played at a 29 fps frame rate.

The video for this project shows that the visualization of an effervescent tablet dissolving in water can be quite interesting and beautiful when shown in slow motion. The project was an enjoyable way to explore the chemical reactions that occur with citric acid and sodium bicarbonate as well as learning how to use video editing software. The fluid physics are shown very well as the effervescent process is clearly demonstrated. In a future project it would be neat to further quantify the chemical reaction process as well as develop a better method to further expand the depth of field to get a crisper video image. It would also be interesting to explore how changing the amount of surface area of the tablet affects the bubble size and dissolution rate.

References:

[1] J. Bru, “Process for Manufacturing Effervescent Granules and Tablets,” U.S. Patent 4,614,648, Sep. 30, 1986.

[2] Chemistry of the effervescene, Alka-Seltzer article [Online] Wikipedia. <http://en.wikipedia.org/wiki/Alka-Seltzer>, last accessed April 24, 2011.

[3] G. Liger-Belair. The Science of Bubbly. *Scientific American*. 2002.

[4] S. Sovani, P. Sojka, A. Lefebvre, Effervescent atomization, *Progress in Energy and Combustion Science*. Vol. 27 (2001) pp. 483-521.