Photoacoustic Effect

Kimberly Hoffman, *Biomedical Engineering, University of Rhode Island*
BME 281 First Presentation, October 1, 2013 <khoffman11@my.uri.edu>

***Abstract*—Scientists have discovered a way to detect some diseases that change the shape of red blood cells by using a laser. When a laser is applied to red blood cells they produce a high frequency sound wave which can be detected by sensors, and any distortion in the shape of the red blood cell can be identified.**

I. Introduction

THERE are a few diseases that will change the shape of red blood cells. Some of the more commonly known diseases are malaria and sickle cell anemia. Malaria causes the cells to become infected with a parasite, which will multiply and make the red blood cell distort and swell. Eventually, the cell will burst, and release more parasites into the bloodstream. Another disease, sickle cell anemia, causes an elongated, sickle shaped red blood cell. Both of these diseases can lead to many other health problems if left untreated. The method they discovered can be used to diagnose some of these diseases quickly and easily.

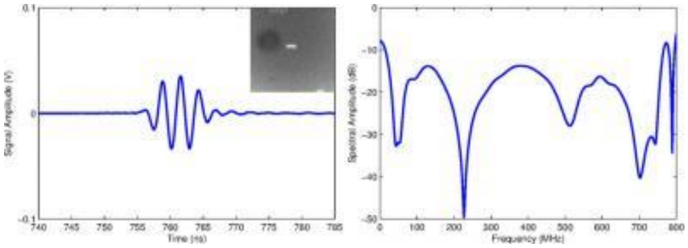
The photoacoustic effect was first discovered by Alexander Graham Bell in 1880. He found out that a disc would give off sound when it was hit by sunlight through a rotating slotted disk. This technique was also used on liquids and gasses first by Alexander Graham Bell, and later on, by John Tyndall and Wilhelm Röntgen. Scientists stopped using this method, because it relied on listening to the sound produced. In 1938 Mark Leonidovitch Veingerov experimented with the photoacoustic effect, using it to measure carbon dioxide in nitrogen. Improvements are currently being made using lasers, transducers, and sensors for efficiency and more sensitivity to the sound waves that are emitted.

II. Methods

The photoacoustic effect is caused by light. The light can either change intensity or be turned on and off rapidly to produce the sound. Although electromagnetic radiation can cause the photoacoustic effect, ultraviolet and infrared light are typically used. The photoacoustic microscope uses a laser on the sample, and as it absorbs the light it heats up and makes the sample expand. As the sample goes back to its normal shape, it releases the sound waves. The sound waves are detected by an ultrasonic transducer that sends information to a computer, where an image can be displayed.

III. Results

Previously, scientists have only used frequencies under 100 megahertz, because the sensors couldn't detect higher frequencies. At lower frequencies they could only determine there was a cell there, but they couldn't accurately identify the size or shape of the cell. Ryerson University in Toronto increased the performance of the sensors and used higher frequencies over 100 megahertz, and they were able to identify the shape and size of the cell more accurately. They could then correctly identify malaria and sickle cell anemia in the red blood cells.



To diagnose those diseases, scientists would need a larger sample of blood, and look at it through a microscope. By using the photoacoustic effect, only 21 cells are needed, which could be found in a drop of blood, and it only takes fractions of a second to complete. Currently, the photoacoustic effect works best with red blood cells due to the way the cells absorb the laser. White blood cells and platelets don't absorb the laser as well.

IV. Discussion

Scientists are creating a microfluidic device that can diagnose diseases with a single drop of blood, instead of using the photoacoustic microscope. This would make the process easier and quicker, because the device performs most of the work, instead of someone having to look at the cells through a microscope or interpret the image and results from sound waves. They also hope to use this method on white blood cells and be able to identify cells grouping together to form blood clots.

References

[1] "Blood Cell Sounds Reveal Shape." *Stuff*. Web. <http://www.stuff.co.nz/science/8882552/Blood-cell-sounds-reveal-shape>.

[2] Cell Whisperer: Lasers Unlock Secrets of the Blood." *Scientific American*. Web. <http://www.scientificamerican.com/article.cfm?id=cell-whisperer-lasers>.

[3] "Lasers Help Speed Blood Diagnoses." *The Journal Gazette*. Web. <http://www.journalgazette.net/article/20130705/NEWS10/307059971/0/FRONTPAGE>.

[4] "Listening to Blood Cells: Simple Test Could Use Sound Waves for Diagnosing Blood-related Diseases." *Science Newsline*. <http://www.sciencenewsline.com/articles/2013070218150004.html#footer>.

[5] "Photoacoustic Effect." *Wikipedia*. Wikimedia Foundation, 09 Apr. 2013. <http://en.wikipedia.org/wiki/Photoacoustic_effect>.

[6] "Photoacoustic Imaging in Biomedicine." *Wikipedia*. Wikimedia Foundation, 15 July 2013. <http://en.wikipedia.org/wiki/Photoacoustic_imaging_in_biomedicine>.

[7] "Photoacoustic Spectroscopy." *Wikipedia*. Wikimedia Foundation, 28 Aug. 2013. <http://en.wikipedia.org/wiki/Photoacoustic_spectroscopy>.