Using Fluorescence Imaging to Diagnose Tuberculosis

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Introduction

In 2010, it was believed that one third of the world’s population was affected by Tuberculosis, especially in developing countries and areas prone to poverty. TB, caused by the many strains of mycobacteria, most commonly Mycobacterium tuberculosis (Mtb), is easily spread through the air, and may potentially infect not only the lungs but also other vital organs. In order to effectively treat this disease, it is imperative that it is diagnosed in its early stages; nonetheless, with the current technologies, cost effective, quick, and accurate diagnostic tests fail to reach the gold standard. Fortunately, recent research from the lab of Dr. Jianghong Rao at Stanford University has been successful creating a potential rapid point of care detection method for Mtb using BLAC (Beta-lactamase, an enzyme specific to and naturally expressed by Mtb) as a marker and a chemically engineered fluorescent protein (CDG-DmE) as a detection probe. In less than ten minutes, Mtb can be detected in substances as noninvasive as unprocessed human sputum. Using the data from this research, the goal of our project is to develop a fluorescent imaging box that is suitable for not just consumer use but also for field work in impoverished areas.

Needs Specifications

Target Consumers:

1. Consumers with little access to health care
2. Organizations working in these areas
3. The everyday consumer

Needs

• Consumer Cost: < $100
• Speed: < 4 hrs
• Portability: < 10 lbs
• Clinical Independence
• Noninvasive
• Safe and Sanitary

Nice to have

• Consumer Cost: < $50
• Speed: < 2 hrs
• Portability: < 5 lbs
• Aesthetically pleasing
• Reusable

Prototype

D/E

Prototype 4

Concept Analysis

1. Breathalyzer – Detect volatile particles created by the bacterium in the users breath
2. Paper Microscope Analysis – Use Manu Prnkash’s paper microscope to inexpensively analyze a sputum sample
3. Imaging Box – (final concept) explained below

Materials

• Laser-cut black acrylic plastic (1/8 inch thick) with non-reflective interior to build the bulk of the box
• 1-inch diameter clear plastic tubing with electrical tape to channel and concentrate the light
• Arduino kit hooked up with phototransistor and LED light to detect and indicate the presence of fluorescence
• Electrical Wiring
• LED light with brightness over 50 lumens to optimize fluorescence
• Excitation filter (490 nm) and emission filter (530 nm)
• Fluorescin as a substitute fluorescent dye for CDG-DmE

Machinery

• Laser Cutter, LaserCAMM
• Acrylic Glue
• Bandsaw

Conclusion

The goal of this project was to make an at-home diagnostic for Tuberculosis. To do so, we created a light-tight box that uses fluorescence to detect the presence of Mycobacterium tuberculosis. We were able to successfully detect the fluorescence with the iPhone app and are currently working to modify and improve both our light sensor and the fluorescent imaging components within our box. This model serves as a proof of concept for a non-invasive, non-clinical method for diagnosing Tuberculosis.

Future Work

There are several improvements that we plan to make to our device in the future:
1. Create a more sensitive light sensor that does not rely on an Arduino kit.
2. Test the device with CDG-oME instead of fluorescein as a substitute.
3. Use our box to diagnose a variety of other diseases using different fluorescent dyes.
4. Make the box more robust and user-friendly.

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References