Science MATTERS! ... IN CONNECTICUT

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NIE ACTIVITY

How Much Does Pollution Affect You?

A Detection System to Identify Hazardous PM2.5 Exposure in Exhaled Breath

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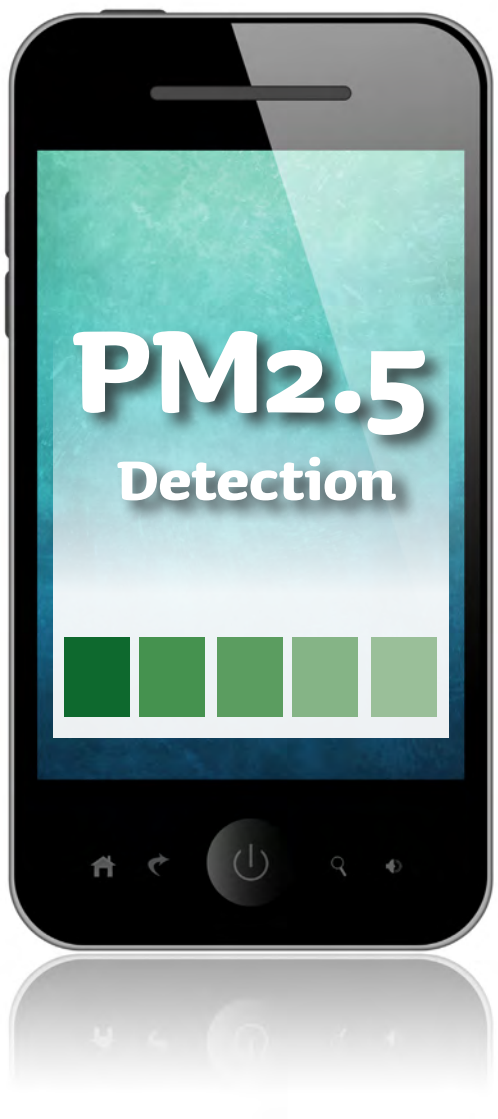
PM2.5, commonly known as fine particulate matter, are the tiny particles of less than 2.5 micrometers present in air pollution. They are present everywhere, from wildfires in California, factory pollution in India, to car exhaust on highways. Annually, 5-8 million people die from continuous exposure to PM2.5, which penetrate the lung and cause inflammation in the epithelial cells. **Nitric Oxide** (NO) is a gas that is exhaled by individuals, and in certain concentrations, can be a biomarker for exposure to high levels of PM2.5. An excess concentration of Nitric Oxide is greater than 40 parts per billion (ppb) in adults and greater than 25 ppb in children.

I was inspired by my own experience to pursue this project, upon witnessing the severity of the impact of PM2.5 on a trip to New Delhi, India. In my project, I set out to create a personalized, quantifiable, and smartphone-based system to measure and identify hazardous PM2.5 exposure. The goal of this system is to help prevent disease before it develops.

Diaminofluorescein-2, simply known as DAF-2, is a **reagent** that is highly reactive with NO. After exposure to NO, the dye is converted to the **fluorescent** DAF-2T, causing the intensity of its brightness to increase. After confirming this was a viable substance to use, I embedded the dye onto a filter-paper-based sensor, in the form of a ¼ inch circle, found to be stable at room temperature. Next, a linear relationship between 60 ml of 0-1000 ppb of NO breath concentrations and the illumination of the DAF-2 detector was found, first through **luminescence spectroscopy** and second with smartphone images. I created the smartphone system with 490 and 560 nm filters, which were attached to the flash and camera of the phone. In addition, I made a 60 ml breath-collection device and a 3D printable dark-box to ensure images taken were constant lighting. Next, a newly created smartphone application rapidly converts the detection card images to green-color values, with a developed algorithm determining the NO-breath concentration down to 10 ppb. These results are time-stamped and shared, along with GPS coordinates, to build color-coded, live, and geographic PM2.5 exposure trends at a per-test cost of about $5.



In conclusion, I was able to create a rapid, visual, inexpensive, and portable system to identify those exposed to hazardous levels of PM2.5, an opportunity to set the basis for live-saving medical consultation, especially where diagnosis is difficult.

Meet the Scientist

Science has always been something that has interested me, starting as a sense of general curiosity thanks to my family's frequent trips to museums, and evolving into a passion. I believe that STEM is the future, the one thing driving progress more than anything else. My love for science takes many forms, from my interest in computer programming to my curiosity about how to solve some of the world's scientific challenges. Outside of research, I debate competitively, play the viola, and enjoy volunteering in STEM-based initiatives.

Ambika Grover is the Connecticut Science and Engineering Fair's Life Science-Senior Division Winner. For this accomplishment she also was awarded by the Connecticut Academy of Science and Engineering a 2021 H. Joseph Gerber Medal of Excellence. Additionally, Ms. Grover was the Connecticut Junior Science and Humanities first place awardee.

Skills & Kowledge

The multifaceted nature of this research allowed me to explore fields including medical diagnosis, chemistry, and technology. In the initial parts of my research, I learned about the chemical interactions between substances like DAF-2 and NO, and how to make NO in a lab setting. Under the guidance of my mentor, I learned how to use equipment like an ATR-FTIR (Attenuated total reflectance - Fourier transform infrared spectroscopy) and luminescence spectrometer. I learned about different methods of medical diagnosis and investigated how NO in the body is produced; in addition, I incorporated and designed technology to make my system more accessible.

Words To Know

Reagent: a substance or compound added to a system to cause a chemical reaction or added to test if a reaction occurs.

Nitric Oxide: Exhaled Nitric Oxide is a marker for hazardous PM2.5 exposure when present in concentrations greater than 40 ppb in adults and greater than 25 ppb in children.

Fluorescence: The emission of light by a substance that has absorbed light, a form of luminescence. It occurs when an electron returns to the ground state from the excited state and loses its excess energy as a photon.

Luminescence spectroscopy: an analytical technique that is used to determine the excitation/emission or light-emitting intensity of a given substance.

hyperlinks

https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

https://pubmed.ncbi.nlm.nih.gov/15019093/

https://www.nytimes.com/interactive/2019/12/02/climate/air-pollution-compare-ar-ul.html

For Students and Teachers Making Curriculum Connections, see the following:

Connecticut State Department of Education (CSDE) - Common Core State Standards (CCSS): Mathematics

- CCSS.Math.Practice.MP1 Make sense of problems and persevere in solving them
- CCSS.Math.Practice.MP3 Construct viable arguments and critique the reasoning of others
- CCSS.Math.Practice.MP5 Use appropriate tools strategically

CSDE - Next Generation Science Standards: Scientific and Engineering Practices

- Asking questions and defining problems; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using Mathematics and computational thinking; constructing explanations and designing solutions; engaging in argument from evidence; and obtaining, evaluating, and communicating information.

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