Jan 1st, 12:00 AM

Design, Construction, and Characterization of a Combined Mini-CO_2/VOC Sensor and Gas Chromatograph For Field Research

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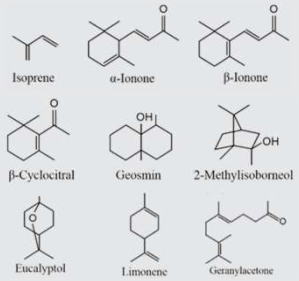
Abstract

Volatile Organic Compounds (VOCs) are commonly used as indicators of an organism's health, among other factors. Traditionally, combinations of gas chromatographs (GC) and mass spectrometers are used to classify these but are prohibitively expensive and impractical. This project utilizes open-sourced technology to create a portable, low-cost device that detects and records the concentrations of VOCs and carbon dioxide. This will then be leveraged into the development of a portable GC, which will be characterized for field use. The GC is novel due to its use of a single sensor used to intelligently trigger and conduct analysis.

Introduction

- Volatile organic compounds (VOCs) are key indicators of an organism's health, but due to their transient nature, are often difficult to collect and analyze in real time
- Determining the amount and composition of VOCs is paramount to understanding more about the organisms that generate them, especially for environmental and conservation studies
- Traditional analysis tools cost thousands of dollars and even "portable" versions can weigh several kilograms
- GCs usually require a nonreactive inert phase that must be disposed of once a single analysis is run; this is expensive and detrimental to the environment
- Open-source technology is a reliable and cost-effective way of developing new systems

Common Environmental VOCs



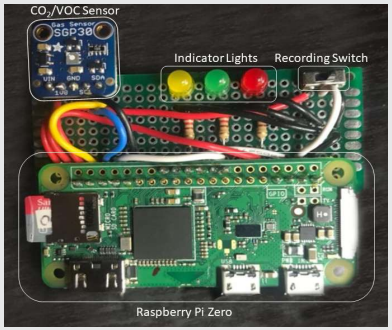
Objectives

- Build a portable CO_2/VOC sensing device that locally stores generated data
- Build a portable GC that can differentiate between 15 peaks in 20 minutes

CO_2/VOC Sensor Function

Current device is capable of measuring and recording generic VOC concentrations in parts per billion (PPB) and CO_2 concentration in parts per million (PPM). This data is outputted as a .CSV (Excel) and .txt (text) file, which can then be viewed locally on the device or moved via a USB flash drive to another computer. LEDs are used to indicate status of each device. Once the recording switch is activated, it will begin recording.

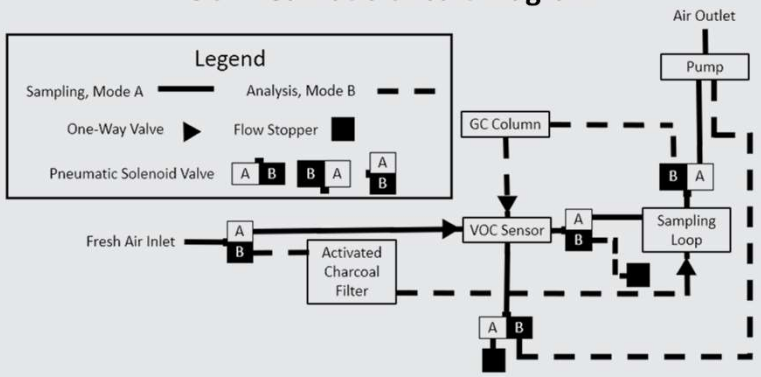
CO_2 /VOC Sensor Prototype



Gas Chromatograph Function

The GC will be able to generate a similar output along with a graphical representation of the analysis. It will autonomously run multiple analyses based on feedback from the sensor to determine when to switch between sampling and analysis.

GC Pneumatic Circuit Diagram



Key Novel Characteristics

- CO_2/VOC Sensor can be powered by a standard phone power bank
- CO_2/VOC Sensor can be produced for less that $100
- GC implements an "Active Listener" that allows analysis to take place only once VOC levels reach a sufficient concentration
- GC uses clean air as its mobile phase, eliminating the need to refill gas cartridges and prolonging usage time

Current Progress

- Calibration of existing CO_2/VOC Sensor
- Early implementation of CO_2/VOC Sensor into target studies
- Prototyping of Mini-GC

Planned Expansions

- Addition of a night vision camera for motion-activated data recording
- Data transfer and visualization over Wi-Fi
- Built-In Calibration Curve
- Floating Case for long-term tracking in wetlands
- Detachable mount for use as a drone payload
- Screen for displaying live data feed

Applications

- Characterizing Huntington's Disease in collaboration with UCF College of Medicine
- Tracking emotional responses in dogs
- Classifying VOCs to detect human emotions
- Tracking learning response in the classroom
- Tracking algal growth in marshlands
- Ecosystem monitoring in St. Kitts
- Implementing into drone payload for long-distance data gathering
- Predicting wandering events in Alzheimer's patients

References

Zuo Z (2019) Why Algae Release Volatile Organic Compounds—The Emission and Roles. *Front. Microbiol*. 10:491. doi: 10.3389/fmicb.2019.00491

Acknowledgements

A special thanks to Brandon, Hunter, Nathan, and the rest of the VOC team at Dr. Hampton's Lab.